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(54) **ACCELERATOR PEDAL MODULE**

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(57) **ABSTRACT**

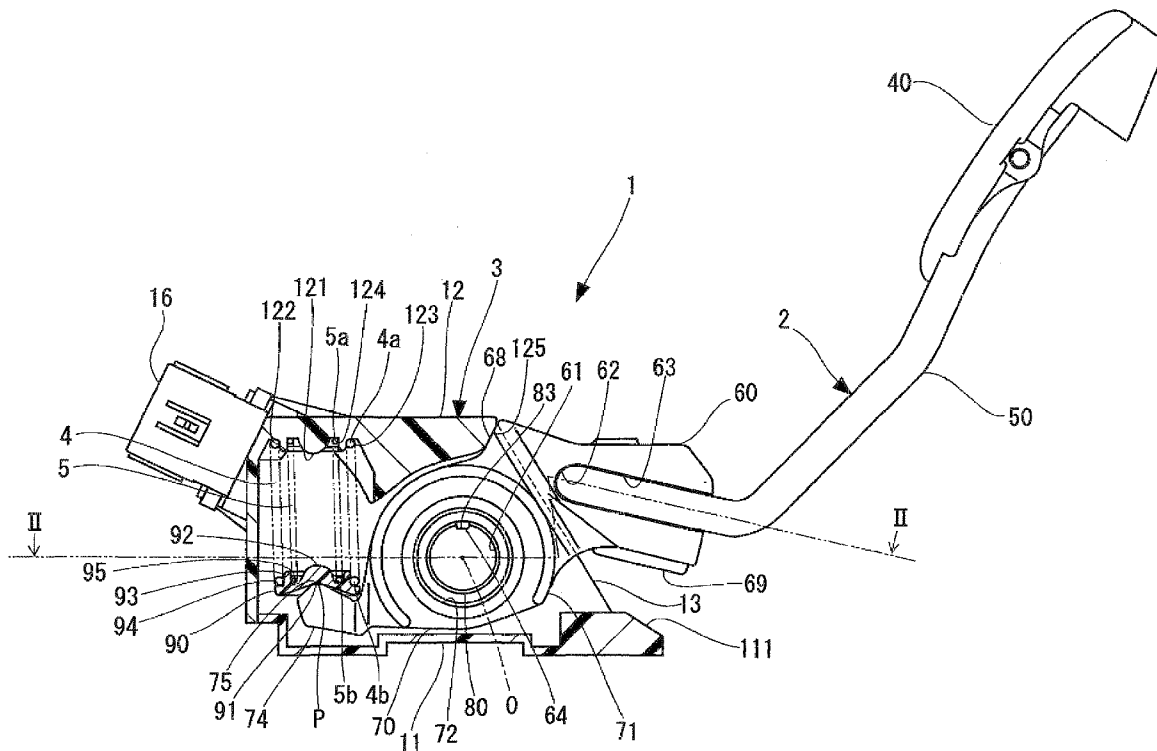
An accelerator pedal is engaged with the rotor so that the accelerator pedal is pivotable about a rotation axis. A coil spring is arranged on a biasing axis that is generally tangential to an arc path, along which a protrusion of the rotor passes when the rotor rotates about the rotation axis. A holder is interposed between the protrusion of the rotor and the coil spring. A concave surface of the holder contacts a convex surface of the protrusion. A receiving portion of the holder receives the coil spring. The contact point is located between a second end and a first end of the coil spring. The concave surface of the holder and the convex surface of the protrusion are curved to satisfy a predetermined relationship.

