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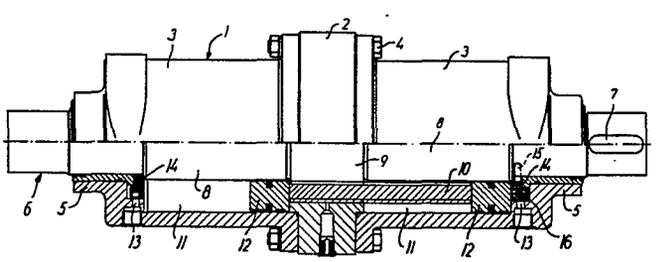
(54) Rotary actuator.

(57) The actuator comprises a casing (1) and a spindle (6) coupled together by means of a threaded sleeve (10). An axial displacement of the sleeve along the spindle produces the desired relative rotation between the two main parts (1, 6). The displacement occurs in response to the supply of a fluid to a chamber (11) between one end (5) of the casing and a piston (12) which is displaceable along the spindle, and which in turn presses on the sleeve (10). The outflow of fluid through an aperture (13) is throttled at one or more predetermined points of the rotation by means of a spring loaded shoe (16). During the rotation the shoe overlaps the aperture (13) whereby a desired retardation of the rotation is obtained. Undesired throttling of the inflow of fluid, when the shoe overlaps the aperture et the opposite direction of rotation, is avoided due to the fact that the pressure of the fluid overcomes the spring load.



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Rotary Actuator

The present invention relates to a rotary actuator comprising two relatively rotatable and axially fixed main parts defining between them at least one working chamber with an aperture provided in a surface of one of said main parts of the actuator for inflow and outflow of a working fluid to and from said working chamber, and means for throttling the outflow of working fluid when said main parts assume at least one predetermined relative angular position.

These main parts may, for example, be a cylinder casing and a spindle coupled together by means of a threaded sleeve located between two pistons which are axially displaceable along the spindle and each of which defines, together with an end wall of the casing, a working chamber between the casing end in question and the threaded sleeve. When a pressurized working fluid (liquid or gas) is supplied to one working chamber while the other working chamber is connected to a zone of lower pressure, such as the tank of a hydraulic system, the piston associated with the first mentioned working chamber moves away from the casing end wall taking the sleeve with it. Through the threaded connection the axial movement of the sleeve is transformed into a relative rotation between the spindle and the casing.

When a rotary actuator is employed for moving massive objects, e.g. for effecting the slewing of the jib of an excavator, it is desirable that the rotary movement is automatically retarded or dampened when the moving object approaches one or more predetermined angular positions, in particular one of the extremities of the movement, since otherwise the substantial inertia forces can give rise to serious damage.

From published German Patent Application DE-OS 2 808 375 there is known a rotary actuator of the kind referred to above in which the or each throttling means consists of a plunger which is slidable in a bore in the stator of the actuator. The bore intersects a duct for the inflow and outflow of the working fluid and the plunger is spring biased radially inward against a cam secured to the rotor of the actuator. In the peripheral surface of the plunger there is a narrow annular groove and when the plunger is displaced outwardly by the cam, the fluid duct is partially obstructed by the plunger whereby the working fluid has to flow through the narrow groove so that the flow is throttled. Since the throttling action depends solely on the angular position of the rotor, it is equally effective whether the duct functions as inflow or as outflow duct. When it is desired to reverse the rotation of the rotor after a preceding retardation and standstill it is, however, desirable that the inflow of the working fluid can occur as unimpeded as possible in order to ensure a suitable high acceleration of the rotor. In order to permit this the prior art actuator comprises, associated with each throttling plunger, a system of by-pass ducts including a spring loaded non-return valve which prevents the outflow of fluid from the working chamber, but permits inflowing working fluid to by-pass the throttling plunger and, thus, avoid the throttling action thereof.

According to the present invention there is provided a rotary actuator of the kind initially referred to which is characterized in that the or each throttling means is constituted by at least one shoe which is mounted on the other of said main parts of the actuator for movement towards and away from the

surface wherein said aperture is provided, and spring biased to effect abutment between a surface on the shoe and said first mentioned surface, which shoe, by overlapping said aperture, forms a restricted passage for the outflow of the working fluid through the aperture.

