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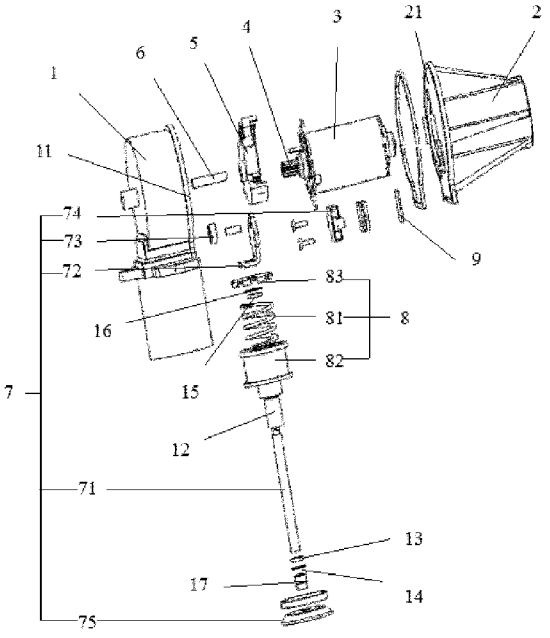



Fig. 1

(57) Abstract: The present invention relates to a linear exhaust control valve, comprising: a housing; an end cover fitted to the housing; an electric machine; a transmission gear meshed with an output gear on an output shaft of the electric machine, the transmission gear being mounted on a gear shaft fixed inside the housing; and a linear motion assembly which is fitted to the transmission gear and converts rotational motion of the transmission gear to linear motion; an axis of a regulating rod in the linear motion assembly does not intersect with an axis of the gear shaft. The linear exhaust gas control valve provided by the present invention has the advantages of structural compactness, small volume, light weight, a good sealing result and a simple assembly process.

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Description

Linear exhaust gas control valve

TECHNICAL FIELD

The present invention relates to a motor vehicle component product, in particular to a linear exhaust gas control valve used in a motor vehicle powertrain.

Background Art

In the motor vehicle industry, in order to reduce emissions of nitrogen oxides and increase fuel economy, it is often necessary for a valve apparatus capable of precisely controlling air intake and discharge of gases to be used in a powertrain system, e.g. an apparatus such as an exhaust gas recirculation control valve used in an engine exhaust gas recirculation system. Such a valve apparatus is in most cases a linear exhaust gas control valve which uses an electric machine as a power drive source, then converts a rotational output of the electric machine to linear motion of a linear motion component (e.g. a valve rod).

Linear exhaust gas control valves on the market at present have the following characteristics: an electric motor is fitted in a housing, using multi-stage transmission and gear external meshing, and torsion or flat spiral spring return. The abovementioned structure and layout have the following shortcomings: the volume of the whole component is large, the cost of components is high, sealing is very difficult, and the spring installation process is complex.

SUMMARY OF THE INVENTION

The object of the present invention is to provide a linear exhaust gas control valve, which solves the problems afflicting existing linear exhaust gas control valves, namely lack of structural

compactness, large volume, complex assembly process, poor sealing and high costs.

The linear exhaust control valve provided by the present invention comprises: a housing; an end cover fitted to the housing; an electric machine; a transmission gear meshed with an output gear on an output shaft of the electric machine, the transmission gear being mounted on a gear shaft fixed inside the housing; and a linear motion assembly which is fitted to the transmission gear and converts rotational motion of the transmission gear to linear motion, the linear motion assembly comprising a regulating rod; an axis of the regulating rod does not intersect with an axis of the gear shaft.

Furthermore, the output gear on the electric machine output shaft meshes internally with the transmission gear.
Furthermore, the electric machine is located in the end cover.
Furthermore, the linear exhaust gas control valve further comprises: a spring return system mounted on the linear motion assembly.

Furthermore, the spring return system comprises a return spring surrounding the regulating rod, a spring fixing device which is pressed into the housing and fixed therein and surrounds the return spring. and a spring support retaining ring installed on the regulating rod, wherein when the transmission gear moves in a particular direction, the spring support retaining ring can apply a compressing force to the return spring and thereby compress the return spring.
Furthermore, the linear exhaust gas control valve further comprises a bush, the bush being pressed into the spring fixing device in an interference fit, with the regulating rod being inserted into and passing through the bush.

