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(54) Title: LINEAR DRIVING DEVICE, CONNECTOR AND EXHAUST GAS RECIRCULATION CONTROL VALVE

(57) Abstract: The present invention relates to a linear drive device (1) comprising: a motor (2); a speed-reducing transmission stage comprising a pinion gear (5) fixedly connected to an output shaft of the motor and a transmission gear (6) meshing with the pinion gear (5); and a linear transmission stage for transforming a rotational movement of the transmission gear (6) into a linear movement of an output connecting rod (7), the output connecting rod being received in a sleeve member (10) so as to merely move linearly; wherein a spiral trench (8) is provided on the transmission gear (6), a follower (9) capable of moving in the trench (8) is received in the trench (8), the follower (9) is connected to the output connecting rod (7) via a connector (17), and the connector (17) is designed as a right-angle member.

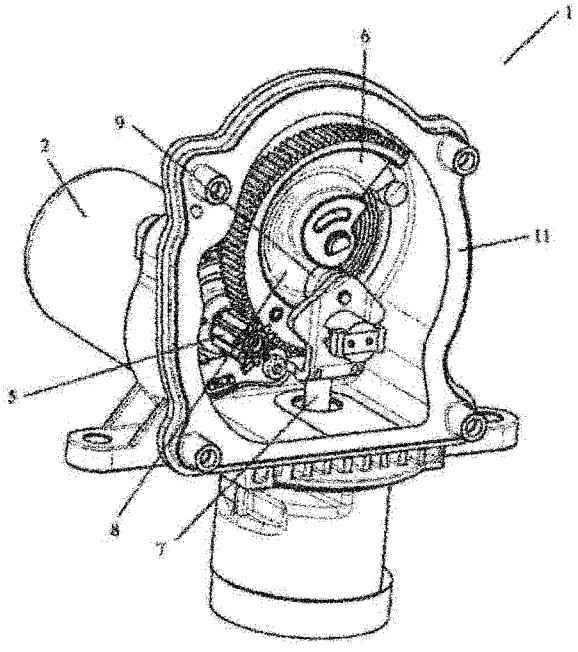

Fig. 1

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LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

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Description

Linear driving device, connector and exhaust gas recirculation control valve

Technical field

The present invention relates to a linear drive device, a connector for a linear drive device and an exhaust gas recirculation control valve with a linear drive device.

Background Art

In industries such as the automotive industry, a valve device able to be precisely controlled is generally required, for example, an exhaust gas recirculation control valve for use in an engine exhaust gas recirculation system. In such a valve device, a linear drive device able to be precisely controlled is required, and it is desirable that this valve device can be as light as possible and miniaturized.

A connector for a rotational movement part and a linear movement part generally has a complex structure and high machining costs, and can hardly avoid the influence of shaking or swinging on a sensor.

Contents of the invention

The technical problem to be solved by the present invention is that of proposing a linear drive device, in which a connector for connecting a rotational movement part and a linear movement part allows easy assembling, the capability of guiding, and avoids the influence of a substantial rotation on a sensor signal.

The present invention proposes a linear drive device, comprising:

a motor;

a speed-reducing transmission stage comprising a pinion gear fixedly connected to an output shaft of the motor and a transmission gear meshing with the pinion gear;

a linear transmission stage for transforming a rotational movement of the transmission gear into a linear movement of a output connecting rod, said output connecting rod being received in a sleeve member so as to merely move linearly;

wherein a spiral trench is provided on the transmission gear, a follower capable of moving in the trench is received in said trench, the follower is connected to said output connecting rod via a connector, and said connector is designed as a right-angle member.

In a preferred embodiment, said follower comprises a bearing and a pin shaft inserted into an inner ring of said bearing.

In a preferred embodiment, a first hole for connecting the pin shaft of the follower is provided in a vertical face of said connector.

In a preferred embodiment, a second hole for connecting a connecting rod journal of the output connecting rod is provided in a horizontal face of said connector.

In a preferred embodiment, a third hole for connecting a sensor pointer of a position sensor is further provided in the vertical face of said connector.

In a preferred embodiment, centre axes of the first hole, the second hole and the third hole are all located in a centre plane of the connector.

In a preferred embodiment, an arcuate wing portion is provided in the vertical face of said connector.

In a preferred embodiment, two inwardly concave reinforcement ribs are provided at the right-angle corner where the vertical face and the horizontal face of the connector meet each other.

In a preferred embodiment, said reinforcement ribs are formed by stamping, and/or said reinforcement ribs intersect the vertical face at an angle of 30 degrees to 60 degrees.

The present invention further relates to a connector which is designed as a right-angle member, characterized in that a first hole is provided in a vertical face of said connector, a second hole is provided in a horizontal face of said connector, a third hole is further provided in the vertical face of said connector, centre axes of the first hole, the second hole and the third hole are all located in a centre plane of the connector, and an arcuate wing portion is provided in the vertical face of said connector.

The present invention furthermore relates to an exhaust gas recirculation control valve for use in an exhaust gas recirculation circuit of an engine, the exhaust gas recirculation control valve comprising a linear drive device according to the present invention.

Description of the accompanying drawings

Figure 1 shows a perspective view of a preferred embodiment of a linear drive device according to the present invention.

Figure 2 shows another perspective view of the preferred embodiment of the linear drive device according to the present invention, without showing an external housing.

Figure 3 shows a sectional view of the preferred embodiment of the linear drive device according to the present invention.

Figure 4 shows a front view of a transmission gear according to the present invention as well as a follower received in a trench thereof.

Figure 5 shows a front view of an output assembly comprising an output connecting rod and the follower.

Figure 6 shows a side view of the output assembly comprising the output connecting rod and the follower.

Figure 7 shows a sectional view of the output assembly comprising the output connecting rod and the follower.

Figure 8 shows a perspective view of a connector.

Figure 9 shows a front view of the connector.

Figure 10 shows a side view of the connector.

Figure 11 shows a top view of the connector.

Figure 12 shows a rear view of the connector.

Figure 13 shows a front view of a sector gear.

Figure 14 shows a perspective view of a volute spring together with an axle.

Figure 15 shows a front view of the volute spring together with the axle.

Specific embodiments

The linear drive device, the connector and the corresponding exhaust gas recirculation control valve according to embodiments of the present invention will be described with reference to the drawings. In the following description, many specific details are set forth in order to enable a person skilled in the art to more completely understand the present invention. However, it will be apparent to a person skilled in the field that the present invention may be achieved without some of these specific details. Furthermore, it should be understood that the present invention is not limited to the particular embodiments described herein. Instead, it is envisaged herein that any combination of the following features and elements can be used to implement the present invention, regardless of whether or not they are involved in different embodiments. Therefore, the following aspects, features, embodiments and advantages are merely illustrative and should not be regarded as elements or definitions of the claims, unless explicitly stated in the claims.

Taking a linear drive device of an exhaust gas recirculation control valve for use in the engine exhaust gas recirculation as an example, the linear drive device according to the present invention will be explained below, but the present invention is not limited thereto. The linear drive device according to the present invention can be used with any equipment requiring small precise linear control, such as a variety of valves and actuators.

