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(54) **Contactless position sensor with displacement transmission structure and displacement transmission structur therefor**

(57) The present invention relates to a position sensor (4) for detecting the position of an actuator piston adjusting, for example, a variable geometric turbo charger or an exhaust gas recirculation valve, comprising a displacement transmission structure, as well as a kit (1,4) for an actuator (1) comprising said position sensor (4), and a method for determining the position of an actuator piston. In order to facilitate the detection of the position of the actuator piston of an pneumatic actuator (1), even if the piston is tilted with respect to the actuator box, the displacement transmission structure comprises a slider (39), to be lineally displaced in the position sensor (4), with at least one marker (40'), of which the translational position can be detected by the sensor (4), a transmission element (38) for interconnecting the actuator piston and the slider (39), a first connection means (41) adapted to connect the slider (39) and the transmission element (38) translationally rigid and pivotable on at least two rotation axes that are perpendicular to each other and a second connection means (42) adapted to connect the transmission element (38) and the actuator piston translationally rigid and pivotable on at least two rotation axes that are perpendicular to each other, and the sensor (4) further comprises a sensor body with a reception (44') adapted for guiding the slider (39), and at least one sensor element (68) adapted to generate an output signal indicating the position of the marker (40') in the reception (44').

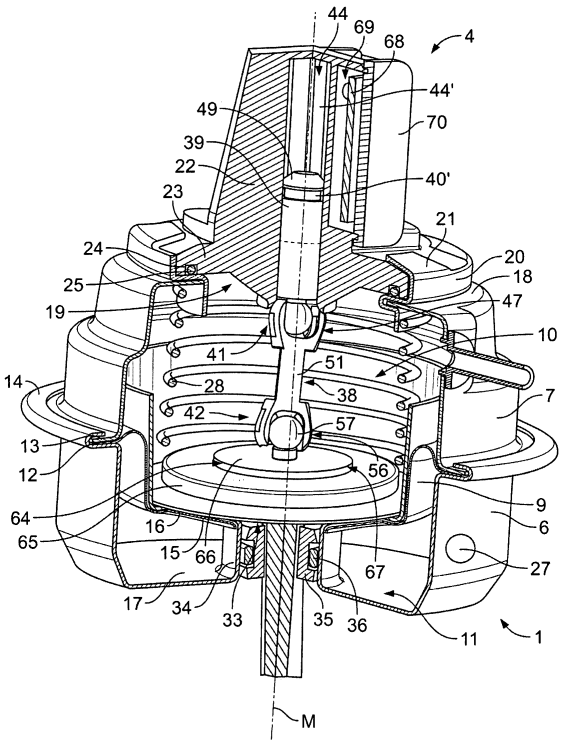


Fig. 2

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Description

[0001] The present invention relates to a position sensor for detecting the position of an actuator piston adjusting, for example, a variable geometric turbo charger or an exhaust gas recirculation valve, comprising a displacement transmission structure. The invention further relates to a kit for an actuator comprising said position sensor, and a method for determining the position of an actuator piston.

[0002] Pneumatic servos, also referred to as pneumatic actuators, are used, for example, in exhaust gas flow-driven pressure-charging devices for combustion engines (turbo chargers). Pneumatic actuators can be used to rotate the vane of a variable geometric turbo charger or an exhaust gas recirculation valve. For monitoring the adjustment angle of the vane, which corresponds to a displacement position of the driving actuator piston, the pneumatic servo can be provided with a position sensor determining the position of the piston.

[0003] According to the prior art, a conventional pneumatic servo is usually conceived as a cylinder operating in a simple manner wherein a piston rod of a transmission member is connected to a diaphragm affixed to the cylinder instead of to a piston.

[0004] EP 1 852 588 discloses a pressure regulator having a box covered by a lid with a first flexible membrane spanned by its outer edge between outer edge of the box and the lid. The flexible membrane, its support part and the connection for the underpressure source are assembled and arranged so that the control rod moves out of the regulator on connecting to the underpressure source. The pressure regulator can be provided with a position sensor detecting the position of a magnet arranged on and displaceable with the control rod.

[0005] The problem with the actuator arm of a pneumatic actuator driving a variable geometric turbo charger or an exhaust gas recirculation valve is that said actuator arm is not displaced lineally. For rotating the vane, the driving element, for example, the turbo charger arm, must be displaced in a rotational movement so that the actuator piston likewise performs a circular, rotational movement at its connection with the driving element. This rotational movement results in a tilting or tumbling displacement of the actuator piston with respect to the actuator box. This roto-translational movement, wherein the actuator piston is not only lineally displaced, but also tilts and is shifted laterally with respect to its longitudinal axis, makes it difficult to exactly monitor the position of the actuator piston. Since the sensor is usually mounted to the actuator box, whereas the marker indicating the position is arranged on the piston, accuracy of the measurement is problematic.

[0006] According to the prior art, the target for the sensor may be guided within the sensor itself, whereby the target is pushed onto the piston by means of a return spring. However, such return spring exerts a force influencing the movement of the actuator piston and a spring-mass-system is sensitive to the vibrations that commonly occur in vehicles having a combustion engine. If the target is mounted to the piston, however, the target also performs the tumbling movement of the actuator piston leading to an inaccuracy of the sensor measurement.

[0007] The object of the present invention is therefore to facilitate the detection of the position of the actuator piston of an pneumatic actuator, even in cases where the actuator piston is roto-translationally displaced, i.e. tilts with respect to the actuator box.

[0008] This problem is achieved in accordance with the invention, for the displacement transmission structure mentioned at the outset, by comprising a slider, to be lineally displaced in the position sensor, with at least one marker, of which the translational position can be detected by the sensor, a transmission element for interconnecting the actuator piston and the slider, a first connection means adapted to connect the slider and the transmission element translationally rigid and pivotable on at least two rotation axes that are perpendicular to each other and a second connection means adapted to connect the transmission element and the actuator piston translationally rigid and pivotable on at least two rotation axes that are perpendicular to each other.

[0009] For the position sensor mentioned at the outset, this object is achieved in accordance with the invention, in that the position sensor the above-described displacement transmission structure as well as a sensor body with a reception adapted for guiding the slider and at least one sensor element adapted to generate an output signal indicating the position of the marker in the reception.

[0010] The kit for an actuator achieves this object in accordance with the invention by comprising an actuator having a displaceable actuator piston and the above position sensor, wherein, in the assembled state, the slider is placed in the reception of the sensor body, the first connection means connects the slider and the transmission element translationally rigid and pivotable on at least two rotation axes that are perpendicular to each other, and the second connection means connects the transmission element and the actuator piston translationally rigid and pivotable on at least two rotation axes that are perpendicular to each other.

[0011] Finally, this object is achieved in accordance with the invention, for the method mentioned at the outset, in that the displacement of the actuator piston is transmitted via a transmission element, which is connected to the actuator piston translationally rigid and pivotable on at least two rotation axes that are perpendicular to each other, to a substantially lineal displacement of a slider, which is connected to the transmission element translationally rigid and pivotable on at least two rotation axes that are perpendicular to each other.

[0012] The advantage of this simple solution is that each actuation position of the actuator piston corresponds to a distinct position of the substantially lineally displaceable slider. By interconnecting the transmission element between the actuator piston and the slider as a

kinematic pair having two connections that are translationally rigid, it is assured that the translational movement of the actuator piston is directly transferred to the slider. Moreover, each of the connections between the actuator piston and the transmission element as well as the transmission element and the slider is pivotable on at least two rotational axes that are perpendicular to each other, which allows for a compensation of the tumbling and tilting motion of the actuator piston without the need for spring elements. The displacement transmission structure according to the present invention compensates the tumbling and tilting motions of the actuator piston mechanically, rather than using vibration transmission, and thus permits application even in a diverse ambient and operation conditions such as vibrations, high pressures and temperatures. Therefore, the displacement transmission structure and the position sender of the present invention provides a robust and precise determination of the actuator piston's position.

[0013] The solution according to the invention may be combined in any way with the following further advantageous embodiments respectively and further improved.

