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(54) **Pneumatic rotary actuator with increased starting torque.**

(57) The pneumatic rotary actuator (10) comprises a barrel (11) and inside partitions (17, 18) defining an elongated main chamber (14) and at least one lateral chamber (15, 16) communicating with the main chamber (14) via axially aligned passages in said partitions (17, 18). A main double-acting piston (20) reciprocable inside the main chamber (14) has a threaded axial hole (20A), which engages with a thread shaft (21) rotatably supported axially protruding from one end of the actuator. A secondary piston (25, 26) inside each lateral chamber (15, 16) provides an additional thrust to the main piston (20) at the beginning of each reciprocating travel. Guide surface means inside the main chamber (14) prevent the main piston (20) from rotating; fluid under pressure sequentially supplied on corresponding sides of the main (20) and lateral piston or pistons (25, 26), causes the reciprocating movement of the main piston (20) and the consequent reciprocating rotation of the thread shaft (21) with an increased starting torque at the beginning of each travel.

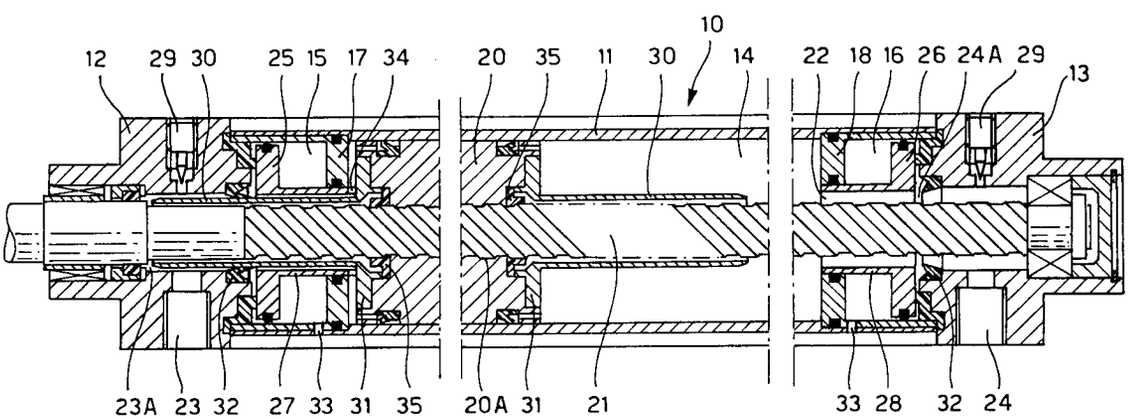

FIG. 1

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The present invention relates to a pneumatic rotary actuator of the type comprising a hollow cylindrical body defining an elongated chamber inside which a double-acting piston member reciprocates; the piston member has a threaded central hole which engages with a thread shaft rotatably supported and axially protruding from one end of the actuator. Fluid under pressure alternately acts first on the sides of the piston member to cause a reciprocating movement and the consequent rotation of the thread shaft of the rotary actuator.

Pneumatic actuators with a rotating shaft, of the type mentioned above, are widely known and used on account of their operating features and their ability to provide high torques over the entire travel of the piston, with the possibility of stopping the latter at any desired point of the rotational arc of the output shaft which may reach and even exceed 360°.

Pneumatic rotary actuators are generally preferred to other types of actuators, for example to actuators of electrical type, whenever, for safety purposes or other reasons, operation under safety conditions is required. However, the pneumatic rotary actuators currently known, unlike electric actuators, provide a torque of constant value over the entire working travel, without the possibility of varying or increasing the said torque in a controlled manner.

Apart from using pneumatic rotary actuators dimensioned to provide only the maximum torque required, no pneumatic rotary actuators able to provide varying torque values are presently known.

In many applications for which the use of pneumatic actuators is particularly recommended, for example for the opening and closing of access doors in rolling stock, or for other special applications, the use of conventional rotary actuators has proved to be unsuitable both on account of the greater overall dimensions which these actuators must necessarily have in order to provide the maximum torques required, and on account of the consequent greater quantity of pressurised air which is used.

Therefore, the main scope of the present invention is to provide a pneumatic rotary actuator of the kind mentioned above, by means of which it is possible to obtain varying torque values, in particular a greater starting torque value in one or both the rotational directions of the actuator shaft or over a desired portion of the piston travel.