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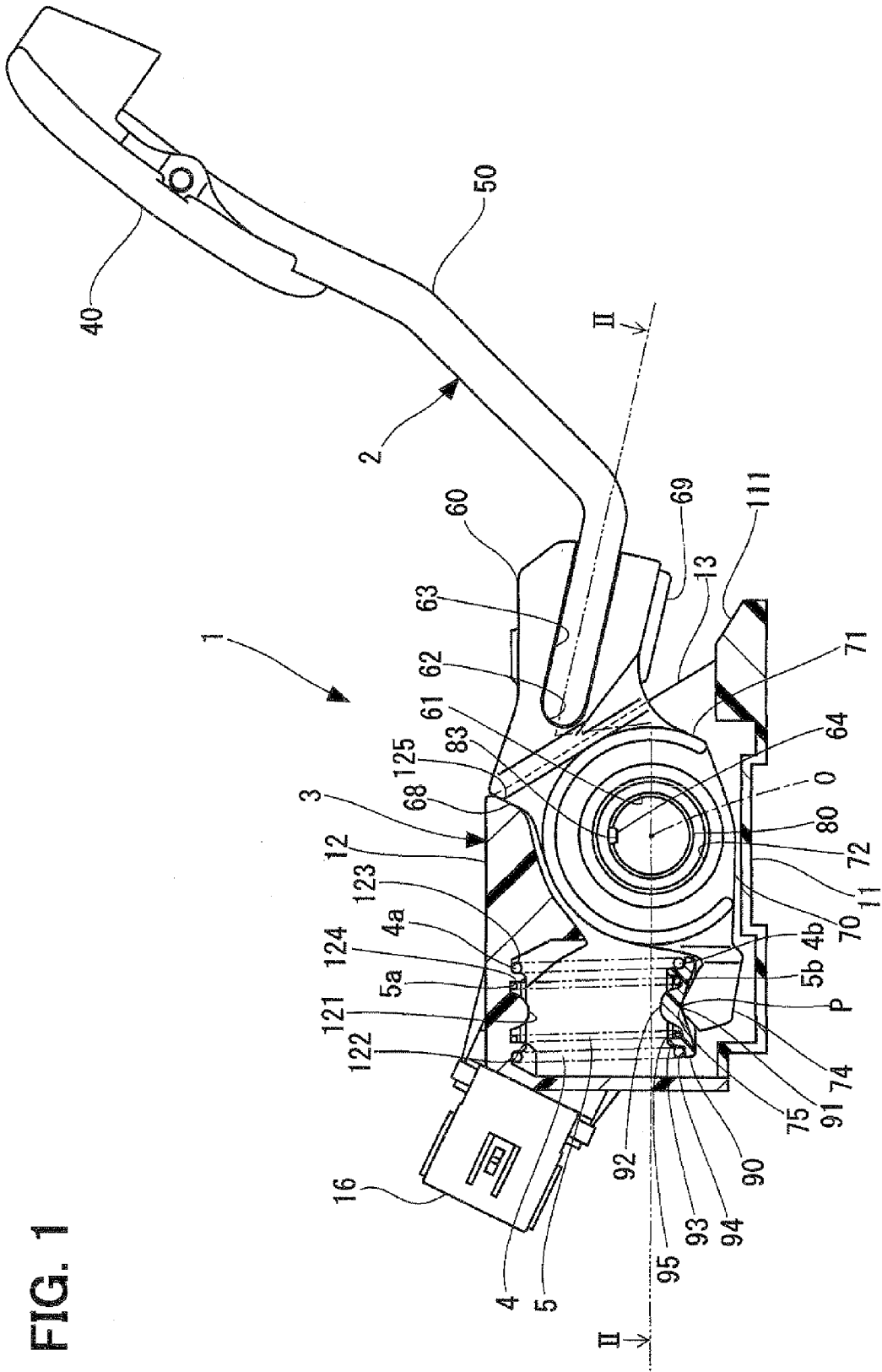


