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(54) Linear pneumatic actuator with a reversible-action locking device.

(57) A linear pneumatic actuator with a reversible-action locking device for presetting of the actuator with an active or passive brake. The actuator comprises a piston (13) which may reciprocate inside a cylinder (10); the linear movement of the piston (13) causes rotation of a threaded shaft (20) connected to a signal generator (25) which continually supplies the relative position of the piston (13). A locking device comprises two interconnected piston members (34, 36) which can be pneumatically actuated in opposite directions and ducts (46, 47) supplying pressurised air which can be selected during assembly so as to activate the locking device as an active brake or passive brake, respectively, in order to block the actuator piston (13).

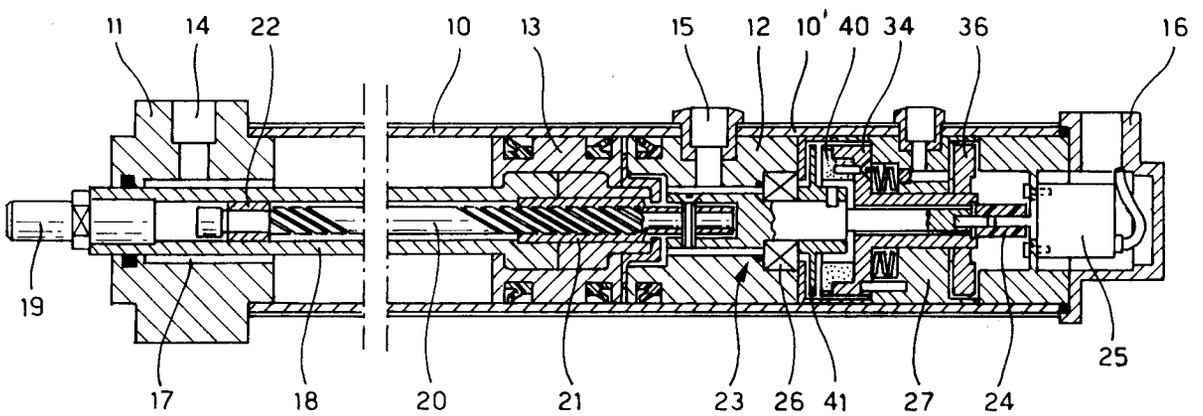

FIG. 1

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The present invention relates to a linear pneumatic actuator and more precisely to an intelligent cylinder provided with a signal generator and a locking device by means of which it is possible to obtain precise control and an exact indication of the stroke of the piston, and in which the locking device is actuated by the same pressurized fluid so as to obtain a locking action which can be automatically controlled with extreme precision from the outside, using a single pneumatic energy source.

In numerous applications, in particular in the construction of pneumatic axes, devices for handling loads and the like, there is the need for pneumatic actuators which not only are able to guarantee precise positioning control, but at the same time can also ensure rapid and safe blocking of the load, keeping it firmly in the desired position.

Intelligent pneumatic actuators comprising a piston movable in a reciprocating manner inside a cylinder have already been proposed, in which the piston is provided with a hollow rod which emerges from one end of the cylinder and in which a threaded shaft is arranged coaxially inside the hollow rod and engages with a threaded axial hole of the piston so as to rotate during the relative movement of the piston itself. The threaded shaft is connected to a signal generator as well as to a locking device which can be pneumatically actuated so as to block or release rotation of the actuator's threaded shaft and, respectively, the linear movement of its piston; counteracting springs are provided in order to activate normally the device for effecting locking as a normally active brake or passive brake.

Some examples of linear pneumatic actuators of the intelligent type, provided with a locking device which can be actuated pneumatically, can be found for example in GB-A-2,154,282 and in EP-A-469253. In particular, the document GB-A-2,154,282 describes a linear pneumatic actuator provided with a brake of the passive type, in which the locking force can be obtained both pneumatically and by the action of a spring so as to provide an adequate degree of safety in the event of a drop in the air pressure in the pneumatic circuit which supplies the actuator.

The document EP-A-469253 in turn describes an intelligent linear actuator provided with a special locking device controlled centrifugally. According to one embodiment, the pneumatic actuator is provided with a passive brake in which springs normally press against the locking device so as to prevent rotation of the threaded shaft. According to a further embodiment the actuator is provided with a locking device of the active type, in which friction members of the locking device are kept normally disengaged by the thrusting action of a spring so as to allow rotation of the threaded shaft and the reciprocating movement of the piston.

The solutions proposed hitherto require specific locking devices which in each case must be specially manufactured and associated with a pneumatic actuator depending on whether active or passive locking of the actuator is required.

