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(71) Applicant: **Migliori, Luciano**
Via F.lli Cervi
Residenza del Sagittario 29/1
I-20090 Milano 2 (Segrate) (IT)

(72) Inventor: **Migliori, Luciano**
Via F.lli Cervi
Residenza del Sagittario 29/1
I-20090 Milano 2 (Segrate) (IT)

(74) Representative: **Coloberti, Luigi**
Via E. de Amicis No. 25
I-20123 Milano (IT)

(54) Pneumatic actuator with adjustable stop and damping device.

(57) A pneumatic linear actuator comprising a cylinder body (10) defining an elongated piston chamber (10a) closed by head pieces (11, 12) at both ends; a piston (17) reciprocable in said piston chamber (10a), and stop and fluid actuated damping means (15, 22) telescopically adjustable inside the cylinder body (10), to decelerate and stop the piston (17) at the end of the stroke.

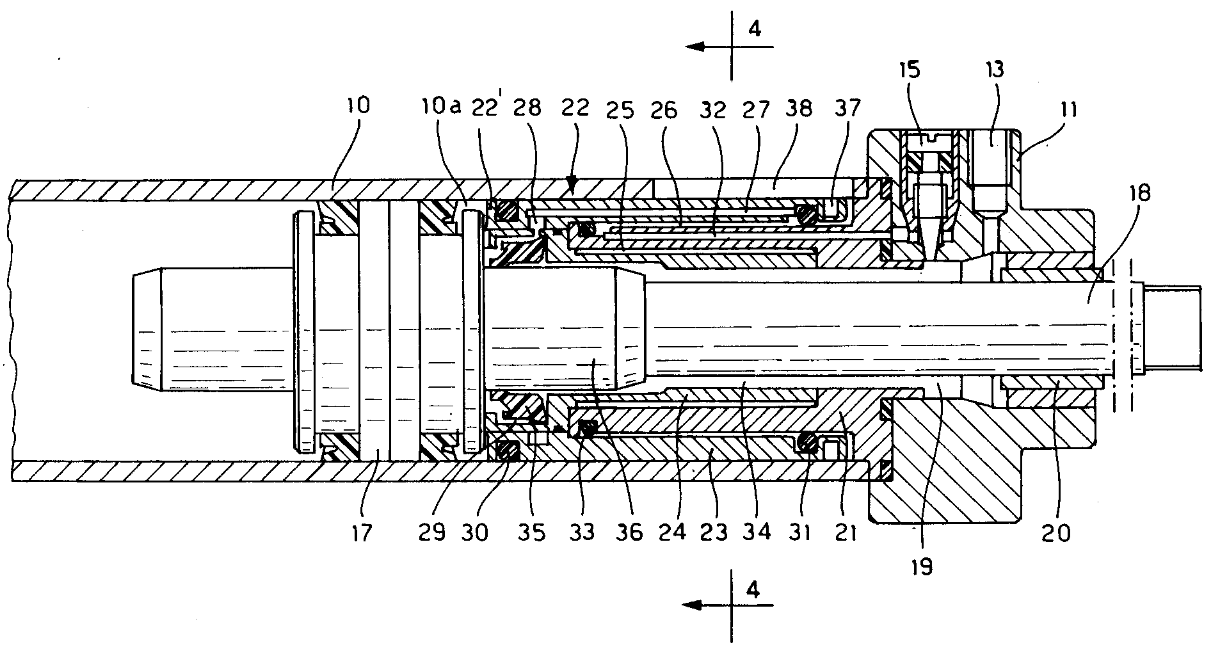

FIG. 2

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The present invention relates to improvements to pneumatic linear actuators, and concerns more particularly a pneumatic cylinder provided with pneumatic damping means and a mechanical stop whose position can be axially adjusted in order to modify the effective working stroke of the actuator itself.

Pneumatic dampers are widely used in linear actuators to absorb most of the kinetic energy of the load by decelerating the piston at the end of the working stroke. In general these pneumatic dampers are provided on the closure heads of the cylinder and are based on the principle of dissipation of energy by releasing a predetermined quantity of pressurised air through a throttling valve at the end of each stroke of the piston. The dampers of this type generally have a fixed position, which cannot be adjusted or modified, so that they would be totally ineffective in the case wherein it is necessary to change the mechanical stop which limits the effective working stroke of the piston. With traditional pneumatic dampers it is therefore impossible to regulate their position, especially on the side relating to the piston rod, nor are suitable solutions to this problem known.

For these reasons use is generally made of independent mechanical stops and hydraulic damping systems outside the actuator.

The use of outer hydraulic systems for decelerating the piston, adjustable externally, in general requires complex solutions, which cannot always be adopted in certain working conditions, in that an hydraulic damper added to a pneumatic cylinder not only creates greater bulk, but is also a source of possible further causes of malfunctioning.

It has not been possible to date to dispose of pneumatic actuators provided with an integrated pneumatic damping and piston stop device which is an integral part of the same actuator and which at the same time allows adjustment of its position in order to adapt to any change in the effective working stroke of the piston.