A preferred embodiment of a linear drive device according to the present invention is shown in figures 1-3. In the embodiment, the linear drive device 1 comprises a motor 2, a first transmission stage (speed-reducing transmission stage) and a second transmission stage (linear transmission stage). The linear drive device causes a linear movement of an output connecting rod 7 by means of the driving of the motor 2. In order to prevent dust or other foreign substances from entering and thus damaging the drive device, a housing 11 and a corresponding sealing system are provided.

The first transmission stage, namely the speed-reducing transmission stage comprises a pinion gear 5 fixedly connected to an output shaft of the motor and a transmission gear 6 meshing with the pinion gear 5. When the motor 2 operates, the pinion gear 5 is driven to rotate, so that the transmission gear 6 meshing with the pinion gear 5 is rotated.

The second transmission stage is a linear transmission stage for transforming the rotational movement of the transmission gear 6 into the linear movement of the output connecting rod 7. The second transmission stage comprises a spiral trench 8 formed on the transmission gear 6, a follower 9 received in the trench 8 and the output connecting rod 7 fixedly connected to the follower 9.

The spiral trench 8 is for example of an involute shape. The centre of the spiral trench 8 coincides with the centre of the transmission gear 6. Since the arc length by which the spiral trench 8 rotates in one stroke of the linear transmission stage may be very large, the pressure angle between the trench 8 and the linear transmission stage is reduced. In the case that the transmitted force required has a given component in the direction of the linear movement, the reduction in the pressure angle results in an increase in the cosine value thereof, and thus an reduction in the transmission force between the trench 8 and the linear transmission stage. Therefore, the spiral trench 8 extends through an angle of 90 degrees to 320 degrees, preferably 90 degrees to 300 degrees, and more preferably 180 degrees to 300 degrees, in a circumferential direction of the transmission gear 6.

The follower 9 may comprise a roller or a rolling bearing or a sliding bearing. Preferably, the follower 9 comprises a ball bearing as shown in figure 4. By using the ball bearing, the friction loss is reduced and the efficiency is improved. In the embodiment shown in figure 5, the follower 9 comprises a ball

bearing 91 and a pin shaft 92, wherein the ball bearing 91 bears in the trench 8 of the transmission gear 6 and is able to roll along the trench, and one end of the pin shaft 92 is connected to an inner ring of the ball bearing 91 and the other end is supported in a connector 17.

Figures 5-7 show an output assembly comprising the follower 9 and the output connecting rod 7, wherein the output connecting rod is connected to the pin shaft 92 of the follower 9 via the connector 17.

The connector 17 for connecting the follower 9 with the output connecting rod 7 will be explained below by means of figures 8-12. The connector 17 is designed as a right-angle member, and is provided in a vertical face thereof with a first hole 18 for connecting the follower 9. In particular, the pin shaft 92 of the follower 9 is received in said first hole 18. A second hole 19 for connecting a connecting rod journal 71 of the output connecting rod 7 is provided in a horizontal face. Furthermore, a third hole 20 for receiving a sensor pointer 22 of a position sensor is further provided in the vertical face. The sensor pointer 22 is used for transferring information on the position of the connector to the sensor. The centre axes of the first hole 18, the second hole 19 and the third hole 20 are all located in a centre plane A of the connector 17 (see figures 9 and 11). The centre plane bisects the connector 17 in a vertical direction. In other words, the connector 17 is generally in mirror symmetry to the centre plane.

During assembling, the pin shaft 91 of the follower 9 is pre-installed in the first hole 18 in a tight fit, and then the two are welded in order to ensure the connection strength; a riveting method and the like can also be used to achieve the connection. This is also the case of the connection of the output connecting rod 7 and the connector 17, wherein firstly the connecting rod journal 71 is pre-installed in the second hole 19 in a tight fit, and then welding is carried out in order to ensure

the connection strength; a riveting method and the like can also be used to achieve the connection. The sensor pointer 22 is in snap fit with the connector, and a hot riveting method and the like can also be used.

Finally, an arcuate wing portion 21 is provided in the vertical face. The arcuate wing portion 21 protrudes towards one side of the transmission gear 6, and is close to the transmission gear 6 as much as possible but not in contact therewith, so as to prevent the generation of scraping which would otherwise damage the gear. When the connector 17 swings, one side of the arcuate wing portion 21 comes into contact with the transmission gear 6, thereby preventing a substantial swinging of the connector which would otherwise influence the sensor signal.

Two inwardly concave reinforcement ribs 23 are provided at a corner where the vertical face and the horizontal face of the connector 17 meet each other. Said reinforcement ribs 23 increase the bending strength of the part as a whole. The reinforcement ribs are formed by stamping, and intersect the two right-angle faces at an angle of 30 degrees to 60 degrees, particularly 45 degrees.

This connector is small in volume, is easy to machine and achieves a variety of functions: connecting and transmitting moment of force, connecting the sensor pointer and preventing a substantial rotation.

The output connecting rod 7 is provided in a sleeve member 10, and thus it can only linearly move up and down (see figure 3). When the transmission gear 6 rotates, the follower 9 is displaced along the trench 8, and due to the spiral shape of the trench 8, the follower 9 is moved up and down, so that the output connecting rod 7 is driven to move up and down.

In one embodiment, as shown in figure 6, the transmission gear 6 is a sector gear. Since an unused portion is eliminated, the material is saved and the assembly is facilitated.

In one embodiment, a form-fitting structure exists between the transmission gear 6 and the housing 11 for enclosing the linear drive device. In the illustrated embodiment, a pin 12 is fixed to the transmission gear 6 (see figure 4), and the pin, when mating with a feature on the housing 11, can be used as a mechanical stop to prevent the follower 9 from falling out of the trench 8 of the transmission gear 6.

Preferably, the dimensions of the sectoral face of the sector gear are exactly adapted to the length of the spiral trench 8. That is to say, the entire sectoral face is used for the transmission.

In order to enable the output connecting rod 7 to return back to the initial position even if the motor 2 malfunctions or is de-energized, the linear transmission device preferably further comprises a restoring system for restoring without electricity as shown in figures 7 and 8. It is well known that when the motor is energized, the driving thereof in two opposite directions can achieve the driving and the restoring. However, when the motor is de-energized (for example, due to a failure or for other reasons), it is desirable that the transmission device can also restore to the initial position, so that there is a need for such a restoring system.

The restoring system comprises an axle 13 for bearing the transmission gear 6 and a spring. The spring may be a torsion spring (such as a spiral torsion spring or a torsion bar spring). In addition, the spring may also be the volute spring 14 fixed to the axle 13 as shown in the figure. The axle 13 is mounted at two end portions thereof to the housing 11 via bearings. The axle 13 and the transmission gear 6 are connected in a relatively non-rotatable manner. One end of the volute spring 14 is fixed to the housing 11 of the device, and the other end is directly

or indirectly fixed to the axle 13. After the assembling is completed, in the initial position of the transmission device, the volute spring 14 is in a pre-stressed state and applies a torque to the axle 13, so that the linear transmission stage trends to move upwards. Since the spring in the initial position is already in a pre-stressed state, when the valve is opened to the largest degree, the pre-stressing force of the spring is higher. By means of using the volute spring 14, the restoring force is increased and the fixing is facilitated, with a saving in space.