Furthermore, the linear exhaust gas control valve further comprises a first sealing ring and a first washer located on one side of the bush, and a second sealing ring and a second washer located on another side of the bush, with the regulating rod being inserted into and passing through the first washer, first sealing ring, second sealing ring and second washer. The first sealing ring is located between the first washer and the bush and forms an interference fit with the spring fixing device; the first washer is used to support the first sealing ring. The second sealing ring is located between the second washer and the bush and forms an interference fit with the spring fixing device, and the second washer is fixed to the spring fixing device by riveting.

Furthermore, the linear exhaust gas control valve further comprises a carbon scraper; the carbon scraper forms an interference fit with the spring fixing device, and the regulating rod is inserted in and passes through the carbon scraper. Furthermore, the linear motion assembly comprises: a connecting rod structure, a bearing, a magnet and a valve head; the connecting rod structure is mounted in a fixed manner at one end of the regulating rod; the bearing and magnet are both mounted on the connecting rod structure, and the bearing cooperates with a structure that is located on the transmission gear and capable of giving rise to linear displacement, so as to convert rotational motion of the transmission gear to linear motion of the linear motion assembly; the valve head is mounted at the other end of the regulating rod.

Furthermore, the structure that is located on the transmission gear and capable of giving rise to linear displacement is a groove part, a protrusion or an eccentric circle.

Furthermore, the linear exhaust gas control valve further comprises: a sensor mounted inside the end cover.

Furthermore, the housing and the end cover are fitted together, and fitting surfaces of the housing and the end cover are both flat surfaces.

Furthermore, the transmission gear is a cam gear.

Compared with the prior art, the linear exhaust gas control valve provided by the present invention has the advantages of structural compactness, small volume, light weight, a good sealing result and a simple assembly process.

Description of the accompanying drawings

The accompanying drawings, which form part of the present application, are intended to furnish further understanding of the present invention. The schematic embodiments of the present invention and the explanations thereof are intended to explain the present invention, without constituting an inappropriate limitation thereof. Drawings:

Fig. 1 is an exploded schematic view of the linear exhaust gas control valve of the present invention;

Fig. 2 is a front view of the linear exhaust gas control valve shown in Fig. 1 after assembly;

Fig. 3 is a front sectional view of the linear exhaust gas control valve shown in Fig. 2;

Fig. 4 is a 3D perspective view of some of the components of the linear exhaust gas control valve shown in Fig. 2 after assembly;

Fig. 5 is a front view of the linear motion assembly shown in Fig. 4;

Fig. 6 is a schematic diagram of the installation of components inside the end cover.

PARTICULAR EMBODIMENTS

The linear exhaust gas control valve of the present invention is described below by means of embodiments with reference to the accompanying drawings.

As shown in Figs. 1 to 6, the linear exhaust gas control valve of the present invention comprises: a housing 1; an end cover 2 fitted to the housing 1; an electric machine 3; a transmission gear 5 meshed with an output gear 4 on an output shaft of the electric machine 3, the transmission gear 5 being a cam gear or a gear having a feature such as a groove, protrusion or eccentric circle, etc., wherein the transmission gear 5 is mounted on a gear shaft 6 fixed inside the housing 1, and the function thereof is split into two parts, one part being to realize meshed rotation of gears through meshing with the output gear 4, and the other part being to realize the conversion of rotational motion to linear motion through a structure thereon which can give rise to linear displacement; a linear motion assembly 7 that is fitted to the transmission gear 5 and converts rotational motion of the transmission gear 5 to linear motion, one of the main components of the linear motion assembly being a regulating rod 71, wherein an axis A of the regulating rod 71 does not intersect with an axis B of the gear shaft 6; a spring return system 8 which surrounds the linear motion assembly 7 and is installed in a fixed manner in the interior of the housing 1, wherein when the linear exhaust gas control valve has been powered off, the spring return system 8 can drive the linear motion assembly 7 back to an initial position; and a sensor 9 installed in the end cover 2, which sensor 9 may be fixed by hot riveting or adhered with glue inside the end cover 2.