The object of the present invention is to provide a linear actuator provided with an integrated pneumatic damping and stop device as mentioned above which can be applied to cylinders both with and without rod, and which allows simultaneous regulation both of the mechanical stop and of the pneumatic damping device.

A further object of the present invention is to provide a pneumatic linear actuator, as related above, provided with an adjustable pneumatic damping means, which is able to maintain its damping efficiency substantially unchanged, independently of the position assumed, in this way guaranteeing a deceleration effect of the piston which remains unchanged and reliable, thus allowing high accuracy of stopping and positioning of the load moved by the actuator.

A further object of the present invention is to provide a pneumatic linear actuator of the kind mentioned above, provided with an adjustable pneumatic damping device which can be housed inside the same actuator, without substantially increasing its overall dimensions, and which can be applied in cylinders or actuators either with or without rod, maintaining an arrangement coaxial to the reciprocable piston.

The above can be achieved in a pneumatic linear actuator according to the invention, comprising a telescopically extendable fluid actuated damper and mechanical stop means, according to the features of the claim 1.

These and other features of a pneumatic actuator provided with adjustable damping and stop means according to the invention, will be illustrated in greater detail hereinunder, with reference to the accompanying drawings, in which:

- Fig. 1 is a top view of a pneumatic cylinder with rod, provided with adjustable damping and stop means according to the invention;
- Fig. 2 is an enlarged longitudinal sectional view along line 2-2 of Figure 1, with the damping and stop means in a first working condition;
- Fig. 3 is a sectional view similar to the previous Figure, with the damping and stop means in a second working condition;
- Fig. 4 is an enlarged cross sectional view along line 4-4 of Figure 2;
- Fig. 5 is an enlarged sectional view of one end of a rodless cylinder provided with adjustable damping and stop means according to a further embodiment of the invention.

As shown in Figures 1 and 2, the pneumatic actuator substantially comprises a cylinder body 10 defining a piston chamber 10a closed by two end heads 11 and 12. Each head is provided with a hole 13, 14 for feeding and discharging compressed air, as well as a throttle valve 15, 16 forming part of a pneumatic shock absorber device described hereinbelow.

Inside the cylinder 10 is a reciprocating piston 17 provided with a rod 18 which extends externally along a hole 19, through a seal 20 in the corresponding head 11 of the actuator.

The piston 17, in the case shown, has at each end a cylindrical shank 21, only one shown in Figure 2, having a diameter greater than the rod 18 for actuating at the end of the stroke a respective pneumatic damping device which, in a manner in itself known, allows the kinetic energy accumulated by the piston to be dissipated, thus decelerating the same by discharging from the chamber 10a the pressurized air remaining in the final portion of the piston stroke via one or the other of the throttling valves 15 or 16, provided in a respective end head 11, 12 of the actuator.

With particular reference to Figures 2 and 3, we will describe hereinunder a first embodiment of the adjustable damping and stop device according to the invention, designed especially to be applied on the side of the head 11 crossed by the rod 18; if required, this device, suitably modified, could also be adopted on the opposite side of the rear head of the actuator.

The pneumatic damping and stop device according to the invention substantially comprises a telescopically extendable flow-path unit 22, having a flanged end seated in the head 11 to project, tightly, inside the cylinder body 10. The telescopic unit 22 has an axially extending bore 34 having a diameter greater than the rod 18 to define an annular main duct for feeding and discharging compressed air respectively, leading on one side into the chamber 10a of the cylinder body 10 and on the other into the feed/discharge port 13. Said telescopic flow-path unit 22 of the damping and stop device at its inner end, has a first seal element in the form of an annular seal 35 coaxially arranged to the main duct 34 which cooperates with a second seal element carried by the piston 17, for example in the form of a cylindrical shank 36 having a diameter greater than the rod 18 to penetrate the annular seal 35 to close the main duct 34, as shown. The cylindrical extension of the head 11 forming the pneumatic damping and stop device 22, comprises moreover a branched flow-path to connect the chamber 10a of the cylinder to the main duct 34, via an adjustable throttling valve 15 in the head 11. The branched path, as explained in greater detail hereinbelow, is formed between two tubular members coaxially arranged and sliding one to the other to allow the telescopic lengthening and shortening of the pneumatic damping and stop unit 22, maintaining the connection of the chamber 10a with the throttling valve 15, without substantially varying the required volume of pressurized air which has to be vented by valve 15 for damping and deceleration of the piston 17. In particular, as shown in the example in Figures 2 and 3, the unit 22 comprises a first fixed sleeve 21 which extends axially inside the cylinder body 10, starting from the end closure head 11. Coaxially arranged to the fixed sleeve 21 or equivalent tubular element, a second tubular element is provided in the form of a double walled sleeve sliding longitudinally to the first one and guided by the internal surface of the cylinder body 10. The double sleeve comprises a first outer wall 23 which surrounds the fixed sleeve 21, and a second inner wall 24 which surrounds the fixed sleeve 21 and which defines the main duct 34 for feeding and discharging pressurized air. The inner wall 24 of the double sleeve is appropriately connected to the outer wall 23 at their remote end, while the opposite surface of the two walls 23 and 24 facing corresponding surface of sleeve 21 have different diameters and are spaced apart in order to form an annular groove having a closed bottom end wherein the fixed sleeve 21 extends.

