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(54) **Rotary actuation system for moving a door with orientable wings, in particular in vehicles**

(57) A rotary actuation system (1) for moving a door (2) with orientable wings, in particular for vehicles, said rotary actuation system (1) defining a rotation axis (3)

and comprising a fluid-dynamic linear actuator (8) and a screw transmission (11) in which a stator shaft (4) and a cylindrical outer wall (6) of the screw transmission defines a pressure chamber (9) of the linear actuator (8).

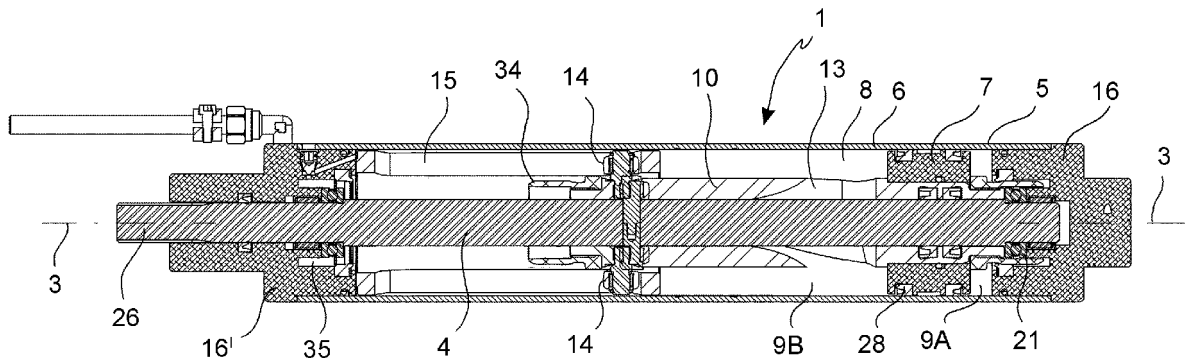


FIG. 6

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Description

[0001] The present invention concerns a rotary actuation system for moving a door with orientable wings, in particular for vehicles, for example buses and trains.

[0002] The orientable wing of the door of a vehicle, for example a bus, is connected through orientable arms or directly to a rotary column and can be moved, through a rotary movement of the rotary column, from an open position to a closed position.

[0003] In a first known configuration, the movement of the rotary column takes place through a rotary actuation system with an outer housing constrained to the structure of the vehicle and an output shaft supported in the outer housing and connected to the rotary column so as to rotate as a unit. The movement of the wing thus takes place in response to a rotation of the output shaft, while the housing is stationary. In this first configuration it is known to use a rotary actuation system with a pneumatic linear actuator and a screw transmission that converts the linear movement of the linear actuator into a rotary movement of the output shaft.

[0004] In a second known configuration, the movement of the rotary column takes place through a rotary actuation system with an outer housing that itself forms the rotary column, as well as with a stationary shaft supported in the outer housing and constrained to the structure of the vehicle. Unlike the first configuration, the movement of the wing takes place in response to a rotation of the outer housing, while the shaft is stationary.

[0005] In this second configuration it is known to use electric rotary actuation systems since known fluid-dynamic actuation systems have diameters that are too large to be able to themselves act as a rotary column.

[0006] However, there is a need to be able to exploit the advantages of fluid-dynamic rotary actuation systems, in particular pneumatic ones, also for applications in which the outer housing of the actuation system acts directly as a rotary column for the wing of the door of a vehicle.

[0007] The purpose of the present invention is therefore to provide a fluid-dynamic rotary actuation system for moving a door with orientable wings, in particular for vehicles, for example buses, having a small outer diameter so that the outer housing can act as a rotary column.

[0008] Yet another purpose of the invention is to provide an energy-efficient rotary actuation system, with simplified and strong structure.

[0009] This and other purposes are achieved through a rotary actuation system for moving a door with orientable wings, in particular for vehicles, said rotary actuation system defining a rotation axis and comprising:

- a stator shaft coaxial with the rotation axis and intended to be constrained so as not to rotate about the rotation axis;
- an outer housing connected to the stator shaft in a rotary manner about the rotation axis, said housing

having a cylindrical outer wall coaxial with the rotation axis;

- a fluid-dynamic linear actuator with an annular piston received in an annular pressure chamber formed between the stator shaft and the outer wall, said piston being in sealed sliding contact with the stator shaft and with the outer wall and able to translate parallel to the rotation axis;
- a screw transmission with a tubular rotor received in the annular pressure chamber and connected with the piston so as to translate together with the piston parallel to the rotation axis, in which the stator shaft, through one or more rolling members, engages a helical rolling track formed in the rotor, so that a translation of the rotor relative to the stator shaft causes a simultaneous rotation of the rotor relative to the stator shaft about the rotation axis, in which the rotor, through one or more rolling members, engages a linear guide of the housing, so that the rotor can translate relative to the housing parallel to the rotation axis and the housing rotates together with the rotor relative to the stator shaft about the rotation axis.