It is obvious that with the solutions proposed hitherto there are problems associated with productivity and production management on account of the need to provide specific solutions for each individual application, with a consequent increase in the overall production costs.

It would therefore be desirable to have a linear actuator comprising an intelligent cylinder and a locking device which can be universally used and which can be easily adapted so as to operate with an active or passive brake, while keeping the structure and general features of the entire actuator substantially unaltered.

Therefore, the scope of the present invention is to provide a linear pneumatic actuator which is provided with a reversible locking device capable, that is, of operating as an active brake or as an passive brake without having to modify the locking device itself, while ensuring a high degree of operative reliability, a safe locking action and precise positional control.

Yet another scope of the present invention is to provide a linear pneumatic actuator, as referred to above, made using standardised components, in which the active or passive action of the locking device can be preset during assembly; in this way it possible to standardise the entire production of the actuator, intervening as required only during assembly in order to modify operation of the locking device according to requirements and needs. In this way a universally utilisable linear pneumatic actuator is provided, which can be manufactured at an extremely low cost and is extremely versatile.

The above can be achieved by means of a linear pneumatic actuator with a selectable locking device, which has the characteristic features of the claim 1.

A particular embodiment of a linear pneumatic actuator with a reversible-action braking device, according to the invention will be described in greater detail hereinbelow with reference to the accompanying drawings, in which:

Fig. 1 is a longitudinal section through the pneumatic actuator according to the invention;

Fig. 2 is an enlarged detail of the locking device of the actuator according to Figure 1.

With particular reference to Figure 1, the actuator comprises a pneumatic cylinder 10 with endpieces 11 and 12. A piston 13 is arranged inside the cylinder 10 so as to be able to move in a reciprocating manner with respect to the latter un-

der the thrust of a pressurised fluid, for example pressurised air which can be supplied through a port 14 in the front end-piece 11 and a port 15 provided in the internal end-piece 12 closing the cylinder chamber. The tubular body of the cylinder 10 is extended at the rear by a part 10' closed by a rear end-piece 16 for accommodating a locking device and signal generator, described below.

With particularly, as shown in Figure 1, the front end-piece 11 of the cylinder is provided with an axial hole 17 through which a hollow rod 18 extending axially forwards from the piston 13 passes and slides.

The rod 18 of the piston is supported in an axially slidable manner by the front end-piece 11 and the piston 13 is prevented from rotating by suitable guide means inside the cylinder 10, for example by shaping the cylinder 10 so as to have a polygonal cross-section. The tubular rod 18 in the totally retracted condition of the piston 13 projects partially from the front end-piece 11 and is provided with a threaded front part 19 for connection to an external member or load.

The piston 13 has an axial hole, namely the tubular rod 18 extends through the piston so as to allow the passage of a threaded shaft 20 which extends forwards inside the tubular rod 18; the threaded shaft 20 engages with an internally threaded cylindrical sleeve 21 fixed inside the axial hole or inside the rod 18 of the piston so as to cause rotation of the rod itself by means of the reciprocating movement of the piston. The threaded shaft 18 at its front end is therefore rotatably supported inside the hollow rod 18 by means of a bush 22 or in another suitable manner. The threaded shaft 20 extends behind the piston and is connected to a pilot shaft 23 in turn connected, by means of a coupling 24, to an electric signal generator or encoder 25 accommodated in the front end-piece 16 of the actuator.

The pilot shaft 23, and consequently the threaded shaft 20, is rotatably supported by means of a bearing 26 accommodated in the body of the internal end-piece 12 closing the cylinder chamber; the pilot shaft, moreover, passes through the body of an internal cylindrical cartridge 27 inside which there is a reversible-action pneumatic locking device, shown in the enlarged detail of Figure 2.

The threaded sleeve 21 inside the piston 13 therefore engages operationally with the threaded shaft 20 such that the reciprocating linear movement of the said piston is translated into a corresponding alternating rotational movement of the threaded shaft 20, pilot shaft 23 and signal generator 25.

According to the embodiment of Figure 2, the rear end 28 of the threaded shaft 20 has a smaller diameter which extends into a cup-shaped cavity 29 of the pilot shaft 23. In turn the pilot shaft 23 has a middle portion 30 for supporting respectively the bearing 26, and a friction disc of the locking device described below.

The pilot shaft 23 has a rear part 31 with a smaller diameter which extends, freely rotatably, through the axial hole of a cylindrical shank 32 connected between a first piston element 34 sliding inside a pneumatic chamber 35 and a second piston element 36 movable inside a chamber 37. The two pistons 34 and 36 are movable axially, being guided during their short stroke by the tubular stem 32, while they are prevented from rotating by means of a pin 38 which from the internal tubular body 27 extends partially into a hole 39 in the piston 34.