More precisely, as shown in Figure 2, the opposite cylindrical surfaces of the fixed sleeve 21 and of the inner wall 24 of the sliding sleeve have screw connection means in the form of threading 25 to allow a telescopic sliding movement of the sleeves 21, 24 as explained hereinbelow. Contrarily, the external cylindrical surface of the fixed sleeve 21 and the internal cylindrical surface of the outer wall 23 of the sliding sleeve have slightly differing diameters or are radially spaced apart such as to form a narrow annular gap 26 which extends axially for a length equal to or greater than the adjustable stroke of the pneumatic damping and stop device 22.

The annular gap 26 which is formed between the two sleeves, at one end is connected to a longitudinal bore 27 in the outer tubular wall 23 of the sliding sleeve, which hole 27 at the other side opens towards the chamber 10a of the cylinder body 10 via an annular groove 28 and a slot or slots 29 formed between a lip seal 35 and a respective seat in an extension 22' with a small diameter. This extension 22' also defines a mechanical stop surface for the piston 17. Seals 30 and 31 at the two ends of the outer tubular wall 23 of the sliding sleeve provide tightness in respect of the cylinder body 10 and the fixed sleeve 21 respectively. In this way tightness is ensured whatever axial position is adopted by the wall 23 of the sliding sleeve.

The annular gap 26 on the side opposite the previous one additionally is connected to a second bore 32 formed in the fixed sleeve 21. The bore 32 extends in the head 11 opening at the throttling or needle valve 15. A third seal 33 is finally disposed between the internal end of the fixed sleeve 21 and the internal surface of the tubular wall 23 of the sliding sleeve.

In order to allow the necessary closure of the main duct 34, when the pneumatic damping device is actuated, that is to say to prevent direct communication between the chamber 10a of the cylinder body and the bore 13 for discharging pressurized air, at the internal end 22' of the sliding sleeve a lip seal 35 is provided, designed to form a seal with a shank 36 coaxially arranged to the rod 18 of the piston.

Finally reference 37 in Figures 2 and 4 denotes radial holes provided in angularly spaced positions on the outer tubular wall 23 of the sliding sleeve, made accessible at a wide opening 38 in a wall of the cylinder body 10 to vary the length of the damping and stop device by means of a simple rotation of the same sliding sleeve in respect to the fixed sleeve. Obviously the axial length of the opening 38 in the wall of the cylinder body 10 must be greater than the adjusting stroke of the abovementioned damping and stop device.

In the case shown, the pneumatic damping and stop device has been advantageously provided on the side of the rod 18 of the cylinder, nevertheless the same device may be provided on the opposite side of the cylinder, at the rear head 12, forming in the latter a special seating for inserting the shaped end of the fixed sleeve 21.

From what has been said it is clear that an extremely advantageous pneumatic damping and stop device has been provided, in that not only does it enable its position to be changed together with adjustment of the mechanical stop for the piston 17, consequently varying the effective working stroke of the piston, but also allows the characteristics of shock absorption and the deceleration effect of the piston to be maintained wholly unaltered in that the volume of pressurised air which has to be vented through the throttling valve 15 remains substantially unchanged. This is extremely important in that adjustment which involves an increase in the volume of air to be ejected would render the damping device wholly ineffective as it would reduce its effect. Maintaining at a substantially constant value the volume of air to be ejected during the damping phase is therefore a positive and critical factor for the efficacy of the device. All this has been made possible by providing a telescopic elongation of the stop device and of the branched path for connection to the throttling valve, thanks to the extremely small volume of the gap 26 which connects the bores or ducts 27 and 32 in the two sleeves, fully independently of the position assumed by the sliding sleeve 23. In fact, as the length of the bores 27 and 32 remains unchanged, and since the variation in volume of the gap 26 is extremely small and wholly insignificant in relation to the volume of air which remains in the chamber 10a of the cylinder at the start of the damping phase, it is clear that the volume of air to be ejected , which remains substantially unchanged, is determined solely by the length of the shank 36 of the piston 17. The efficacy of the damping action remains in turn unchanged and independent of the stroke of the piston and the position assumed by the movable sleeve of the device. Furthermore, the entire device can be provided in the form of a cartridge placed fully inside the cylinder body 10, perfectly coaxial to the piston, eliminating any outward bulk. In this way a pneumatic actuator is provided with an adjustable stroke and pneumatic damping device allowing a mechanical stop of the piston which can be adjusted according to the requirements, maintaining a simple and substantially strong structure of the entire actuator.

