

[54] **DEVICE FOR CONTROLLING THE RECIPROICATION OF A WORKING PISTON**

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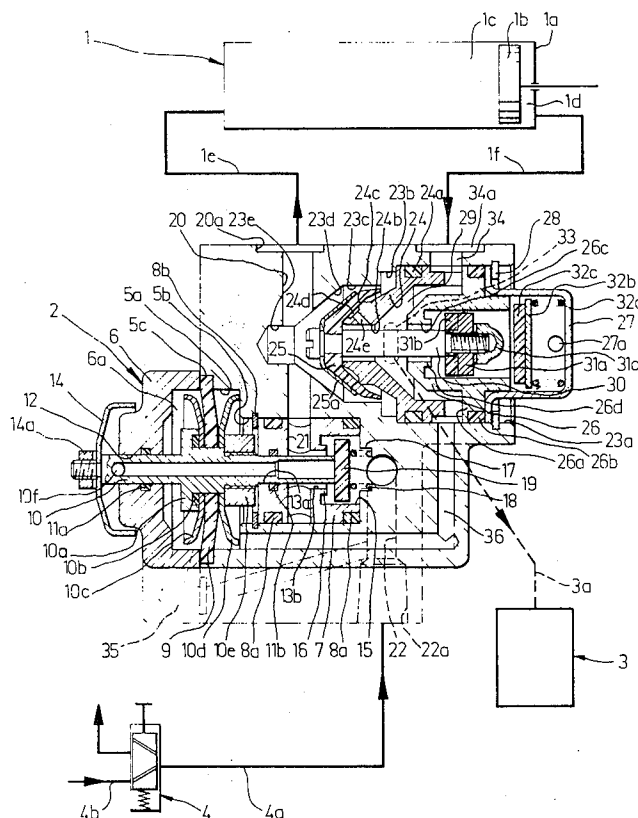