A further scope of the present invention is to provide a pneumatic rotary actuator of the abovementioned kind which has extremely small dimensions, for a same working travel and maximun torque value, and by means of which the reactive twisting moment which normally acts on the operating piston of the actuator can also be distributed over a large area; in this way it is possible to achieve smooth sliding of the piston, substantially without any reaction problems.

These and other scopes may be achieved by means of a pneumatic rotary actuator, according to the invention, and as defined in claim 1, characterized by the combination of a main operating piston which engages with the thread shaft of the actuator, and by at least a secondary piston in a separate chamber, provided with a tubular shaft extension sliding through a partition to act on the main piston to provide an additional thrust each time the travel is reversed at one or both ends of the actuator.

A preferred embodiment of a pneumatic rotary actuator according to the invention will be described hereinbelow, with reference to the figures of the accompanying drawings, in which:

Fig. 1 is a longitudinal sectional view of the actuator;

Fig. 2 is an enlarged sectional view of the left-side end of the actuator shown in Fig. 1, in a different operating condition;

Fig. 3 is a cross-sectional view along the line 3-3 of Figure 2.

As shown in the various figures, the actuator 10 comprises a hollow cylindrical body consisting for example of a barrel 11 axially extending and having a polygonal cross-section, and of two closing end-pieces 12 and 13.

The cylindrical body 11 is divided up into a main chamber 14 extending in the axial direction of the actuator, and into two lateral chambers 15, 16 of smaller length than the main chamber 14, which are separated from the main chamber 14 for example by internal partitions 17, 18 provided by the bottom wall of a corresponding cup-shaped elements defining the lateral chambers 15, 16; each cup-shaped member is sealingly inserted in the barrel 11 against suitable stop means provided by an annular shoulder inside the barrel and retained by the end-piece 12 and 13; tie-rods, not shown, pass through suitable holes in the end-pieces 12, 13 and are screwed into corresponding holes in the barrel 11 of the actuator, as for example indicated by 19 in Figure 3.

Inside the main chamber 14 reciprocates a main double-acting piston 20 having a polygonal cross-section corresponding to that of the barrel 11, the internal surfaces of which therefore define guide means preventing rotation of the piston 20.

The piston 20 is made from a material having a low friction and has an axial hole 20A which is internally provided with a threaded portion so as to engage with a thread shaft 21 of the actuator which is supported so as to rotate coaxially and emerging from one end of the body 10 of the actuator, passing through central openings 22 (only one is shown in Figure 1) in the partitions 17, 18 which

separate the main chamber 14 from the lateral chambers 15 and 16; ports 23, 24 are provided in the end pieces 12 and 13 for sequentially supplying and discharging compressed air in the chambers of the actuator.

Inside each lateral chamber 15, 16 there is provided a respective secondary single-acting piston 25, 26 having a tubular shaft extension 27, 28 sliding in a sealed manner through the central hole 22 of the partitions 17, 18 so as to extend through the same, towards and against the main piston 20 in such a way as to provide an additional thrusting action for an initial portion of the travel of the piston 20 at each end of chamber 14, in the manner described further below.

Rotating seals 35 are provided at both ends of the main piston 20 in such a way as to be adapted to the threading of the shaft 21 so that an adequate sealing action is provided between the two sides of the main chamber 14.

The pneumatic rotary actuator according to the invention is provided moreover with pneumatic damping means which act to brake the sliding movement of the piston 20 and hence rotation of the shaft 21 when piston 20 approaching the two ends of the travel of the piston itself.

The pneumatic damping means comprises substantially an adjustable needle valve 29 in each end-piece 12, 13 to connect chamber 14 to the exterior through a corresponding annular passage 23A, 24A supplying compressed air into the aforementioned chambers 14, 15 and 16. In the example shown, the damping means, on each side of the main piston 20, comprise a tubular element 30 axially extending around and spaced apart from the threaded shaft 21 and tubular shaft 27; the tubular element 30 protrudes from a plate 31 which is fixed, for example screwed to a corresponding end face of the piston 20. The tubular element 30 has an internal diameter slightly greater than the maximum diameter of the shaft 21, and an external diameter slightly smaller than the internal diameter of the tubular extension 27, 28, respectively, of the two secondary pistons 25, 26 so as to provide the necessary passages for the fluid under pressure.

The tubular element 30 cooperates moreover with a lip seal 32 for the required sealing action with respect to the needle valve 29, necessary for obtaining the desired pneumatic damping effect.