Specifically, as shown in Figs. 1, 2 and 3, in order to better convert rotational motion of the transmission gear 5 to linear motion in a straight line, the linear motion assembly 7 is further

composed of the following components: the regulating rod 71, a connecting rod structure 72, a bearing 73, a magnet 74 and a valve head 75; the connecting rod structure 72 is mounted at one end of the regulating rod 71; the valve head 75 is mounted at the other end of the regulating rod 71; the bearing 73 and the magnet 74 are both mounted on the connecting rod structure 72, with the bearing 73 being located in a groove part of the transmission gear 5, so as to convert rotational motion of the transmission gear 5 to linear motion of the linear motion assembly 7 (in other embodiments, a person skilled in the art could also choose to achieve the conversion of rotational motion to linear motion by having the bearing 73 cooperate with another structure that is located on the transmission gear 5 and capable of giving rise to linear displacement, for example a protrusion or an eccentric circle, not shown in the figures). Preferably, as shown in Fig. 5, the axis A of the regulating rod 71 does not intersect with the axis B of the gear shaft 6.

Preferably, to make the structure of the linear exhaust gas control valve more compact, internal tooth meshing is employed between the output gear 4 on the output shaft of the electric machine 3 and the transmission gear 5.

Preferably, likewise in order to make the structure of the linear exhaust gas control valve more compact, lower costs and facilitate assembly, the end cover 2 is of a plastic material, and the electric machine 3 is installed in the end cover 2, wherein pins of the electric machine 3 are on connecting wires of connection plugs on the end cover 2 (not shown in the figures), so as to realize the supply of power to the electric machine 3. Thus, the electric machine 3, the sensor 9, and the sealing ring located between the housing 1 and the end cover 2 may be pre-assembled, and then fitted to the housing 1 as a single unit;

this makes it easier to test the sealing performance, and characteristics after electric machine assembly, of a sub-assembly, and both the feasibility and the convenience of such testing are considerably increased. In addition, once the electric machine 3 has been transferred into the end cover 2, the amount of material used in the housing 1 (metal material) and the machining area are reduced, thereby lowering costs.

Preferably, the spring return system 8 comprises: a return spring 81 which surrounds the regulating rod 71 of the linear motion assembly 7; a spring fixing device 82 which is pressed into the housing 1 (forming a partial interference fit with the housing 1) and both surrounds and supports the return spring 81; a spring support retaining ring 83 installed on the regulating rod 71 of the linear motion assembly 7, wherein when the transmission gear 5 moves in a particular direction (e.g. when the electric machine 3 drives the valve head 75 to move to open the valve), the spring support retaining ring 83 can apply a compressing force to the return spring 81 and thereby compress the return spring 81. In normal circumstances, the spring support retaining ring 83 tightly abuts the connecting rod structure 72 under the action of the spring force, and in the course of movement, assists the connecting rod structure 72 in pushing the return spring 81 downwards to achieve compression of the latter; the spring fixing device 82 can support the return spring 81, and at the same time ensure that the return spring 81 does not tilt in the course of movement. In an initial position of the linear exhaust gas control valve, the return spring 81 is already in a preloaded state, and when the valve (the valve will open if the valve head 75 moves in one direction, and close if the valve head moves in the opposite direction) opens under the driving action of the electric machine 3, the return spring 81 is compressed further. Since the axis A of the regulating rod 71 does not intersect with the axis B of the gear shaft 6, the action force of the return spring 81 is

offset from the center point of the gear shaft 6 by a certain distance, and is therefore equivalent to having a moment acting on the transmission gear 5; this moment enables valve return without electricity. In this embodiment, this moment impels the transmission gear 5 shown in Fig. 5 to rotate anticlockwise against system friction.