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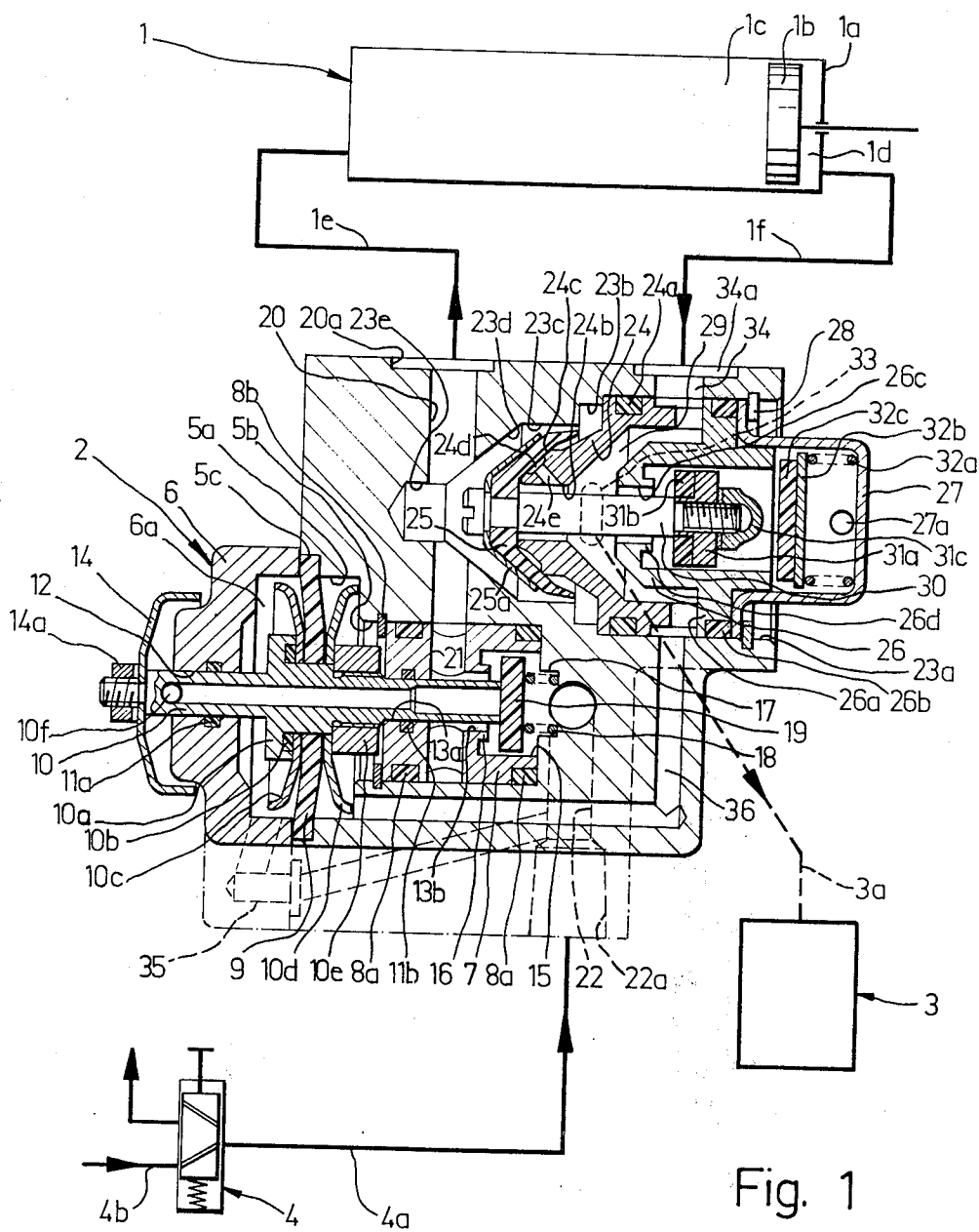
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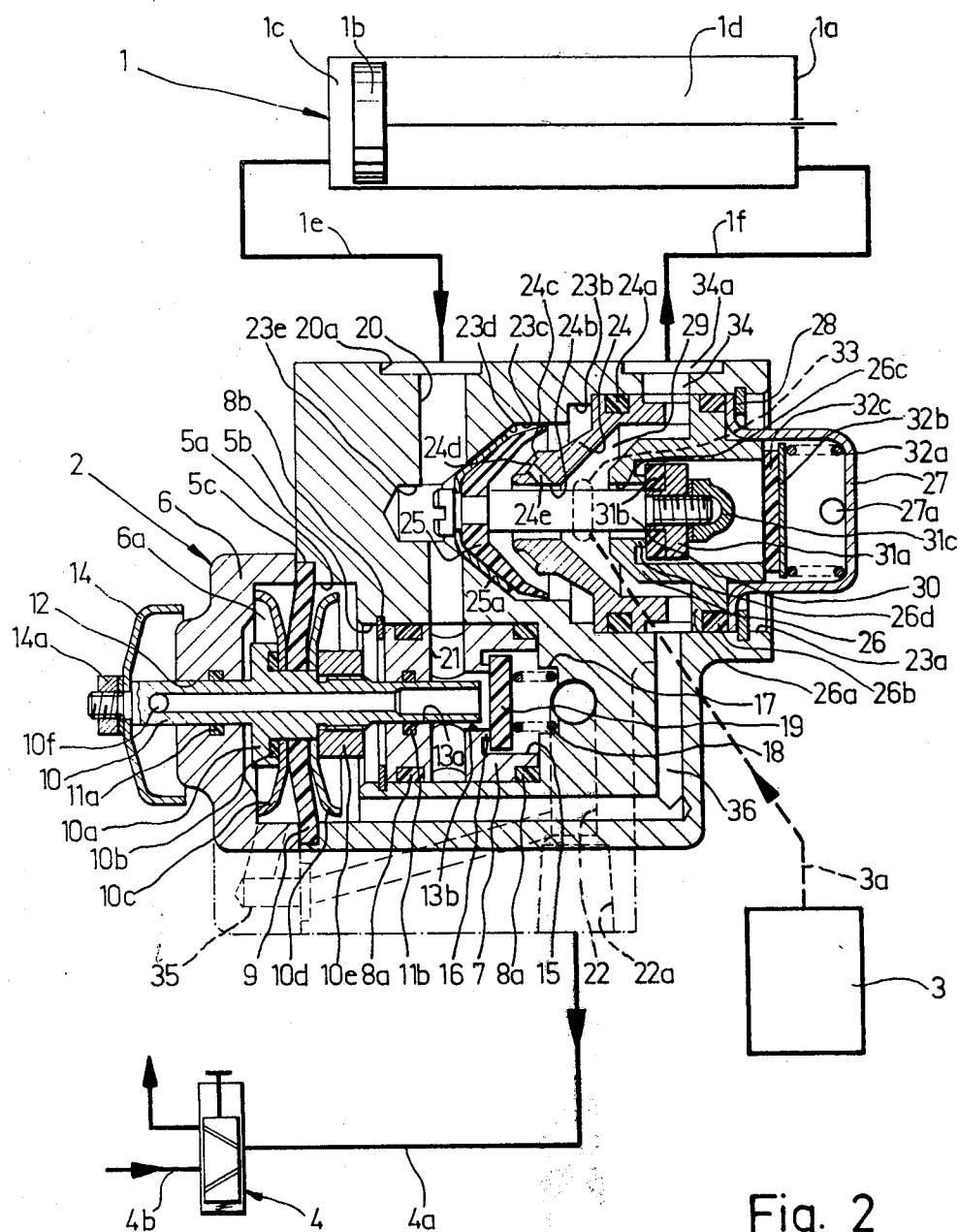
[57] **ABSTRACT**