FIG. 1

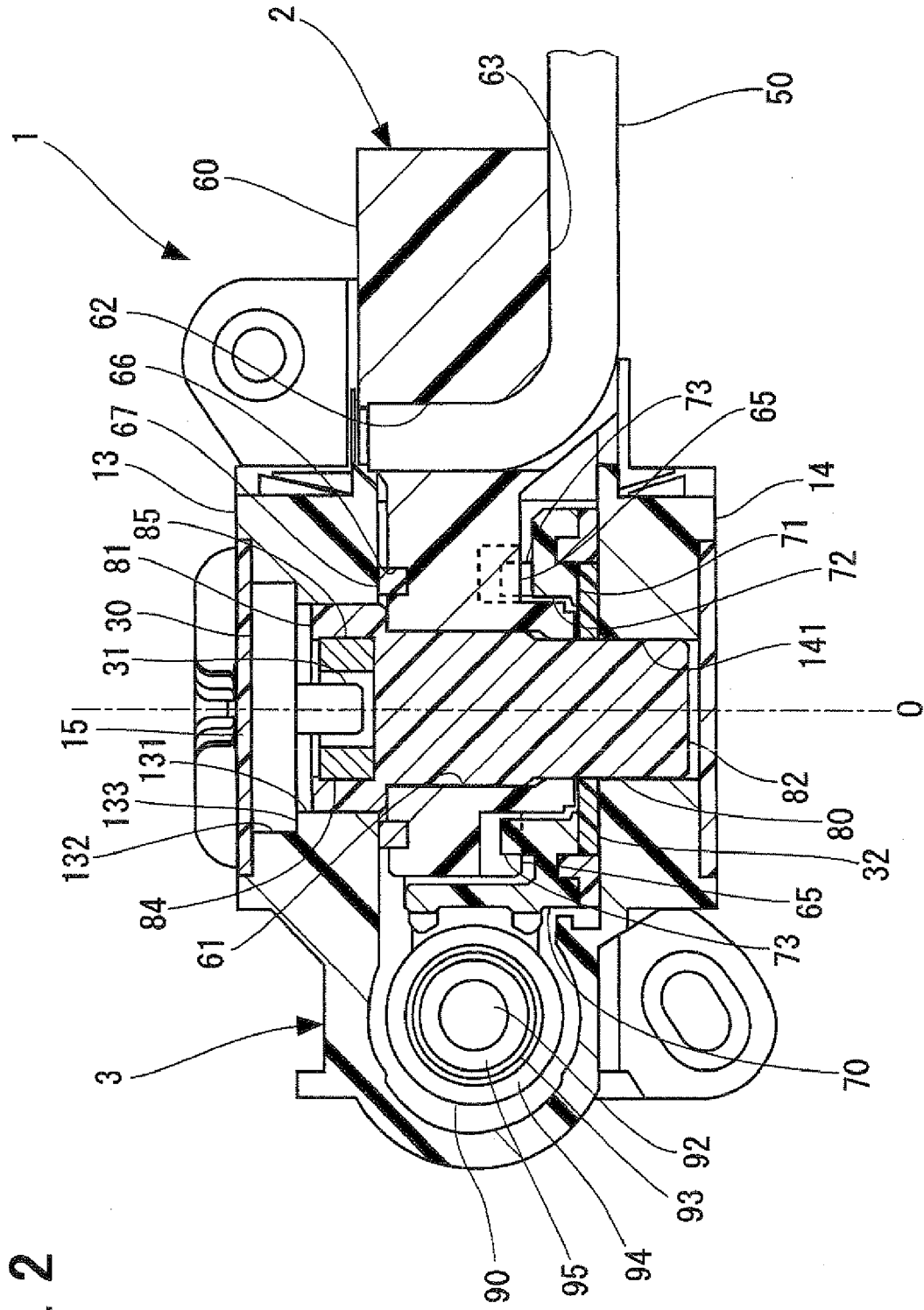
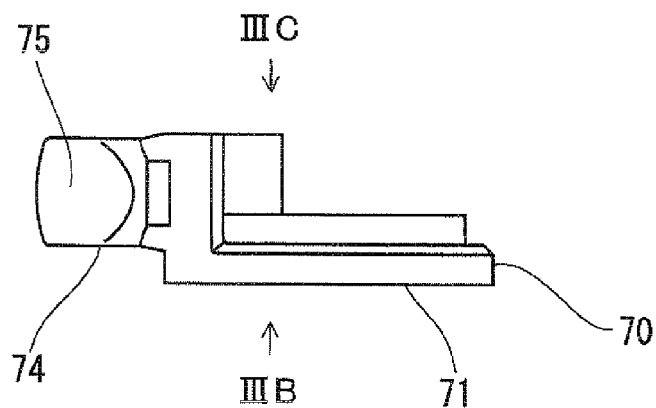
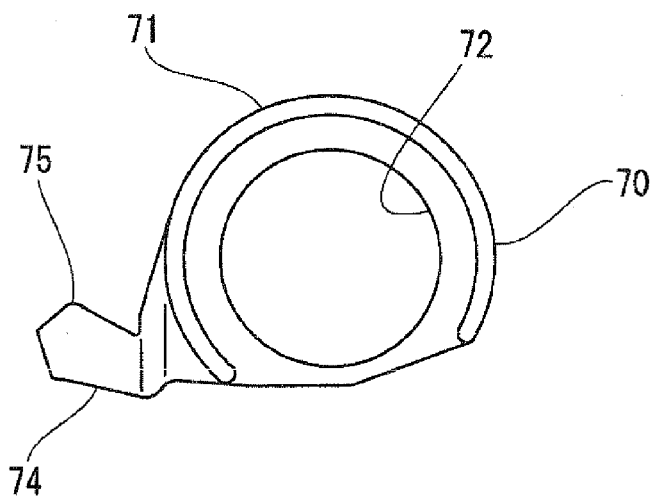