[0010] Thanks to the integration of the stator shaft in the structure of the fluid-dynamic cylinder and to the construction of the helical track in the tubular rotor instead of in the stator shaft it is possible to reduce the diameter of the stator shaft and the outer diameter of the housing that forms the fluid-dynamic cylinder. This makes it possible to reduce the radial bulk relative to the rotary actuation systems of the prior art and allows the use of the outer housing as a rotary column for the wings of doors for means of transport. Moreover, the arrangement of the rotor in the annular pressure chamber of the fluid-dynamic group results in a structural simplification and a saving of material and time for processing and assembling the actuation system.

[0011] In order to better understand the invention and appreciate its advantages, some non-limiting example embodiments will be described hereafter, with reference to the drawings, in which:

[0012] figure 1 is a perspective view of a rotary actuation system forming the rotary column of a door of a means of transport;

[0013] figure 2 is an enlarged view of a rotary actuation system according to an embodiment;

[0014] figure 3 is a view of a rotary actuation system according to an embodiment, in which an outer wall has been removed;

[0015] figure 4 is a view of the rotary actuation system of figure 3, in which a linear guide of the housing has been removed, making an annular rotor visible;

[0016] figure 5 is a partial view of the rotary actuation system of figure 3, in longitudinal section;

[0017] figure 6 is a view of the rotary actuation system in longitudinal section in a first operating configuration

(piston drawn back);

[0018] figure 7 is a view of the rotary actuation system in longitudinal section in a second operating configuration (piston forward);

[0019] figure 8 is a view of the rotary actuation system in cross section highlighting rolling members engaged with a helical rolling track of a rotor, according to an embodiment;

[0020] figure 9 is a view of the rotary actuation system in cross section highlighting rolling members engaged with a linear guide of the outer housing, according to an embodiment.

[0021] With reference to the figures, a rotary actuation system 1 for moving a door 2 with orientable wings, in particular for vehicles, is wholly indicated with reference numeral 1.

[0022] The rotary actuation system 1 defines a rotation axis 3 and comprises a stator shaft 4 coaxial with the rotation axis 3 and intended to be constrained so as not to rotate about the rotation axis 3.

[0023] The actuation system 1 also comprises an outer housing 5 connected to the stator shaft 4 so as to be able to rotate about the rotation axis 3, said housing 5 having a cylindrical outer wall 6 coaxial with the rotation axis 3.

[0024] An annular piston 7 of a fluid-dynamic actuator 8 is received in an annular pressure chamber 9 formed between the stator shaft 4 and the outer wall 6. The piston 7 is in sealed sliding contact with the stator shaft 4 and with the outer wall 6 and is able to translate parallel to the rotation axis 3.

[0025] A tubular rotor 10 of a screw transmission 11 is received in the annular pressure chamber 9 and connected with the piston 7 so as to translate together with the piston 7 parallel to the rotation axis 3.

[0026] The stator shaft 4, through one or more first rolling members 12, engages a helical rolling track 13 formed in the rotor 10, so that a translation of the rotor 10 relative to the stator shaft 4 causes a simultaneous rotation of the rotor 10 relative to the stator shaft 4 about the rotation axis 3. Moreover, the rotor 10, through one or more second rolling members 14, engages a linear guide 15 of the housing 5, so that the rotor 10 can translate relative to the housing 5 parallel to the rotation axis 3 and the housing 5 rotates together with the rotor 10 relative to the stator shaft 4 about the rotation axis 3.

[0027] Thanks to the integration of the stator shaft 4 in the structure of the fluid-dynamic cylinder and to the construction of the helical track 13 in the tubular rotor 10 instead of in the stator shaft 4 it is possible to reduce the diameter of the stator shaft 4 and the outer diameter of the housing 5 that forms the fluid-dynamic cylinder. This makes it possible to reduce the radial bulk compared to rotary actuation systems of the prior art and allows the use of the outer housing as a rotary column for the wings of the doors of means of transport. Moreover, the arrangement of the rotor 10 in the annular pressure chamber 9 of the fluid-dynamic group results in a structural simplification and a saving of material and time for

processing and assembling the actuation system 1.

[0028] In accordance with an embodiment, the fluid-dynamic actuator 8 can be configured as a double-acting actuator in which the pressure chamber 9 is divided by the piston 7 into a first pressure chamber 9A and a second pressure chamber 9B arranged on opposite sides of the piston 7. In this case, the stator shaft 4 can directly define a part of both of the first and second pressure chambers 9A, 9B. Advantageously, the translatable rotor 10, the linear guide 15 and the first and second rolling members 12, 14 are also received inside the annular pressure chamber 9.