The fixing of the volute spring 14 to the axle 13 may be carried out by using a spring bushing 15. The spring bushing 15 is fixed to the axle 13 in such a way that it surrounds the axle 13 and is provided with a groove 16, and an end portion of the volute spring 14 is received in the groove 16. With this approach, the fixing of the spring is more convenient, and the force is transferred to the axle 13 better.

The axle 13 may also be integrally formed with the spring bushing 15, such that the spring is directly connected to the axle 13. Of course, it is also contemplated that the groove 16 for receiving the end portion of the volute spring 14 is directly provided in the axle 13 to realize the function of connection.

Of course, other methods for fixing the spring are also contemplated, for example, by fixing one end of the spring to the housing and the other end to the transmission gear. In addition, as to the volute spring, the rotation may be along either an inner ring or an outer ring.

In one embodiment, the axle 13 at least partially has a non-circular cross section, for example a D-shaped cross section as shown in figures 7 and 8, or may be of other shapes such as square and the like. As a result of the design, the relatively non-rotatable connection of the axle 13 and the transmission gear

6 can be easily achieved by means of providing a form-fitting through-hole in the transmission gear 6.

The linear drive device 1 may comprise a sensor (not shown) for detecting a position of the connecting rod, and said sensor may be an inductive sensor, a Hall sensor, a magnetoresistive sensor or a contact sensor. These sensors can be arranged in different positions, and can detect different types of movements depending on the different types of sensors.

The linear drive device 1 can be used in a valve device, in particular an exhaust gas recirculation control valve in an engine exhaust gas recirculation system. The engine exhaust gas recirculation system is well known. In such an exhaust gas recirculation system, the exhaust gas recirculation control valve is used in an exhaust gas recirculation pipe to control the amount of the recirculated exhaust gas.

For applications in the exhaust gas recirculation valve or other valve devices, the output connecting rod 7 of the linear drive device is connected to a valve head 3, and drives the valve head 3 to move when the output connecting rod 7 moves, so as to change the distance of the valve head from a valve seat (not shown), thereby realizing an adjustment of the valve. The motor 2 of the linear drive device 1 of the exhaust gas recirculation control valve is controlled to drive the valve head 3 to move up and down by means of the output connecting rod 7 of the linear drive device, so that the valve is closed or opened. When the exhaust gas recirculation control valve is de-energized, due to the pre-stressing of the spring, a spring force is applied to the axle 13 and causes the axle 13 to rotate, thereby driving the rotation of the transmission gear 6, and the trench 8 on the transmission gear 6 drives the follower 9, thereby driving the connecting rod 7 to move upward until the valve is closed.

In addition, the current position of the output connecting rod 7 is detected by the sensor and is transmitted to a control device so as to control the exhaust gas recirculation control valve.

While the present invention has been disclosed above by means of the relatively preferred embodiments, the present invention is not limited thereto. A variety of changes and modifications made by a person skilled in the art, without departing from the spirit and scope of the present invention, should be included in the scope of protection of the present invention, and thus the scope of protection of the present invention is defined by the claims.

List of reference signs

1	linear drive device
2	motor
3	valve head
5	pinion gear
6	transmission gear
7	output connecting rod
8	trench
9	follower
10	sleeve member
11	housing
12	pin
13	axle
14	volute spring
15	spring bushing
16	groove
17	connector
18	first hole
19	second hole
20	third hole
21	wing portion
22	sensor pointer
23	reinforcement rib
71	connection journal
91	ball bearing
92	pin shaft
A	centre plane

Patent claims

1. A linear drive device (1), comprising:
a motor (2);
a speed-reducing transmission stage comprising a pinion gear (5) fixedly connected to an output shaft of the motor and a transmission gear (6) meshing with the pinion gear (5); and
a linear transmission stage for transforming a rotational movement of the transmission gear (6) into a linear movement of a output connecting rod (7), said output connecting rod being received in a sleeve member (10) so as to merely move linearly;
characterized in that,
a spiral trench (8) is provided on the transmission gear (6), a follower (9) capable of moving in the trench (8) is received in said trench (8), the follower (9) is connected to said output connecting rod (7) via a connector (17), and said connector (17) is designed as a right-angle member.

2. The linear drive device as claimed in claim 1, characterized in that said follower (9) comprises a bearing (91) and a pin shaft (92) inserted into an inner ring of said bearing (91).

3. The linear drive device as claimed in claim 2, characterized in that a first hole (18) for connecting the pin shaft (92) of the follower (9) is provided in a vertical face of said connector (17).

4. The linear drive device as claimed in claim 3, characterized in that a second hole (19) for connecting a connecting rod journal (71) of the output connecting rod (7) is provided in a horizontal face of said connector (17).

5. The linear drive device as claimed in claim 4, characterized in that a third hole (20) for connecting a sensor pointer

(22) of a position sensor is further provided in the vertical face of said connector (17).

6. The linear drive device as claimed in claim 5, characterized in that centre axes of the first hole (18), the second hole (19) and the third hole (20) are all located in a centre plane (A) of the connector (17).

7. The linear drive device as claimed in claim 1, characterized in that an arcuate wing portion (21) is provided in the vertical face of said connector (17).

8. The linear drive device as claimed in claim 1, characterized in that two inwardly concave reinforcement ribs (23) are provided at the right-angle corner where the vertical face and the horizontal face of the connector (17) meet each other.

9. The linear drive device as claimed in claim 8, characterized in that said reinforcement ribs (23) are formed by stamping, and/or said reinforcement ribs (23) intersect the vertical face at an angle of 30 degrees to 60 degrees.

10. A connector, the connector (17) being designed as a right-angle member, characterized in that a first hole (18) is provided in a vertical face of said connector (17), a second hole (19) is provided in a horizontal face of said connector (17), a third hole (20) is further provided in the vertical face of said connector (17), the centre axes of the first hole (18), the second hole (19) and the third hole (20) are all located in a centre plane of the connector (17), and an arcuate wing portion (21) is provided in the vertical face of said connector (17).

11. An exhaust gas recirculation control valve for use in an exhaust gas recirculation circuit of an engine, characterized in that said exhaust gas recirculation control valve

comprises a linear drive device (1) as claimed in any one of claims 1-9.