The device, for controlling the reciprocation of a working piston movable in a cylinder under the force of fluid pressure supplied both from an operating fluid pressure source and a storage source, regulates the movement of the piston from a first position through a working path to a second position and its return to the first position. A two-way valve selectively connects a control block to the operating pressure and to atmosphere and the control block is connected to the fluid pressure storage source. The control block includes a pair of fluid pressure responsive valve assemblies.

5 Claims, 2 Drawing Figures







DEVICE FOR CONTROLLING THE RECIPROICATION OF A WORKING PISTON

FIELD AND BACKGROUND OF THE INVENTION

This invention relates in general to the construction of control devices for operating fluid pressure controlled pistons and, in particular, to a new and useful device which includes a control block connected between an operating fluid pressure source and a storage container maintained under fluid pressure and an operating piston which is movable in a cylinder.

DESCRIPTION OF THE PRIOR ART

Ordinarily, for reversing the motion of a working piston in a pneumatic drive unit, a mechanically actuated two-way directional control valve with five ports is used, through which compressed air is selectively admitted to the respective one of the cylinder spaces on one side of the piston and the cylinder space at the opposite side of the piston is simultaneously connected to the outer atmosphere for removing the counterpressure. Such an arrangement is suitable in cases where the control valve can be located at a small distance from the drive unit. If greater distances must be considered, however, the piston under pressure in the drive unit is prevented from a rapid displacement because losses in the long connection line make the pressure difference too small and the air escapes too slowly. To remedy this drawback, in all cases where a disturbingly long distance is provided between the actuating mechanism and the pneumatic drive unit, the directional control valves are designed as solenoid operated valves and mounted directly on the drive unit while the actuating mechanism is located at any convenient place. Nevertheless, in this arrangement, a shortcoming not to be underestimated is that electric lines are necessary in addition to the pneumatic ones and the help of an electrician is needed for the wiring, inspection and maintenance. Further difficulties occur, for example, in spaces which are humid or involve explosive hazards. That is why, frequently, a slowly working pneumatic equipment is preferred to the electric one.

According to an unpublished proposal intended to eliminate the mentioned drawbacks, a device for reciprocating a drive piston comprises a two-way control valve with three ports and a control member including a differential piston displaceable in a three-step bore and formed with end portions having unequal cross-sectional areas and with a narrower portion therebetween. The bore is axially limited by a smaller and a larger end surface with each of these surfaces having an opening, the smaller one for a direct connection of a compressed air source and the larger one for connection of the directional control valve. The valve is connected to a compressed air source and to the open air so that in accordance with the position of the valve, the large end of the bore is connected either to the compressed air source or to the outer atmosphere. A bypass is provided in the zone of the large end of the bore and, in the zone of its middle diameter, the bore communicates with an air vent. Finally, two connection ports for lines leading to the drive unit are located so that, in each end position of the differential piston, one of the two ports communicates with the respective neighboring end opening of the bore and the other port communicates with the air vent.

It is true that, in this arrangement, the control members must be located close to and, if possible, immediately adjacent the drive unit. However, the directional valve which is connected to the control member through a single line may be located at a relatively large distance without incurring time lags due to air escape because air escapes into the atmosphere directly from the control member. Nevertheless, this arrangement has a not negligible drawback in the limited possibilities of its application. The differential piston is sealed against its guiding surfaces by a plurality of O-rings causing great frictional resistances. Thus, to assure a reliable operation, a certain minimum pressure difference between the operating and the atmospheric pressure must be maintained permitting at any time to displace the piston without difficulties. Moreover, two pressure lines are necessary between the valve and the control member.

To eliminate the last-mentioned drawbacks, another device of this type has been provided differing from the prior art and comprising a directional control valve with five ports and two distinct positions, a compressed air container, and a control element connected to the latter through pressure lines, in which the control element is formed in its interior with two pairs of conical surfaces including an inner conical surface and an outer conical surface and with two bores each terminating in the center of the respective surface, and a cap-shaped seal is provided between each of the pairs of surfaces and mounted freely displaceable so that each seal hermetically closes one of the bores in both the one and the other end position, the bore of the first inner conical surface being connected through a line to the input-output port of the directional control valve, the bore of the adjacent first outer conical surface being connected to an outlet port, the space between the two first conical surfaces communicating both with a connection port leading to one of the working spaces of the pneumatic unit and with the bore of the second inner conical surface, the space between the latter and the second outer conical surface communicating with a connection port leading to the compressed air container, the bore of the second outer conical surface being connected to a connection port leading to the other working space of the pneumatic unit, and the seal between these second conical surfaces being secured to a rod so that, in accordance with the end position of the cap-shaped seal, a valve, actuated by the rod, separates the bore of the second outer conical surface from, or connects it to, another output port.

Experience with the just described control elements has shown that the function of the cap-shaped seals is difficult to control. The structure of the element requires a high precision in manufacture and the individual plays of the valves must be adjusted with utmost accuracy. However, in spite of all precision, attempts to completely remove the pressure from the respective cylinder space with the aid of the control element have failed and, in each case, there remained a small residual pressure with sometimes disturbing effects.

SUMMARY OF THE INVENTION

The present invention is directed to the problem of eliminating these remaining drawbacks appearing in devices of the mentioned type. In particular, a device is provided comprising a control part which does not require a too high precision of adjustment of the indi-

vidual valves mounted therein and still ensures a completely satisfactory operation.

Accordingly, it is an object of the invention to provide an improved device for controlling the reciprocation of a working piston which is movable in a cylinder by fluid pressure from a first position through a working path to a second position and then returning to the first position and using an operating fluid under pressure and a storage container of compressed fluid which are connected through the device to the cylinder on respective sides of the working piston, and wherein the device includes two separately defined interior cavities in a control block with one having a hollow control rod which is movable by a flexible diaphragm and the other having a rod member which is movable to position a valve in respect to a passage for the purpose of controlling of the pressurizing of the respective ends of the cylinder and the discharge thereof.

A further object of the invention is to provide a device for controlling the reciprocation of a working piston which is simple in design, rugged in construction, and economical to manufacture.

For an understanding of the principles of the invention, reference is made to the following description of a typical embodiment thereof as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the Drawings:

FIG. 1 is a partial schematic sectional view of a device for controlling the reciprocation of a working piston constructed in accordance with the invention; and

FIG. 2 is a view similar to FIG. 1 indicating the parts in the other end position.

GENERAL DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings in particular, the invention embodied therein comprises a pneumatic drive unit, generally designated 1, which is connected to a control block 2 for controlling the drive unit. A compressed air container 3 and a directional control valve 4, with three ports and two distinct positions, are connected to the control block 2 through separate pressure lines 3a and 4a respectively.