More precisely, as shown also in the enlarged cross-section of Figure 2, the first piston 34 is in the form of a cup-shaped element inside which there is accommodated a first friction element 40 intended to come into contact with the front surface of a second friction element 41 suitably fixed to the pilot shaft 23, for example by means of one or more dowels 42 or in another suitable manner. In its side wall the cup-shaped element of the piston 34 is provided with an annular seat for accommodating a sealing gasket 43.

Preferably, the friction element 40 is made of elastomeric material with a high Shore hardness degree, for example between 85 and 95. Alternately, the other friction element 41 may be made of a suitable metallic alloy and may have its front surface designed to come into contact with the friction element 40, suitably toothed in order to improve the braking and locking action of the actuator.

The use of an elastomeric material for the friction element 40 and accommodation of the latter inside a cup-shaped piston 34 give rise to a wide area of contact with the other friction element 41, while maintaining an extremely light-weight design which favours the rapid action of the cylinder braking and locking device. Furthermore, as a result of the arrangement of the two pistons in separate chambers and in positions located axially at a distance from one another, it is possible to achieve a standardized design and a reversible action of the locking device, which can be selected during assembly via a single point for supplying the compressed air to one or other of the two pneumatic chambers of the locking device. The chamber 35 accommodating the piston 34 defines at the rear an abutment surface for positioning of the piston when the locking device is in the deactivated condition.

As already mentioned, the locking device can be preset, during assembly of the actuator, for selective supplying of pressurised air to one or other of the chambers 35 and 37 so as to provide

thrusting actions which are reversible or in directions opposite to one another. For this purpose, in a middle position between the two chambers there is provided a hole 46 of an inlet aperture which is able to communicate selectively with the chambers 35, 37 of the locking device via a branched duct 47 which on one side leads into an annular chamber 48 communicating with the first chamber 35, while on the other it leads directly into the second chamber 37 as shown. The branched duct 47 is internally threaded so as to allow the application of a plug 49 by means of which the supply to one or other of the two chambers is selected during assembly of the actuator.

Figure 2 shows an actuator with a passive brake, that is to say which remains constantly in the locking condition when there is no pressurized air inside the chamber 37 of the piston 36. Therefore, in this case, the annular chamber 48 has arranged inside it cup springs 50 which act in opposition to the piston 36 in order to push and keep the first friction element 40 against and constantly engaged with the second friction element 41. Alternately, in the case where one wishes to convert the locking device from passive to active, i.e. so that it is constantly disengaged when there is no pressurised air, the springs 50 should be eliminated and replaced with weaker springs 51 inside the chamber 37 of the second piston, as illustrated in broken lines in Figure 2. In this case the position of the plug 49 must be reversed during assembly, with respect to that shown, so as to allow the supply of air only towards the annular chamber 48 and the chamber 35 of the first piston 34 which accommodates the friction element 40.

From the description and drawings it will therefore be understood that it has been possible to provide a linear pneumatic actuator consisting of an intelligent cylinder which is governed by an encoder or similar signal generator and which is provided with a special reversible locking device able to perform the dual function of an active brake or passive brake simply by selecting during assembly of the actuator the path of the pressurised fluid towards one or other, respectively, of the chambers of the two pistons with which this device is provided. In this way, an intelligent linear pneumatic actuator has been provided, which is extremely versatile and highly reliable and whose operating mode can be changed, if necessary, without modifying the structure of the actuator.

Claims

1. A linear pneumatic actuator with a reversible-action locking device comprising: a cylinder body (10) and a piston (13) movable in a reciprocating manner in the cylinder (10), said piston (13) being provided with a hollow rod (18) which emerges from one end (11) of the cylinder (10); a threaded shaft (20) which axially extends through and which engages an internally threaded hole (21) of the piston (13) so as to rotate during the relative axial movement of the piston (13) itself, and a locking device connected to said threaded shaft (20), said locking device comprising a first and a second friction element (40, 41) which can be engaged and disengaged with respect to one another, the first friction element (40) being prevented from rotating with respect to the cylinder (10) of the actuator, the second friction element (41) being rotatable with the threaded shaft (20), one (40) of said friction elements (40, 41) being moreover slidable axially towards the other one (41) and subject to elastic counteracting means (50) acting to move said one friction element (40) respectively towards or away from the other one (41); the actuator comprising moreover pneumatic means (34. 35. 36. 37) for actuating the locking device (40, 41), characterised in that said pneumatic means comprise a first and a second pneumatic chambers (35, 37) axially spaced apart from one another, a first and a second piston elements (34, 36) provided respectively inside said first and second pneumatic chambers (35, 37), said piston elements (34, 36) being interconnected with one another, the first one (34) of said piston elements (34, 36) being in turn connected to the axially movable friction element (40); and in that there air supply ducts (46, 47) are provided, which can be selectively closed or open during assembly, for supplying pressurised air respectively to the first one or to the second one of the piston chambers (35, 37) and for providing thrusts in opposite directions on the movable friction element (40), keeping said friction elements (40, 41) constantly engaged or disengaged with respect to each other.