The possibility never provided to date of placing an adjustable pneumatic damping device on the outlet side of the piston rod, maintaining the damping effectiveness of the device substantially unchanged, together with the adjustment of the mechanical stop for the piston, allows extreme precision of stopping and positioning of the load connected to the actuator to be achieved.

Figures 1 to 4 show an embodiment of the damping and stop device which is particularly suitable for application to an actuator having a rod.

Figure 5 of the accompanying drawings shows a second embodiment of the telescopic damping and stop device which has been especially designed for a rodless actuator, and which, like the previous one, allows telescopic regulation of position and the use of a flow path duly set for expulsion of the air through the throttle valve, which maintains the necessary volume of air substantially unchanged.

Figure 5 partially represents a rodless cylinder in itself known. In general a rodless cylinder comprises a tubular body 40 inside of which a piston 41 moves. The piston 41 is connected to an external member (not shown) through a longitudinal slot 42 on one side of the body 40, normally closed by a flexible band schematically denoted by 43. The piston 41, on each side, has a hole 44 which is penetrated by a tubular shank 45 connected to a port 46 for feeding and discharging pressurized air provided in the head 47, via an axial duct 48 in a tubular member 49 which in this specific case define a threaded shaft rotatably supported by the head 47 and which can be actuated by a control knob 50.

The tubular shank 45 co-operates with a seal 51 placed in a seating at one end of piston 41 coaxially to the hole 44 to close communication of the chamber 52 towards the duct 48 and the port 46 for feeding/discharging air at the end of the piston stroke as shown in Figure 5.

The tubular shank 45 is tightly attached to the internal end of a sleeve 53 which in turn telescopically and tightly slides in the chamber 52 of the cylinder body 40. The sleeve 53 is provided with internal threading 54 engaging with the threaded shaft 49 to move the sleeve 53 forwards and backwards by simply rotating manually the knob 50. The sleeve 53 has a portion 53a, with a small diameter, telescopically guided by a cylindrical sleeve portion 47a of the head 47, which extends inside the cylinder body 40. The sleeve 53 is prevented from rotating by a pin 55 which projects from the head 47 and which sliding penetrates, a hole 56 of the sleeve 53.

Like the previous solution, albeit in a modified embodiment, the pneumatic damping device described here also comprises a telescopically extending branched path for discharging air through a throttle valve 57. The branched path which, like the previous case, can be lengthen and shorten telescopically without producing significant variations in the volume of air to be ejected during damping, in this specific case consists of a first duct in the form of a calibrated tube 58 longitudinally extending inside the cylinder body 40 and attached on the internal side of the head 47. The duct 58 on one side leads to the valve 57 through appropriate passage ports, while on the other side it leads to a hole 59 which extends in the sleeve 53 parallel to its sliding axis, and wherein the same tube 58 can freely and telescopically slide. The hole 59 opens into the chamber 52 of the cylinder body near an annular element 60 at the internal end of the sleeve 53 designed to form a stop for a ring nut 61 at the opposite end of the piston 41. Suitable seals provide the necessary tightness between the sleeve 53 and the cylinder body 40, and between the latter and the head 47 respectively, as well as between the sleeve 53 and the tube 58.

As shown by a broken line in the same Figure 5, it is clear that, by rotating the threaded shaft 49, actuating the knob 50 by hand, it is possible to move the sleeve 53 forwards or backwards with the shank 45, and hence vary the stop position and the working stroke of the piston 41, maintaining unchanged the efficacy and a pneumatic damping effect.

From what has been said and shown in the accompanying drawings it is therefore clear that the invention consists of a special pneumatic damping and stop device whose position can be adjusted telescopically, suitable both for cylinders with a rod, and for rodless cylinders by means of which the numerous advantages and improved features of the invention are obtained, maintaining substantially unchanged the capacity to pneumatically dampen the kinetic energy accumulated by the piston 41 and by the load connected thereto, independently of the position adopted by the same device.

Claims

1. A pneumatic linear actuator of the type comprising a cylinder body (10) defining an elongated piston chamber (10a; 52) having air inlet and outlet ports (13, 14; 46); a piston (17; 41) reciprocable in said piston chamber (10a; 52);

stop means (22'; 60) for stopping said piston (17; 41) at least at one end of the piston stroke;

damping means for decelerating said piston (17; 41) at least at one end of the piston stroke, said damping means comprising an air-flow venting path having a throttling valve 15, 16; 57),

characterised in that said stop and damping means comprises a movable stop member (23; 53) tightly sliding and coaxially arranged inside said piston chamber (10a; 52), actuable control means (25; 54) for adjustably moving said stop member (23; 53) between advanced and retracted stop positions for stopping said piston (17; 41), and in which the air-flow path of said damping means comprises a telescopically extendable air-flow venting conduit (26; 58, 59) between said throttling valve (15, 16; 57) and the movable stop member (23; 53) mentioned above.