Drawings of description

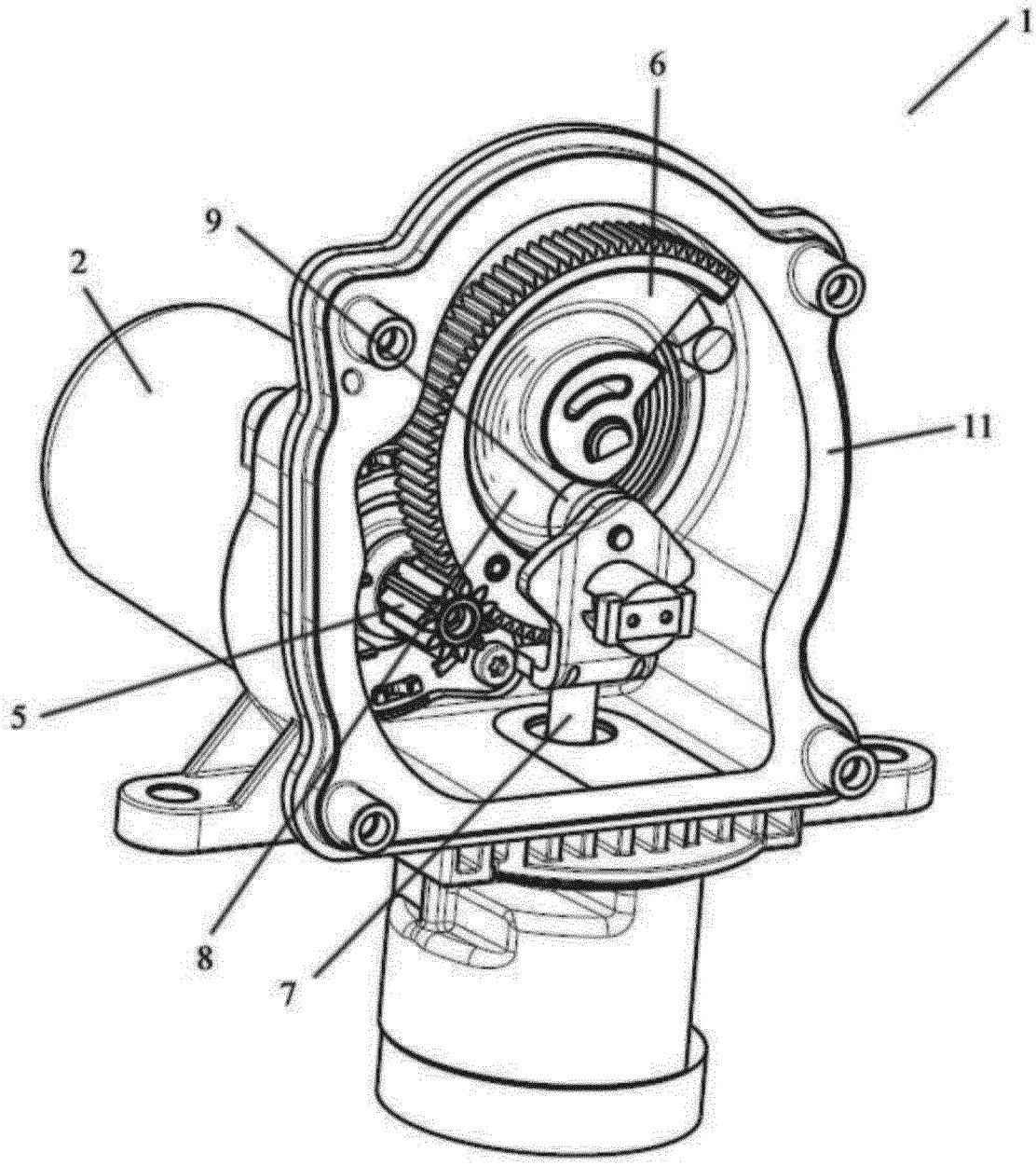

Fig. 1

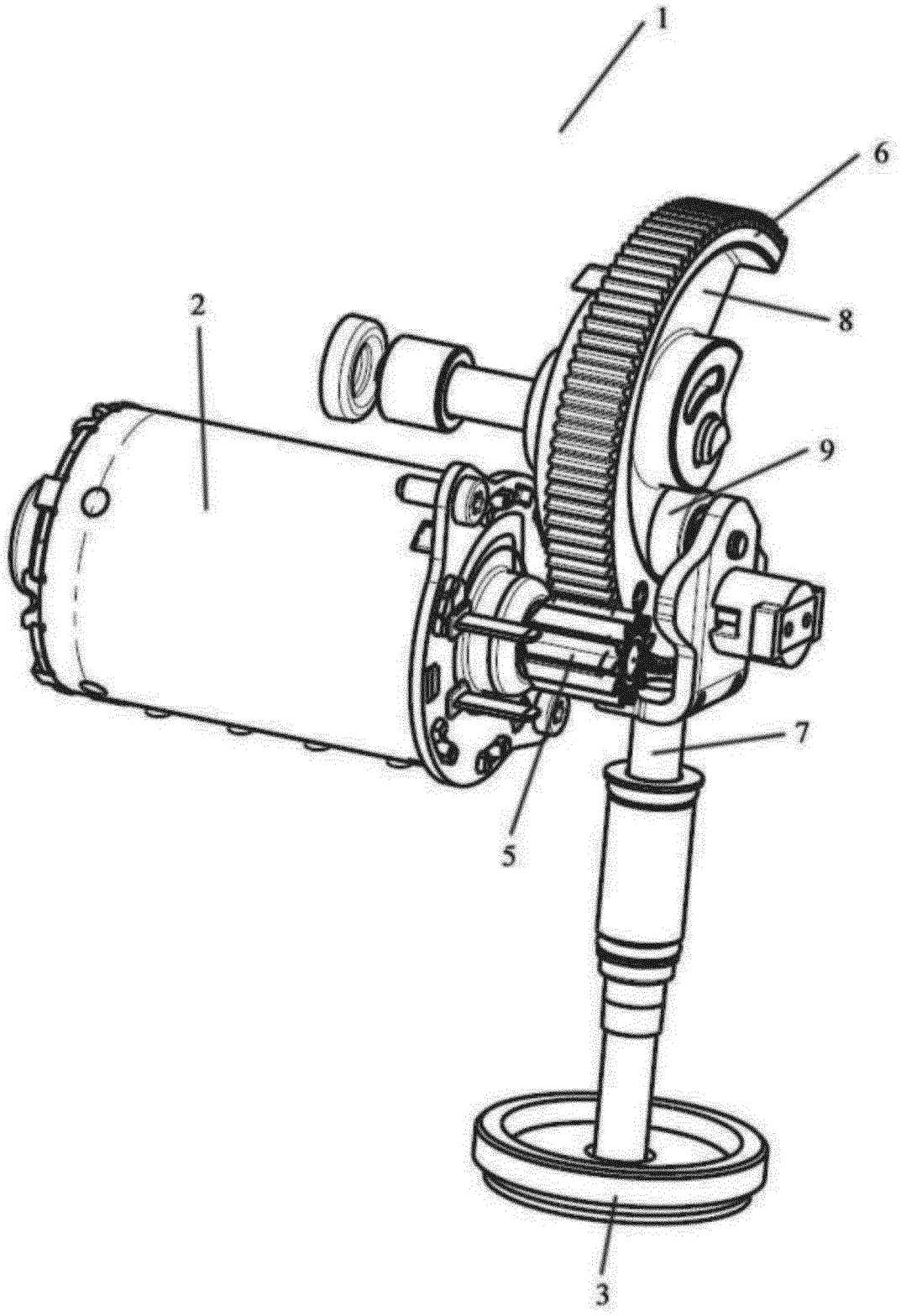

Fig. 2

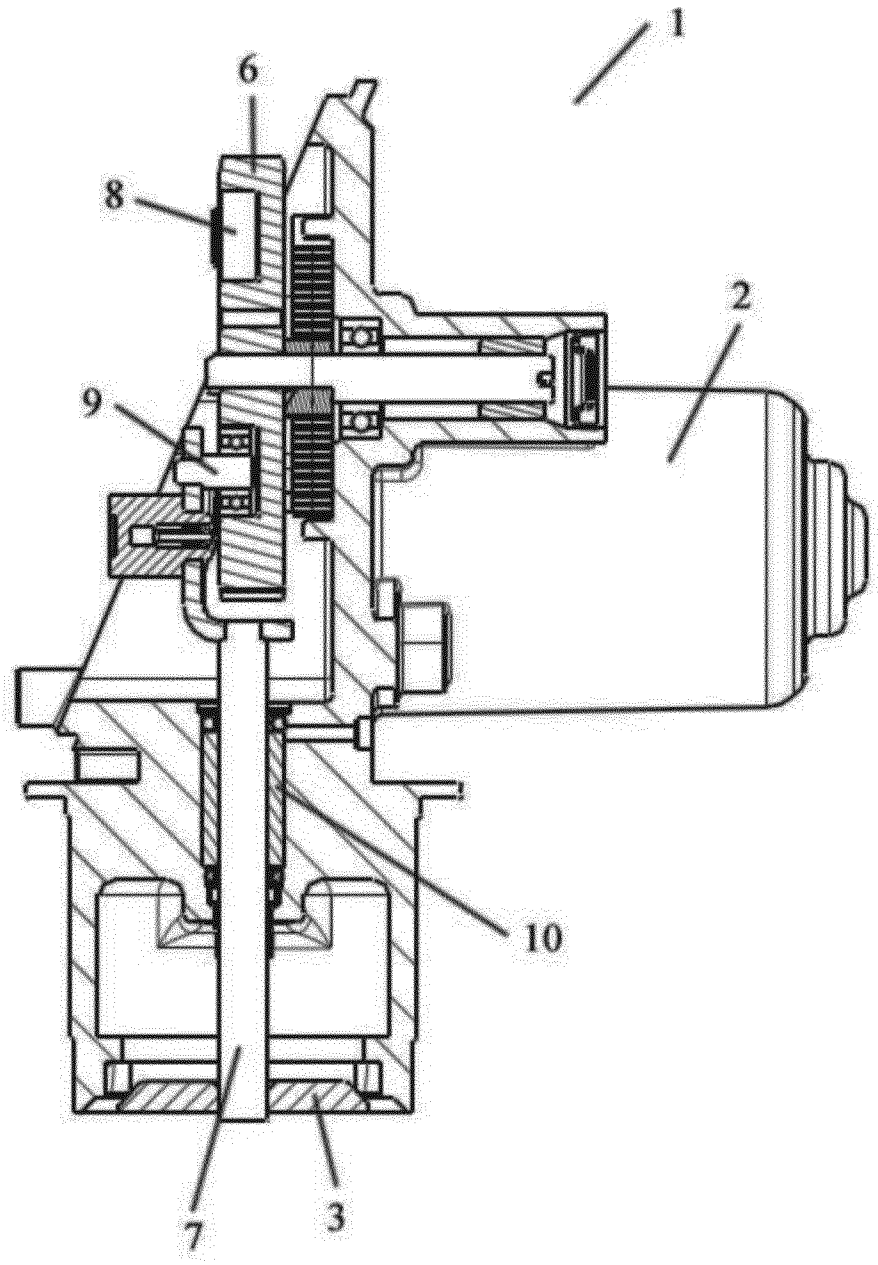

Fig. 3

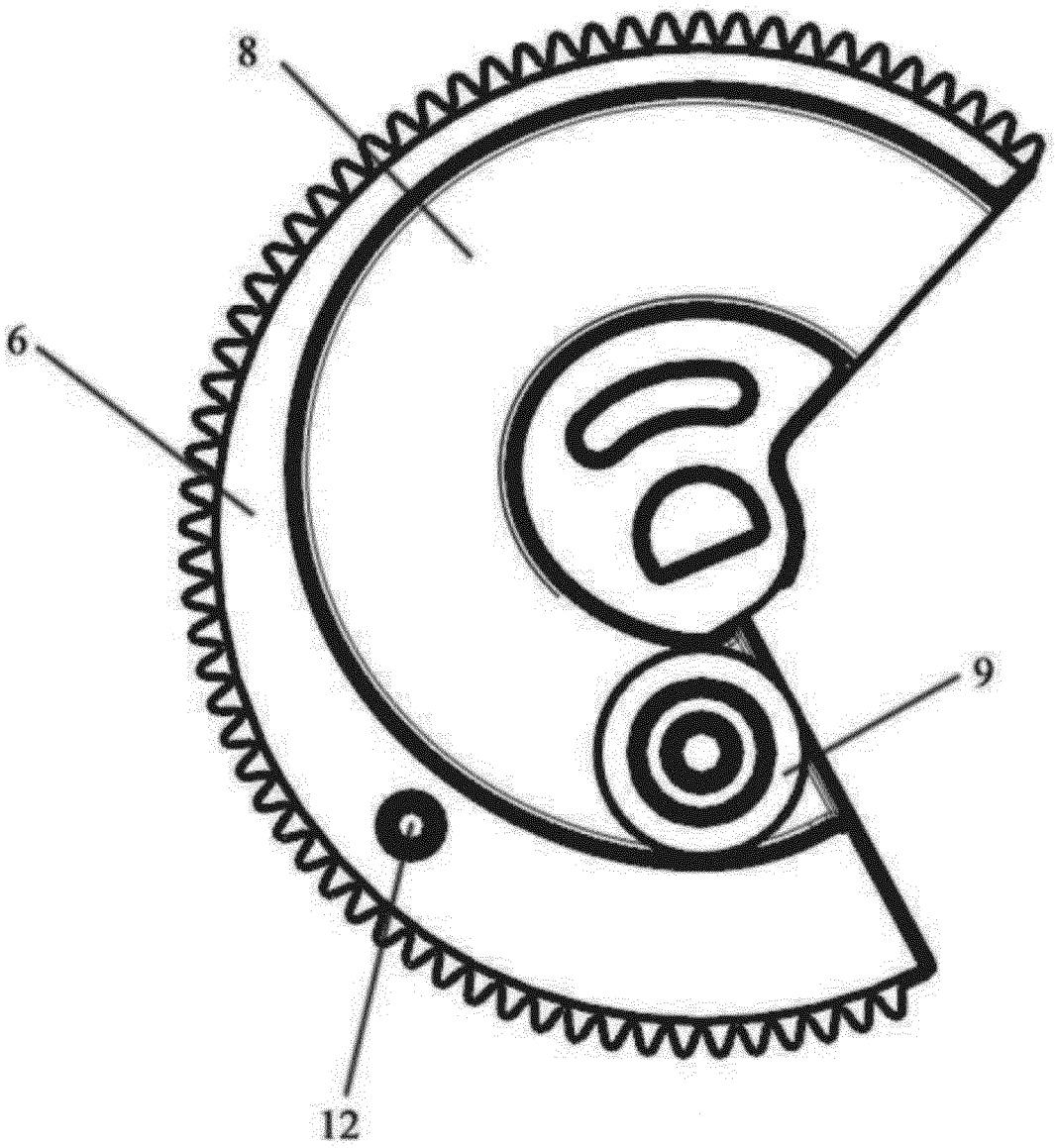

Fig. 4

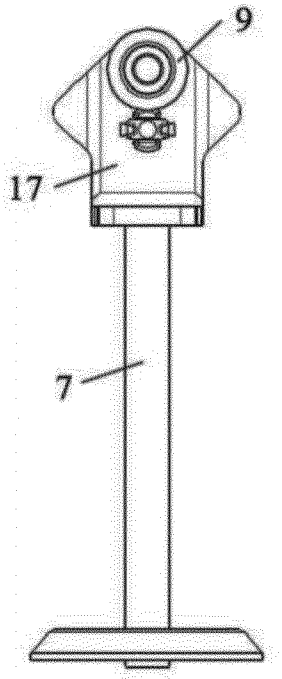

Fig. 5

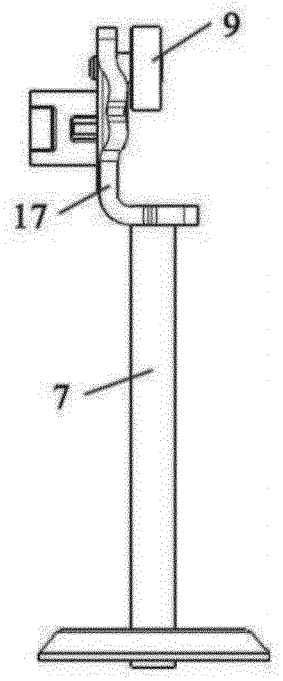

Fig. 6