The pneumatic drive unit 1 includes a pressure cylinder 1a in which a working piston 1b is mounted for reciprocating motion. The working piston 1b subdivides the inner space of the cylinder 1a into two spaces 1c and 1d of which, in the present example, the space 1c shown at the lefthand side of the drawing, is the working space, i.e., the space in which the air is under pressure and acts on the piston during the working stroke. Each of the two spaces is connected, through respective pressure lines 1e, 1f, to respective connection ports 20a and 34a provided in control block 2.

Directional control valve 4 is formed with three ports of which one is connected through a pressure line 4a to control block 2 and the other two are connected to a compressed air source (not shown) through a line 4b, and the other is connected directly to the outer atmosphere through vent line 4c. In accordance with the position of the valve 4', either compressed air is directed from the line 4b into the control block 2 or compressed air is evacuated from the control block into the open air through line 4c.

The compressed air container 3 serves as a pressure reservoir and is connected to the control block 2 connected to a line 3a through a central port in chamber 29.

The control block, generally designated 2, is a metal body assembled of several parts joined together and formed with a plurality of bores, passages, and chambers in which rods, valve members and other particular parts are mounted. In the following, the indications of location or direction such as left, right, lateral, above, below, horizontal and vertical are used in accordance with the representation in the present drawings. The real position of the control block relative to the drive unit, of course, will not necessarily correspond thereto.

In the lower part of the control block 2, adjacent its lefthand lateral surface, a stepped bore is provided, having a narrower inner portion 5b and a wider outer portion 5a. The opening of the bore in the lateral surface is hermetically closed by a cap-shaped cover 6. A cylindrical body 7 is tightly received in the inner portion 5b of the bore, sealed by means of two gasket rings 8a and fixed by a guard ring 8b which is engaged in a corresponding groove provided in the bore wall.

A circular groove 5c, formed at the opening of the outer portion 5a of the bore in the lateral wall, retains an elastic diaphragm 9 by which the bore is closed. The diaphragm 9 engages the circular groove 5c by its border and is squeezed and firmly held in its position by the rim of cover 6. The interior space 6a of cover 6 is substantially cylindrical, its diameter corresponds to that of the outer portion 5a of the bore, and its depth is equal to the depth of the bore portion 5a reduced by the thickness of the diaphragm 9.

A hollow rod 10, frontally open at one of its ends, extends axially of cover 6 and stepped bore 5a, 5b, and is mounted for axial displacement, but tightly, both in cover 6 and in cylindrical body 7. The sealing is assured by two gasket rings 11a, 11b, each retained in a circular groove provided in coaxial bores 12 and 13a, 13b of cover 6 and cylindrical body 7, respectively, the gasket ring 11b being located in the portion 13a of the guide bore of the cylindrical body 7 and the portion 13b having a larger diameter relative to the outer diameter of rod 10 in this zone.

Rod 10 extends through the center of the elastic diaphragm 9 and is secured firmly thereto. For this purpose, in its portion close to cover 6, rod 10 is formed with a flange-shaped collar 10a which, at its side facing the diaphragm 9, is provided with a circular groove into which a sealing ring 10b is inserted. A rotationally symmetrical metal cap 10c is fixed to the rod 10 between the collar 10a and the diaphragm 9, the convex side of cap 10c being turned to the diaphragm 9 and the largest diameter of the cap being slightly smaller than the diameter of the inner space 6a of cover 6. At the other side of diaphragm 9, symmetrically thereof, a second metal cap 10d, identical with the first one, is fixed to the rod 10. All of these parts are bolted together by means of a nut 10e, so that the diaphragm 9 and rod 10 are rigidly joined to each other, and any deflection of the diaphragm in the one or the other direction necessarily results in a corresponding displacement of the rod. The two metal caps 10c, 10d serve as limiting stops abutting against either the shoulder formed by the different diameters of the bore portions 5a, 5b, or against the inner front face of the cover 6, thereby defining a first, inner end position of the rod 10 shown in FIG. 1,

or a second, outer end position of the rod 10, shown in FIG. 2. The intermediate space 6a formed by the interior of cover 6 and the wider bore portion 5a serves as the control chamber and is sub-divided into two compartments by diaphragm 9.

The end portion of rod 10 extending through the cover 6 is formed with a cross bore 10f through which the interior of the rod 10 communicates with the outside of the control block 2. To prevent the compressed air passing through the cross bore 10f from being expelled directly to the outside, a bell-shaped top 14 is provided at the end of rod 10, with its cavity turned to the cover 6, and is fixed by means of a nut 14a. Thus, the escaping air is deviated and does not flow out as a jet.

The cylindrical body 7 is formed, at its end facing the interior of control block 2, with a coaxial cylindrical recess or main valve chamber 15 whose depth is approximately equal to a third of the body length. The recess 15 has a larger diameter than the bore 13b in the central part of the cylindrical body which terminates rearwardly in a circular rim 16 projecting into the recess and which forms a main valve seat.

The bottom of bores 5a and 5b include is formed a cylindrical coaxial recess 17 in which a helical spring 18 is received. The free end of spring 18 carries a cylindrical main valve shutter 19 and urges the same in the direction of the main valve seat 16.

The length of the hollow rod 10 is exactly dimensioned so that, in its first end position represented in FIG. 1, the rod extends through the main valve seat 16 thereby displacing the main valve shutter or valve disc 19 from the seat 16. Simultaneously, the main valve disc 19 closes the frontal opening of the hollow rod 10. In the second end position of the rod 10, shown in FIG. 2, the open end of the rod 10 does not project beyond the main valve seat 16 so that the shutter 19 is applied against the seat. In this position, the bore portion 13b communicates with the interior of the hollow rod 10. The combination of the rod 10 with the seat 16 and the valve disc 19 forms a two-way directional control valve with three openings.