During the relative rotation of the main parts of the actuator the shoe rotates correspondingly relative to the aperture through which the working fluid flows, and as long as the shoe is angularly spaced from the aperture, the fluid flow is unimpeded thereby. When the abutment surface on the shoe begins to overlap the aperture through which the outflow of fluid occurs, the fluid has to flow through the restricted passage and the resulting throttling of the flow retards the rotary movement. The throttling causes an increase of the pressure prevailing in the working chamber and, hence, an additional force acting on the shoe to ensure its abutment against the surface surrounding the outflow aperture. As a consequence of this additional force only a weak spring load on the shoe is required and when the direction of rotation is to be reversed by a reversal of the flow so that the working fluid now flows into the working chamber through the aperture partially closed by the shoe, the fluid pressure is readily capable of pressing the shoe backwards so that straight from the outset the inflow takes place through the entire cross-sectional area of the aperture with the consequential fast start and acceleration of the rotary movement.

It will be seen that those functions, viz. retardation of the rotation during its final phase and unimpeded inflow of the working fluid in the initial phase of the rotation, which in the prior art

actuator required both a throttling member and a system of by-pass ducts including a spring loaded non-return valve, are performed by a single throttling member in the actuator according to the present invention. Consequently, there has been achieved a considerable structural simplification of the actuator which in turn manifests itself in a lower production price due to fewer component parts and fewer machining operations, and in a greater reliability in service.

In a preferred embodiment of the invention the restricted flow passage is provided by a groove extending tangentially of the abutment surface on the shoe while the remainder of the abutment surface is shaped complementary to the opposed surface in which the throughflow aperture is provided. By suitably designing the tangentially extending groove it is possible to obtain a desired throttling pattern.

More particularly, the cross-sectional area of the groove may decrease inwardly from the leading edge of the abutment surface on the shoe so that the throttling effect increases gradually when the abutment surface on the shoe moves across the aperture.

There may be provided a plurality of circumferentially spaced shoes associated with the or each throughflow aperture. It is then possible to establish a temporary retardation of the rotary movement at such additional predetermined points between its extremities where this may be desired.

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

Fig. 1 is a combined elevation (upper half) and axial section (lower half) of an actuator embodying the invention,

Fig. 2 is a simplified sectional view, on a

larger scale, of one end of the actuator casing,

Fig. 3 is a section along line III-III of Fig. 2,

Fig. 4 is a section, corresponding to Fig. 2, through a modified embodiment,

Fig. 5 is a section along line V-V of Fig. 4,

Fig. 6 is a plan view of the operative or abutment surface of a shoe, seen in the direction of arrow VI in Fig. 3, and

Fig. 7 is a section along line VII-VII of Fig. 6.

The rotary actuator illustrated in Figs. 1-3 comprises a casing consisting of a centre part 2 and two cylinders 3 with flanges which are clamped to opposite sides of centre part 2 by means of through bolts 4. Each cylinder includes an end part 5 and a spindle 6 is supported for rotation in the end parts 5 and axially fixed relative to the casing. By means of a key 7 in a protruding spindle end the spindle can be connected to one of two component parts (not shown) which are adapted to be rotated relative to one another by means of the actuator. In a manner not shown, casing 1 can be secured to the other of said component parts.

Spindle 6 comprises two cylindrical and smooth sections 8 and an intermediate section 9 with rectilinear splines on its peripheral surface. A threaded sleeve 10 has internal splines engaging with the intermediate spindle section 9 and an external, multi-start coarse thread engaging with a corresponding internal thread on the centre part 2 of casing 1. A working chamber 11 is defined on each side of sleeve 10 between centre part 2 and a cylinder end part 5 and in each working chamber a piston 12, which is inwardly sealed against the smooth spindle section 8

and outwardly sealed against the internal surface of cylinder 3, is freely movable. It is pointed out that pistons 12 may be omitted if the threaded sleeve is designed so as to function as a double-acting piston intermediate the two working chambers.