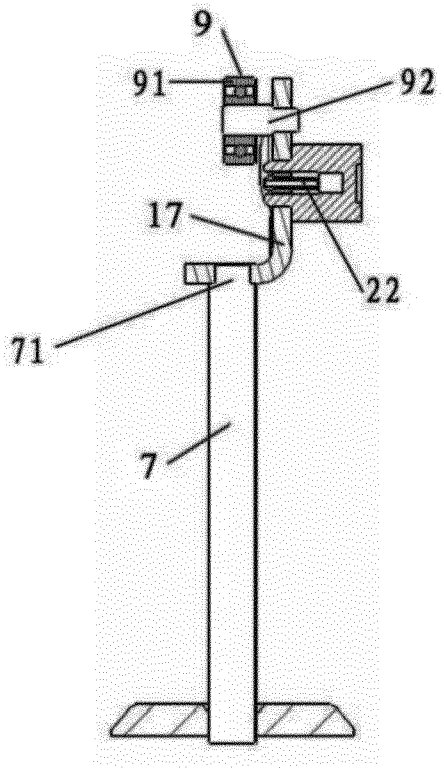

Fig. 7

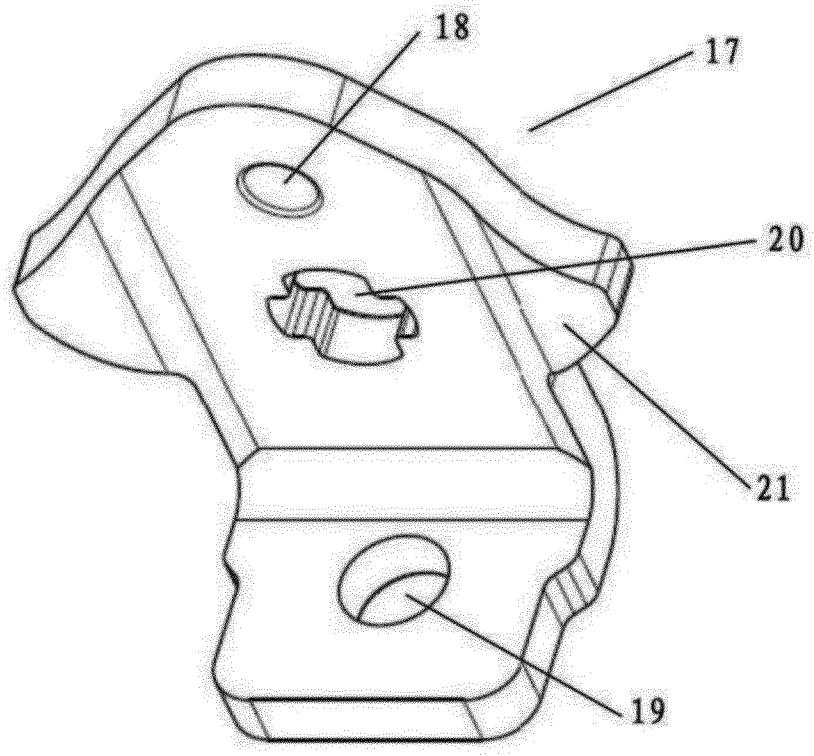

Fig. 8

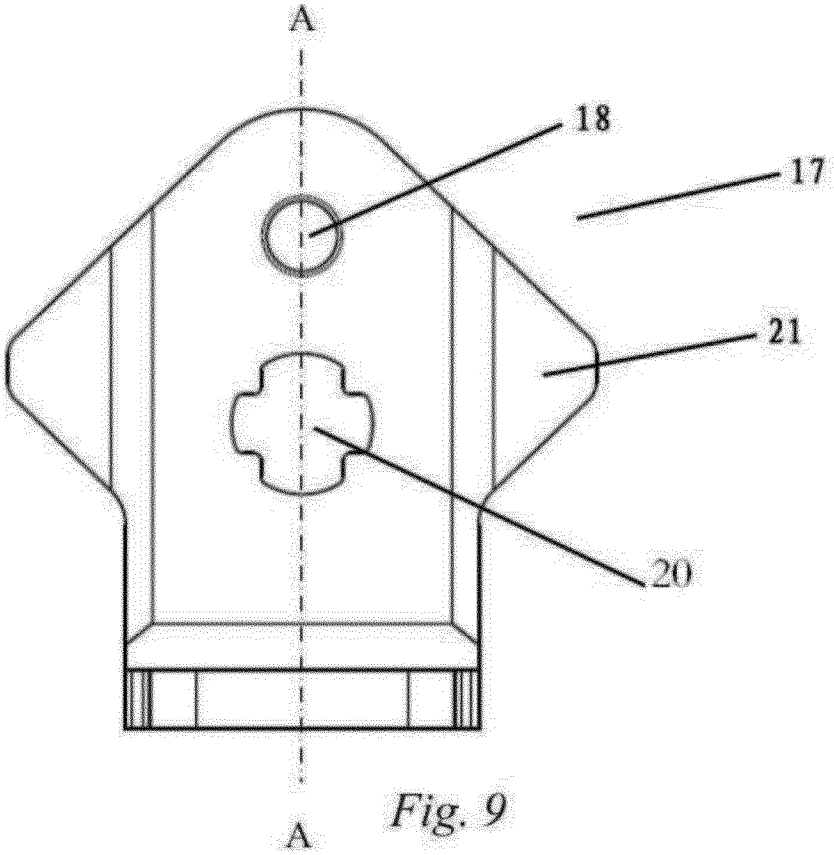

Fig. 9

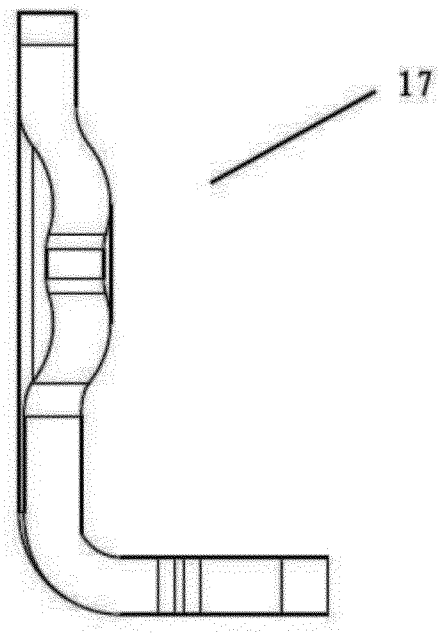

Fig. 10

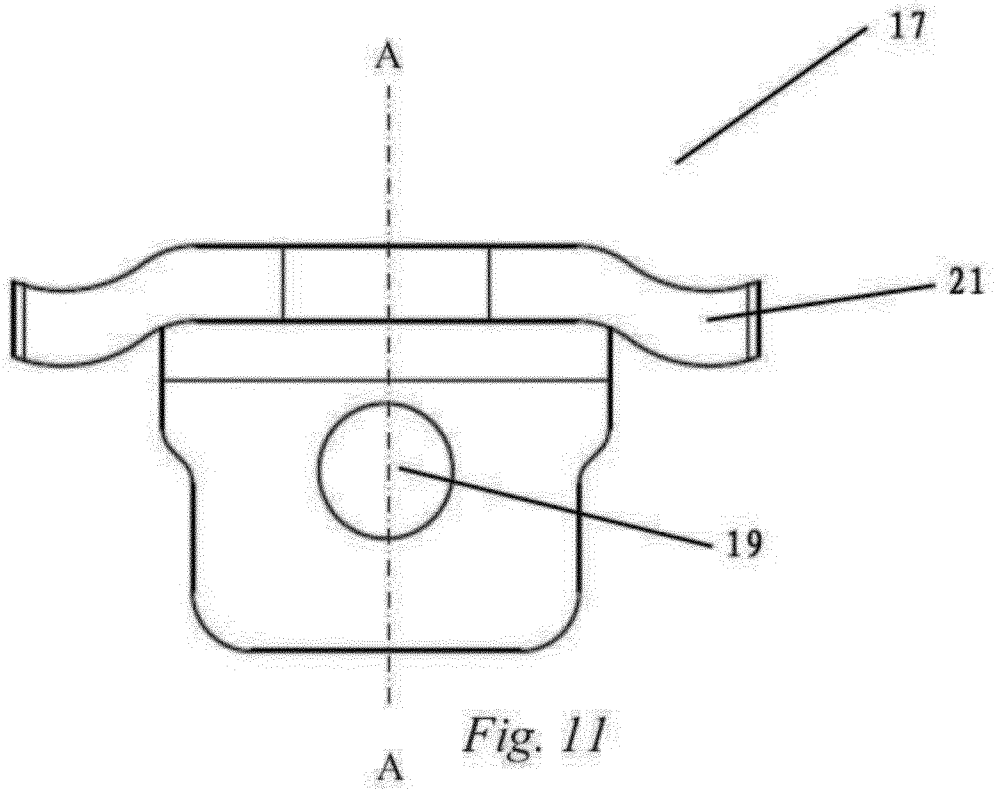

Fig. 11

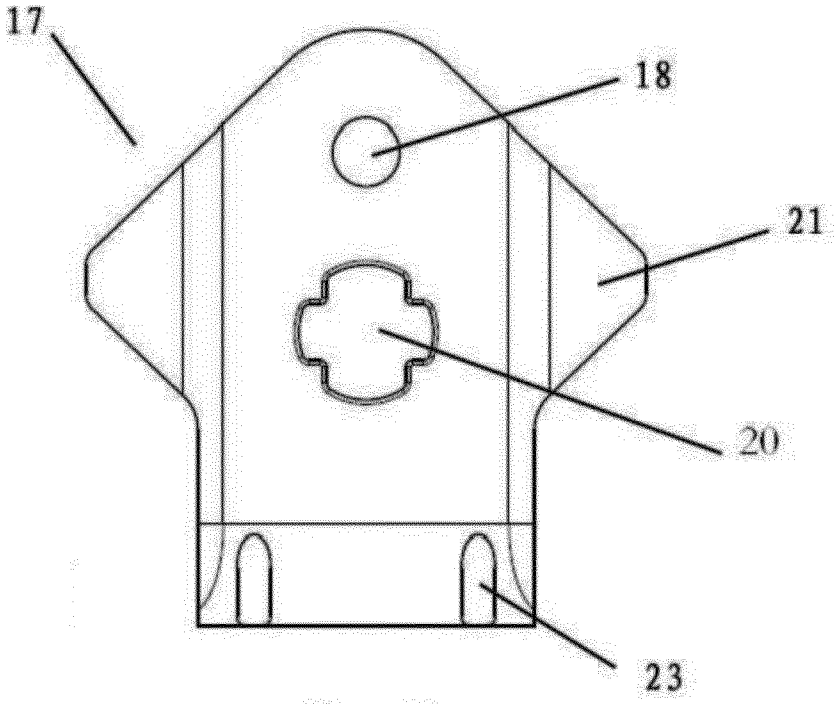

Fig. 12

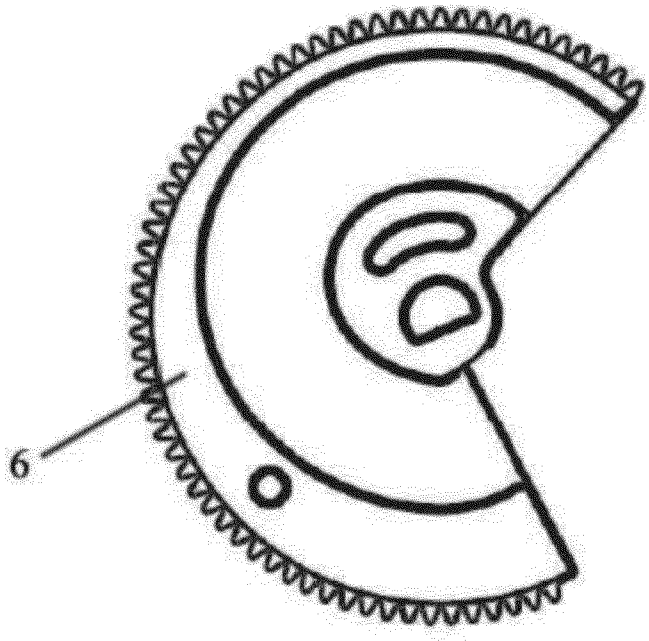