Preferably, the present invention also comprises a sealing system and a carbon scraping means which work in cooperation with the spring return system, the sealing system comprising: a bush 12, a first sealing ring 13, a first washer 14, a second sealing ring 15 and a second washer 16. The bush 12 is pressed into the spring fixing device 82 in an interference fit, with the regulating rod 71 being inserted into and passing through the bush 12. The first sealing ring 13 and first washer 14 are located on one side of the bush 12, the second sealing ring 15 and second washer 16 are located on another side of the bush 12, and the regulating rod 71 is inserted into and passes through the first washer 14, first sealing ring 13, second sealing ring 15 and second washer 16 in sequence. The first sealing ring 13 is located between the first washer 14 and the bush 12 and forms an interference fit with the spring fixing device 82; the first washer 14 is used to support the first sealing ring 13; the second sealing ring 15 is located between the second washer 16 and the bush 12 and forms an interference fit with the spring fixing device 82, and the second washer 16 is fixed to the spring fixing device 82 by riveting. The carbon scraping means is specifically a carbon scraper 17, the function of which is to scrape accumulated carbon off the regulating rod 71 during the reciprocating motion of the latter; the carbon scraper 17 forms an interference fit with the spring fixing device 82, and the regulating rod 71 is inserted in and passes through the carbon scraper 17.

The spring return system 8 and sealing system designed in the manner described above have the following advantages: 1) Various components of the systems may be pre-assembled, to form sub-components which, after being inserted into the linear motion assembly 7, are fitted into the housing 1 as a single unit; compared with previous designs, such a method of assembly has vastly reduced process complexity. 2) With the previous flat spiral spring replaced by a compression spring, structures such as a bearing, bush assembly and sealing cap behind the flat spiral spring are eliminated; at the same time, the machining area on the housing 1 is considerably reduced, and costs are significantly lowered.

Preferably, as shown in Figs. 1 to 3, in order to achieve a better sealing result, the housing 1 and end cover 2 must be fitted together, and fitting surfaces of the housing 1 and end cover 2 are both flat surfaces (flat surface 11 and flat surface 21 shown in Fig. 1), not inclined surfaces as in conventional designs. Besides making sealing easier, another aspect of this feature is that the sealing ring (shown in Fig. 1 but not labelled) in the end cap 2 is changed from an inclined surface to a straight surface, so the sealing effect is enhanced, production is simple and costs are lowered.

Based on the description of Fig. 5, the operating principles of the linear exhaust gas control valve are as follows:
When the linear exhaust gas control valve is powered on: the output gear 4 of the electric machine 3 rotates clockwise, impelling the transmission gear 5 to rotate clockwise; the rotation of the transmission gear 5 then impels the bearing 73 to move downwards; the downward movement of the bearing 73 pushes the connecting rod structure 72, regulating rod 71 and valve head 75 to move downwards, so that the valve opens, and exhaust gas

enters through a valve port. The sensor 9 feeds signals back to an engine control unit by sensing the position of the magnet 74 or another inductive element, and the output gear of the electric machine 3 regulates the size of a valve opening by rotating clockwise/anticlockwise, thereby controlling the gas flow rate.

When the linear exhaust gas control valve is powered off: the return spring 81 is already compressed and preloaded in the initial position; once the power is cut, the preload of the return spring 81 acts on the transmission gear 5 through the connecting rod structure 71 and the bearing 73; there is an offset distance between the action force position of the return spring 81 and the center of the gear shaft 6, therefore this is equivalent to the return spring 81 applying a torque to the transmission gear 5; the transmission gear 5 rotates anticlockwise under the action of this torque, at the same time impelling a rotor of the electric machine 3 to rotate; the transmission gear 5 impels the linear motion assembly 7 to move upwards until the valve closes, thereby enabling closure of the valve without electricity to be controlled.

Although the present invention has been disclosed above by way of preferred embodiments, the present invention is not limited thereto. Changes and amendments of all kinds made within the spirit and scope of the present invention by any person skilled in the art shall be included in the scope of protection of the present invention. Thus the scope of protection of the present invention shall be the scope defined by the claims.

Patent claims

1. A linear exhaust control valve, comprising:
a housing;
an end cover fitted to the housing;
an electric machine;
a transmission gear meshed with an output gear on an output shaft of the electric machine, the transmission gear being mounted on a gear shaft fixed inside the housing;
a linear motion assembly which is fitted to the transmission gear and converts rotational motion of the transmission gear to linear motion, the linear motion assembly comprising a regulating rod;
characterized in that
an axis of the regulating rod does not intersect with an axis of the gear shaft.