[0014] According to a first advantageous embodiment, the first connection means and/or the second connection means may be a swivel joint. Such a swivel joint, for example a universal joint or a ball and socket joint, provides a detachable connection that is translationally rigid and pivotable on at least two rotation axes that are perpendicular to each other. Translationally rigid means in this context that the two elements connected by the connecting means have no translational freedom so that each translational movement of one of the connected parts is directly transferred to the other connection partner. There is at least one translational direction, in which there is no relative movement of the two elements coupled by the connection means. Further, such swivel joints are of simple construction and provide pivotable connection in an easy way.

[0015] In another embodiment, the first and/or the second connection means may be a flexible element. For example, the transmission element and the slider can be connected with each other translationally rigid and pivotable on at least two rotation axes that are perpendicular to each other by means of a bendable joining element, such as a connecting web. In a preferred embodiment thereof, the transmission element, the first connection means and the slider can be formed as a single piece. The flexibility of the first connection means can be achieved by the shape or the material of the area that constitutes the first connection means within the single piece. For example, the piece may be formed with an bending area having, e.g., a thinner diameter allowing for bending. Likewise, the material of the single piece may be flexible in general and the area building the slider and the transmission element may be provided with stiffeners or a stiffening profile preventing bending of the material in this regions.

[0016] According to further possible advantageous embodiment, the second connection means may comprise a coupling means adapted to be attached to the actuator piston. A coupling means can, for example, be designed as an attachment disc that is pressed onto the piston by the actuator spring. The coupling means may be provided with the ball swivel or the socket element of a swivel joint. This embodiment has the advantage that no modification of the actuator piston is necessary for providing the connection of the actuator piston with the transmission element via the second connection means. Rather, standard actuators can be used to whose pistons the coupling means of the second connection means is attached building the mechanical anchor for the displacement transmission structure.

[0017] The mounting and the handling of the displacement transmission structure or the position sensor of the present invention can be advantageously improved if the first connection means and/or the second connection means is provided with a tilt stopper limiting the tilting of the pivotable connection to a maximum tilting angle. The tilt stopper ensures that the displacement transmission structure, if connected to the actuator piston via the second connection means, is held in a more or less upright position because the maximum lateral tilting angle of the first and/or the second connection means is limited. This facilitates insertion of the slider into the reception of the sensor when mounting the sensor to the actuator box. The tilt stopper may advantageously be a protrusion received in a recess. Using a protrusion received in a recess is constructionally simple and easy to manufacture. No moving parts are necessary and by varying the geometry of the protrusion and/or the recess, the maximum tilting angle of the pivotable connection can be easily set. In an advantageous embodiment, the protrusion may be formed frustoconical with the inclination angle of the cylindrical jacket determining the tilting angle. The corresponding recess may be formed funnel-shaped having correspondingly inclined side walls.

[0018] If the first connection means and/or the second connection means is a swivel joint, each of the protrusion or the recess may be arbitrarily arranged at the swivel or at the socket element.

[0019] According to a further advantageous embodiment, a sensor body comprises an insertion opening for inserting the slider into the reception, which opening is surrounded by a ramp structure forming an angular guideway towards the insertion opening. This embodiment facilitates insertion of the slider into the reception of the sensor body when mounting the position sensor, for example, to an actuator box. As long as the distal tip of the slider at its insertion end is brought into contact with the ramp structure during the assembly, the tip of the slider is led down the angular guideway towards the insertion opening. In a preferred embodiment, the ramp structure may be formed by a plurality of guiding elements, wherein the maximum distance between adjacent guiding elements is smaller than the outer scale of the slider. This embodiment is material-saving and minimiz-

es the weight of the sensor body, while at the same time ensuring safe guidance of the slider along the guiding elements towards the insertion opening.

[0020] Most preferably, the guiding elements may be formed as a plurality of guiding rips having inclined lead faces arranged star-like around the insertion opening.

[0021] Mounting of the sensor body to the actuator box, which is usually done by the customer, can be facilitated and performed in a blind assembly if, according to a further preferred embodiment, each of the first and the second connection means is provided with a tilt stopper, and wherein the sum of the maximum tilting angle of the first and the second connection means is smaller than the inclination angle of the angular guideway with respect to the insertion opening. Usually, the reception in the sensor body as well as the second connection means are arranged at the centre axis of the position sensor and the actuator box. When the maximum tilting angle of the slider with respect to the centre axis, which corresponds to the sum of the maximum tilting angles of the first and second connection means, is smaller than the inclination angle of the angular guideway, the tip of the slider that is to be inserted into the guide opening will always hit on the guide ramp under a contact angle at which the slider is led towards the insertion opening.

[0022] According to a further possible advantageous embodiment, the lateral distance from the centre of the insertion opening to the lateral edge of the ramp structure is larger than the maximum lateral deflection of the slider, preferably the center of the distal tip of the slider, from the center of the second connection means. Thereby, it is ensured that the tip of the slider will always hit the ramp structure when mounting the sensor body to the actuator box because the ramp structure is wider than the slider can possibly be deflected.

[0023] As long as the sum of the maximum tilting angle of the first and second connection means is smaller than the inclination angle of the angular guideway, and if the lateral distance from the centre of the insertion opening to the lateral edge of the ramp structure is larger than the maximum deflection of the slider from the centre of the second means, blind assembly of the sensor to the actuator is possible. In this case, it is ensured that the slider will always hit on the ramp structure due to the defined width of the ramp structure. Furthermore, the defined geometry of the inclination angle of the angular guideway with regard to the maximum lateral titling angle of the first and second connection means further makes sure that the tip of the slider will always be directed towards the centre of the ramp structure, where the insertion opening is located, rather than to the outside.

[0024] The invention will be described hereafter in greater detail and in an exemplary manner using advantageous embodiments and with reference to the drawings. The described embodiments are only possible configurations in which, however, the individual features as described above, can be provided independently of one another or can be omitted. In the drawings:

Fig. 1 is a schematic side view of a pneumatic actuator having a piston rod adjusting the driving element of a variable geometric turbo charger or an exhaust gas recirculation valve according to an embodiment of the present invention;

Fig. 2 is a schematic cross-sectional view of the sensor and the actuator shown in Fig. 1;

Fig. 3 is a movement design sketch showing the movements of the kinematic chain from the driving element via the piston rod over the actuator piston up to the elements of the displacement transmission structure;

Fig. 4 shows a schematic view of the slider and the transmission element of the displacement transmission structure according to an embodiment of the present invention;

Fig. 5 is a cross-sectional view along the centre axis of the kit comprising the sensor and the actuator shown in Fig. 1, in a pre-assembled state where the sensor is separate from the actuator; and

Fig. 6 is a schematic view of the sensor body shown in the previous figures.

[0025] Fig. 1 is a schematic side view of a pneumatic actuator 1 having a displaceable piston rod 2 that is adapted to act on a driving element 3, e.g., a variable geometric turbo charger or an exhaust gas recirculation valve (not shown). A position sensor 4 capable of determining the position of the actuator piston 5, that actuates the piston rod 2, is mounted to the pneumatic activators 1.

[0026] The pneumatic actuator 1 comprises a cylindrical body 6 and a cylindrical cover 7 which are assembled forming a cylindrical actuator box 8. Inside the actuator box 8, a diaphragm 9 is arranged between the cylindrical body 6 and the cylindrical cover 7, said diaphragm 9 dividing the actuator box into two pressure chambers 10, 11 that are substantially symmetrical about the centre axis M of the pneumatic actuator 1.

[0027] The outer edge 12 of the diaphragm 9 rests against an outer collar 13 of the cylindrical cover 7. The edge of the cylindrical body 6 is a crimp 14, which encompasses the collar 13 at the cylindrical cover 7 and the outer edge of the diaphragm 9, thereby connecting and sealing the cylindrical body 6 and the cylindrical cover 7.

[0028] The diaphragm 9 is formed as a pot diaphragm. The flat base 15 of the diaphragm 9 is reinforced on the side facing the cylindrical cover 7 with the bottom of the base plate 16 of the actuator piston 5. The actuator piston 5 has the shape of a cup and is arranged such the base plate 16 is parallel to the base 17 of the cylindrical body 6 and the base 18 of the cylindrical cover 7, whereby the bottom of cup-shaped actuator piston 5 is directed to-

wards the cylindrical body 6 and the opening faces the cylindrical cover 7.