Finally 33 in Figure 2 denotes venting holes for the chambers 15 and 16 on the side of the secondary piston which is opposite to the supplying side for the fluid under pressure, while 34 denotes radial holes in the tubular extensions 27 and 28 of the two lateral pistons, for allowing the passage of the fluid under pressure from the respective supply port 29, via the lip seal 32, to the fluid supply side of each lateral chamber 15, 16, along the annular duct formed between each tubular extension 27, 28 and the respective tubular element 30 of the pneumatic damping system, towards the corresponding side of the main chamber 14, through radial holes 34.

The operation of the pneumatic rotary actuator according to the invention is briefly as follows: let us assume that the actuator is in the condition shown in Figure 1 and that the air under pressure is supplied via the port 23. Under these conditions, the compressed air flowing along the path described above reaches simultaneously the main chamber 14 and the lateral chamber 15 on the corresponding sides of the two pistons 20 and 25 which will begin to move towards the right in Figure 1. Therefore, the piston 20 will be subject to a thrust force which is twice or greater than that exerted by the compressed air inside the chamber 14 only of the piston, since will be added the thrust exerted by the piston 25 via its tubular extension 27 which protrudes through the central hole 22 in the partition 17 and acts against the plate 31, pushing the piston 20. The thrusting action of the secondary piston 25 combined with that of the piston 20 will be exerted for a short portion of the travel of the piston 25, due to short length of chambers 14 and 15 i.e. for a length in any case sufficient to overcome the starting friction and provide a speed sufficient to start the movement of the load connected to the shaft 21. When the secondary piston 25 or the secondary piston 26, respectively, have completed their forward travel, the movement of the central piston 20 is made to continue by the action alone of the air inside a respective side of the chamber 14; this thrust which is equal to half or in any case is less than the initial thrust is now more than sufficient to continue the sliding of piston 20 and the rotational movement of the shaft 21; in this way a considerably smaller amount of compressed air is requested.

When the piston 20 approaches the end of its forward travel, the tubular element 30 penetrates into the tubular extension 28 of the corresponding secondary piston 26, coming into contact with the lip seal 32 which prevents the passage of air to the corresponding venting valve 29; in this way there is compression of the air remaining inside the chamber 14 and a consequent dampening action of the piston 20 and load movement. After movement of the piston 20 and of the load connected thereto has been completed in one direction, operation of the actuator 10 may be reversed, by supplying the fluid under pressure by the other port 24.

It will therefore be understand from what has been said and illustrated, that it has been possible to provide a pneumatic rotary actuator of the type having a rotating shaft, provided with a starting

torque greater than that normally supplied during the normal travel of the actuator, on account of the original combination of a main piston and at least one secondary piston which act, at the start of each working stroke, to provide an additional thrust along an initial portion of the travel corresponding to the travel of the secondary piston itself. As a result of the coaxial arrangement of the assembly and the use of suitable internal guiding surfaces for the main piston, it is also possible to obtain a rotary actuator of very small dimension, which is safe to use and extremely reliable. Finally an extremely advantageous design ensuring suitable operation of the actuator is achieved as a result of the use of suitable anti-frictional material for the piston and rotating seals which are adapted to the geometry of the threading of the shaft 21.

Claims

1. Pneumatic rotary actuator of the type comprising a hollow body (11) defining an axially extending main chamber (14) a main double-acting piston (20) reciprocable in said main chamber (14), said main piston (20) having an internally threaded axial hole (20A) for coupling with a thread shaft (21) rotatably supported and coaxially extending from one end of the actuator body (11), characterized in that, at least one end, said actuator comprises additional pneumatically actuated piston means (25, 26), each additional piston means (25, 26) acting to forwardly thrust the main piston (20) for a short initial portion of the working stroke, and in that said antirotational guide means are provided on facing surfaces of the hollow body and said main piston (20) of the actuator.

2. Pneumatic rotary actuator according to Claim 1, characterized in that each side of the main chamber (14) and a corresponding side of a piston chamber (15, 16) for said additional piston means (25, 26) are connected to a same inlet port for fluid under pressure through an annular passage axially extending around the threaded shaft (21).