2. The linear exhaust gas control valve as claimed in claim 1, characterized in that the output gear on the electric machine output shaft meshes internally with the transmission gear.

3. The linear exhaust gas control valve as claimed in claim 1, characterized in that the electric machine is located in the end cover.

4. The linear exhaust gas control valve as claimed in claim 1, characterized by further comprising: a spring return system which surrounds the linear motion assembly and is installed in a fixed manner in the interior of the housing.

5. The linear exhaust gas control valve as claimed in claim 4, characterized in that the spring return system comprises: a return spring surrounding the regulating rod.

6. The linear exhaust gas control valve as claimed in claim 5, characterized in that the spring return system further comprises: a spring fixing device which is pressed into the housing and fixed therein and surrounds the return spring.

7. The linear exhaust gas control valve as claimed in claim 6, characterized in that the spring return system further comprises: a spring support retaining ring installed on the regulating rod, wherein when the transmission gear moves in a particular direction, the spring support retaining ring can apply a compressing force to the return spring and thereby compress the return spring.

8. The linear exhaust gas control valve as claimed in claim 6, characterized by further comprising a bush, the bush being pressed into the spring fixing device in an interference fit, with the regulating rod being inserted into and passing through the bush.

9. The linear exhaust gas control valve as claimed in claim 8, characterized by further comprising a first sealing ring and a first washer located on one side of the bush, and a second sealing ring and a second washer located on another side of the bush, with the regulating rod being inserted into and passing through the first washer, first sealing ring, second sealing ring and second washer.

10. The linear exhaust gas control valve as claimed in claim 9, characterized in that the first sealing ring is located between the first washer and the bush and forms an interference fit with the spring fixing device, and the first washer is used to support the first sealing ring.

11. The linear exhaust gas control valve as claimed in claim 9, characterized in that the second sealing ring is located between the second washer and the bush and forms an interference fit with the spring fixing device, and the second washer is fixed to the spring fixing device by riveting.

12. The linear exhaust gas control valve as claimed in claim 6, characterized by further comprising a carbon scraper; the carbon scraper forms an interference fit with the spring fixing device, and the regulating rod is inserted in and passes through the carbon scraper.

13. The linear exhaust gas control valve as claimed in claim 1, characterized in that the linear motion assembly further comprises: a connecting rod structure, a bearing, a magnet and a valve head;
the connecting rod structure is mounted in a fixed manner at one end of the regulating rod;
the bearing and magnet are both mounted on the connecting rod structure, and the bearing cooperates with a structure that is located on the transmission gear and capable of giving rise to linear displacement, so as to convert rotational motion of the transmission gear to linear motion of the linear motion assembly;
the valve head is mounted at the other end of the regulating rod.

14. The linear exhaust gas control valve as claimed in claim 13, characterized in that the structure that is located on the transmission gear and capable of giving rise to linear displacement is a groove part, a protrusion or an eccentric circle.

15. The linear exhaust gas control valve as claimed in claim 1, characterized by further comprising: a sensor mounted inside the end cover.

16. The linear exhaust gas control valve as claimed in claim 1, characterized in that the housing and the end cover are fitted together, and fitting surfaces of the housing and the end cover are both flat surfaces.

17. The linear exhaust gas control valve as claimed in claim 1, characterized in that the transmission gear is a cam gear.