[0029] The base 18 of the cylindrical cover 7 has an opening 19 for mounting position sensor 4 to the actuator 1. An attachment ring 20 is connected on the outside of the base 18 forming a circular border around the opening 19. The attachment ring 20 is provided with a plurality of lugs 21 forming a rabbet for mounting the sensor body 22 of the position sensor 4 to the actuator 1. For mounting, the sensor body 22 has an attachment collar 23 that laterally protrudes from the sensor body 22. In the assembled state, the attachment collar 23 rest on the attachment ring 20 and the lugs 21 encompass the attachment collar 23 crimping the sensor body 22 to the attachment ring 20 of the cylindrical cover 7.

[0030] When the body 22 of the position sensor 4 is attached to the pneumatic actuator 1, the sensor body 22 closes the opening 13 in the base 11 of the cylindrical cover 7. To insure an air-tight connection between the attachment collar 23 of the sensor body 22 and the attachment ring 20 of the cylindrical cover 7, the attachment collar 14 is provided with a circumferential groove 24 in which a sealing ring 25 is placed.

[0031] The diaphragm 9 thus divides the actuator box 8 into a vacuum pressure chamber 10 and a normal pressure 11.

[0032] The vacuum pressure chamber 10 is the space surrounded by the cylindrical cover 7, the diaphragm 9, the actuator piston 5 as well as the sensor body 22 mounted in an air-tight manner to the attachment ring 20 of the cylindrical cover 7. The jacket of the cylindrical cover 7 is provided with a vacuum connector 26 that is in communication with the vacuum pressure chamber 10 and to which a pressure generator (not shown) can be connected for evacuating the vacuum pressure chamber 10.

[0033] The normal pressure chamber 11 is surrounded by the cylindrical body 6 and the diaphragm 9. The jacket of the cylindrical body 6 is provided with a ventilation hole 27 so that the normal pressure chamber 11 is always at ambient pressure.

[0034] Inside the vacuum pressure chamber 10, a spring 28 is arranged supported at the base 16 of the actuator piston 5 with one end and on the base 18 of the cylindrical cover 7 with the other end. The spring 28 exerts a spring force pushing the actuator piston 5 down, that is in the direction of the base 17 of the cylindrical body 6. When evacuating the vacuum pressure chamber 10 via the vacuum connector 27, the actuator piston 5 is moved against the spring force towards the basis of the cylindrical cover 7 due to the different pressures in the vacuum pressure chamber 10 and the normal pressure chamber 11 acting on the diaphragm 9. By changing the low pressure in the vacuum pressure chamber 10, the displacement position of the actuator piston 5 can thus be adjusted, the movement of which is transferred to the piston rod 2 connected to the centre of the base 16 of the actuator piston 5.

[0035] Alternatively to the embodiment shown in the Figures, the return spring 28 and the vacuum connector 26 may be arranged in the lower chamber that is surrounded by the cylindrical body 6. In this alternative embodiment (not shown) the lower chamber constituted the vacuum chamber 10 and evacuating said lower chamber would move the piston 5 toward the base 17 of the cylindrical box 6.

[0036] As can be best seen in Fig. 5, on the side of the diaphragm 9 facing the base 17 of the cylindrical body 6, a disc-shaped retainer 29 rests against the diaphragm base 15 from beneath with its flattened side. The diaphragm base 15 is therefore sandwiched between the base 16 of the actuator piston 5 and the retainer 29. On the other side of the actuator piston's base 16 facing the cylindrical cover 7, a washer 30 is arranged. The piston base 16, the diaphragm base 15, the retainer disc 29 and the washer 30 are provided with a central bore 31, through which one end of the piston rod 2 projects. The head 32 of this end of the piston rod 2 is configured in such a way that it holds the piston base 16, the diaphragm base 15, the retainer disc 29 and the washer 30 by means of a type of rivet joint.

[0037] In this case, the piston rod 2 projects through an opening 33 arranged in the centre of an inversion 34 in the base 17 of the box base 6, the retainer disc 29 being supported on an inversion 34 which is raised from the base 22 of the body base 17. The piston rod 2 is guided by an gimbal 35 which is inserted from outside the pneumatic actuator 1 into the inversion 34 in the body base 17 and which a sealing ring 36 seals against the body base 17.

[0038] With reference to Fig. 3, the principle functioning of the pneumatic actuator 1 and the position sensor 4 for detecting the position of an actuator piston 5 for a variable geometric turbo charger will now be described.

[0039] The driving element 3 of a variable geometric turbo charger or an exhaust gas valve moves rotationally I on a circular path to adjust the angle of incidence of a control vane (not shown). Due to this rotational movement 1, the piston rod 2 of a pneumatic actuator actuating the driving element 3, must be moved in a roto-translational movement 11. The actuator piston 5 that is rigidly connected with the piston rod 2 continues the roto-translational movement inside the actuator box 8 so that the actuator piston 5 is not displaced unidirectionally, but rather tilts with respect to the actuator body 6 and performs a tumbling movement inside the actuator box 8.

[0040] This tumbling movement is compensated by the inventive displacement transmission structure 37 comprising a transmission element 38 and a slider 39 so that the slider 39 performs a substantially lineal movement III.

[0041] For this compensation, the inventive displacement transmission structure 37 comprises a transmission element 38 and a slider 39 with a marker 40, a first connection means 41, adapted to connect the slider 39 and the transmission element 38 translationally rigid and pivotable on at least two rotation axes that are perpendicular to each other, and a second connection means 42 adapt-

ed to connect the transmission element 38 and the actuator piston 5 translationally rigid and pivotable on at least two rotation axes that are perpendicular to each other. The displacement transmission structure 37 ensures that one actuation position of the actuator piston 5 of the pneumatic actuator 1 corresponds to only one sensor position of the marker 40, here a permanent magnet 40' along the translational movement in which the slider 39 is lineally displaced as described in detail below.

[0042] Translationally rigid means that no translational movement of the two parts connected by the first 41 and the second connection means 42 is possible so that the translation of the actuator piston 5 is directly transferred via the first connection means 41, the transmission element 38, the second connection means 41 to the slider 39. The translational movement of the individual components must not be in the same direction because the pivotable connection of the first 41 and second connection means 42 mechanically compensates tilting.

[0043] The displacement transmission structure 37 according to the present invention, e.g. shown in detail in Fig. 4, will now be described in more detail.

[0044] The displacement transmission structure 37 comprises a transmission element 38 and a slider 39. The slider 39 comprises a magnetic marker 40, which is a permanent magnet 40' in the embodiment shown in the figures. A cylindrical bushing 43 forms the body of the slider 39 that is arranged lineally displaceable in a reception 44 adapted for guiding the slider 39 in the sensor body 22. The reception is formed as a guiding channel 44' whose longitudinal axis corresponds to the centre axis M, in the assembled state shown in Fig. 2, and principally aligns with the central bores 31, 33.

[0045] The permanent magnet 40' forming the marker 40 of the displacement transmission structure 37 is arranged in the bushing 43. At the displacement end 45 of the bushing 43, a first ball swivel 46 is arranged forming part of a first ball joint 47, by means of which the transmission element 38 and the slider 39 can be pivotably connected.

[0046] At the insertion end 48 of the slider 39, that is opposite to the displacement end 45, a cap 49 is arranged. The cap 49 is provided with inclined guiding faces 50 facilitating the insertion of the slider 39 into the guiding channel 44' of the position sensor 4.

[0047] The transmission element 38 comprises a transmission rod 51 having a signal end 52 to be pivotably coupled with the slider 39 and a actuation end 53 to be pivotably coupled with the actuator piston 5. For pivotably connecting the transmission element 38 with the slider 39, a first socket element 54 is provided at the signal end 52, which first socket element forms the first ball joint 47 together with the first ball swivel 46 of the slider 39.

[0048] At the actuation end 53 of the transmission rod 44, a second socket element 55 is provided wh ich forms a second ball joint 56 together with a second ball swivel 57 of the actuator piston 5.

[0049] In the embodiment of the transmission element 38 shown in the figures, two holding tongues 58 arranged substantially parallel to each other and forming a principally U-shaped cross section together with the respective end of the transmission rod 51, form a clamp fork providing the socket element 54, 55 of the respective ball joint 47, 56.