[0029] In this way, the area of conversion of the translation motion into rotary motion is completely contained in the pressure chamber 9 of the fluid-dynamic linear actuator 8, thus allowing a single outer housing 5 to be made for the entire rotary actuation system 1, the top wall 16 and side wall (outer wall 6) of which can also directly define the pressure chamber 9.

[0030] This also reduces the axial dimensions of the entire rotary actuation system, simplifies and lightens its structure and makes it easier to process and assemble.

[0031] In accordance with a further embodiment, the first rolling members 12 comprise a pin 17 formed at or connected to the stator shaft 4 and a bush 18 rotatably supported on the pin 17 through the interposition of a series of (cylindrical) rollers and having a cam-follower surface 19 that engages the rolling track 13 formed in the tubular rotor 10 in rolling contact.

[0032] The first rolling members 12 are thus made from rolling bearings using (cylindrical) rollers the inner support of which (pin 17) is connected to the stator shaft 4 and the outer ring of which (bush 18) forms the cam-follower surface 19 in contact with the cam surface of the rolling track 13 of the tubular rotor 10.

[0033] Similarly, the second rolling members 14 comprise a pin 17 formed at or connected to the tubular rotor 10 and a bush 18 rotatably supported on the pin 17 through the interposition of a series of (cylindrical) rollers and having a cam-follower surface 19 that engages the linear guide 15 of the housing 5 in rolling contact.

[0034] Advantageously, the orientation of the pins 17 of the first and second rolling members 12, 14 or, in other words, the local rolling axis of the bush 18 is substantially radial relative to the rotation axis 3 that in turn corresponds to the longitudinal axis of the stator shaft 4.

[0035] There could be two first rolling members 12 diametrically opposite positions relative to the rotation axis 3 or three rolling members with angular pitch of 120°.

[0036] The cam-follower surfaces of the rolling track 13 and/or of the linear guide 15 are advantageously convex or convexly rounded in the direction of the rolling axis to avoid sliding friction due to the rolling differential between the radially outer area of the bush and its radially inner area.

[0037] In accordance with an example embodiment, the outer housing 5 is formed from the cylindrical outer wall 6 and two opposite top walls 16 connected to the

outer wall 6 through a plurality of screws 20.

[0038] The top walls 16 support the stator shaft 4 radially and axially (with reference to the rotation axis 3) through axial ball bearings 21 against which a shoulder 22 of the stator shaft 4 abuts.

[0039] The linear guide 15 comprises a cylindrical tube arranged in the annular space between the outer wall 6 and the rotor 10 and having two linear grooves 25 extending parallel to the rotation axis 3 and forming rolling tracks for the second rolling members 14.

[0040] The cylindrical tube of the linear guide 15 can be constrained to a first top wall 16' so as to rotate as a unit through a geometric connection between one or more axial projections 23 of the first top wall 16' and one or more corresponding axial recesses 24 of the cylindrical tube or vice-versa.

[0041] The linear guide 15 can be constrained to the housing 5 so as to translate as a unit through a press-fit connection with the outer wall 6 or through a connection to the first top wall 16' through screws.

[0042] One of the top walls 16 (preferably the first top wall 16' to which the linear guide 15 is constrained) has a central hole through which an end 26 of the stator shaft 4 extends outside of the housing 5. The end 26 of the stator shaft 4 can be grooved or profiled so as to allow a pivotally integral connection with a user, in particular with a vehicle, for example a bus or a railway carriage.

[0043] The piston 7 can comprise an annular body in a single piece or consisting of many pieces joined together, and that forms:

- a circumferentially outer surface 27, preferably with one or more seats that receive outer annular gaskets 28, for the sliding sealed engagement with a cylindrical inner surface of the outer wall 6, and
- A circumferentially inner surface 29, preferably with one or more seats that receive inner annular gaskets 30, for the sliding and sealed engagement with the outer surface 31 of the stator shaft 4.

[0044] The rotor 10 comprises a tubular portion that forms the helical rolling track 13 and that can be formed in a single piece (or in other words: monolithically) with the piston 7 or connected so as to rotate and translate as a unit with it.

[0045] The return of the piston 7 can be obtained through pneumatic or hydro-dynamic control (pressurisation of the second pressure chamber 9B in the case of a double-acting actuator (shown in figures) or, alternatively, through a return spring acting on the piston (not illustrated).

[0046] In accordance with a further aspect of the invention, the linear actuator 8 comprises a pneumatic damping system that slows down the movement of the piston 7 when it enters into an end stop area.