FIG. 2

**FIG. 3A**



**FIG. 3B**



**FIG. 3C**

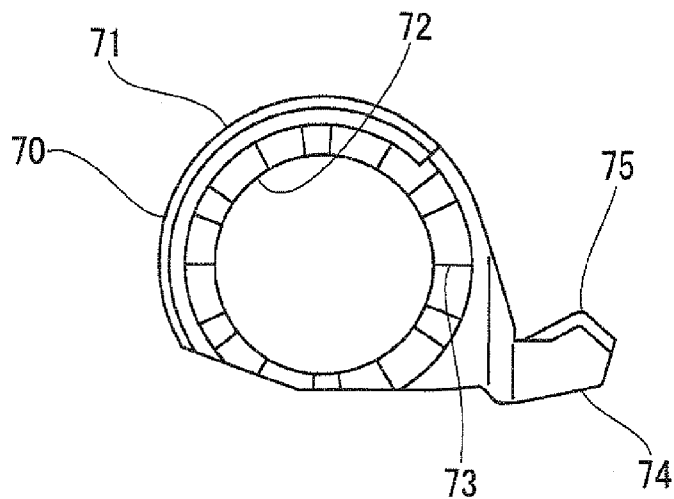


FIG. 4A

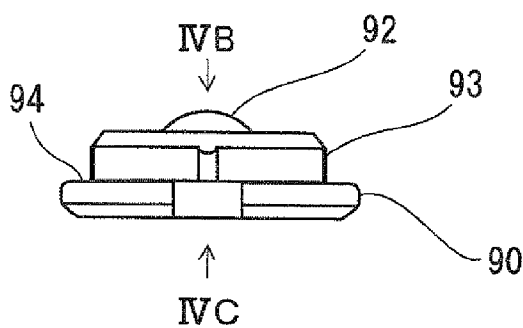