[0050] Each holding tongues 58 is provided with a central opening 59, in which the curvature of the corresponding ball swivel 46, 57 is placed, when the ball swivel 46, 57 is clipped between the two holding tongues 58 in a manner constituting the first and second ball joint 47, 56 to be rotated with respect to all three spacial dimensions. At the same time, the ball joint 47, 56 ensures a rigid translational connection between the transmission element 38 and the slider 39 as well as between the transmission element 38 and the actuator piston 5.

[0051] While the transmission element 38 and the slider 39 can be freely rotated relative to each other around the rotary axis running along the longitudinal axis L of the transmission element 38 and the slider 39, the rotation around the other two, the lateral direction that are perpendicular to the longitudinal axis L is limited to a maximum tilting angle $\alpha 1$ between the transmission element 38 and the slider 39.

[0052] The restriction of the tilting is achieved by a tilt stopper 60 which is formed by a recess 61 in the first ball swivel 46 and a protrusion 62 of the first socket element 54.

[0053] The recess 61 of the first ball swivel 46 is formed at the front face of the ball swivel that comes into contact with the actuation end 53 of the transmission rod 51, that is, the part of the first ball swivel 46 that is directed away from the bushing 43. The recess 61 is formed funnel-shaped like a crater having inclined side walls 63. The slope of this side walls 63, with respect to the longitudinal axis L of the first ball swivel 46 and the slider 39, which corresponds to the centre of the recess 61, determines the maximum tilt angle $\alpha 1$ of the first ball joint 47.

[0054] When the first ball joint 47 is connected by fixing the first ball swivel 46 within the first socket element 54 such that the first ball swivel 46 is clamped between the two holding tongues 58 and rests on the actuation end 53 of the transmission rod 51, the protrusion 62 enters the recess 61.

[0055] The protrusion 62 is formed in frustoconical shape and is arranged at the actuation end 53 of the transmission rod 51 directed substantially in the direction of the longitudinal axis L. The slope of the cylinder barrel of the protrusion 62 with respect to the longitudinal axis L of the transmission rod 51 is also about $\alpha 1$.

[0056] When tilting the first ball joint 47, the cylindrical casing of the frustoconical protrusion 62 abuts against the inclined side wall 63 of the recess 61, thereby limiting the tilting angle of the first ball joint 47 and hence the tilting of the slider 39 with respect to the transmission element 38 to a maximum tilting angle of $\alpha 1$.

[0057] Fig. 2 shows a pneumatic actuator 1 with a position sensor 4 assembled thereto. In the assembled

state, the sensor body 22 is mounted with its attachment collar 23 to the attachment ring 20 of the cylindrical cover 7. The guiding channel 44' in the sensor body 22 runs along the centre axis M of the pneumatic actuator 1.

[0058] In the assembled state shown in Fig. 2, the slider 39 of the displacement transmission structure 37 is received in the guiding channel 44'. The transmission element 38 interconnects the slider 39 and the actuator piston 5 such that the roto-translational movement II of the actuator piston 5 is converted to a translational movement III of the slider 39 in the guiding channel44'.

[0059] The transmission element 38 and the slider 39 of the displacement transmission structure 37 are pivotably connected with each other by the first connection means 41, which is the first ball joint 47 in the embodiment shown. At its actuation end 53, the transmission element 38 is pivotably connected to the actuator piston 5 by means of the second connection means 42, in the shown embodiment, the second ball joint 49.

[0060] The second ball joint 49 comprises the second socket element 48 at the actuation end 53 of the transmission element 38 and a second ball swivel 57. This second ball swivel 57 is connected to a ball clip 64 which is attached to the interior of the base 16 at the bottom of the cup-shaped actuator piston 5 via an attachment member 65. The ball clip 64 has a base plate 66, wherein the second ball swivel 57 extends at the centre of the base plate 66 in a direction perpendicular to the base plate 66 on one side thereof. The base plate 66 is provided at two opposing sides with a clip (not shown) for connecting the ball the base plate 66 of the clip 64 to the attachment member 65.

[0061] The attachment member 65 also has the form of a disc and has a connection hole 67 in the center thereof. In the assembled state, the base plate 66 of the ball clip 64 is received in the connection hole 67 and fixed to the attachment member 65 via the clips. The attachment member 65 is held at the bottom of the actuator piston 5 by the spring 29 supported on one end on the attachment member 65 pressing said pressing attachment member 65 onto the actuator piston 5. As can be seen in Fig. 2, the ball clip 64 with the second ball swivel 57 and the attachment member 65 are arranged symmetrically with respect to the centre axis M.

[0062] In this assembled state, the displacement transmission structure 37 forms a kinematic pair of the two pivotable connections means 41, 42 between the actuator piston 5 and the transmission element 38 as well as the transmission element 38 and the slider 39. Due to this kinematic pair, the inventive displacement transmission structure 37 is capable of compensating the roto-translational movement II of the actuator piston 5, which is converted into the substantially lineal translational movement III of the slider 39 in the guiding channel 44'. Since each of the pivotable connections 41, 42 is translationally rigid, each activator position corresponds to a defined position of the marker 40 on the slider 39.

[0063] This position of the marker 40 can be detected by a sensor element 68 of the sensor 4. In the embodiment shown, the sensor element 68 is designed as magnetic field sensor adapted to detect a translational position of the permanent magnet marker 40'. The sensor element 68 outputs a signal indicating said translational position of the marker 49 in the guiding channel 44'. As can be seen in Fig. 2, the sensor element 68 is arranged in a chamber 69 of the sensor body 22. The chamber 69 is arranged in the part of the sensor body that is arranged outside the actuator box 8 and is closed by a hood 70 covering the opening of the chamber 69. The output signal can be transferred to a control device (not shown) via a connector (not shown) and a data link (not shown) connecting the connector and the control device. The control device controls the vacuum generator (not shown) generating the low pressure in the vacuum pressure chamber 10 and activating the actuator piston. Thereby, closed loop for the pneumatic actuator 1 is realized.

[0064] In the following, blind assembly of the sensor 4 with the actuator 1 is described.

[0065] As can be best seen in Fig. 5, each of the first ball joint 47 and the second ball joint 56 is provided with a tilt stopper 60, 60a, respectively. In the preferred embodiment shown in the figures, each of the tilt stopper 60, 60a is formed by a protrusion 62, 62a arranged on the socket element 54, 55 working together with a corresponding recess 61, 61 a in the corresponding ball swivel 46, 57. The function of such tilt stopper 60, 60a has already been described above with respect to Fig. 4.

[0066] The tilt stoppers 60, 60a limit the maximum deflection of the slider 39 with respect to the central axis M, which corresponds to the sum of the maximum tilting angles $\alpha 1 + \alpha 2$ of each tilt stopper 60, 60a. The maximum tilting angles $\alpha 1$ is the maximum tilting of the longitudinal axis L1 of the transmission element 38 with respect to center of the second ball swivel 57 that corresponds to the centre axis M. The maximum tilting angles $\alpha 2$ is the maximum tilting of the longitudinal axis L2 of the slider 39 with respect to the longitudinal axis L1 of the transmission element 38.

[0067] By providing each of the first 41 and the second connection means 42 with a tilt stopper 60, 60a, the upright connection position of the displacement transmission structure 37 on the actuator piston 5, shown in Fig. 5, before mounting the sensor body 22 to the cylindrical cover 7 is achieved.

[0068] One requirement of the maximum tilting angle $\alpha 1$, $\alpha 2$ is that the sum $\alpha 1 + \alpha 2$ at least corresponds to the maximum tilting of the actuator piston 5 with respect to the centre axis M in order to compensate the roto-translational movement II of the actuator piston 5. Further, the maximum tilting angle $\alpha 1 + \alpha 2$ should make a blind mounting of the sensor body 22 with the cylindrical cover 7 possible.

[0069] As can be seen in Fig. 5, the displacement transmission structure 37 is pivotably connected to the ball clip 64 at the second socket element 55 arranged at the actuation end of the transmission rod 51. In this pre-

assembly position, the slider 39 is located in the opening 19 of the cylindrical cover 7 and extends from the inside of the actuator box 8 through the opening 19 to the outside of the actuator box 8.