[0047] In an embodiment, the housing 5, in particular the top wall 16, 16', forms a first duct 31 for feeding and discharging the pressurised fluid in communication with

a first opening in the pressure chamber 9 and a second duct 32 for feeding and discharging in communication with a second opening in the pressure chamber, in which the second duct 32 has a throttled section (through an adjustment screw 33) with respect to the section of the first duct 31. Moreover, the piston 7 forms an annular insulation wall 34 suitable for sealably engaging an annular insulation seat 35 (possibly equipped with a gasket) when the piston 7 enters into the end stop area. The annular insulation seat 34 extends between the first opening and the second opening so that, when the piston 7 enters into the end stop areas, the engagement of the insulation wall 34 with the insulation seat 35 separates a volume of air in the pressure chamber 9 from the first opening and forces it to pass only through the second opening and the second duct 32 with the throttling. In this way, the speed of the piston 7 is damped when approaching its end stop.

[0048] In accordance with an embodiment, the second duct 32 connects to the first duct 31 at a point downstream (discharge direction) of the throttling, so as to allow feeding and pressurisation of the pressure fluid (compressed air) always through the first duct 31 and the first opening, thus avoiding undesired slowing down during the initial steps of the movement of the piston 7 and, therefore, of the actuated door.

[0049] As illustrated in figures 6 and 7, such a concept and the structure of the pneumatic damper described can similarly be implemented in both the pressure chambers 9A, 9B of a double-acting actuator.

[0050] Advantageously, angular and axial position sensors can be mounted at the housing 5 of the rotary actuation system 1 and interact with the end 26 of the stator shaft 4 that extends out from the housing 5. Such sensors can for example comprise potentiometric, mechanical, optical and/or inductive sensors.

[0051] The rotary actuation system of the present invention has numerous advantages, and in particular it has small radial dimensions, a strong but simplified structure, as well as high energy efficiency in the transformation of the translation motion produced by the linear actuator into a rotary motion of the housing.

[0052] Of course, the man skilled in the art can bring further modifications and variants to the rotary actuation system according to the present invention, in order to satisfy contingent and specific requirements, all of which are in any case covered by the scope of protection of the invention, as defined by the following claims.

Claims

1. Rotary actuation system (1) for moving a door (2) with orientable wings, in particular for vehicles, said rotary actuation system (1) defining a rotation axis (3) and comprising:

- a stator shaft (4) coaxial with the rotation axis

- (3) and intended to be constrained so as not to rotate about the rotation axis (3),
 - an outer housing (5) connected to the stator shaft (4) so as to be able to rotate about the rotation axis (3), said housing (5) having a cylindrical outer wall (6) coaxial with the rotation axis (3),
 - an annular piston (7) of a fluid-dynamic actuator (8) received in an annular pressure chamber (9) formed between the stator shaft (4) and the outer wall (6), said piston (7) being in sealed sliding contact with the stator shaft (4) and with the outer wall (6) and able to translate parallel to the rotation axis (3),
 - a tubular rotor (10) of a screw transmission (11) received in the annular pressure chamber (9) and connected with the piston (7) so as to translate together with the piston (7) parallel to the rotation axis (3), wherein the stator shaft (4), through one or more first rolling members (12), engages a helical rolling track (13) formed on the rotor (10), so that a translation of the rotor (10) relative to the stator shaft (4) causes a simultaneous rotation of the rotor (10) relative to the stator shaft (4) about the rotation axis (3), wherein the rotor (10), through one or more second rolling members (14), engages a linear guide (15) of the housing (5), so that the rotor (10) can translate relative to the housing (5) parallel to the rotation axis (3) and the housing (5) rotates together with the rotor (10) relative to the stator shaft (4) about the rotation axis (3).
2. Rotary actuation system (1) according to claim 1, wherein the fluid-dynamic actuator (8) is a double-acting actuator and the pressure chamber (9) is divided by the piston (7) into a first pressure chamber (9A) and a second pressure chamber (9B) arranged on opposite sides of the piston (7).
 3. Rotary actuation system (1) according to claim 2, wherein the stator shaft (4) directly defines a part of both the first and second pressure chambers (9A, 9B).
 4. Rotary actuation system (1) according to claim 3, wherein the rotor (10), the linear guide (15) and the first and second rolling members (12, 14) are received inside the annular pressure chamber (9).
 5. Rotary actuation system (1) according to any one of the previous claims, wherein the first rolling members (12) comprise a pin (17) connected to the stator shaft (4) and a bush (18) rotatably supported on the pin (17) through the interposition of a series of rollers and having a cam-follower surface (19) that engages the rolling track (13) of the rotor (10) in rolling contact.
 6. Rotary actuation system (1) according to any one of the previous claims, wherein the second rolling members (14) comprise a pin (17) formed at or connected to the tubular rotor (10) and a bush (18) rotatably supported on the pin (17) through the interposition of a series of rollers and having a cam-follower surface (19) that engages the linear guide (15) of the housing (5) in rolling contact.
 7. Rotary actuation system (1) according to claims 5 and 6, wherein the orientations of the pins (17) of the first and second rolling members (12, 14) and a local rolling axis of the bush (18) are substantially radial relative to the rotation axis (3).
 8. Rotary actuation system (1) according to any one of the previous claims, wherein there are two first rolling members (12) and they are arranged in diametrically opposite positions relative to the rotation axis (3).
 9. Rotary actuation system (1) according to any one of the previous claims, wherein there are two second rolling members (14) and they are arranged in diametrically opposite positions relative to the rotation axis (3).
 10. Rotary actuation system (1) according to any one of the previous claims, wherein cam-follower surfaces of the rolling track (13) and/or of the linear guide (15) are convex or rounded in the direction of a local rolling axis of the rolling members (12, 14).
 11. Rotary actuation system (1) according to any one of the previous claims, wherein the outer housing (5) is formed by the cylindrical outer wall (6) and two opposite top walls (16) connected to the outer wall (6) through a plurality of screws (20), wherein said top walls (16) support the stator shaft (4) radially and axially through axial ball bearings (21) against which shoulders (22) of the stator shaft (4) abut and wherein one of the top walls (16) has a central hole through which an end (26) of the stator shaft (4) extends outside of the housing (5).
 12. Rotary actuation system (1) according to any one of the previous claims, wherein the linear guide (15) comprises a cylindrical tube arranged in the annular space between the outer wall (6) and the rotor (10), said cylindrical tube having two linear grooves (25) extending parallel to the rotation axis (3) and forming rolling tracks for the second rolling members (14), said cylindrical tube being constrained to a first top wall (16') of the housing (5) so as to rotate as a unit through a geometric connection between one or more axial projections (23) of the first top wall (16') and one or more corresponding axial recesses (24) of the cylindrical tube or vice-versa.