FIG. 4B

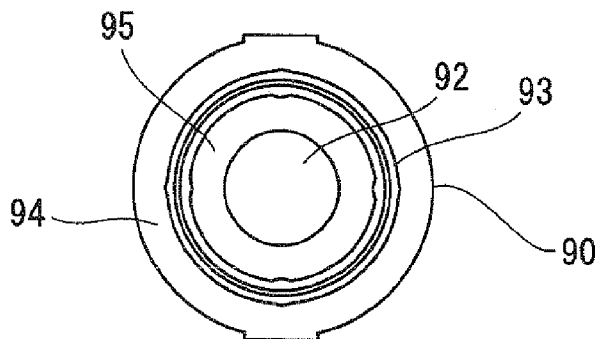


FIG. 4C

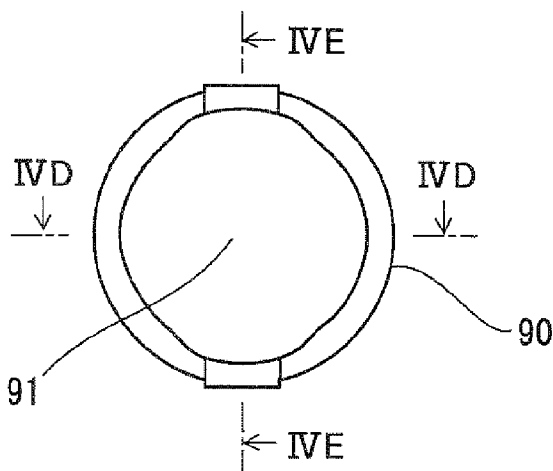


FIG. 4D

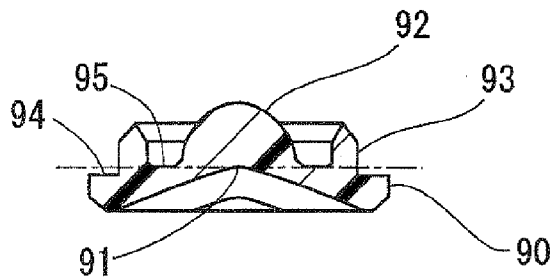