2. A pneumatic linear actuator according to claim 1 comprising a cylinder body (10;40) defining an elongated piston chamber (10a; 52) closed by head pieces (11, 12; 47) at both ends, each of said head pieces (11, 12; 47) having an air inlet/outlet port (13, 14; 46) connected to a main flow path (34; 48) opening into said piston chamber (10a; 52);

a piston (17; 41) reciprocable in said piston chamber (10a; 52);

stop and air actuated damping means (15, 22; 53, 57), said damping means comprising a throttling valve (15, 16; 57) and a branched-off path (32; 58), as well as sealing means (35, 36; 45, 51) on the piston (17; 41) and at the inner end of said main flow path (34; 48) respectively to sealingly close the main flow path (34; 48) near the end of the piston stroke,

characterised in that said stop and damping means (15, 22; 53, 57) comprises a telescopically adjustable stop and damping unit (22; 53) coaxially extending into and from an end of said cylinder body (10; 40), said stop and damping unit (22; 53) comprising a fixed sleeve member (21; 47a) protruding into the piston chamber (10a; 52) from said head piece (11, 12; 47), a movable sleeve member (23; 53) slidingly supported inside the piston chamber (10a; 52) by said fixed sleeve member (21; 47a) of the damping means;

and telescopically extending conduit means (26, 27, 28, 32; 58, 59) in said stop and damping unit (22; 53) to define said branched-off path;

said stop and damping unit furthermore comprising screw actuable control means (25, 37; 49, 50) to adjust said movable sleeve member (23; 53) in any one position between a totally advanced and a totally retracted positions in said piston chamber (10a; 52) of the pneumatic actuator.

3. A pneumatic linear actuator according to claim 2, characterised in that said movable sleeve member comprises an outer tubular wall (23) and an inner tubular wall (24) radially spaced apart to define an annular groove having a closed bottom end wherein the fixed sleeve member tightly extends, the opposite facing surfaces of the outer tubular wall (23) of the movable sleeve member and of the fixed sleeve member (21) being radially spaced apart to form a narrow annular gap communicating with a longitudinal duct (32) in the fixed sleeve member (21) respectively with a longitudinal duct (27) in the mobile sleeve member (23, 24) of said branched-off path.

4. A pneumatic linear actuator according to the previous claims, characterised in that said movable sleeve member (23, 24) is guided and rotatably supported by said fixed sleeve member (21), said screw actuated control means comprising threaded portions on the opposite surfaces of the inner wall (24) of the movable sleeve member (23, 24) and of the fixed sleeve member (21) respectively.

5. A pneumatic linear actuator according to claim 4, characterized in that said screw actuated control means comprise a plurality of angularly spaced radial holes(37), in the outer wall (23) of the movable sleeve member (23, 27), said radial holes (37) being accessible for the rotation of the movable sleeve member (23, 24) through an opening (38) in a wall of the cylinder body (10).

6. A pneumatic linear actuator according to claim 5, characterised in that said opening (38) axially extends to the cylinder body (10) for a length greater than the stroke of the movable sleeve member (23, 24) of the damping unit.

7. A pneumatic linear actuator according to any one of the previous claims, in particular for a cylinder with rod, characterised in that said telescopically adjustable stop and damping unit (22; 53) is coaxially arranged around the piston rod (18).

8. A pneumatic linear actuator according to claim 3, characterised in that the inside end of said movable sleeve member (23, 24) define an adjustable mechanical stop for the piston (17).

9. A pneumatic linear actuator according to claim 2, in particular for rodless cylinders, characterised in that said branched-off path comprises a tubular member (58) attached to a fixed sleeve member (47a) of the closure head (47) said tubular member (58) slidingly extending, in a longitudinal hole of the movable sleeve member (53) of said stop and damping unit of the actuator.

10. A pneumatic linear actuator according to claims 2 and 8, characterised in that said screw actuated control means comprise a threaded shaft (49) rotatably supported by said closure head (47), said threaded shaft (49) axially extending and engaging a threaded hole of the said movable sleeve member (53), and in that sliding means (55) are provided for preventing rotation of the abovementioned movable sleeve member (53).