13. Rotary actuation system (1) according to any one of the previous claims, wherein the linear actuator (8) comprises a pneumatic damping system that slows down the movement of the piston (7) when it enters into an end stop area. 5
14. Rotary actuation system (1) according to claim 13, wherein the housing (5) forms:
- a first duct (31) for feeding and discharging the pressurised fluid in communication with a first opening in the pressure chamber (9), and 10
 - a second duct (32) for feeding and discharging in communication with a second opening in the pressure chamber (9), wherein the second duct (32) has a throttled section relative to the first duct (31), 15
 - and wherein the piston (7) forms an insulation wall (34) that, when the piston (7) goes into the end stop area, sealably engages an insulation seat (35) that extends between the first opening and the second opening so as to separate a volume of air in the pressure chamber (6) from the first opening and force it to vent only through the second opening and the second duct (32). 20 25
15. Rotary actuation system (1) according to claim 14, wherein the second duct (32) connects to the first duct (31) at a point downstream of the throttling seen in the discharge direction. 30

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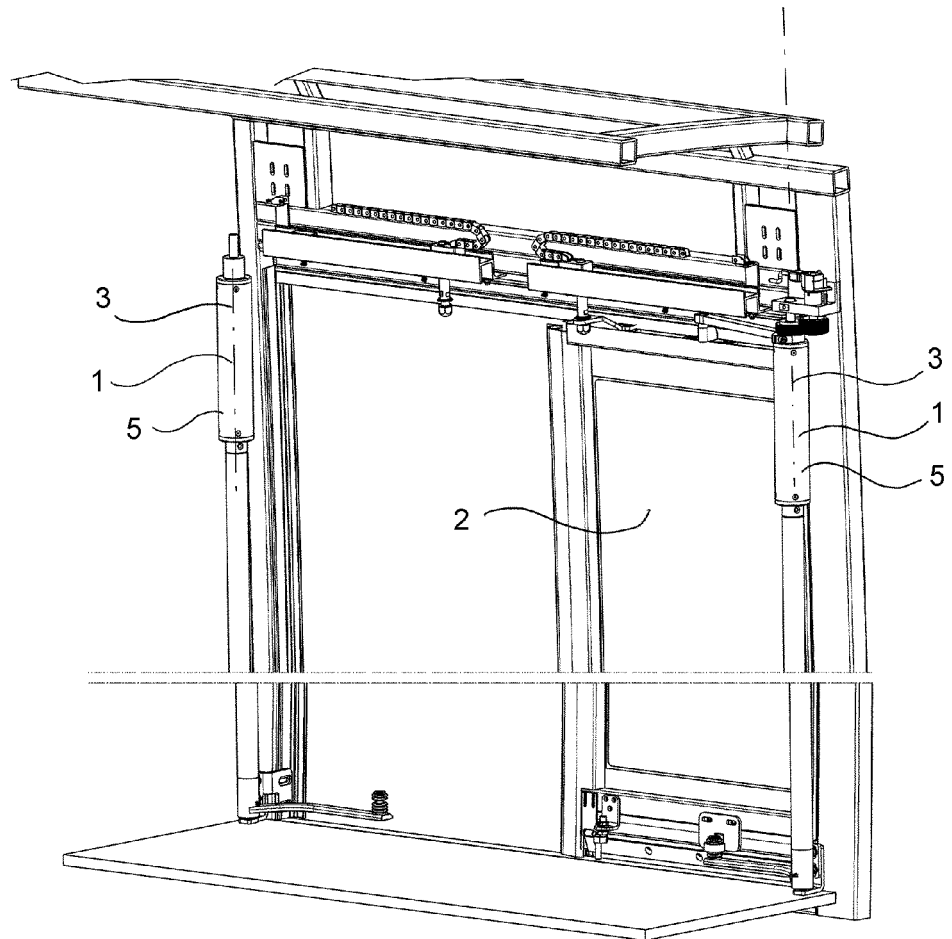
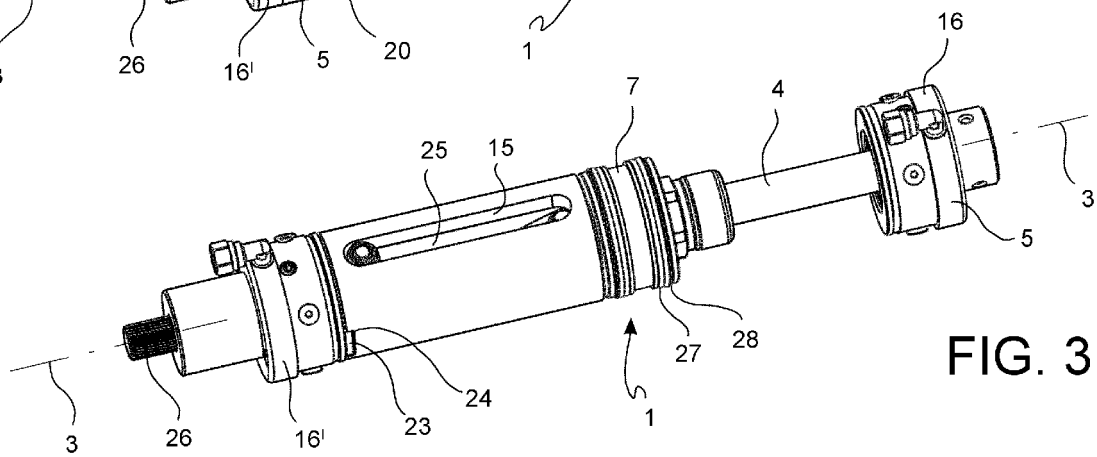
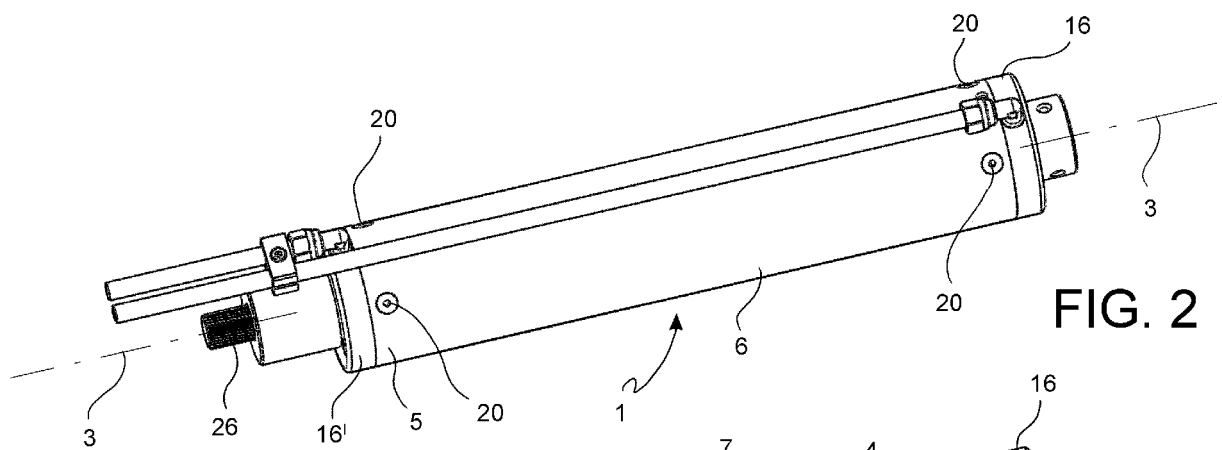