FIG. 4E

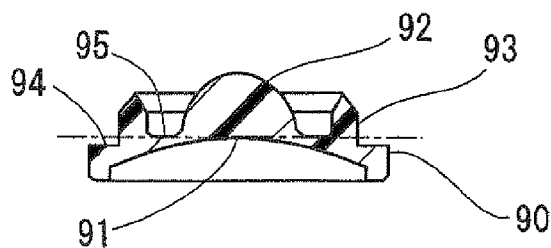


FIG. 5

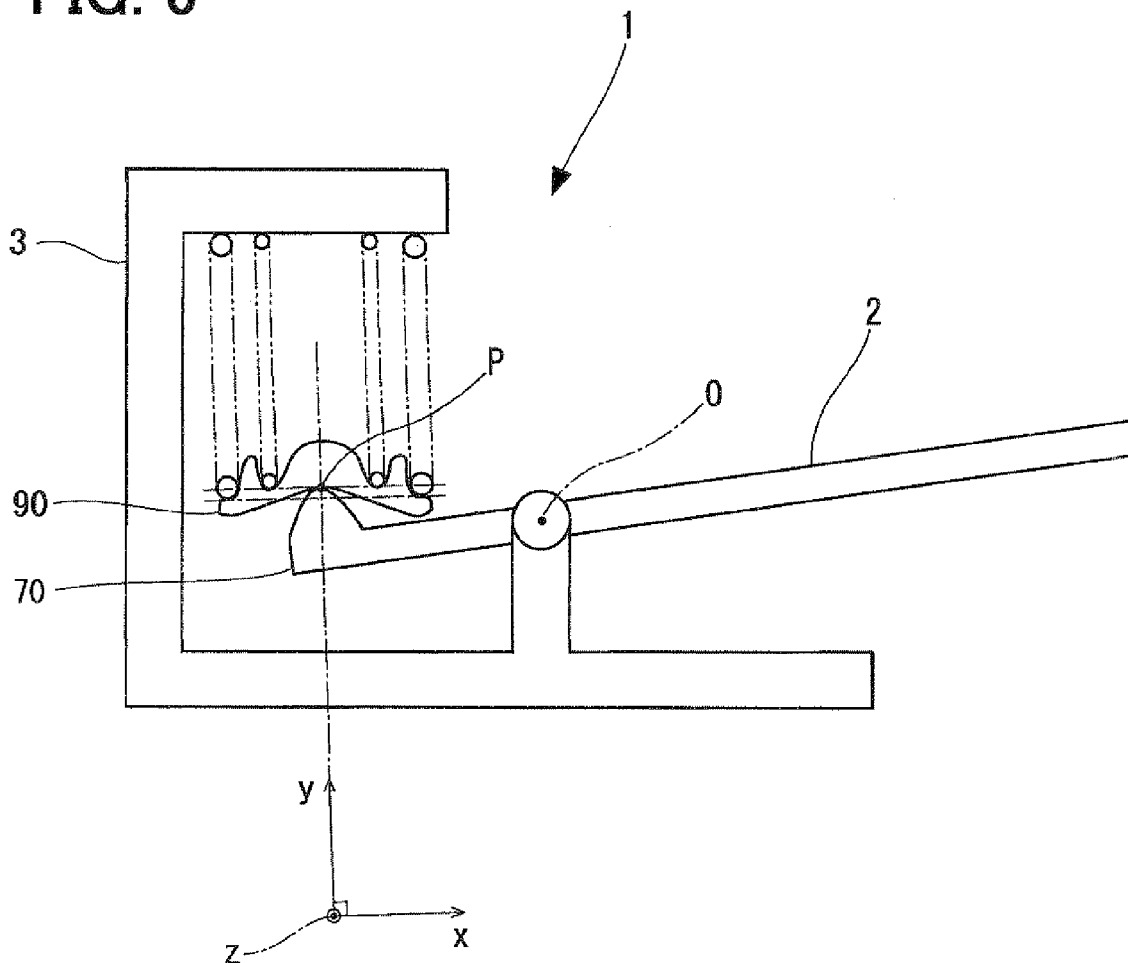


FIG. 6A