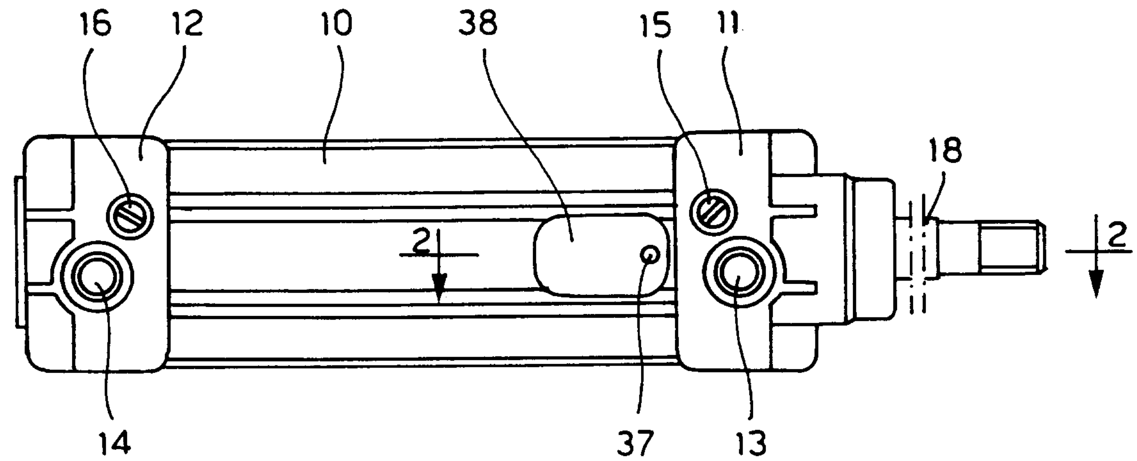

FIG. 1

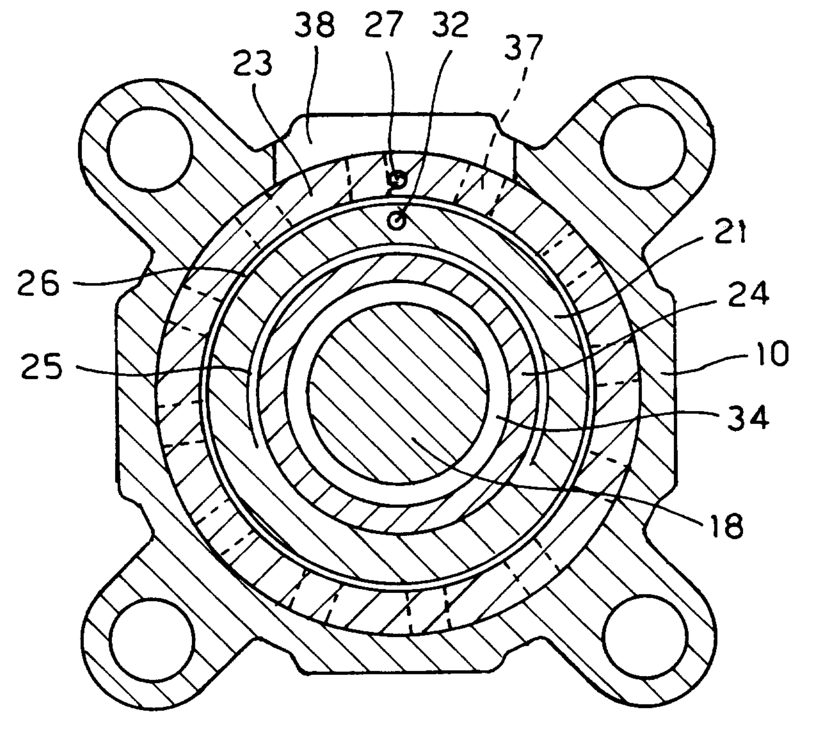

FIG. 4

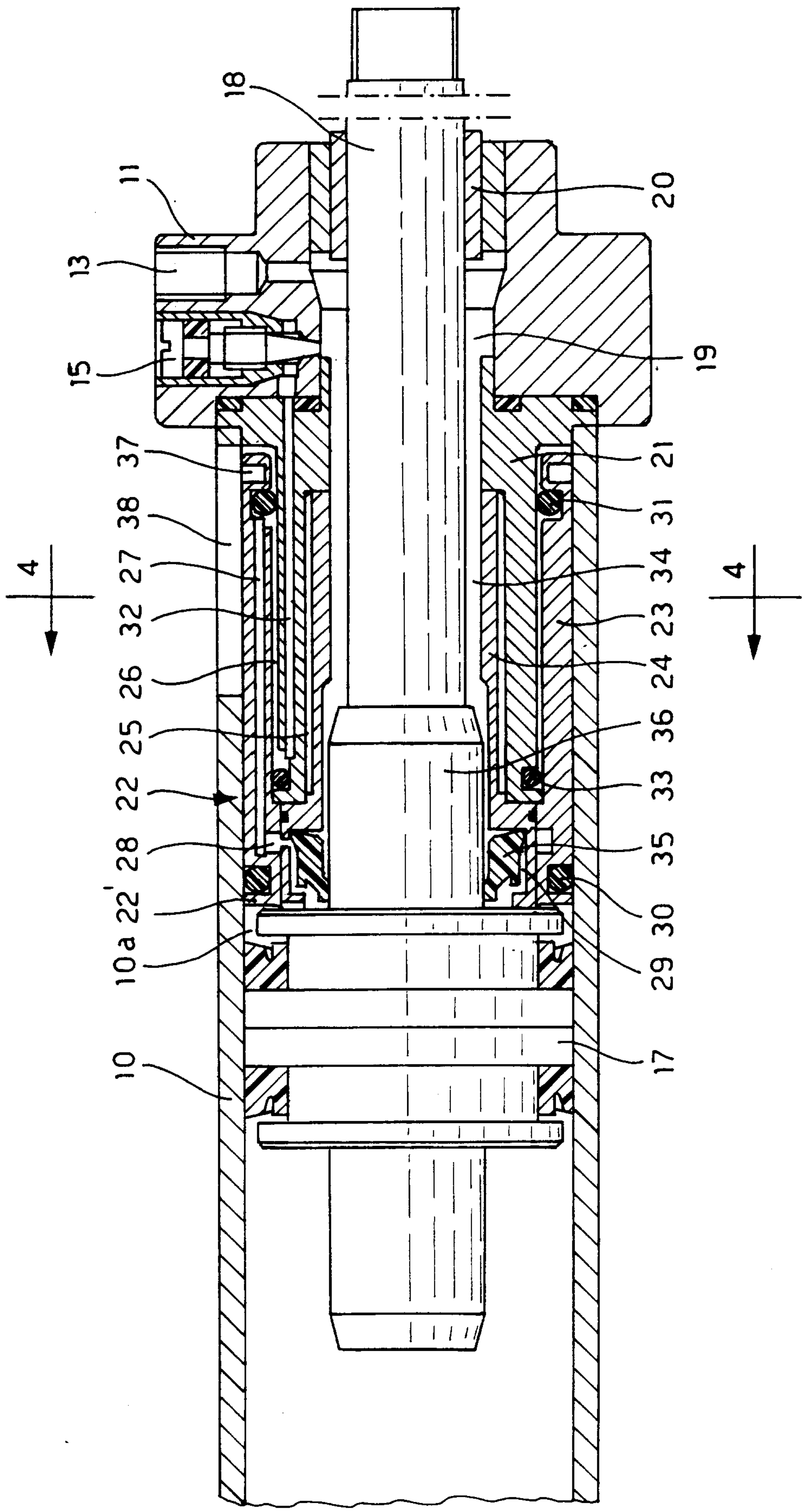