[0070] When mounting the sensor body 22 to the attachment ring 20 by inserting the attachment collar 23 in a direction corresponding to the center axis M into the attachment ring 20 and crimping the lugs 21 encompassing the attachment collar 23, the cap 49 at the free distal end of the slider 39 comes into contact with an angular ramp structure 72 designed at the insertion end 73 of the sensor body 22. The ramp structure 72 surrounding the insertion opening 74 of the guiding channel 44'.

[0071] When assembling, the cap 49 of the slider 39 slides along the substantially funnel-shaped angular ramp structure 72 towards the narrow stem thereof, which is formed by the insertion opening 74 so that the slider 39 is introduced and received with its cap 49 first into the guiding channel 44' of the sensor body 22.

[0072] To ensure correct guidance, that is, movement of the slider 39 towards the narrow stem with the insertion opening 74, the inclination angle β of the ramp structure 60 with respect to the insertion opening 74 must be smaller than the maximum tilt angle $\alpha 1 + \alpha 2$ of the displacement transmission structure 37. Only in case of $(\alpha 1 + \alpha 2) < \beta$, the tip of the dome-shaped cap 49 will contact the ramp structure 72 with an acute angle directing toward the narrow stem, where the insertion opening 74 is located. Hence, the slider 39 is led on the ramp structure 72 towards the insertion opening and not towards the lateral edge 75 of the ramp structure 72.

[0073] Fig. 6 shows a preferred embodiment of the angular ramp structure 72. This ramp structure 72 is formed by a plurality of guiding elements 76, which are designed as guide ribs 76' having inclined guiding faces 77 arranged star-like around the insertion opening 74. The maximum distance d_{max} between adjacent guiding element 76 is smaller than the outer scale d_1 of the slider 39, which makes sure that the slider 39 slides along the ramp structure 72 formed by the plurality of guide ribs 76' and does not enter between the spaces between the individual guiding elements 76. The outer scale d_1, here the diameter of the slider 39 principally corresponds to, i.e. is only slightly smaller than the inner diameter d_2 of a guiding channel 44' to ensure lineal translational guidance of the slider 39 in the guiding channel 44'.

[0074] Further, the distance D1 from the center axis M of the insertion opening 37 to the lateral end of the angular ramp structure 72 is larger than the maximum lateral deflection D2 of the slider 39, at least the center of the cap 49 of the slider 39. This geometry ensures that the cap 49 will hit the angular ramp structure 72 when assembling the sensor body 22 to the sensor body plate 12.

[0075] The aforementioned embodiments of the present invention may be modified within the scope of the invention. For example the sensor body 22 and the cylindrical cover 7 may be designed as one piece which is then assembled with the cylindrical body 6.

[0076] In the embodiment shown in the figure, the first and the second socket element 54, 55 are both arranged on the transmission element. Alternatively, the first and the second ball swivel 46, 57 could be arranged on the transmission rod 51, in which case, the first and the second socket element 54, 55 would be arranged on the slider 39 and the actuator piston 5. Further, the ball clip 64 and the attachment member 65 may be omitted if the actuation end 53 of the transmission rod 51 is directly coupled to the actuator piston 5. Moreover, the assignment of the recess 61 and the protrusion 62 to the socket element 54, 55 and the ball swivel 46, 57 can be arbitrarily selected.

[0077] Even though, both connection means 41 and 42 are transitionally rigid, this does not mean that the direction of translational transmission at the two connection means 41, 42 is the same since the actuator piston 5, the transmission element 38 and the slider 39 are displace in different directions when the roto-translational movement II of the piston 5 is converted to the lineal displacement III of the slider 39 placed in the reception 44 of the sensor body 22.

[0078] Further, the translationally rigid connection means 41, 42 with at least two axis of rotation, said axis that are perpendicular to each other can be provided by any other coupling, e.g. a universal joint allowing such a connection.

[0079] Moreover, the sensor body 22 can be formed with a section building the cylindrical cover 7 of the actuator box 8 rather than designing the sensor body 22 and the cylindrical cover 7 as individual components. A single element comprising the sensor body 22 and the cylindrical cover 7 is easier to assemble since the number of components is reduced. Further, the air-tight connection 20, 23, 25 between the cover 7 and the body 22 can be omitted in such single-piece unit. The embodiment with a separate cylindrical cover 7 to which the sensor body 22 is connected, on the other hand, provides the advantage that the same cylindrical cover 7 can be connected with different sensor bodies 22 and maintenance and repair of the sensor 4 is facilitated since the sensor 4 is detachably connected with the cylindrical cover 7 of the actuator box 8. Likewise, the vacuum connector 26 can be a separate element that is connected with a component 6, 7 of the actuator box 8, or can be formed as one piece with the cylindrical body 6 or the cylindrical cover 7.

[0080] The marker 40 shown in the embodiment of the Figures is a permanent magnet 40'. Of course, any type of marker 40 the position of which can be determined by a sensor element 68 can be alternatively use, such as for example an optical marker in combination with an optical sensor 68.

[0081] In one embodiment, the transmission element, the first connection means and the slider can be formed as a single piece having a flexible region constituting the first connection means within the single piece. Accordingly, the coupling means, the second connection means

and the transmission element may be formed as a single piece, or the coupling means, the second connection means, the transmission element, the first connection means and the slider may be made as a single part having connection means areas that are translationally rigid and pivotable on at least two rotation axes that are perpendicular to each other.

[0082] Finally, the actuator shown as pneumatic activator 1 in the embodiment described, must not be necessarily driven by a vacuum. The present invention works with any actuator whose piston is moved in a rota-translational movement.

Claims

1. Displacement transmission structure (37) for a position sensor (4) detecting the position of an actuator piston (5) adjusting a variable geometric turbo charger or an exhaust gas recirculation valve, comprising a slider (39), to be lineally displaced in the position sensor (4), with at least one marker (40, 40'), of which the translational position can be detected by the sensor (4), a transmission element (38) for interconnecting the actuator piston (5) and the slider (39), a first connection means (41) adapted to connect the slider (39) and the transmission element (38) translationally rigid and pivotable on at least two rotation axes that are perpendicular to each other, and a second connection means (42) adapted to connect the transmission element (38) and the actuator piston (5) translationally rigid and pivotable on at least two rotation axes that are perpendicular to each other.

2. Displacement transmission structure (37) according to claim 1, wherein the first connection means (41) and/or the second connection means (42) is a swivel joint (47, 56).

3. Displacement transmission structure (37) according to claim 1 or 2, wherein the first connection means (41) and/or the second connection means (42) is provided with a tilt stopper (60, 60a) limiting the tilting of the pivotable connection to a maximum tilting angle ($\alpha 1$, $\alpha 2$).

4. Displacement transmission structure (37) according to claim 3, wherein the tilt stopper (60, 60a) is a protrusion (62, 62a) received in a recess (61, 61 a).

5. Displacement transmission structure (37) according to any one of claims 1 to 4, wherein the second connection means (42) comprises a coupling means (64, 65) adapted to be attached to the actuator piston (5).

6. Position sensor (4) for detecting the position of an actuator piston (5) adjusting a variably geometric turbo charger or an exhaust gas recirculation valve, comprising a displacement transmission structure (37) according to any one of claims 1 to 5, a sensor body (22) with a reception (44, 44') adapted for guiding the slider (39), and at least one sensor element (68) adapted to generate an output signal indicating the position of the marker (40, 40') in the reception (44, 44').

7. Position sensor (4) according to claim 6, wherein an insertion opening (74) for inserting the slider (39) into the reception (44, 44') is surrounded by a ramp structure (72) forming an angular guideway towards the insertion opening (74).

8. Position sensor (4) according to claim 7, wherein the ramp structure (72) is formed by a plurality of guiding elements (76, 76'), wherein the maximum distance (d_{max}) between adjacent guiding elements (76, 76') is smaller than the outer scale (d_1) of the slider (39).

9. Position sensor (4) according to claim 7 or 8, wherein each of the first (41) and the second connection means (42) is provided with a tilt stopper (60, 60a), and wherein the sum of the maximum tilting angles ($\alpha 1 + \alpha 2$) of the first (41) and the second connection means (42) is smaller than the inclination angle (β) of the angular guideway with respect to the insertion opening (74).

10. Position sensor (4) according to any of claims 7 to 9, wherein the lateral distance (D1) from the centre of the insertion opening (74) to the lateral edge (75) of the ramp structure (72) is larger than the maximum lateral deflection (D2) of the slider (39) from the centre of the second connection means (42).