A passage 20 is provided in the control block 2 extending perpendicularly to the hollow rod 10 and leading from the upper part of the block to a cross bore 21 of the cylindrical body 7. The cross bore 21 terminates in the wider bore portion 13b so that the passage 20 communicates or can communicate with the recess 15.

Another passage 22 extends from the bottom part of the control block 2 up to the level of the recess 17 where it terminates in the area within the helical spring 18 thereby opening into the recess 15. The passage 22 communicates with the outside of the control block 2 through a connection port 22a to which the line 4a, leading from the directional control valve 4 and serving as a feeding and control line, is connected.

Analogously, the passage 20 terminates in a connection port 20a which is connected by a pressure line 1e to the working space 1c of the drive unit. The passage 20, cross bore 21, bore portion 13b and recess 15 serve as a main valve chamber and, with the passage 22, they form the main conduit of the control block 2. By the main valve chamber 15, the main conduit is divided into two portions of which one is located at the drive unit side and the other at the control line side.

In its upper righthand part, the control block 2 is formed with a multiple-step bore comprising five coax-

ial portions 23a, 23b, 23c, 23d and 23e and having an axis parallel to the hollow rod 10. The outermost portion 23a is cylindrical and it is the largest portion both in diameter and in length. Its length is approximately equal to the total length of all of the other four portions. The second portion 23b is also cylindrical and its diameter is only slightly smaller so that a circular shoulder is formed between the two portions. The length of the second portion 23b is about one-eighth of the length of the first portion 23a. The next portion 23c is cylindrical again and about 2½ times longer than the preceding portion 23b and its diameter is smaller by about the double length of portion 23b. The subsequent portion 23d is tapered, narrowing inwardly down to a diameter which is approximately equal to the double length of portion 23b. The innermost portion 23e is a cylindrical blind hole having a conical bottom. The last two portions are crossed by and communicate with the full section of passage 20 so that communication is established between the five portion bore and the step of the main conduit which is located at the drive unit side.

A rotationally symmetrical insert 24 resembling a hollow truncated cone with an annular socle is received in the multiple-step bore so that the socle engages the lefthand part of portion 23a and abuts the shoulder formed between this portion and the narrower portion 23b. The socle is sealed against the wall of portion 23a by a gasket ring 24a received in a circular groove. The head of insert 24, having the shape of a truncated cone, projects toward the bottom of the multiple-step bore and its frontal face lies in the plane separating the two portions 23c and 23d. The insert 24 is formed with an axial bore 24b having a diameter approximately equal to that of the frontal face of the frustum so that this frontal face is actually reduced to a rim. The outer boundary surface 24c of the insert 24 conically extending from the rim serves as a secondary valve seat for a secondary valve shutter or valve comprising a cap-shaped seal 25 of synthetic material terminated by a lip-like border. The seal 25 is dimensioned so that its inner surface fits the secondary valve seat 24c and its border lip has a diameter which is only slightly smaller than the diameter of the third bore portion 23c. In a position where the seal 25 is applied against the head of the insert 24, the border lip extends up to the shoulder surface between the second and third bore portions 23b and 23c.

A flat circular groove 24d is machined in the secondary valve seat 24c, communicating with the axial bore 24b of the insert 24 through a transverse bore 24e. The function of the latter will be explained hereinafter.

Coaxially of the insert 24, a tubular piece 26 open at both ends is received in the outermost bore portion 23a, engaging the latter along a flange collar 26a provided on the insert and sealed by mean of a gasket ring 26b. The flange collar 26a abuts on the frontal face of the socle of insert 24. A cup-shaped cover 27 projecting outwardly of the control block 2 has its flanged rim applied against the flange collar 26a thereby closing the whole multiplestep bore toward the outside. The cover 27, the tubular piece 26, and the insert 24 are held in their position by a guard ring 28 engaging a corresponding circular groove provided in the wall of the outermost portions 23a.

The tubular piece 26 extends to both sides of its flange collar 26a, outwardly approximately up to the outer surface of the control block 2 and inwardly into

the zone of the socle of insert 24. The outer diameter of the piece 26 is smaller than that of the socle so that a cavity 29 is formed therebetween with an approximately U-shaped cross-section and communicating with the axial bore 24b of the insert 24. The legs of the U-shaped cross-section extend up to the flange collar of the tubular piece 26.

The inner end of the tubular piece 26 is not completely open, the respective frontal face being provided only with a coaxial bore 26c having a diameter equal to that of bore 24b of the insert 24. The thus formed circular bottom of the tubular piece 26 is not plane but formed with a circular rim 26d surrounding the opening of bore 26c and serving as a check valve seat.

A rod 30 is received in the bores 24b and 26c extending coaxially therethrough. To the inner end of rod 30, the seal 25 is rigidly secured by means of a screw and a stiffening metal cap 25a. The outer end portion of rod 30 projecting into the tubular piece 26 carries a check valve shutter or valve disc comprising a metal support 31a and a sealing ring 31b fixed thereto and secured by a nut 31c.