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FIG. 2

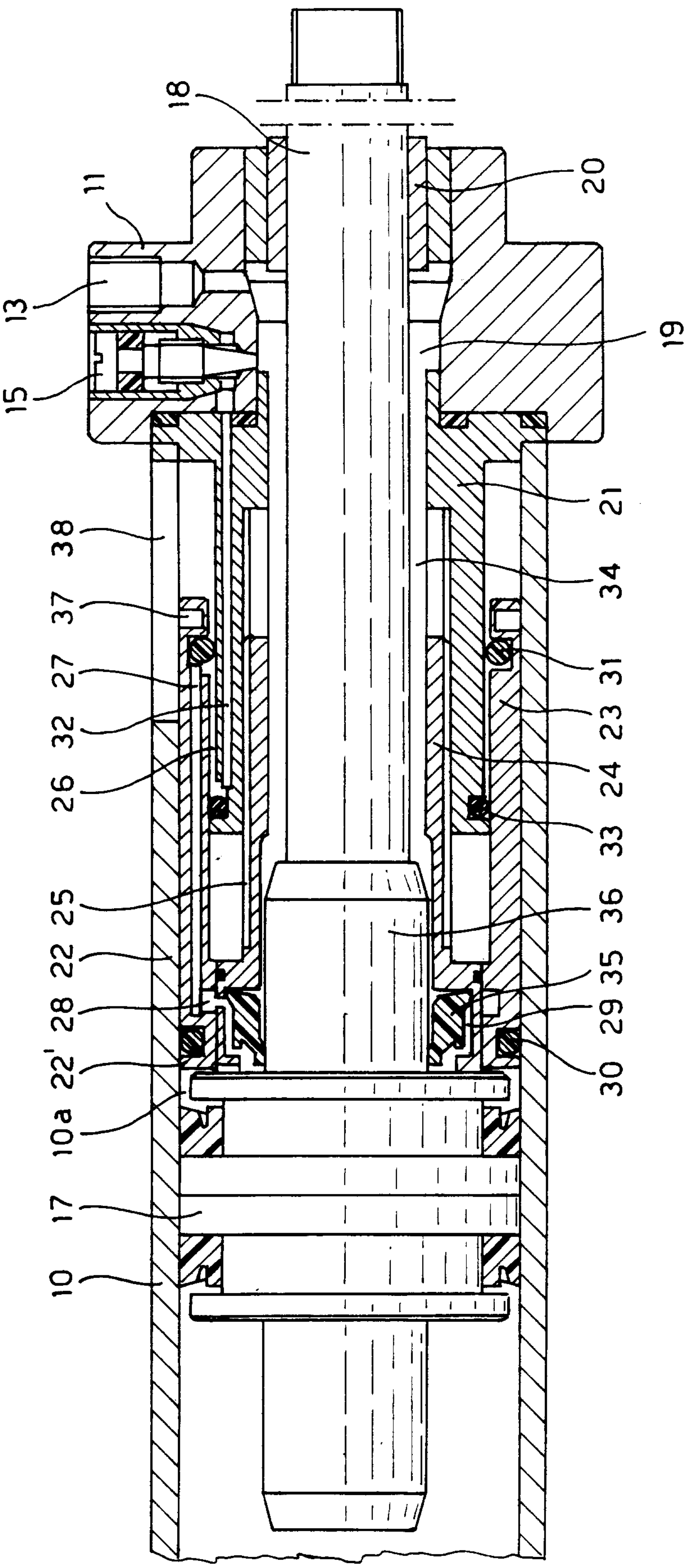
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FIG. 3