Drawings accompanying description

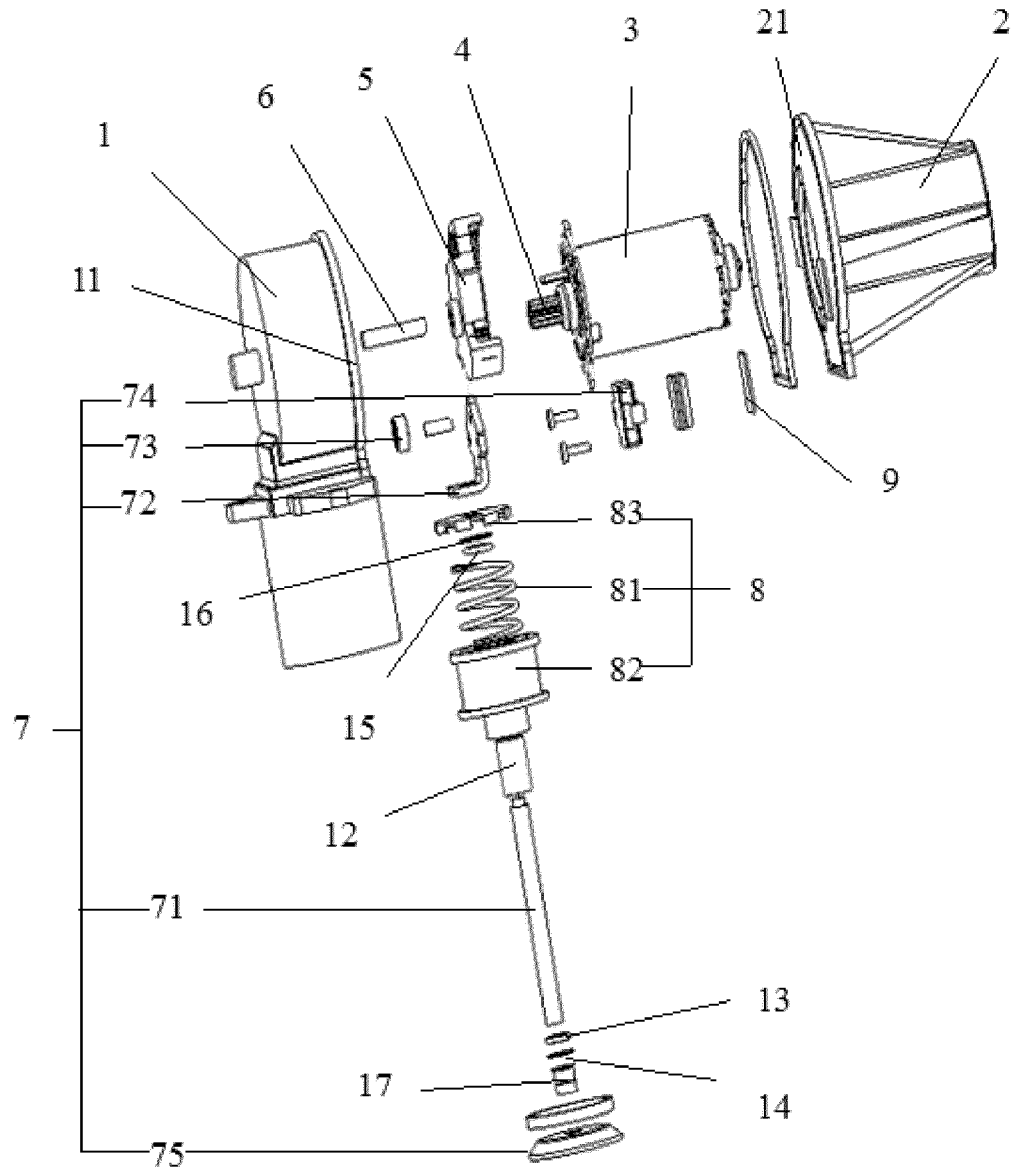



Fig. 1

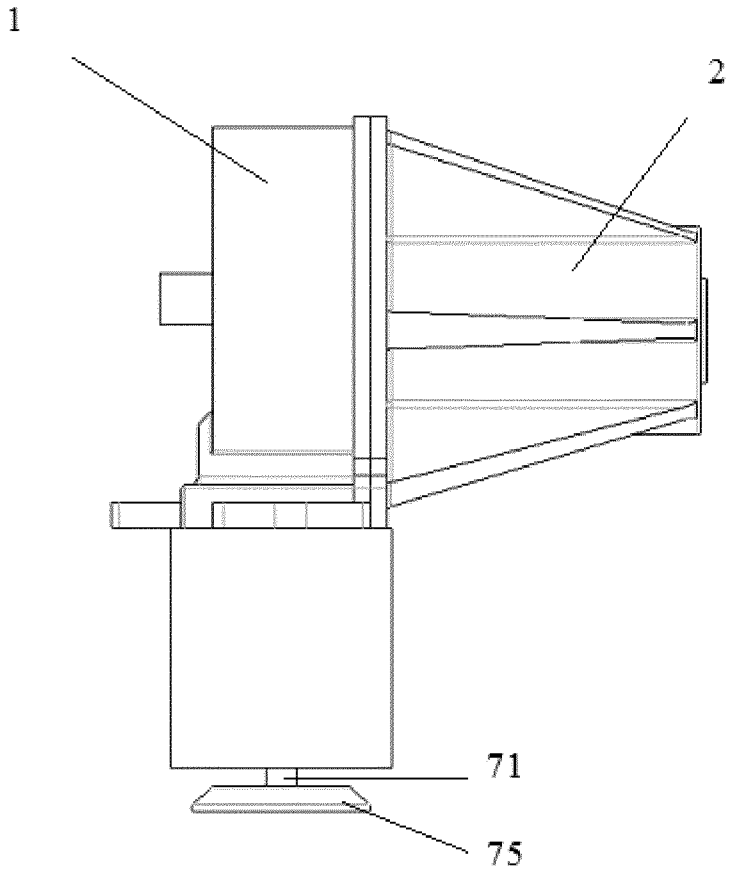



Fig. 2

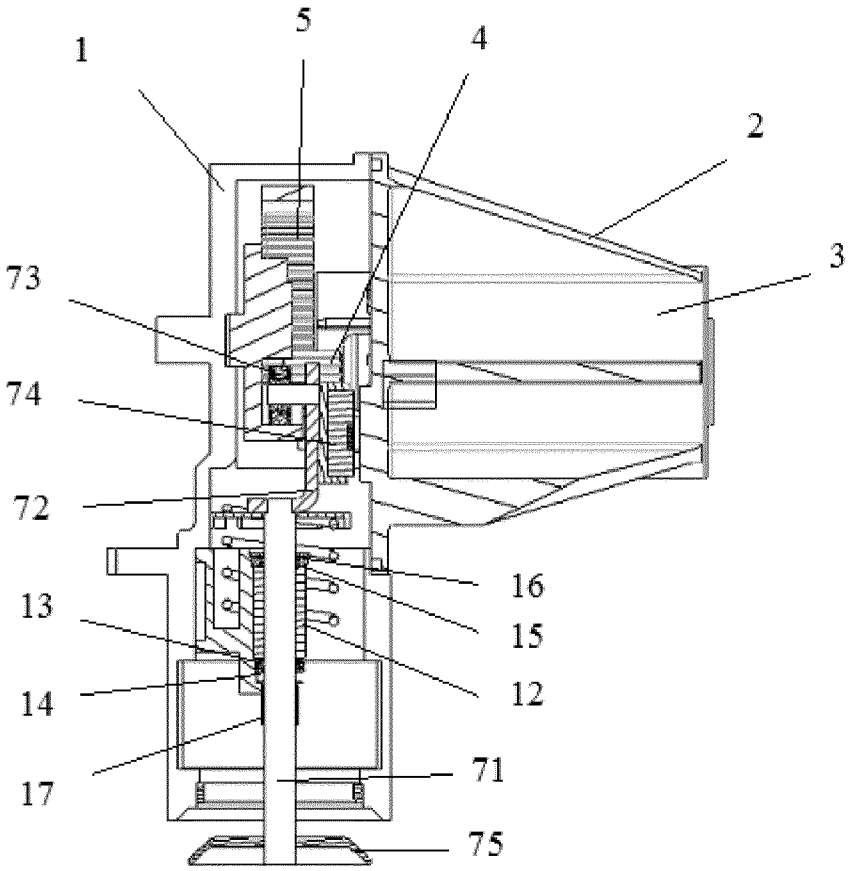



Fig. 3

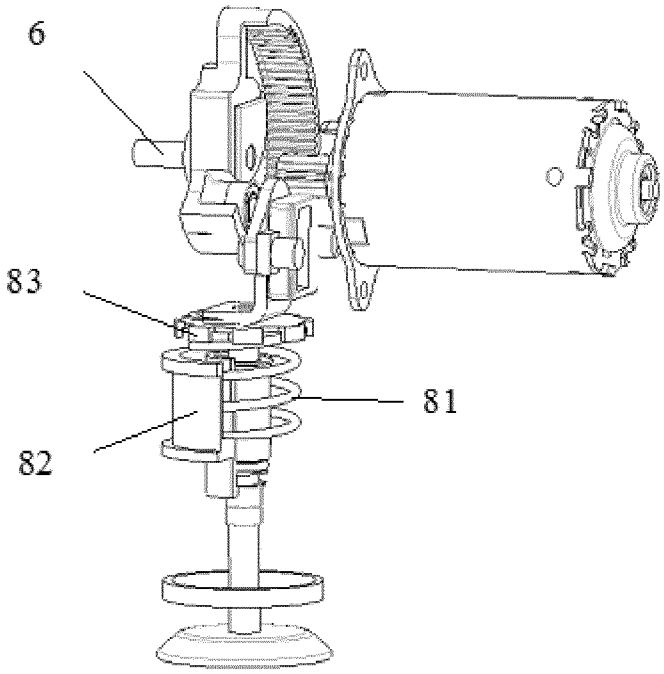



Fig. 4

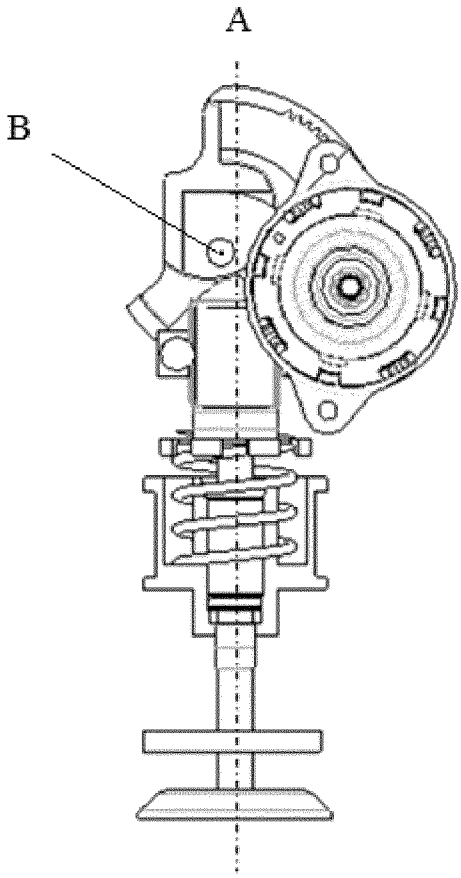



Fig. 5

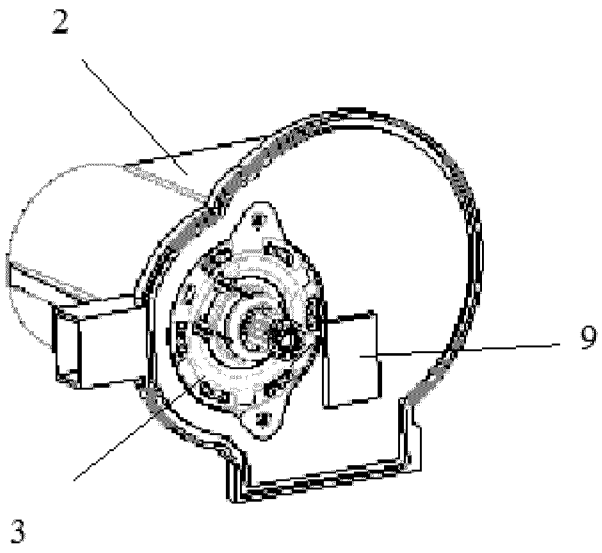



Fig. 6

# INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/068069

A. CLASSIFICATION OF SUBJECT MATTER
INV. F02M26/65 F16K31/04 F02M26/50 F02M26/54
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F02M F16K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
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☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 11 October 2017 | 20/10/2017 |

| Name and mailing address of the ISA/ | Authorized officer |
|---|---|
| European Patent Office, P.B. 5818 Patentlaan 2<br>NL - 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040,<br>Fax: (+31-70) 340-3016 | Rauch, Vincent |

1

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Information on patent family members

International application No
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