The diameter of the rod 30 is substantially smaller than that of the bores 24b, 26c so that compressed air can pass through the latter without hindrance. The length of the rod 30 is dimensioned so that when the cap-shaped seal 25 is applied against the secondary valve seat 24c, the check valve shutter, i.e., the sealing ring 31b, is displaced from the check valve seat 26d. This position of the rod 30 is the first and position. In the second end position of the rod 30, the seal 25 is displaced from the secondary valve seat 24c and its stiffening cap 25a is applied against the tapering wall of the fourth bore portion 23d while the sealing ring 31b of the check valve shutter is pressed against the check valve seat 26d. Thus, the sealing ring 31b and the seat 26d form a check valve.

Another valve is provided within the cup-shaped cover 27 and intended to permit the passage of air only in the direction from the tubular piece 26 into the cover 27 which latter communicates with the outside of the control block 2 through a bore 27a. The valve includes a supporting plate 32b, a sealing disc 32c secured thereto, and a helical spring 32a resting against the bottom of cover 27 and urging the plate with the sealing disc mildly against the opening of the tubular piece 26.

At the rear side of the control block 2, another connection port 33 is provided communicating through a passage with the second bore portion 23b in the space adjacent the outer surface of insert 24. This port 33 is connected to pressure line 3a leading to the compressed-air container 3.

Another passage 34 extending through the control block 2 from the cavity 29 having the U-shaped cross-section upwardly is also terminated by a port 34a to which a pressure line 1f leading to the second space 1d of the drive unit is connected. The passage 34, the cavity 29, the bore 24b, the bore portions 23d, 23c, 23b serving as the secondary valve chamber, and the passage leading to the port 33 form together a secondary conduit which is divided into two portions, namely the portion located at the side of the compressed-air container and the portion located at the drive unit side.

Two further connection conduits 35 and 36 comprising individual passages are provided in the lower part of the control block 2. Conduit 35 connects the passage

22 with the interior 6a of the cover 6 and conduit 36 establishes a communication between the right-hand compartment of the control chamber, i.e., the bore portion 5a located at the inner side of the diaphragm 9, and the cavity 29.

The just described device operates as follows:

For displacing the working piston 1b into its end position shown in FIG. 1, i.e., for effecting the working stroke, the directional control valve 4 is brought into a position in which compressed air flows through the pressure line 4a and the connection port 22a into the passage 2. This compressed air simultaneously passes through the connection conduit 35 into the left-hand compartment of the control chamber 5a, 6a thereby acting on the diaphragm 9 so that, so far as the pressure in the right-hand compartment of the control chamber is smaller which, as will be shown in the following, is surely the case, the diaphragm 9 is deflected in the direction of the interior of the control block 2, as shown in FIG. 1. This causes the hollow rod 10 to move into its first end position so that the main valve shutter 19 is displaced from its seat 19 and compressed air passes unhindered through the main valve chamber 15, bore 13b, cross bore 21, passage 20, port 20a, and pressure line 1e into the working space 1c of the drive unit. In this position, the main conduit is open. Since the main valve shutter 19 is firmly pressed against the opening of the hollow rod 10 by the helical spring 18, compressed air cannot escape through the interior of the rod and is forced to pass through the main conduit.

However, the portion 20 of the main conduit located at the drive unit side also communicates with the secondary valve chamber formed by the portions 23d, 23c, and 23b of the upper bore of the control block 2 so that the compressed air also acts upon the cap-shaped seal 25 and presses the same firmly against the secondary valve seat 24c. Consequently, the compressed air cannot pass through the axial bore 24b into the cavity 29 and presses the elastic border lip of seal 25 toward the insert 24 thereby clearing its way through the portion 23b, the respective passage leading to the port 33, and further through the pressure line 3a into the compressed-air container 3 so that the latter is brought under operational pressure.

At this time, because the cap-shaped seal 25 is applied against the seat 24c, the rod 30 occupies its first and position. The sealing ring 31b is displaced from the check valve seat 26d so that the check valve is open. Therefore, air coming from the space 1d of the drive unit, which is not under pressure, can freely escape through the line 1f, port 34a, passage 34, cavity 29, bore 26c, tubular piece 26, and cover 27 into the outer atmosphere. The sealing disk 32c is displaced from the opening of the tubular piece 26 automatically by the outflowing air. Because all air can escape through the open check valve, there is no pressure in the connection conduit 36 either and the right-hand compartment 5a of the control chamber is under atmospheric pressure.

For producing the idle stroke of the working piston, i.e., for displacing the same into its end position shown in FIG. 2, the directional control valve 4 is reversed so that the pressure line 4a is vented. Thereupon, as soon as the pressure in the main conduit decreases, for example, at 5 atm in excess, by a half atmosphere, the elastic border lip of the seal 25 moves back, away from the insert 24, which movement is simultaneously sup-

ported by the air now flowing from the compressed-air container 3 still under operation pressure, and applies completely against the wall of the bore portion 23c. Due to the pressure difference between the left-hand and right-hand sides of the cap-shaped seal 25, the seal is finally removed from its seat 24c and displaced along with the rod 30 into the second end position. The main conduit or the portion 20 thereof is thereby separated from the secondary conduit which is now open. In consequence, compressed air can flow from the container 3 through the pressure line 3a and the secondary conduit, i.e. the port 33, valve chamber 23b, 23c, transverse bore 24e, axial bore 24b, cavity 29, passage 34, and port 34a, and through the pressure line if into the right-hand space 1d of the drive unit and act upon the piston 1b. At the same time, however, compressed air passes through the connection conduit 36 into the right-hand compartment of the control chamber 5a, 6a, acts on the diaphragm 9 and deflects the same toward the outside because the pressure at the opposite side has been released by the venting. The hollow rod 10 is thereby displaced into its second end position in which its inner end portion no more extends through the main valve seat 16 but is displaced from the main valve shutter 19 and retracted into the bore 13b while the shutter 19 is applied against the seat 16 thereby blocking the main conduit. In this position, the interior of the hollow rod 10 communicates with the bore 13b so that the air coming from the left-hand space 1c of the drive unit, which is no more under pressure can pass through the line 1e, port 20a, passages 20, cross bore 21, bore 13b, interior of rod 10, and cross bore 10 into the outer atmosphere.