A bore 13 in each end part 5 is adapted for the connection of an external line (not shown) carrying a hydraulic or pneumatic working fluid to and from the respective working chamber 11. Aligned with the inner mouth of bore 13 an annular holder 14 is connected to spindle 6 by means of a driver pin 15 engaging in a groove in the holder which, thus, rotates together with the spindle. A milled groove in the periphery of holder 14 serves as guide for a radially displaceable shoe 16 which is outwardly biased by means of a compression spring 17 to abut against that surface of end part 5 in which bore 13 opens.

In its outwardly oriented peripheral or abutment surface 18 shoe 16 has a tangentially extending duct or groove 19, the axial position of which is such that it is located opposite bore 13 when spindle 6 and holder 14 assume the angular position relative to the casing shown in Figs. 2 and 3. It is remarked that in Figs. 6 and 7 the width and depth of groove 19 have been shown exaggerated for the sake of clarity. In practice these dimensions may be about 0.5 mm.

When the two main parts 1 and 6 of the actuator are to be rotated relative to one another from the end position shown in Fig. 1 to their opposite end position, a pressurized working fluid is supplied to bore 13 in the cylinder at the right hand end of Fig. 1. In this relative position of parts 1 and 6 the shoe 16 at the right hand end of the actuator obstructs the inner mouth of bore 13 under the influence of the relatively weak spring 17. Consequently, the pressure of the working fluid can readily

press the shoe backwards and thus permit the free inflow of the working fluid. At the same time bore 13 at the left hand end of the actuator communicates with a non-pressurized zone and holder 14 at that end of the actuator assumes an angular position in which its shoe 16 is angularly spaced from the mouth of bore 13 so that the working fluid can flow unhindered out from the left hand chamber 11 when the pressure on the right hand end of the right hand piston 12 presses that piston and, hence, threaded sleeve 10 and the left hand piston 12 towards the left. During this movement the threaded engagement between sleeve 10 and the centre part 2 of casing 1 produces the desired relative rotation of the casing and the spindle.

Shortly before the termination of the movement shoe 16 at the left hand end of spindle 6 begins to obstruct the outflow bore 13 so that the working fluid flows from the left hand chamber 11 through the relatively narrow groove 19 in the abutment surface 18 of the shoe. The throttling of the flow of the working fluid obtained thereby creates the desired retardation of the movement of the pistons and, hence, of the rotation and the pressure rise in chamber 11 resulting from the throttling ensures that shoe 16 is kept abutting against the cylindrical surface of part 5 in which bore 13 opens. As shown in Figs. 6 and 7 the width and depth of groove 19 may decrease from the leading edge 20 - as seen in the direction of rotation - of the shoe.

The embodiment so far described, in which the working fluid is supplied and exhausted through bores in the casing of the actuator, is particularly suited for applications wherein the casing is secured to a stationary component part. Figs. 4 and 5

illustrate a slightly modified variant in which the fluid inflow and outflow occur through the spindle of the actuator. Those parts of the actuator, which are substantially identical in both embodiments, have been given the same reference numerals as in Figs. 1-3. The working fluid is supplied and exhausted through a central bore 21 in spindle 6 and a connected radial bore 22 which opens in the surface of the smooth spindle section 8. An annular holder 23 is connected to end part 5 for rotation therewith by means of a pin 24 secured in the casing and engaging in a groove in the outer periphery of the holder.

Holder 23 has been shown with three angularly spaced guides for radially displaceable shoes 25, 26, and 27 which are spring-loaded inwardly towards spindle 6. In their inwardly oriented cylindrical surfaces the shoes have throttling grooves similar to groove 19 in the first described embodiment. Shoe 25 functions, in the same way as shoe 16, to throttle the outflow of the working fluid and, thus, retard the rotational movement at the termination thereof. The further shoes 26 and 27 produce, in a similar manner, a throttling and retardation of the rotation when the two actuator parts assume corresponding positions intermediate their end positions. The tangential length of each shoe is chosen dependent on the angle of rotation in which the retardation shall be effective.