Fig. 13

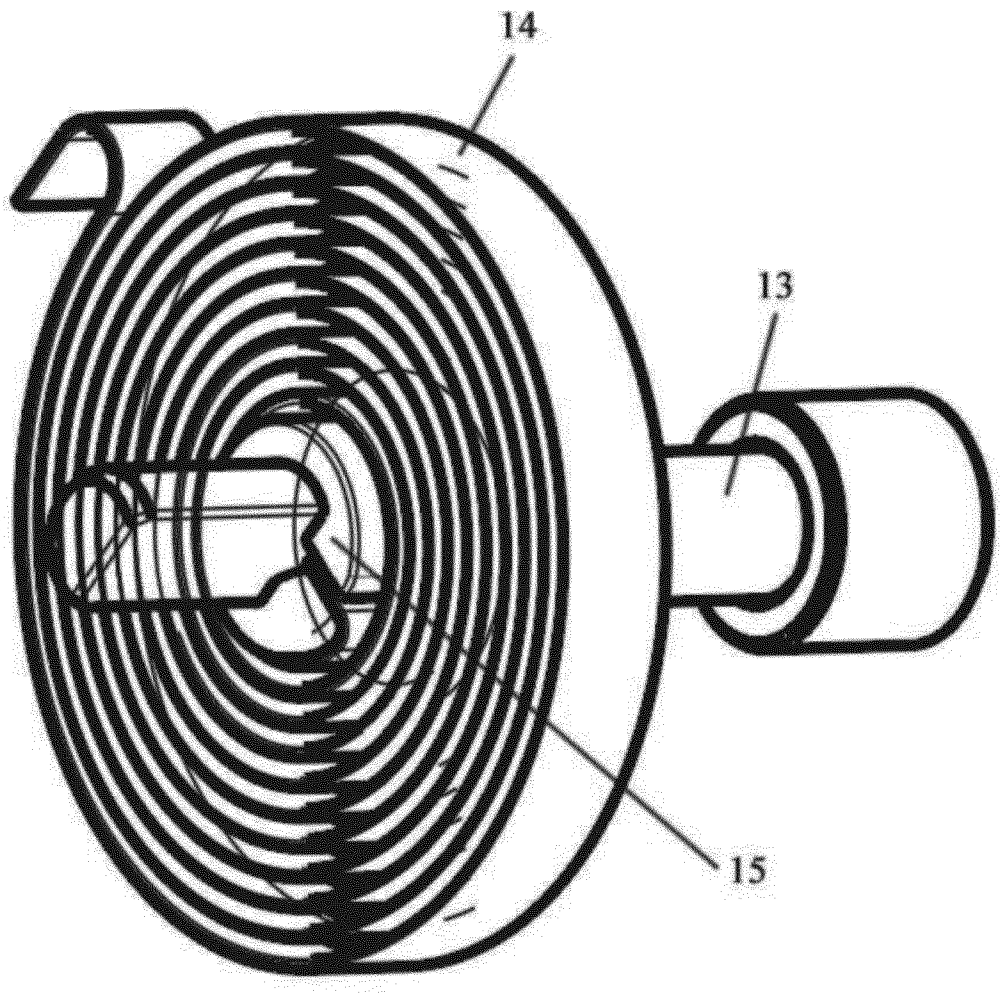

Fig. 14

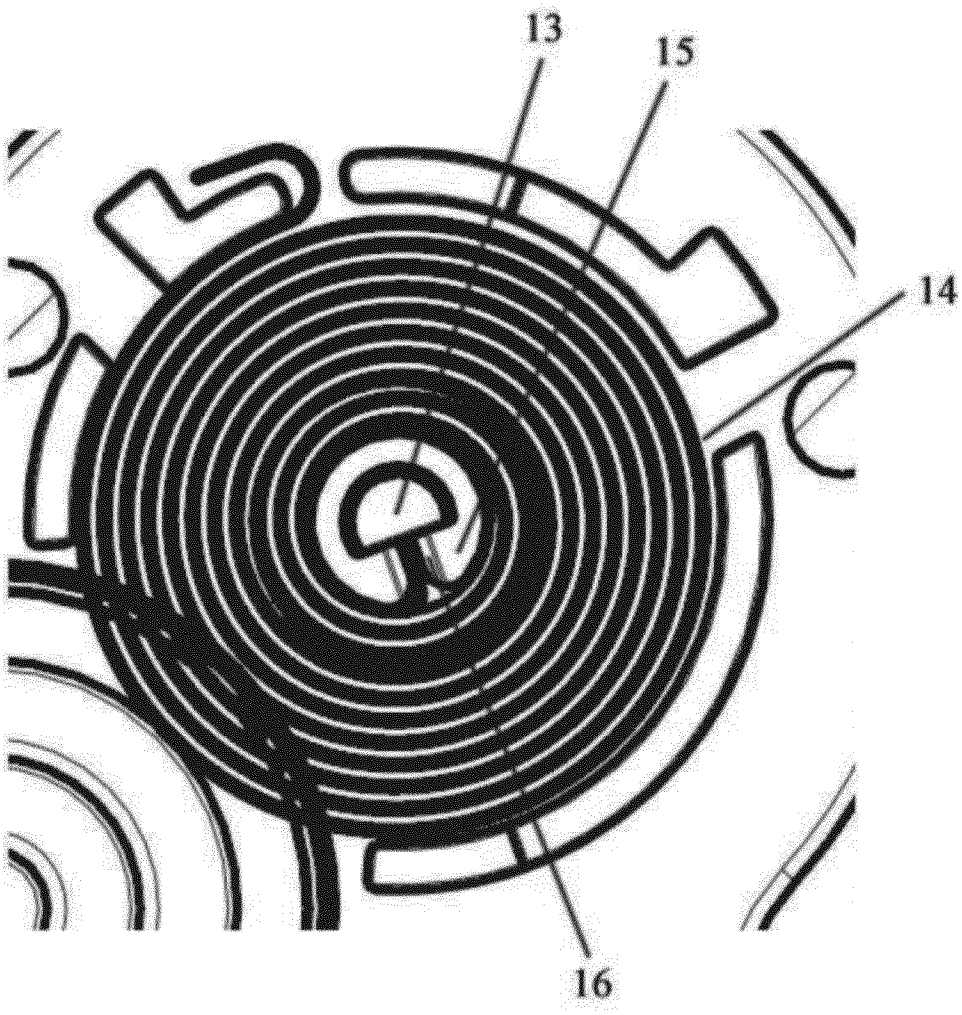

Fig. 15

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/068975

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16H25/18 F02M25/07 F16K31/528 F16K31/53 F16H37/12 F16K31/04
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)
F16H F02M F16K F01L H02K

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.
X	CN 202 561 210 U (CONTINENTAL AUTOMOTIVE WUHU CO LTD) 28 November 2012 (2012-11-28)	1-7,10,
A	figures 1-4	11 8,9

X	CN 201 747 485 U (WUXI LONGSHENG TECHNOLOGY CO) 16 February 2011 (2011-02-16)	1-4,7,11
A	figures	5,6,8-10

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 October 2014	06/11/2014

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

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2014/068975

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
CN 202561210 U	28-11-2012	CN 202561210 U	28-11-2012
		WO 2013167704 A1	14-11-2013
CN 201747485 U	16-02-2011	NONE	