2. A pneumatic actuator according to Claim 1, characterised in that said axially movable friction element (40) consists of an annular element made of elastomeric material and is accommodated inside a cup-shaped element (34) forming the first one of the piston elements (34, 36) of the pneumatic means for actuating the locking device (40, 41).

3. A pneumatic actuator according to Claim 1, characterised in that said selectable air supply ducts (46, 47) comprise a duct (47) branched off from a single pressurised air supply port (46), said branched-off duct (47) communicat-

ing with both the pneumatic chambers (35, 37), and a closing member (48) selectively arranged at one end of the branched-off duct (48) to select active or passive operation of the locking device, by supplying air to the first one or second one of said chambers (35, 37).

4. A pneumatic actuator according to Claim 1, characterised in that said pneumatic means (34, 35, 36, 37) and said locking device (40, 41) are provided inside a cylindrical cartridge member into a rear extension of the cylinder body (10) of the actuator.

5. A pneumatic actuator according to Claim 1, characterised in that one end of the threaded shaft (20) is connected to a pilot shaft (30) supporting the second rotatable locking element (41), said pilot shaft (30) freely extending through said first locking element and being connected to an electric signal generator (25).

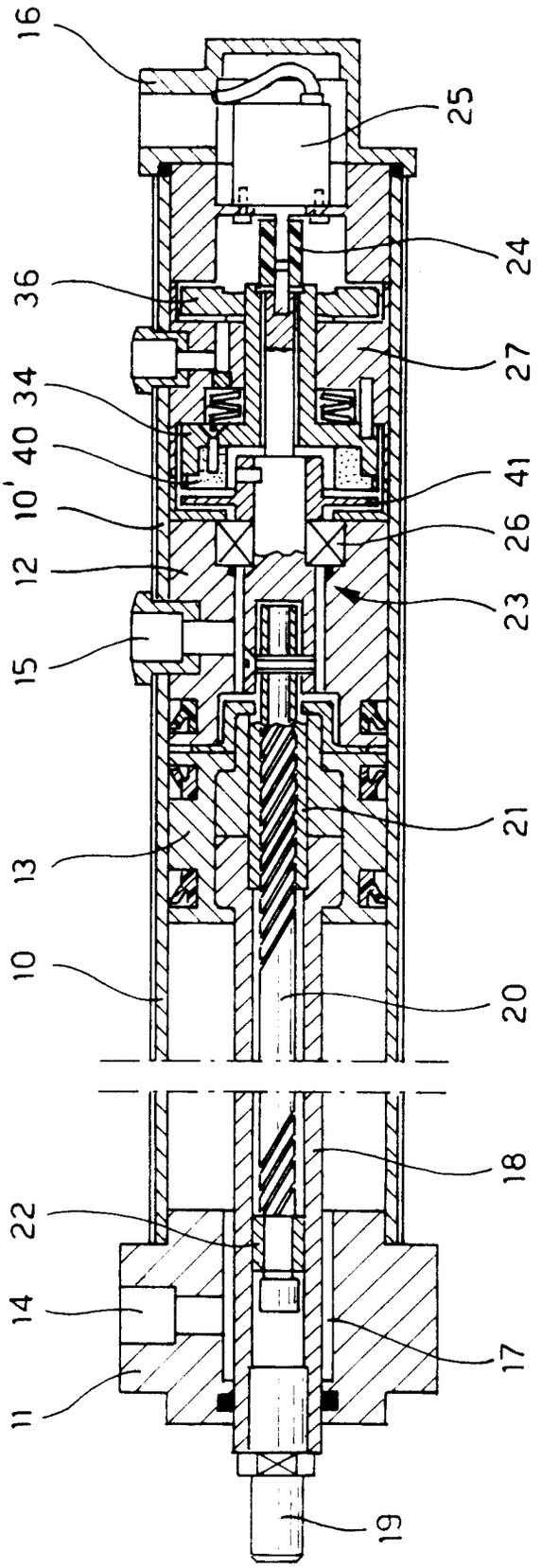

FIG. 1

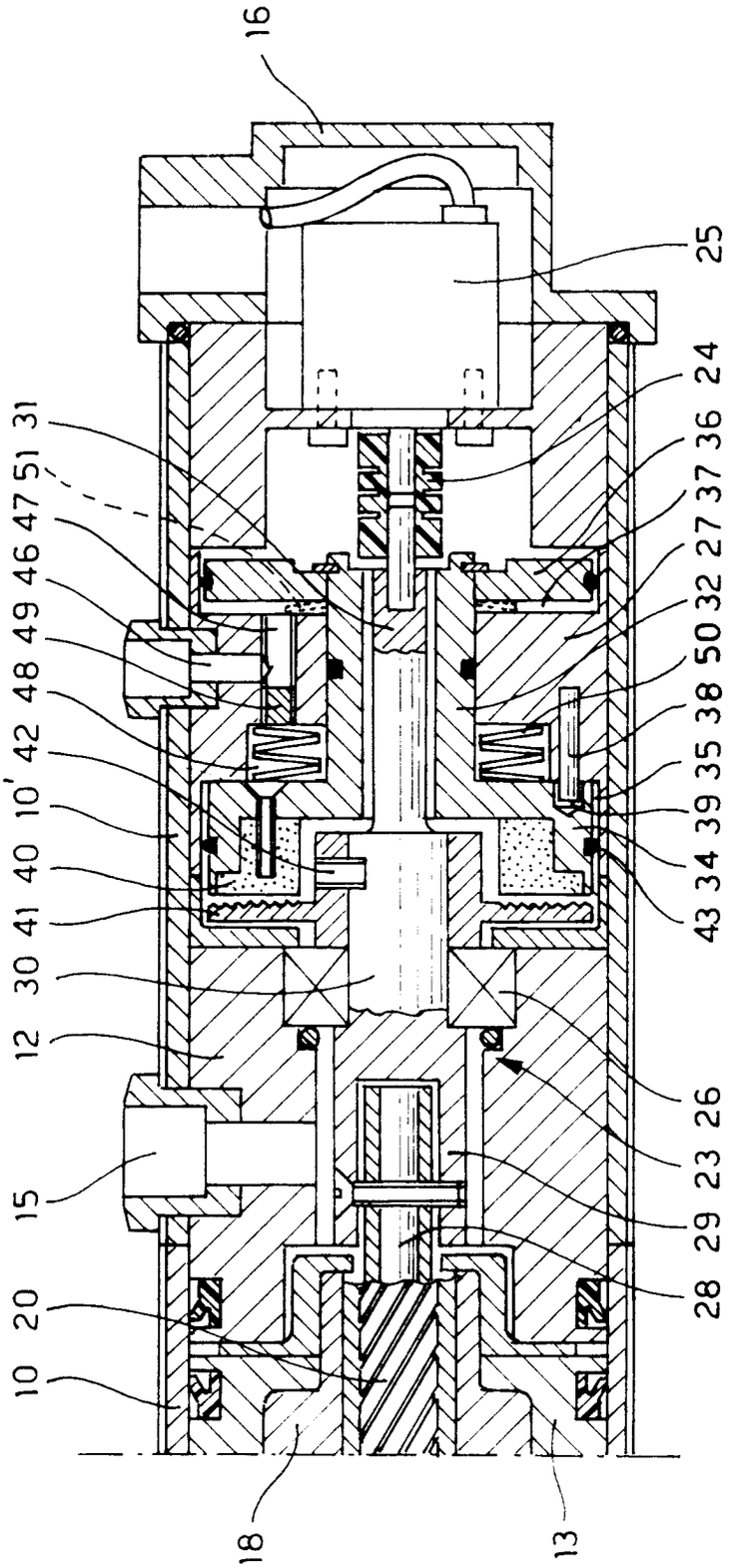
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FIG. 2

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EUROPEAN SEARCH REPORT

Application Number EP 94115580.6

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)
D,A	EP - A - 0 469 253 (UNIVER S.P.A.) * Abstract; fig. 1 *	1-4	F 15 B 15/26
X,D	* Column 4, lines 33-45 *	5	
D,A	GB - A - 2 154 282 (HCH MANUFACTURING LTD.) * Abstract; fig. 1 *	1	
A	GB - A - 2 009 850 (SCHWEIZERISCHE LOKOMOTIV- UND MASCHINENFABRIK) * Abstract; fig. 1 *	1	
A	US - A - 4 932 311 (KAZUO MIBU et al.) * Columns 3,4; fig. 1 *	1	

TECHNICAL FIELDS SEARCHED (Int. Cl. 6)
F 15 B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	30-12-1994	LAHODNY

CATEGORY OF CITED DOCUMENTS

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