To start the working stroke of piston 1b again, the directional control valve 4 is brought into its position represented in FIG. 1. Thereupon, as soon as the pressure in the passage 22 and thereby in the left-hand compartment of the control chamber exceeds the residual pressure in the other compartment, the diaphragm 9 is deflected in the opposite direction and the cycle can be repeated.

While a specific embodiment of the invention has been shown and described in detail to illustrate the application of the principles of the invention, it will be understood that the invention may be embodied otherwise without departing from such principles.

What is claimed is:

1. A device for reciprocating the working piston of a pneumatic drive unit comprising, in combination, a directional control valve with three ports and a control element movable between two distinct positions, with a first port being connected to a source of air under pressure, a second port being connected to atmosphere, and said movable control element being selectively operable to connect the third port to either said first port or said second port; a compressed air storage container; a control block connected to both said directional control valve and said container; said pneumatic drive unit including a cylinder and a working piston therein dividing said cylinder into first and second cylinder chambers; said control block being formed with first and second interior chambers and with a first passage connecting said first interior chamber to said second interior chamber and terminating in a first connection port of said control block; a first connection line connecting said first connection port to said first cylinder chamber; a hollow rod movable axially in said

first interior chamber and having an outer end projecting externally from said control block and formed with a cross bore connecting the interior of said hollow rod, at its outer end, with atmosphere; a flexible diaphragm secured to the periphery of said rod and secured in said first interior chamber to divide said first interior chamber into pressure chambers on opposite sides of said flexible diaphragm; means in said first interior chamber defining an inlet chamber surrounding the inner end of said hollow rod; a second passage formed in said block and connecting said inlet chamber to a second connection port; a second connection line connecting said second connection port to said third port of said directional control valve; a main valve axially displaceable in said inlet chamber adjacent the inner end of said hollow rod; biasing means biasing said main valve in a direction to engage the inner end of said hollow rod to close said inner end; said block being formed with a first axial passage through which said hollow rod extends to define an annular main flow passage connecting said inlet chamber to said first passage, said main flow passage being closed by said main valve, under the influence of said biasing means, when said hollow rod is in a position in which its inner end is retracted inwardly beyond the adjacent end of said first axial passage to disengage said main valve; a third passage connecting said second passage to said first interior chamber on that side of said diaphragm nearer to the outer end of said hollow rod; said diaphragm being flexed, to shift said hollow rod axially, in accordance with the differential between the pressures in said pressure chambers on said opposite sides of said flexible diaphragm; said rod being movable to an end position wherein said main valve closes said first axial passage and the inner end of said hollow rod is disengaged from said main valve to connect the interior of said hollow rod with said first passage through said first axial passage to vent said first passage to atmosphere through said cross bore; a solid rod mounted for axial displacement in said second interior chamber; a cup-shaped secondary valve secured to said solid rod for movement therewith; a frustoconical insert in said second interior chamber surrounding said solid rod and defining therewith a second annular passage communicating at one end with said first passage; said frustoconical insert being formed with a radial passage therethrough closed by said cup-shaped secondary valve in a first position of said solid rod; a tubular piece in said second interior chamber in axially spaced relation to said insert and defining, with said solid rod, a third annular axial passage; the space between said frustoconical insert and said tubular piece defining a cavity communicating with said second and third annular axial passages; a third passage communicating with said cavity and terminating in a third connection port; a third connection line connecting said third connection port to said second cylinder chamber; a fourth connection port communicating with said second interior chamber exteriorly of said frustoconical insert; a fourth connection line connecting said fourth connection port to said compressed air storage container; means, including said control block, defining a cover chamber having a vent to atmosphere and surrounding the end of said solid rod extending from said third annular passage; a valve plate on said last-named end of said solid rod in said cover chamber movable with said solid rod to close said third annular axial passage in a second position of said solid rod in

which said cup-shaped secondary valve uncovers said radial passage; and a valve seat defined in said control block between said first passage and said second interior chamber and engaged by said cup-shaped valve, in said second position of said solid rod, to block communication between said first passage and said second interior chamber and thus to block communication between said first passage and said compressed air storage container; whereby, upon movement of the control element of said directional control valve to a position connecting the first port of said directional control valve to its third port, fluid under pressure is supplied through said third passage to deflect said diaphragm to move said hollow rod in a direction to engage said main valve and to displace said main valve away from said second axial passage for flow of fluid under pressure from said second passage through said inlet chamber to said first passage and thus to said first cylinder chamber to displace said piston axially of said cylinder in a working stroke and, when said control element of said directional control valve is moved to its opposite position to connect the second port of said directional control valve to its third port, said second and third passages are connected to atmosphere to relieve the pressure on said diaphragm for flexing of said diaphragm in a direction to disengage said hollow rod from said main valve for seating of said main valve on the end of said second axial passage and establishment of communication between said first passage and the interior of said hollow rod for venting of the pressure in said first cylinder chamber to atmosphere through said hollow rod with the pressure in said compressed air storage container being effective in said second cylinder chamber to displace said piston toward said first cylinder chamber in an idle stroke; said frustoconical valve, during the working stroke of said piston, occupying a position connecting said first passage through said fourth connection port for supply of fluid under pressure to said compressed air storage container, as a valve plate opening said third annular axial passage for connection of said second cylinder chamber to said cover chamber for venting of the pressure in said second cylinder chamber to atmosphere through said vent, said control block is formed with a fourth passage connecting said cavity to that one of said pressure chambers on the side of said diaphragm more remote from the outer end of said hollow rod.