3. Pneumatic rotary actuator according to Claim 1, characterized in that each additional piston means comprises an additional piston chamber (15, 16) axially aligned with and having a length smaller than that of said main chamber (14), and in that a secondary single-acting piston (25, 26) is axially movable inside said additional chamber (15, 16), said secondary piston (25, 26) having a tubular extension (27, 28) coaxially arranged with respect to the threaded shaft (21), said tubular extension (27, 28) protruding towards said main piston (20) through a central hole in a partitions (17, 18) separating the main chamber (14) from said additional chamber (15, 16) of the actuator.

4. Pneumatic rotary actuator according to Claim 1, characterized in that pneumatic damping means (29, 30) are provided at each end of the main piston (20) and main chamber (14) of the actuator.

5. Pneumatic rotary actuator according to Claim 4, characterized in that said pneumatic damping means comprise a tubular element (30) extending from each end of the main piston (20), said tubular element (30) being axially arranged and radially spaced apart from the tubular extension (27, 28) of the additional piston means, and sealing means at one end of the hollow body, respectively encircling said tubular member (30) of the main piston (20), to provide a seal between each additional chamber (15, 16) and a venting valve (29) connected to a air feeding passage for feeding pressurised air to piston chambers (14, 15, 16) of the actuator.

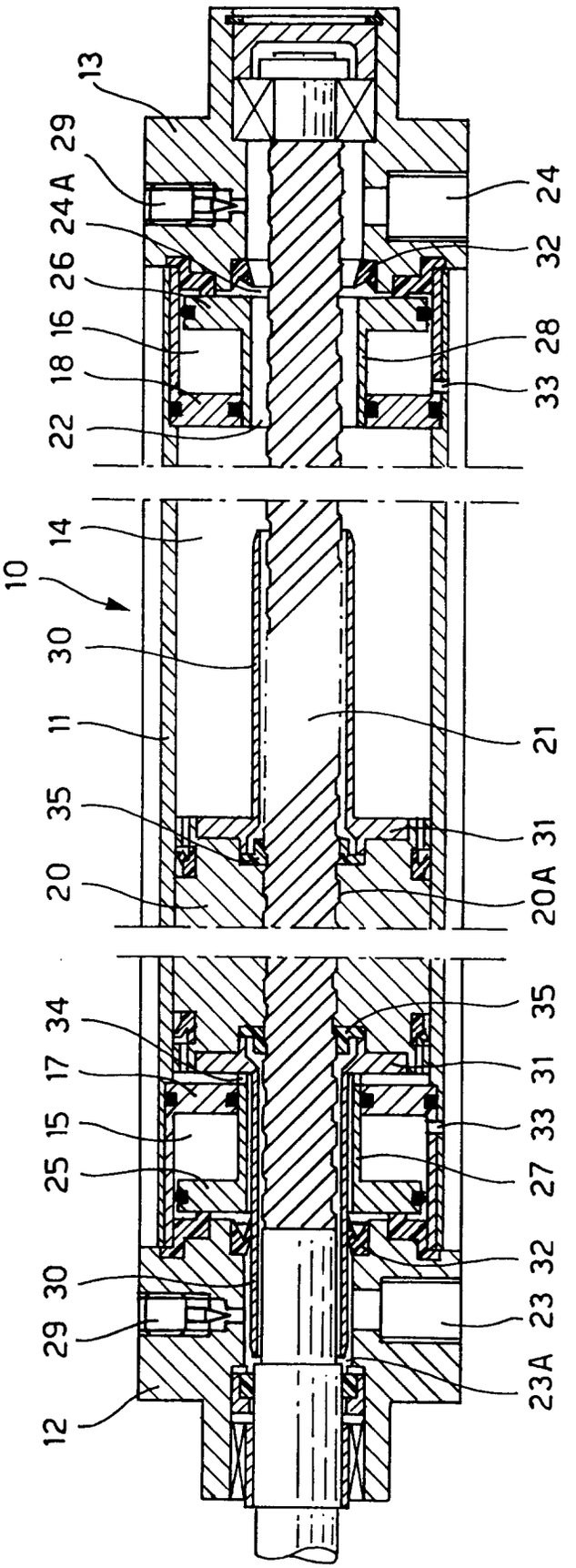
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FIG. 1