It will readily be seen that in the embodiment of Figs. 2 and 3 there is a corresponding option of mounting several mutually staggered shoes in holder 14. The invention may also be embodied in actuators in which one or both connecting bores for the working fluid extend through the casing end parts in parallel to the axis. In that

case the throttling shoe or shoes will be mounted for axial displacement and axially spring-biased against that inner surface of the end part in which the bore opens. A similar arrangement can be employed in rotary actuators designed as so-called rotary-piston or vane motors in which case each radially extending edge of the vane carries a throttling shoe which cooperates with an associated aperture in the adjoining end wall of the cylinder in which the vane oscillates.

CLAIMS

1. A rotary actuator comprising two relatively rotatable and axially fixed main parts (1, 6) defining between them at least one working chamber (11) with an aperture (13) provided in a surface of one (1 or 6) of said main parts of the actuator for inflow and outflow of a working fluid to and from said working chamber, and means for throttling the outflow of working fluid when said main parts assume at least one predetermined relative angular position, characterized in that said throttling means is constituted by at least one shoe (16, 25, 26, 27) mounted on the other (6 or 1) of said main parts for movement towards and away from said surface and spring-biased to effect abutment between a surface (18) on the shoe and said first mentioned surface, which shoe, by overlapping said aperture (13), forms a restricted passage for the outflow of the working fluid through the aperture.

2. A rotary actuator as claimed in claim 1, characterized in that said restricted flow passage is provided by a groove (19) extending tangentially of the abutment surface (18) on said shoe while the remainder of the abutment surface is shaped complementary to the opposed surface in which the throughflow aperture (13) is provided.

3. A rotary actuator as claimed in claim 2, characterized in that the cross-sectional area of the groove (19) decreases inwardly from the leading edge (20) of the abutment surface (18) on the shoe.