FIG. 1



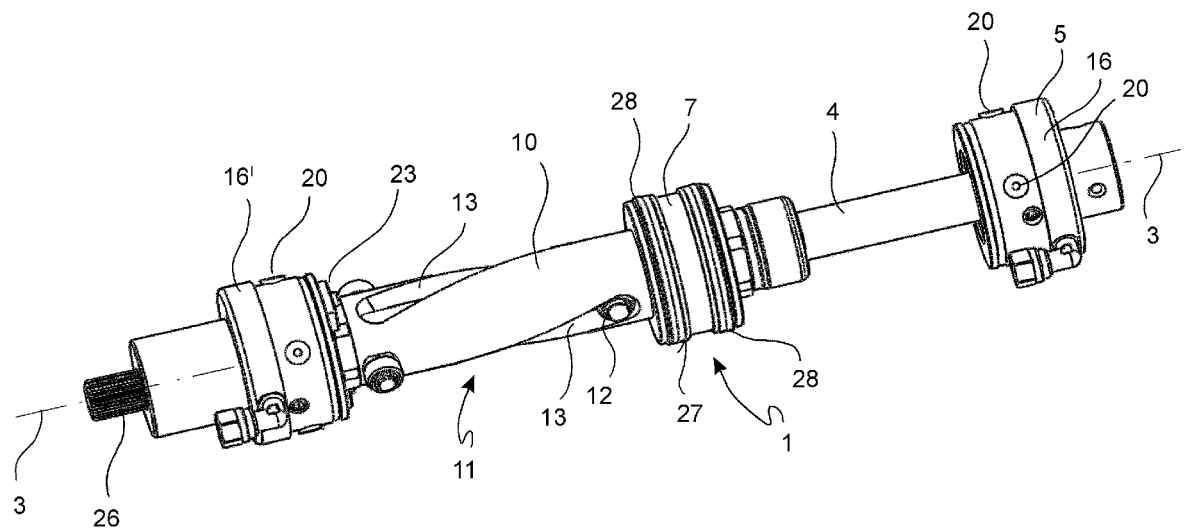


FIG. 4

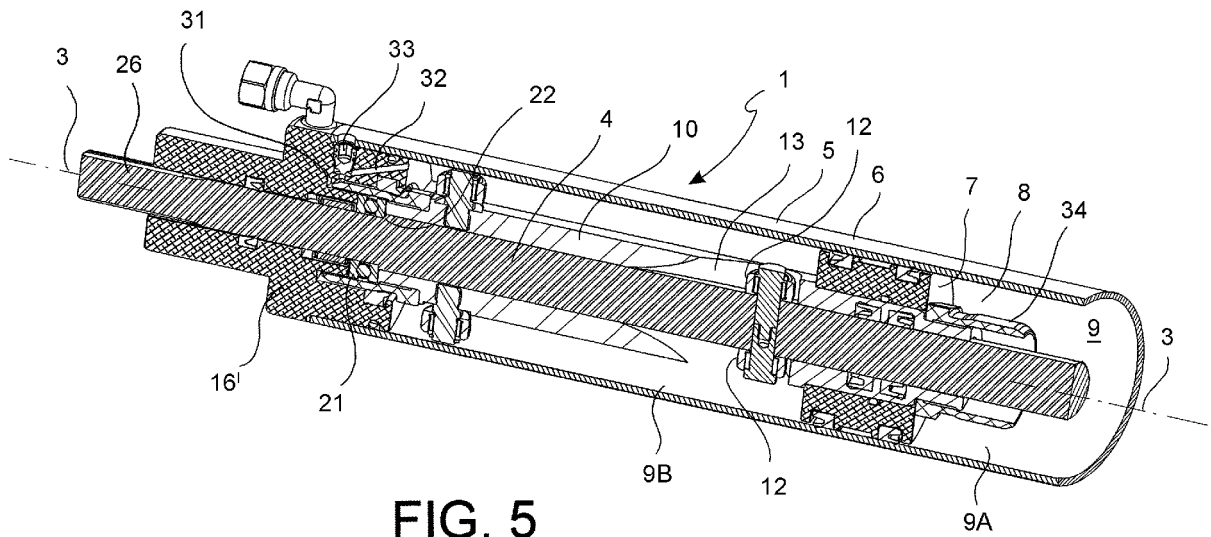


FIG. 5

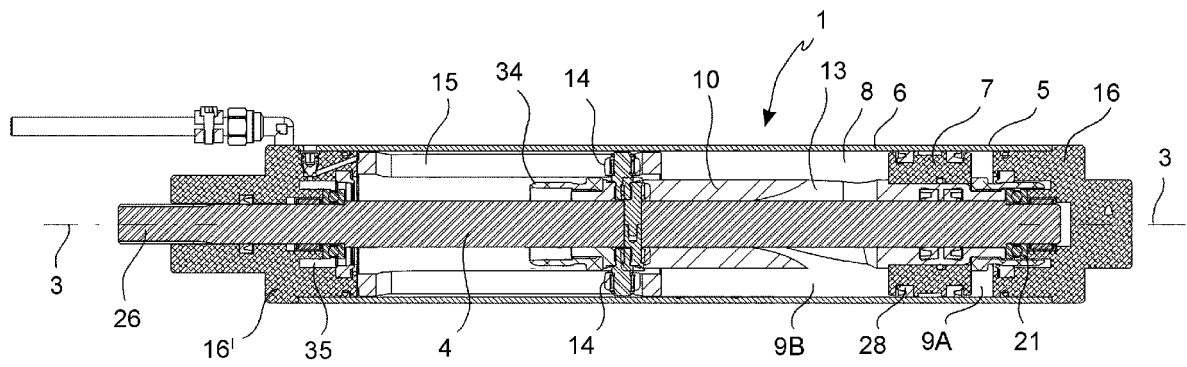


FIG. 6

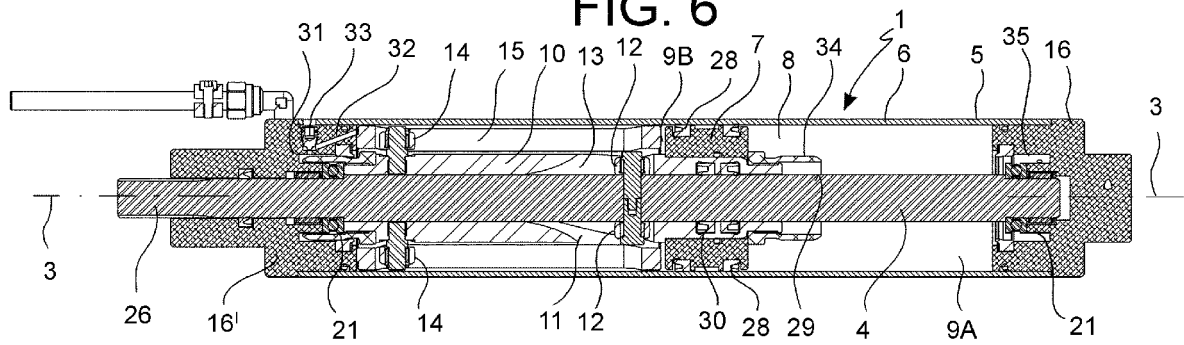


FIG. 7

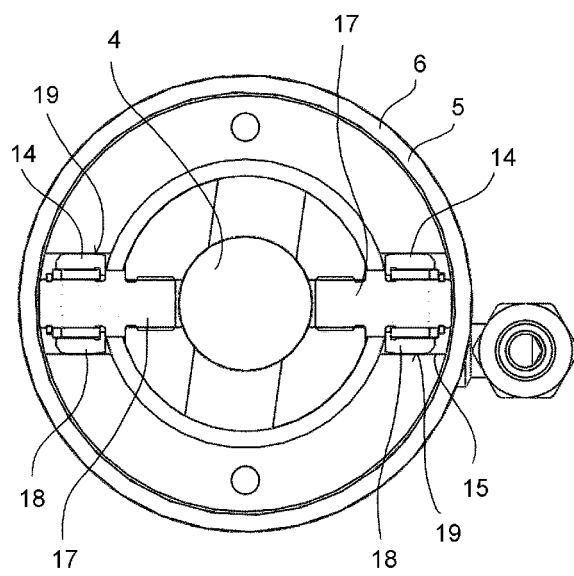


FIG. 9

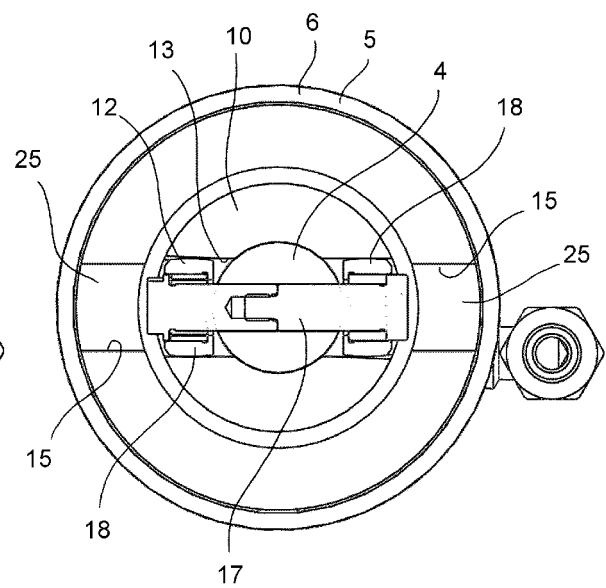


FIG. 8



EUROPEAN SEARCH REPORT

Application Number
EP 11 18 2770

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 15 February 2012	Examiner Witasse-Moreau, C
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 11 18 2770

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