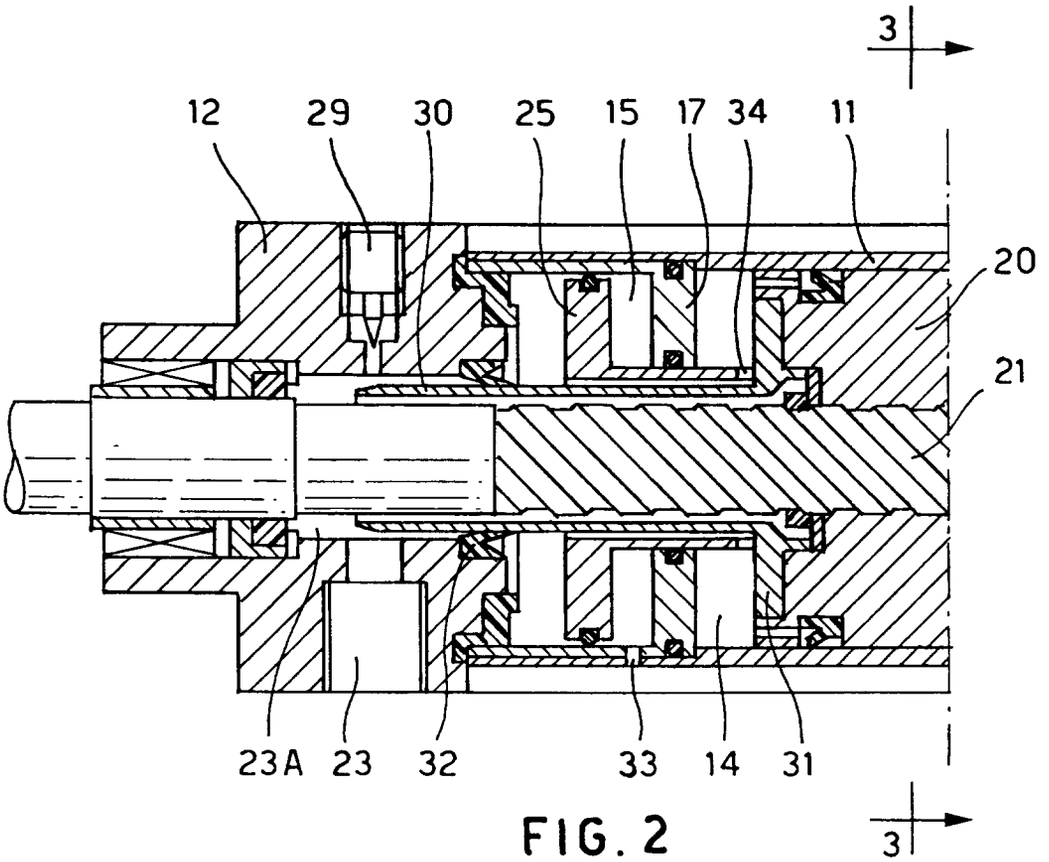

FIG. 2

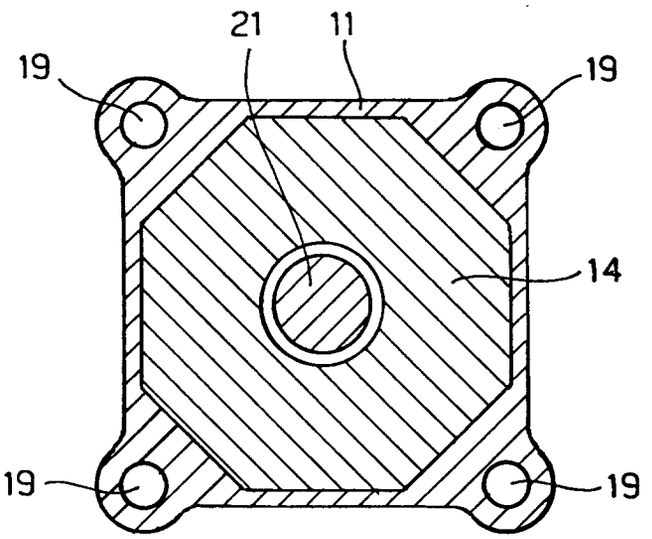

FIG. 3

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EUROPEAN SEARCH REPORT

Application Number

EP 93 10 9868

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.5)
A	US-A-2 932 206 (J. N. TOOTLE) * column 1, line 23 - line 30; figure 1 *	1	F15B15/08
A	DE-A-2 919 435 (IFE GESELLSCHAFT) * claim 1; figure 1 *	1	
A	US-A-2 970 574 (H. M. GEYER)		
A	DE-A-2 748 955 (HOLZER)		

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

F15B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	28 OCTOBER 1993	THOMAS C.

CATEGORY OF CITED DOCUMENTS

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