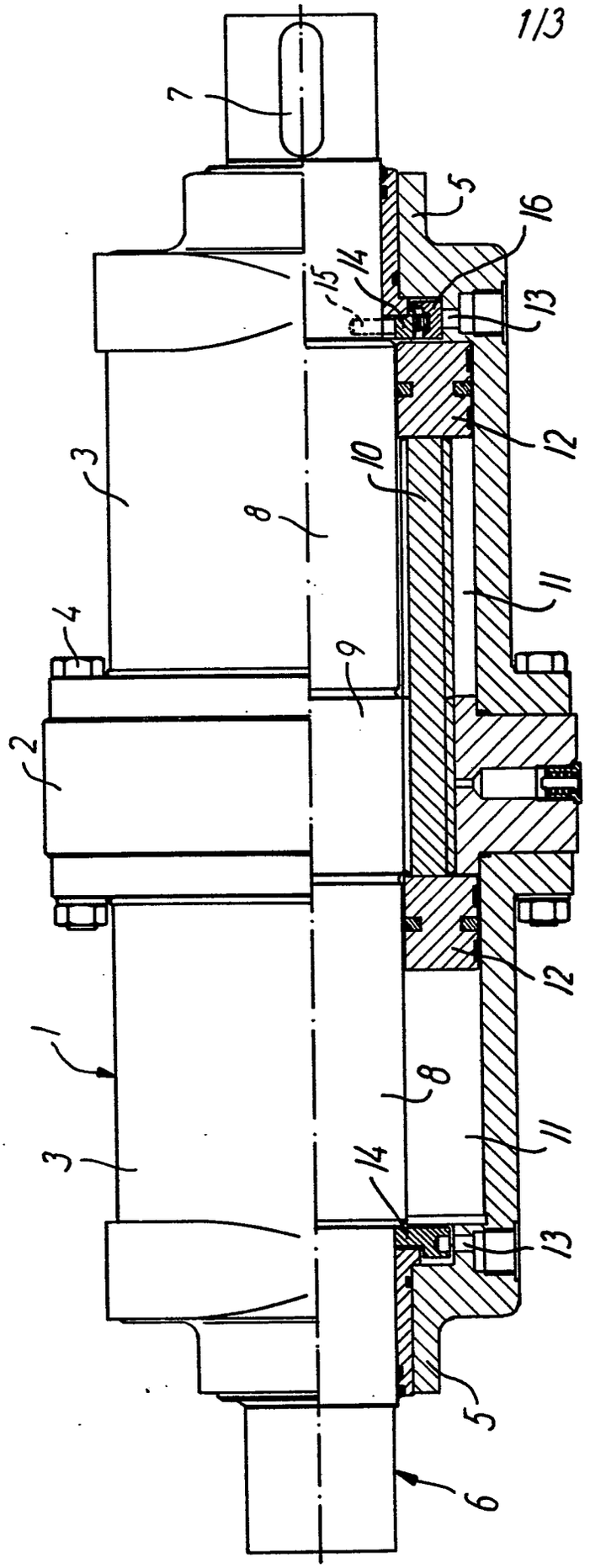

FIG. 1

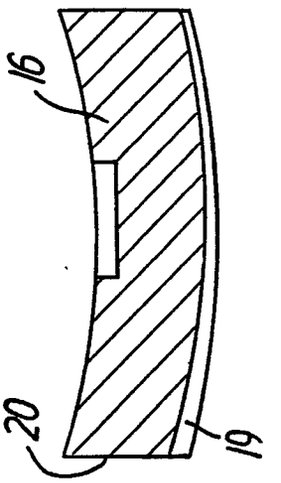

FIG. 7

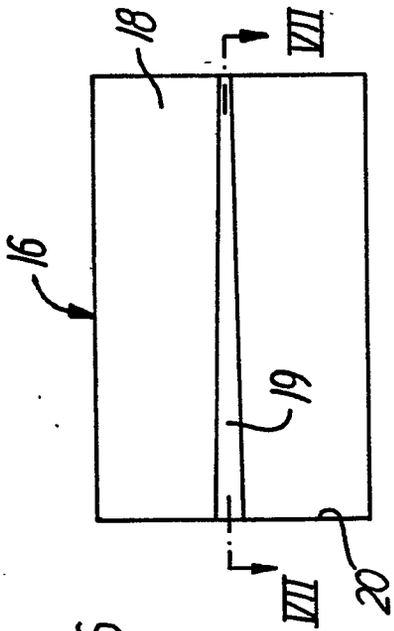

FIG. 6

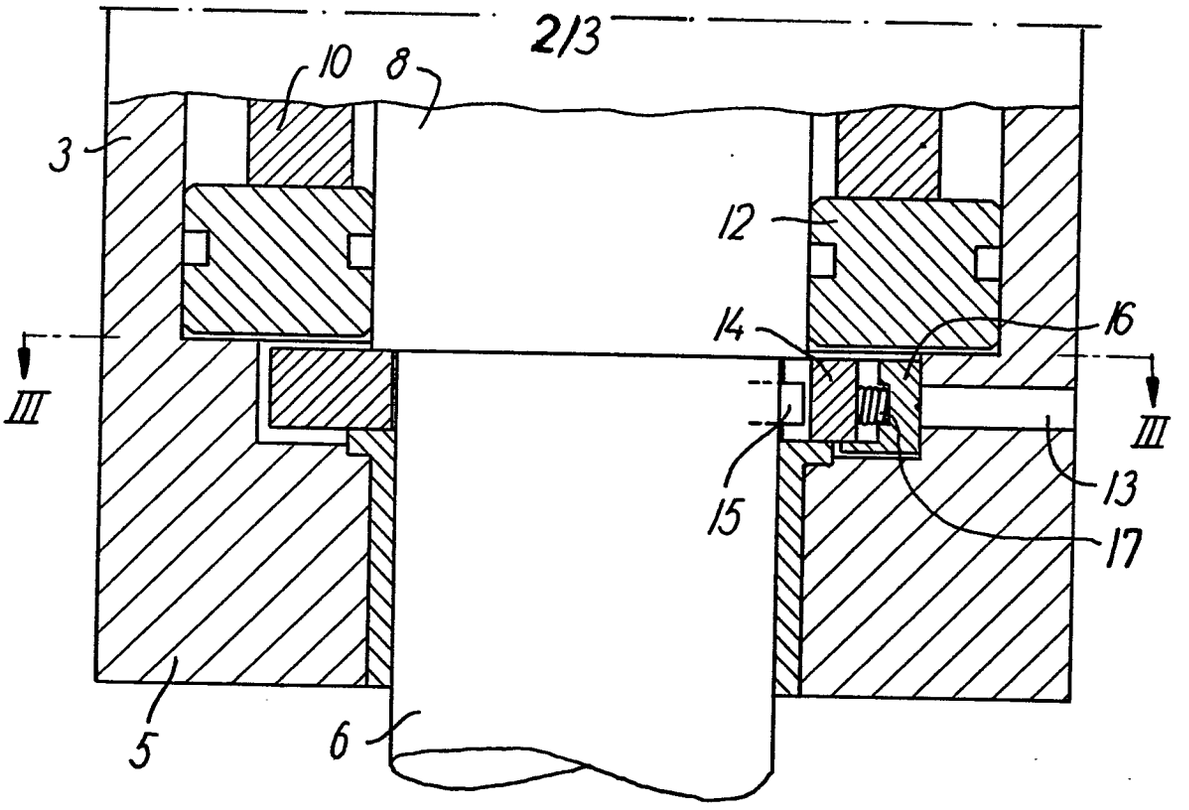

FIG.2

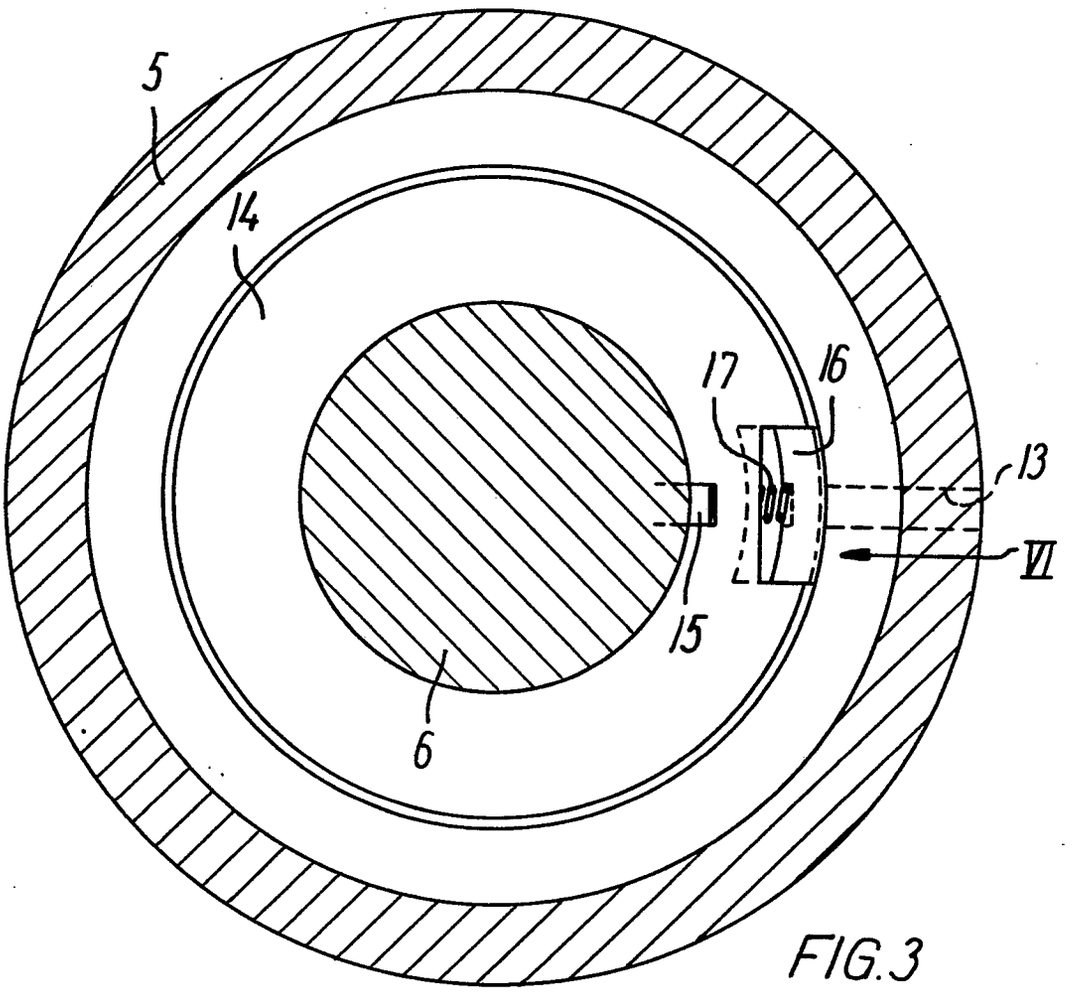

FIG.3

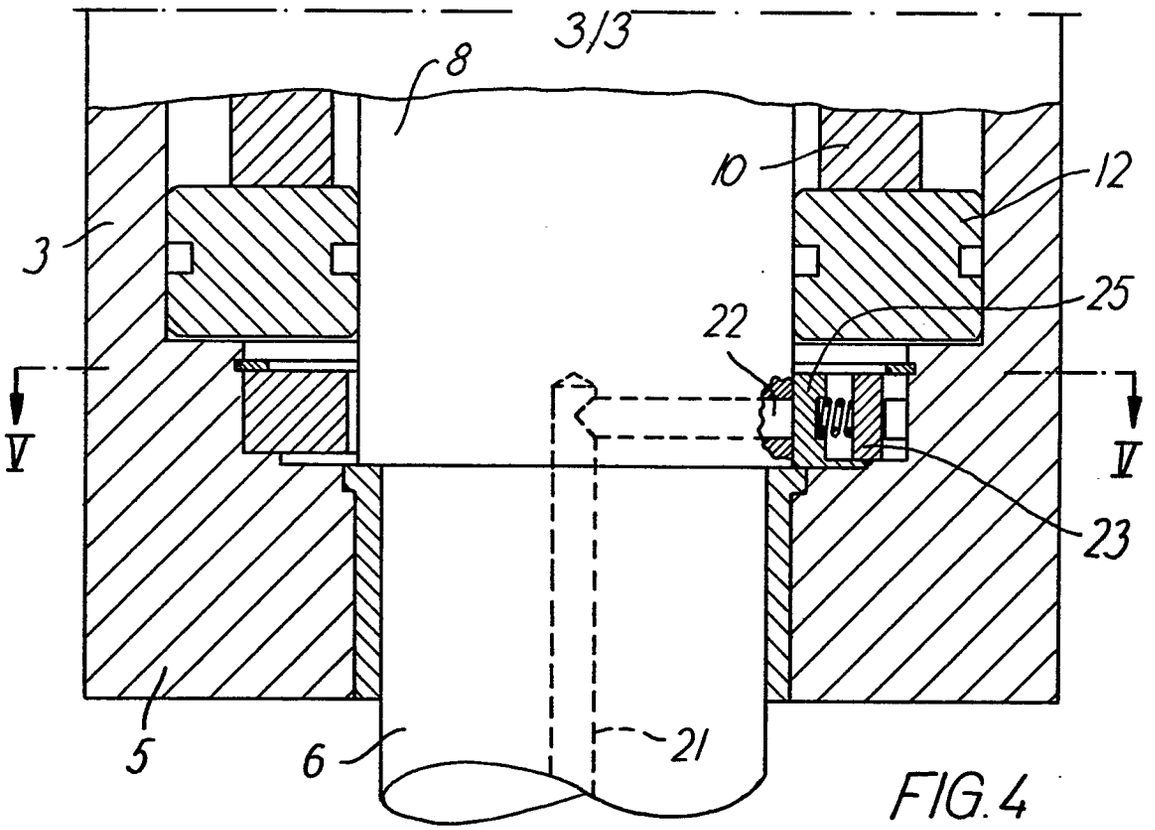