2. A device according to claim 1, including a cover surrounding that portion of said control block where the outer end of said hollow rod projects from said control block, said cover forming a shield around the periphery of the outer end of said hollow rod so that air vented through said cross bore is not discharged directly.

3. A device according to claim 1, including stop means on said hollow rod for limiting the movement thereof.

4. A device according to claim 1, wherein said second interior chamber is divided into a plurality of successive chamber portions each of a different respective diameter, the first one being substantially conical and located adjacent the connection to said first passage and the remaining ones being cylindrical of increasing respective diameters said insert having a cylindrically formed axially extending portion at its periphery engageable in the last of the cylindrical portions which is of maximum diameter.

5. A device for reciprocating the working piston of a pneumatic drive unit comprising, in combination, a directional control valve with three ports and a control element movable between two distinct positions, with a first port being connected to a source of air under pressure, a second port being connected to atmosphere, and said control element being selectively operable to connect the third port to either said first port or said second port; a compressed air storage container, a control block connected to both said control valve and said container; said pneumatic drive unit including a cylinder and a working piston therein dividing said cylinder into first and second cylinder chambers; said control block being formed with a main conduit therein extending between a first connection port and a second connection port; a first connection line connecting said first connection port to said first cylinder chamber; a second connection line connecting said second connection port to the third port of said directional control valve; said main conduit having a relatively larger diameter portion intermediate its ends serving as a main valve chamber; a main valve shutter mounted in said main valve chamber for axial displacement therein between a first end position, in which said shutter clears said main conduit, and a second end position in which said shutter engages a circular main valve seat formed in said main valve chamber to block said main conduit; a spring biasing said shutter to said second end position, said shutter being displaceable to said first end position against the bias of said spring; a hollow rod mounted in said control block in fluid-tight relation and extending axially of said circular main valve seat; the outer end of said hollow rod projecting externally said control block and being open to the atmosphere; said hollow rod being displaceable between a first end position in which its open inner end extends through said circular main valve seat and engages said main valve shutter to retain said shutter in its first end position against the bias of said spring; said hollow rod being displaceable to a second end position in which it disengages said main valve shutter so that said shutter is biased against said circular main valve seat by said spring to block said main conduit and with the open inner end of said hollow rod communicating with that portion of said main conduit leading to said first connection port; said control block being formed with a secondary conduit therein extending between a third connection port and a fourth connection port; a third connection line connecting said third connection port to said second cylinder chamber; a fourth connection line connecting said fourth connection port to said compressed air storage container; said secondary conduit having an increased diameter portion intermediate its ends defining a secondary valve chamber; the portion of said secondary conduit opening into said secondary valve chamber adjacent said main conduit being shaped as a tapered annular secondary valve seat; the wall of said secondary valve chamber opposite said secondary valve seat terminating at an opening into said main conduit; a cap-shaped seal, having its periphery in the form of an elastic lip, mounted in said secondary valve chamber for coaxial displacement relative to said secondary valve seat; said cap-shaped seal having a first end position in which it tightly engages said secondary valve seat to block said secondary conduit while clearing communication between said main conduit and said fourth connection port, and having a second end posi-

tion in which said cap-shaped seal is displaced from said secondary valve seat to clear said secondary conduit with the periphery of said cap-shaped seal tightly engaging the wall of said secondary valve chamber to block communication between said main conduit and said secondary conduit; said control block being formed with a by-pass conduit open at one end to atmosphere and communicating at its opposite end with that portion of said secondary conduit communicating with said third connection port; said by-pass conduit having disposed therein a check valve formed by a circular check valve seat and a check valve shutter; said check valve shutter being mounted on one end portion of a solid rod axially displaceable in said secondary valve chamber and having an opposite end connected to said cap-shaped seal so that, in said first end position of said cap-shaped seal, said check valve is open and, in said second end position of said cap-shaped seal, said check valve is closed; said hollow rod extending through a control chamber formed in said control block; an elastic diaphragm secured to said hollow rod in said control chamber and extending radially of said hollow rod with its periphery sealed to said control block; said elastic diaphragm defining said control chamber into two compartments; said control block being formed with a passage therein connecting that one of said two com-

partments which is nearer to the outer end of said hollow rod directly to said second connection line; said control block being formed with a further passage connecting the other of said two compartments directly with that portion of said secondary conduit extending to said third connection port; whereby, responsive to the pressure in one of said two compartments exceeding the pressure in the other of said two compartments, said hollow rod is displaced into a selected one of its respective end positions; said cap-shaped seal, in its first end position, establishing communication between said main conduit and said compressed air storage container and, in its second end position, blocking communication between said main conduit and said compressed air storage container; said one of said two compartments, when said control element of said directional control valve connects said third port of said directional control valve to said first port thereof, being subjected to the pressure of said source of fluid under pressure and, when said control element of said directional control valve connects said third port to said second port, being connected to atmosphere; said other of said two compartments, being constantly subjected to the pressure of the air in said compressed air storage container.

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