11. Kit (1, 4, 37) for an actuator (1) adjusting a variable geometric turbo charger or an exhaust gas recirculation valve, comprising an actuator (1) having a displaceable actuator piston (5) for positioning a variable geometric turbo charger or an exhaust gas recirculation valve, and a position sensor (4) according to any one of claims 6 to 10, wherein, in the assembled state, the slider (39) is placed in the reception (44, 44') of the sensor body (22), the first connection means (41) connects the slider (39) and the transmission element (38) translationally rigid and pivotable on at least two rotation axes that are perpendicular to each other and the second connection means (42) connects the transmission element (38) and the actuator piston (5) translationally rigid and pivotable on at least two rotation axes that are perpendicular to each other.

12. Method for determining the position of an actuator piston (5), wherein the displacement of the actuator piston (5) is transmitted via a transmission element (38), which is connected to the actuator piston (5)

translationally rigid and pivotable on at least two rotation axes that are perpendicular to each other, to a substantially lineal displacement of a slider (39), which is connected to the transmission element (38) translationally rigid and pivotable on at least two rotation axes that are perpendicular to each other.

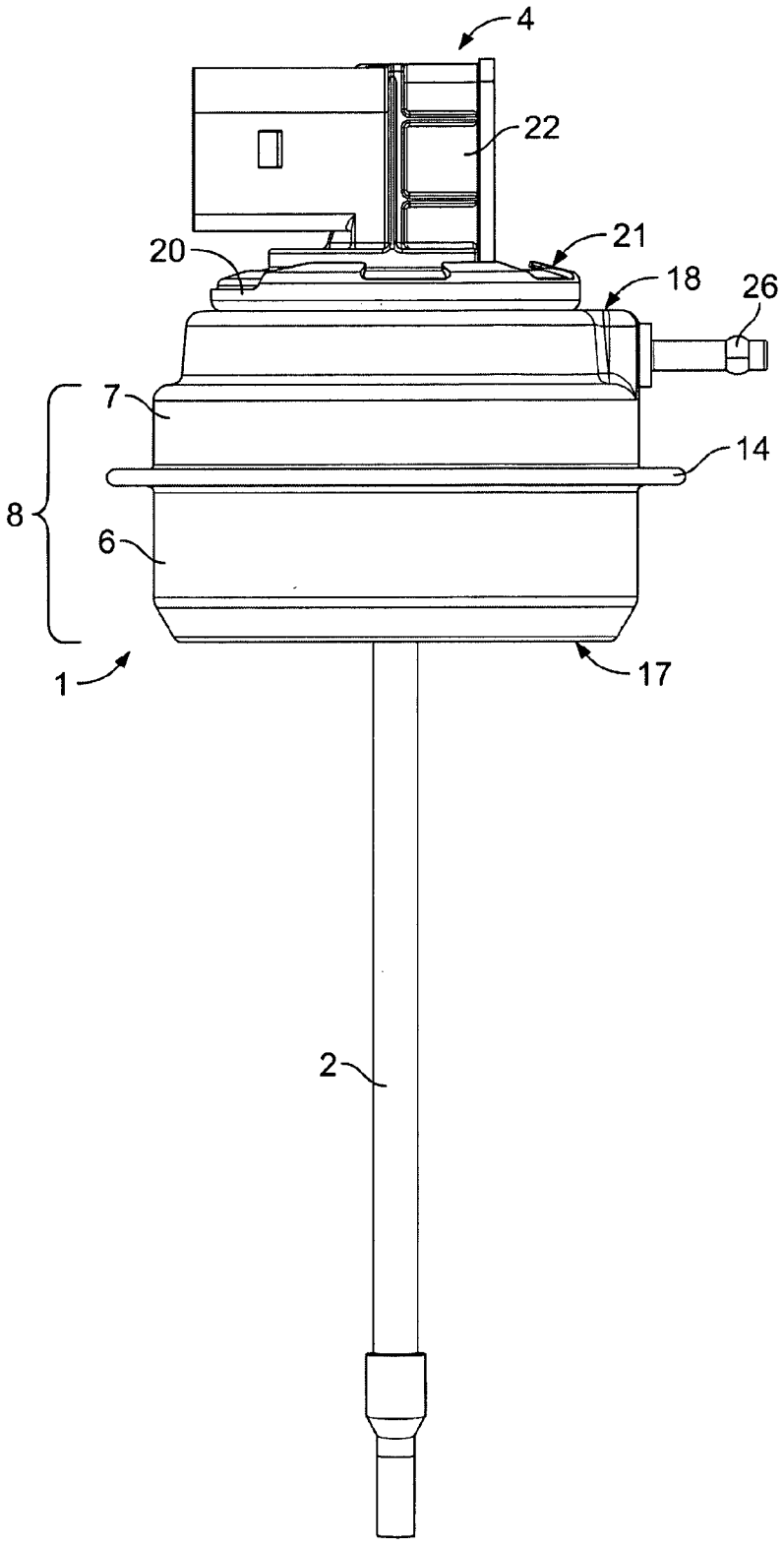


Fig. 1

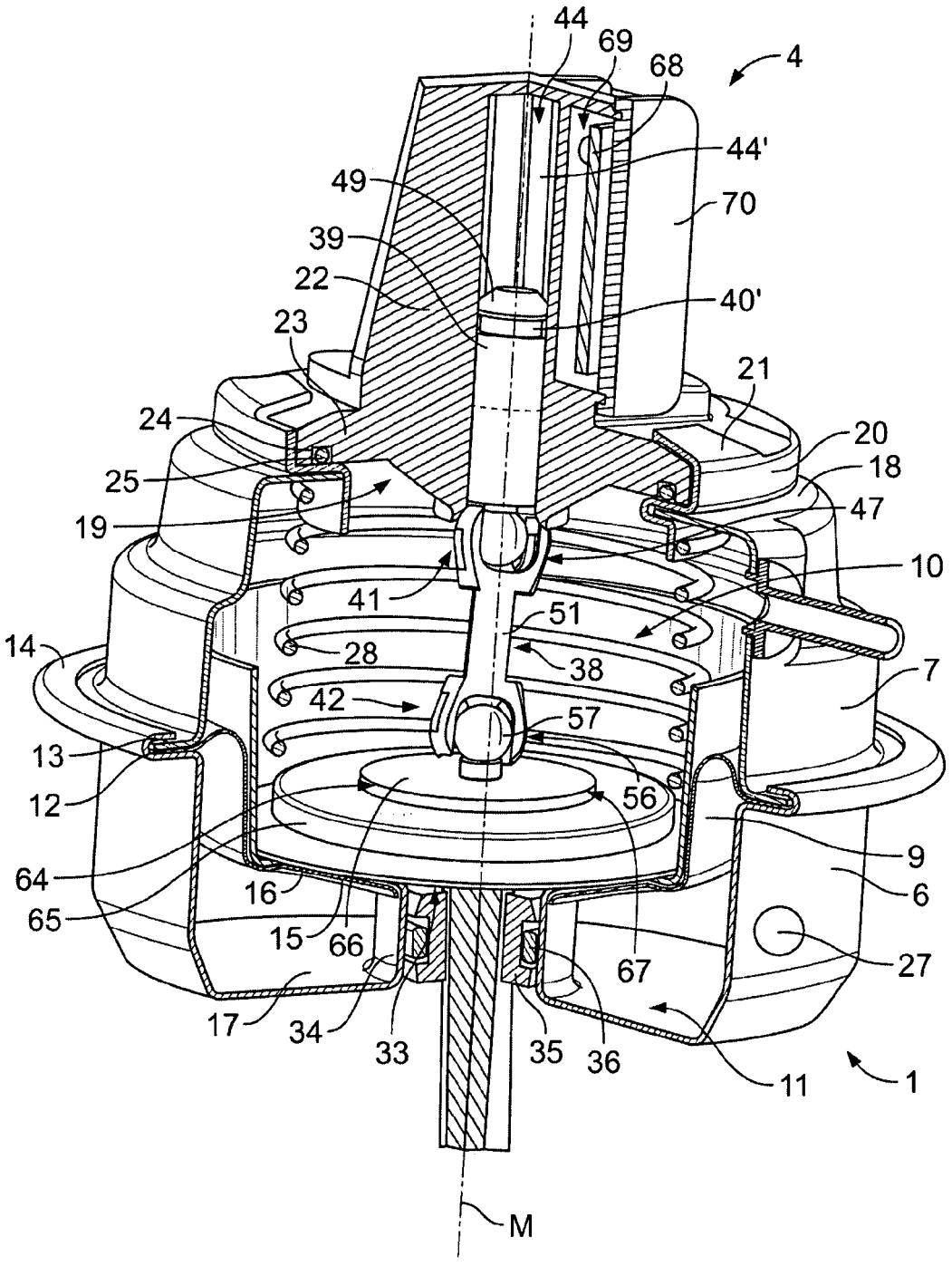

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Fig. 2

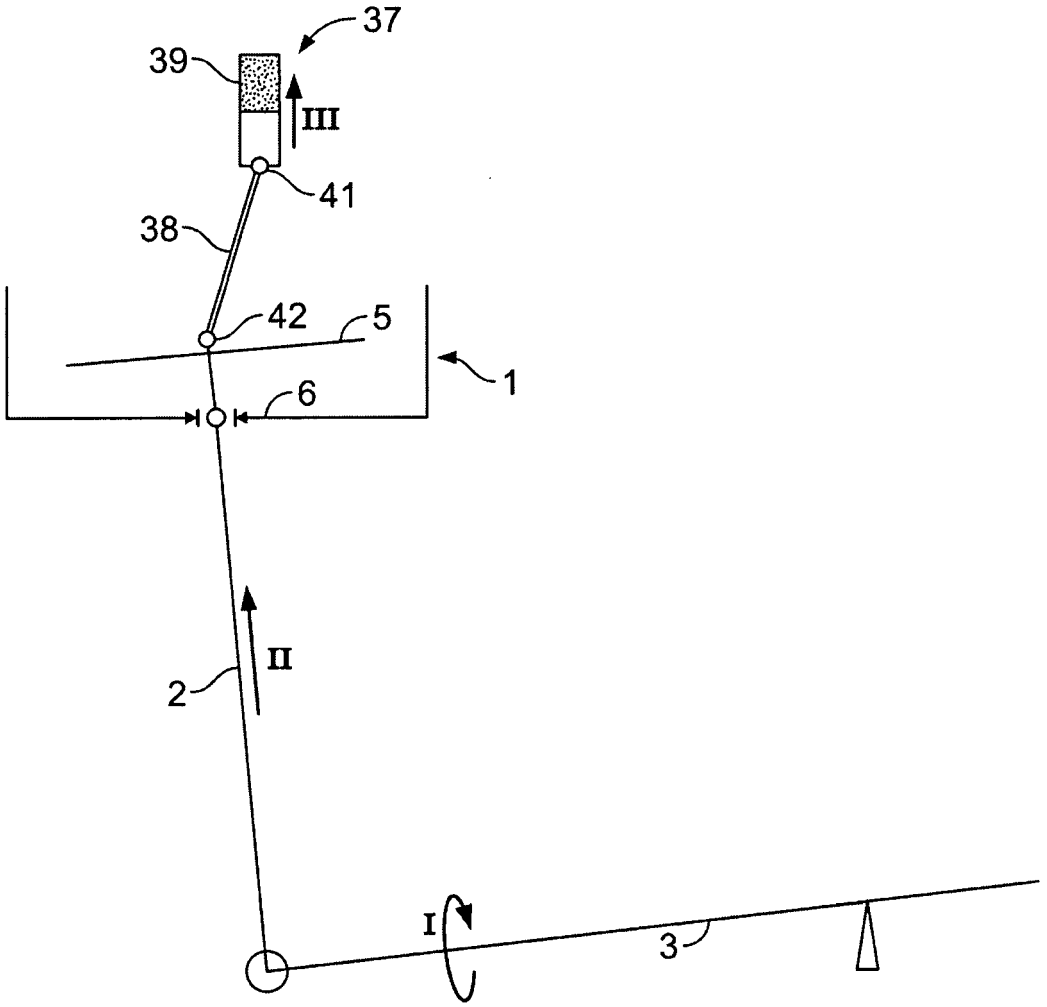


Fig. 3

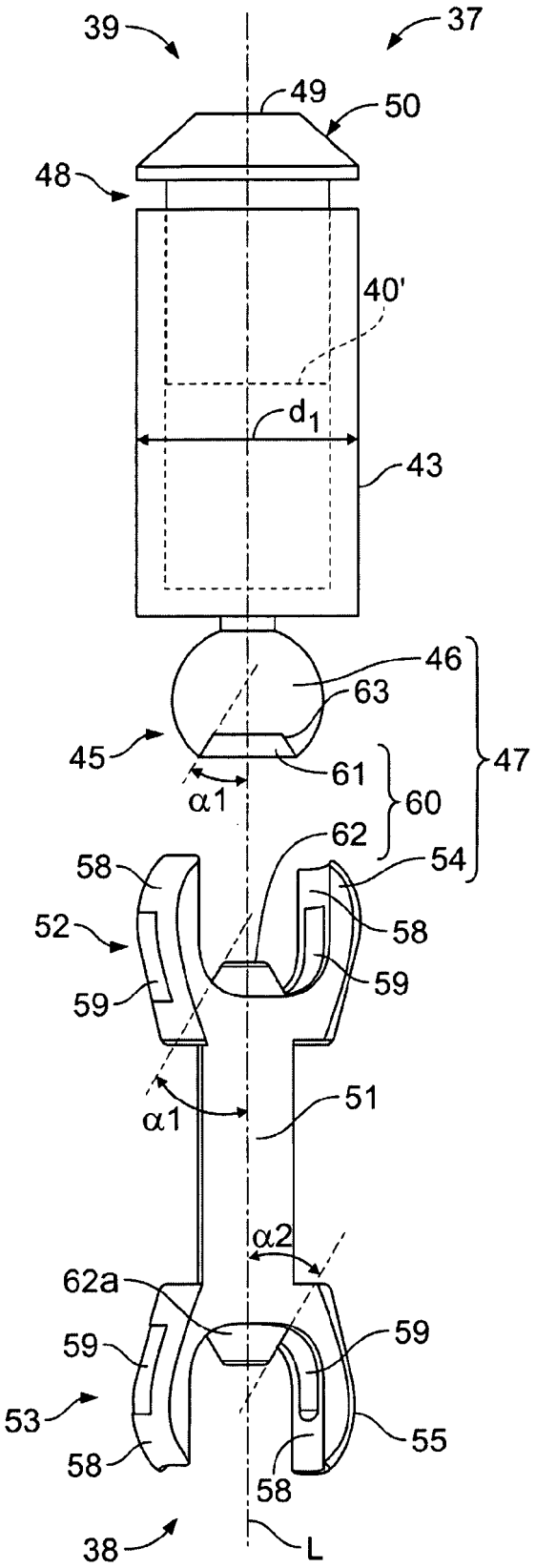

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Fig. 4

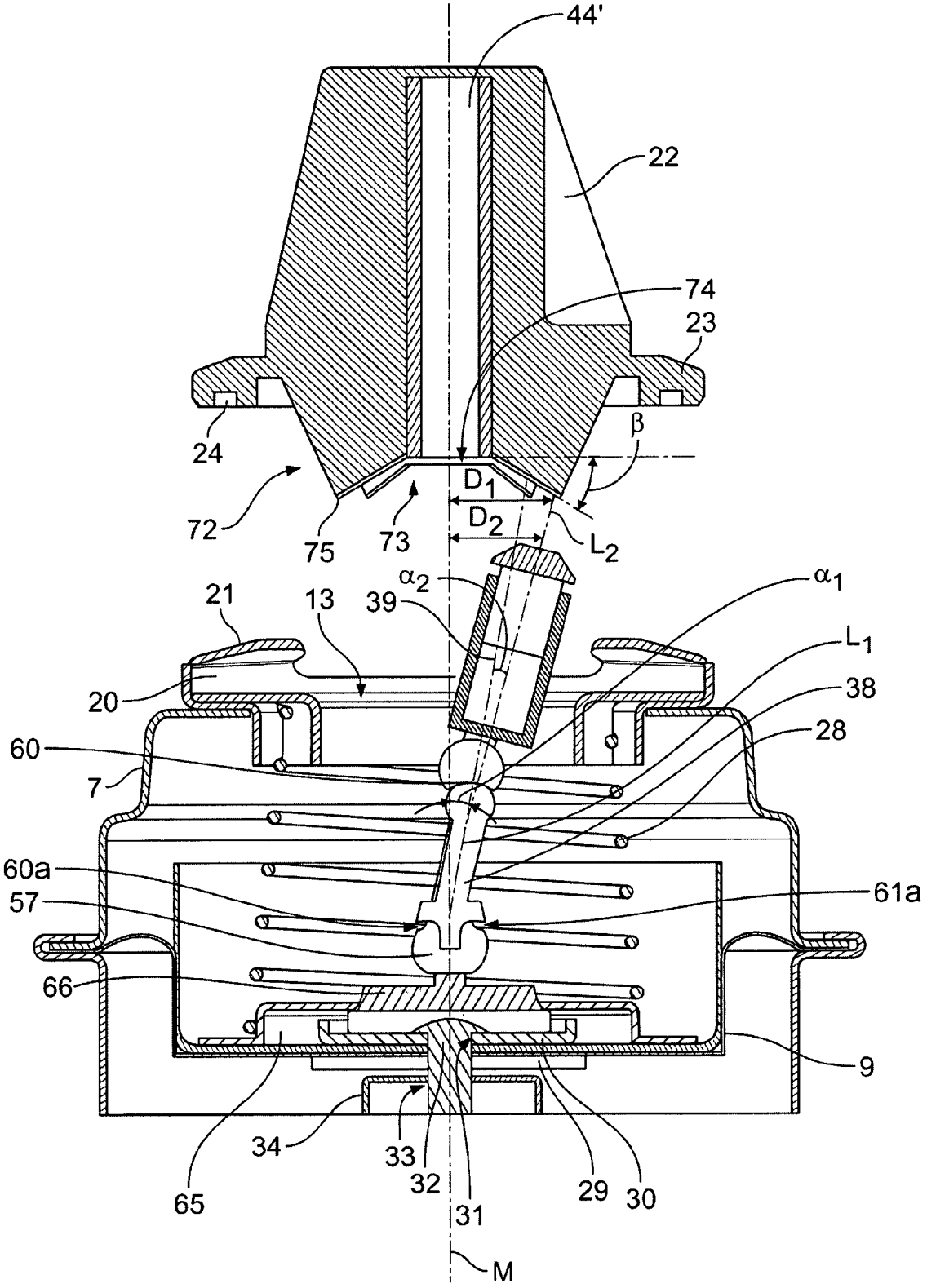

44'
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74
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24
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D1
D2
L2
72
75
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α2
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39
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Fig. 5

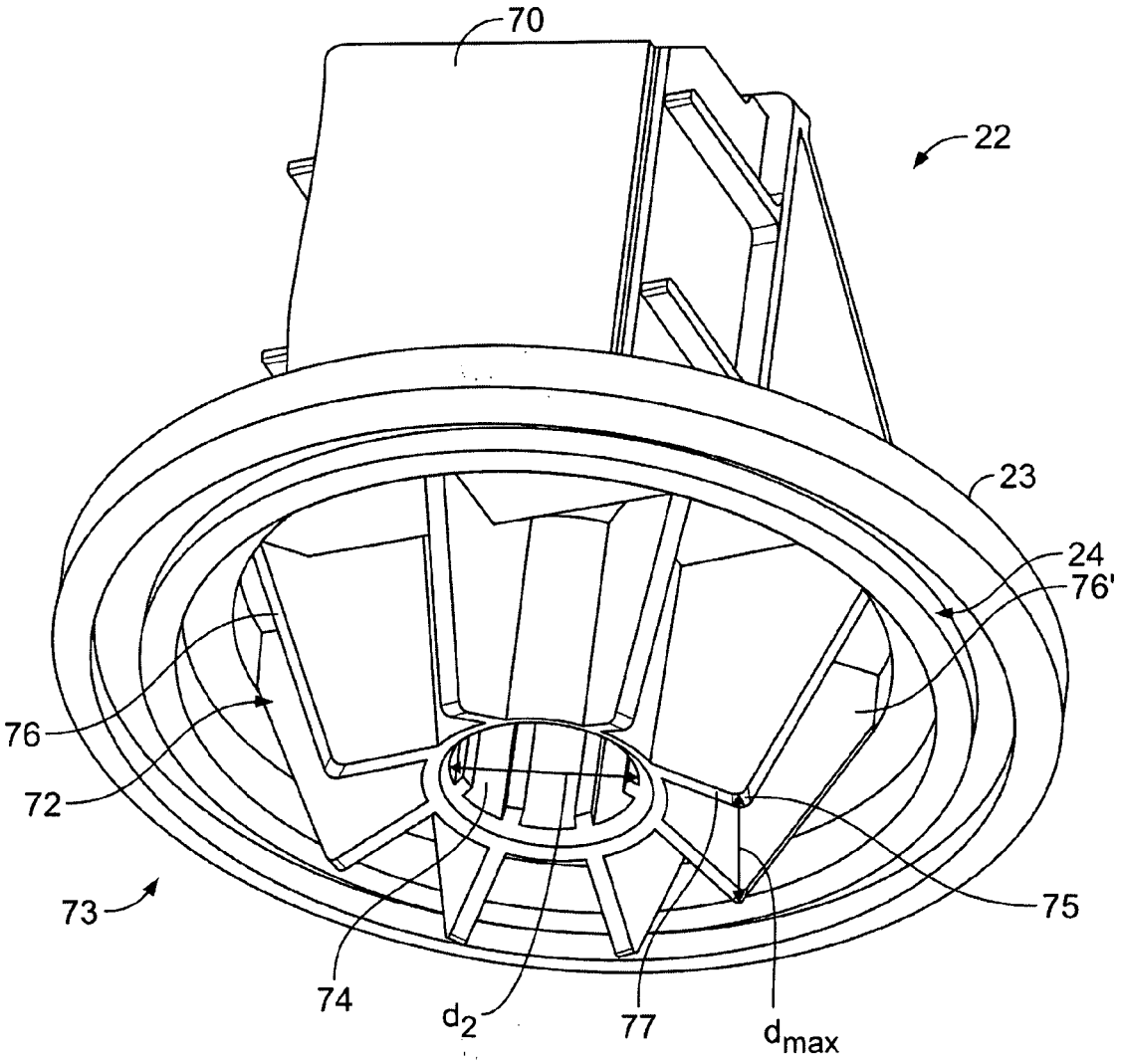


Fig. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 08 38 2034

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	DE 10 2005 029904 A1 (MURRPLASTIK SYSTEMTECHNIK GMBH [DE]) 4 January 2007 (2007-01-04) * paragraph [0021]; figures 3,4a,4b *	12 1-6,11	INV. F15B15/10 F15B15/28