FIG.4

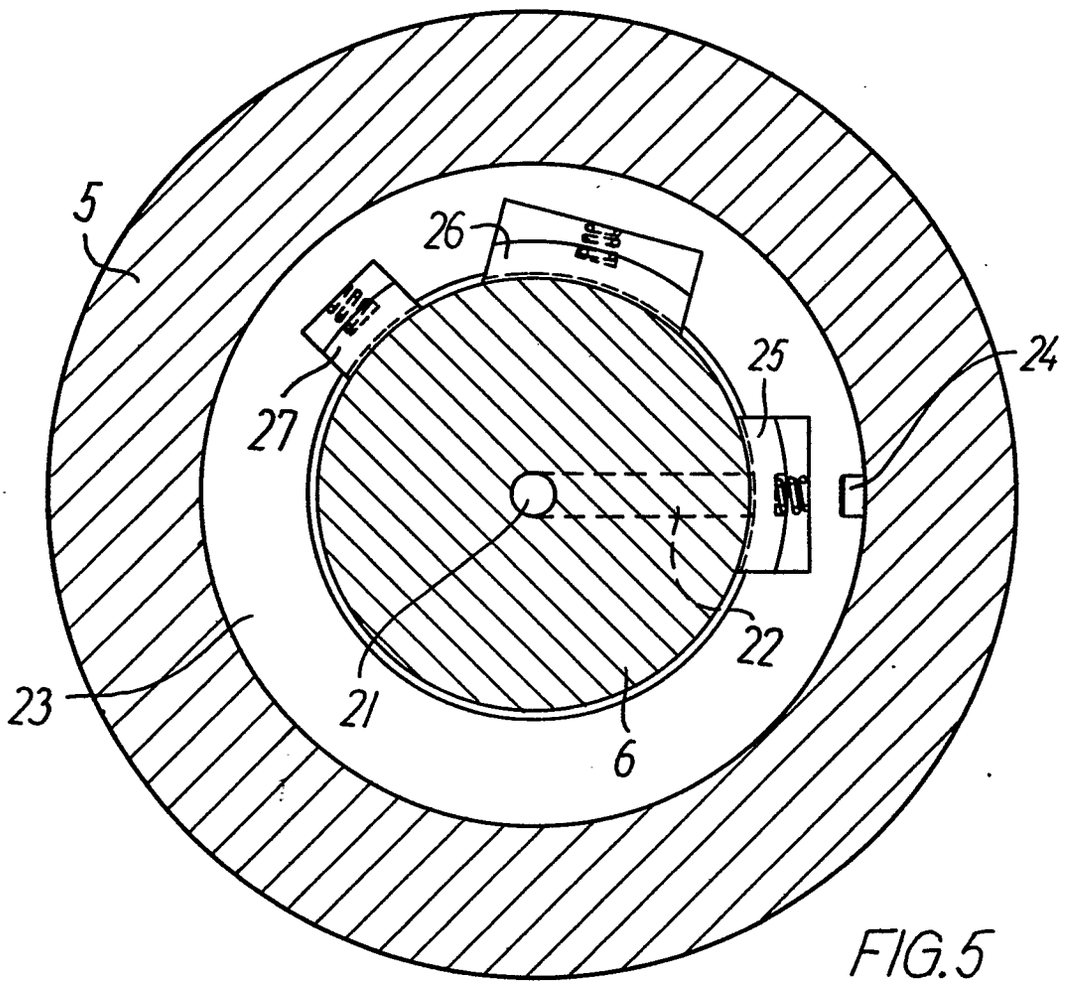

FIG.5

European Patent Office

EUROPEAN SEARCH REPORT

Application number
0034069
EP 81 30 0561

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
	DE - B - 1 300 034 (HOUDAILLE INDUSTRIES INC.) * Column 3, line 15 - column 4, line 32 *	1
	US - A - 3 213 760 (CARR) * Columns 2,3 *	1
	FR - A - 2 428 162 (BELL) * Figures 1-3 *	1-3
	GB - A - 1 074 416 (CESSNA) * Page 2, line 125 - page 3, line 93 *	1-3
DA	DE - A - 2 808 375 (SUDHYDRAULIK)	

CLASSIFICATION OF THE APPLICATION (Int. Cl.³)
F 15 B 15/22
15/08

TECHNICAL FIELDS SEARCHED (Int. Cl.³)
F 15 B

CATEGORY OF CITED DOCUMENTS
X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons
&: member of the same patent family, corresponding document

X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	24-04-1981	THOMANN

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