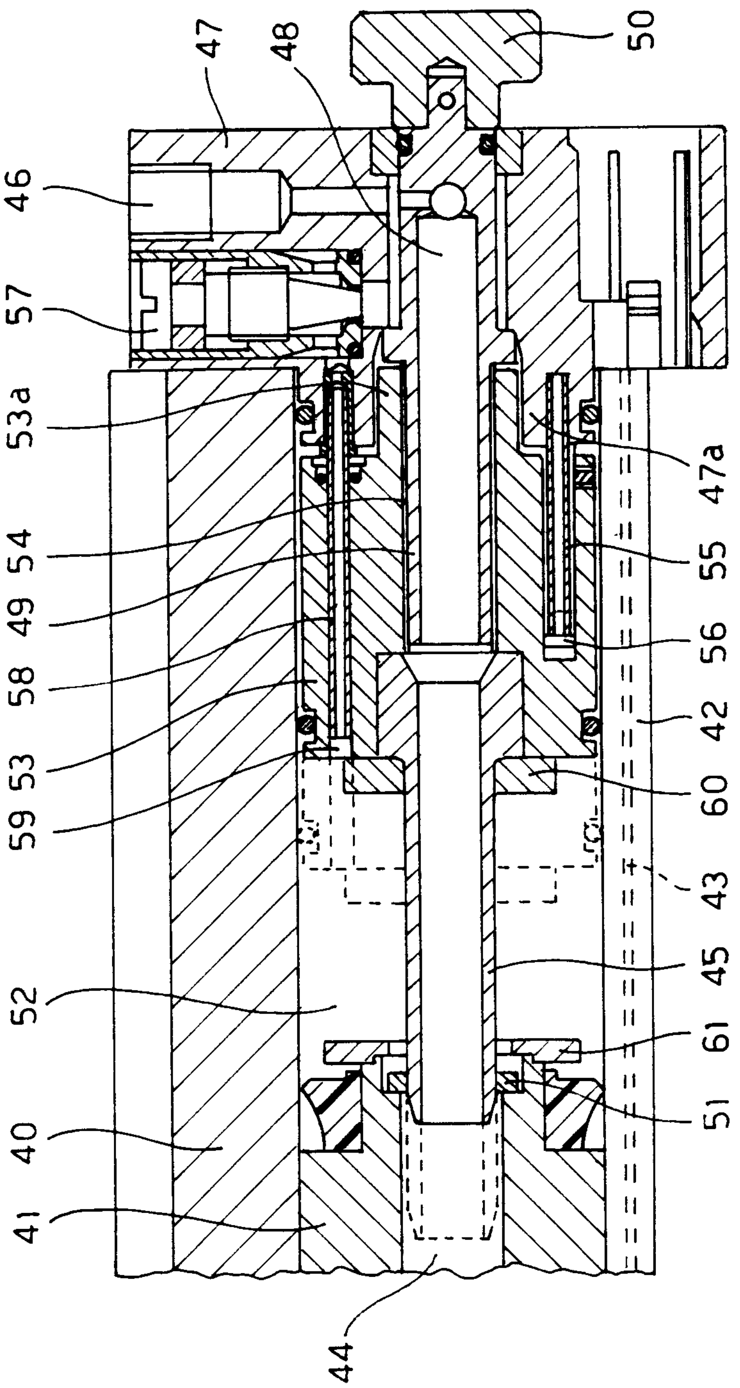
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FIG. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 94 11 6318

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	DE-U-89 04 361 (PREWA) * claims 1-3,5; figure 1 * ---	1,2,4,10	F15B15/24 F15B15/22
A	FR-A-2 560 302 (FESTO) * claim 1; figures 1-3 * ---	1,2	
A	US-A-3 626 807 (SHARTZER) * column 2, line 4 - line 35; figure 1 * ---	1,2	
A	DE-A-35 40 416 (BERNARD) * claim 1; figures 1,2 * ---	1,2	
A	FR-A-2 347 556 (VEREINIGTE OSTERREICHISCHE EISEN- UND STAHLWERKE - ALPINE MONTAN) * claim 1; figures 1,2 * ---	1,2	
A	EP-A-0 005 407 (CLIMAX FRANCE) -----		
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			F15B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	18 January 1995	Thomas, C

CATEGORY OF CITED DOCUMENTS

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