Y	US 6 273 631 B1 (TAKAHASHI KUNIHISA [JP] ET AL) 14 August 2001 (2001-08-14) * column 1, lines 13-19 * * column 3, lines 34-59 * * column 4, lines 41-45; figures 1a,1b,1c,3 *	1-6,11	
A	DE 36 23 677 C1 (DAIMLER BENZ AG) 16 April 1987 (1987-04-16) * column 2, lines 5-18,42-65; figure 2 *	1,6,11	
A,D	EP 1 852 588 A (SMK SYSTEME METALL KUNSTSTOFF [DE]) 7 November 2007 (2007-11-07) * paragraphs [0040] - [0042]; figure 1 *	1,6,11	

TECHNICAL FIELDS SEARCHED (IPC)

F15B
F16K
F02B
F02M
F16D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	29 January 2009	Rechenmacher, M

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29-01-2009

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102005029904 A1	04-01-2007	NONE	
US 6273631 B1	14-08-2001	DE 19958224 A1	21-06-2000
		GB 2344400 A	07-06-2000
		JP 2000170742 A	20-06-2000
		KR 20000057037 A	15-09-2000
		TW 595670 Y	21-06-2004
DE 3623677 C1	16-04-1987	NONE	
EP 1852588 A	07-11-2007	DE 102006021130 B3	09-08-2007

EPO FORM P0459

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Patent documents cited in the description

- EP 1852588 A **[0004]**