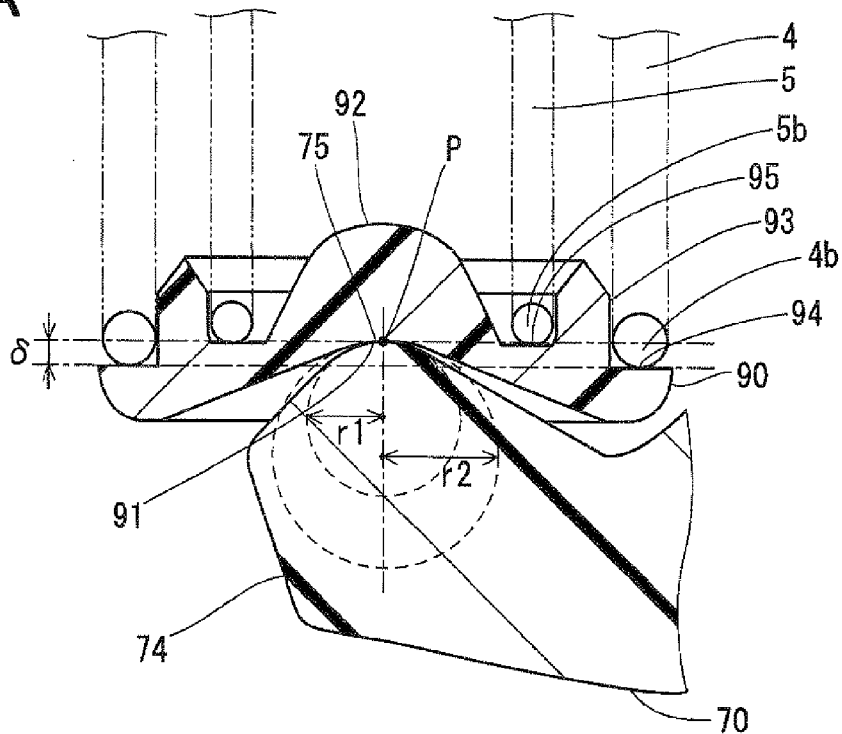


FIG. 6B

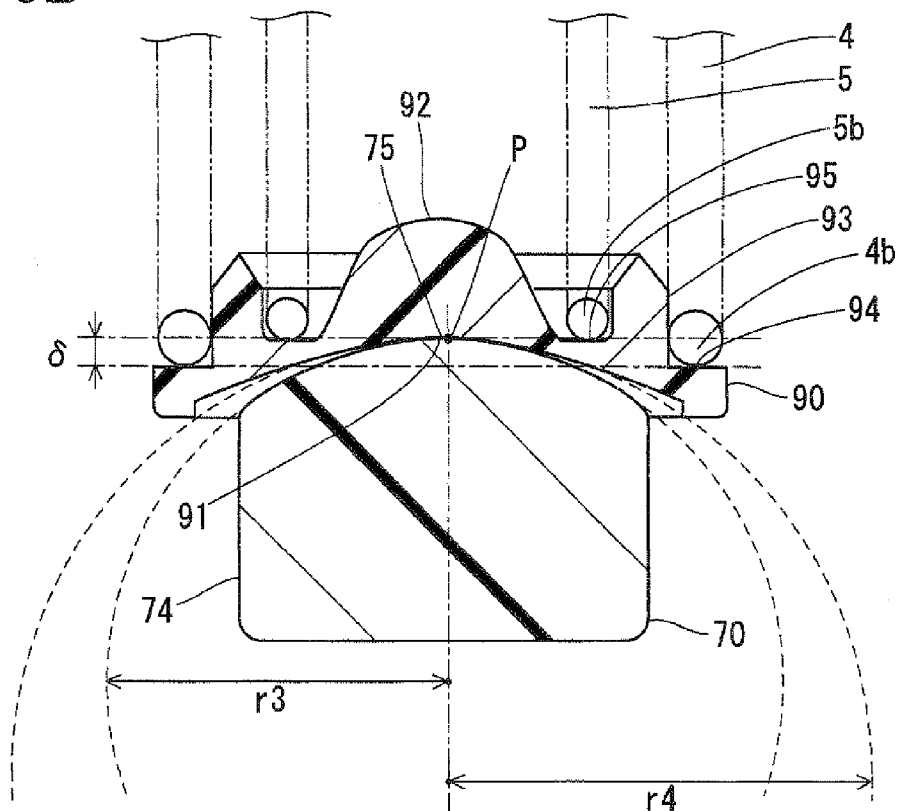
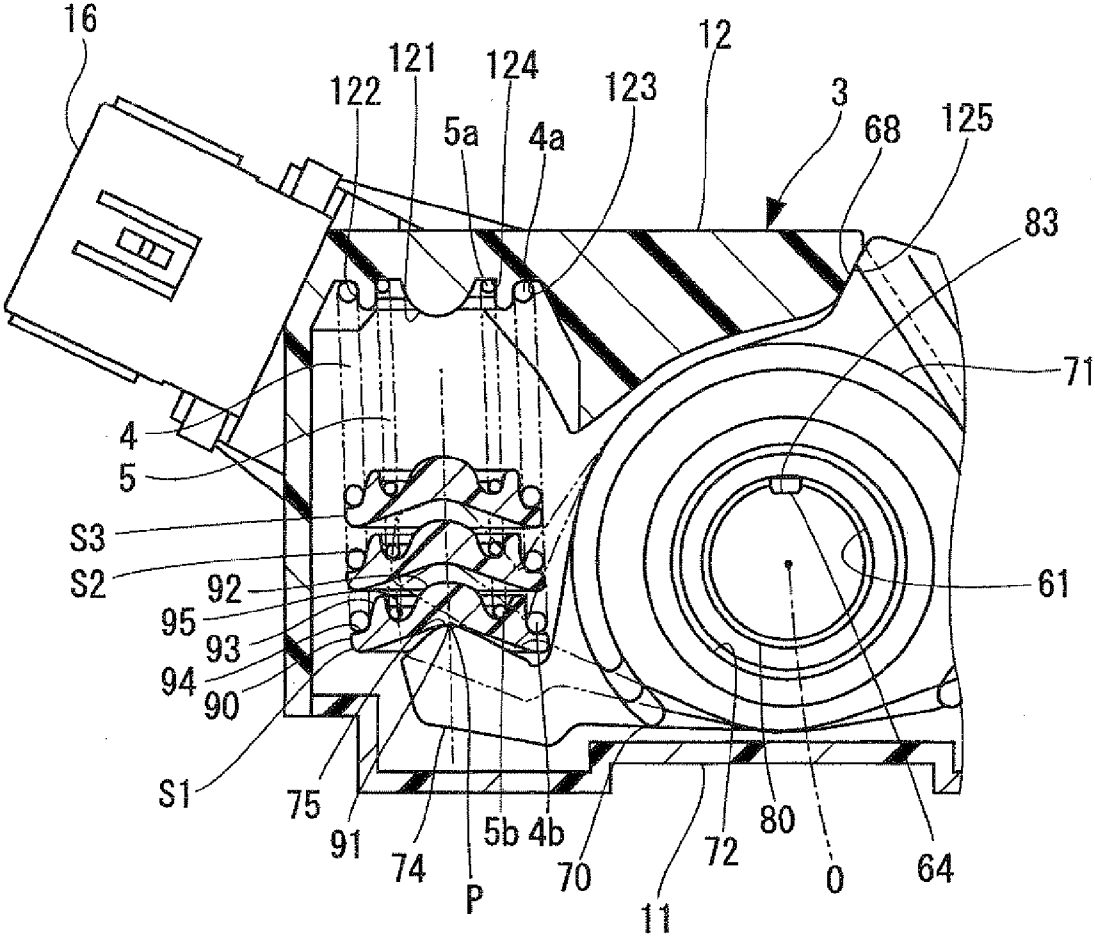


FIG. 7





**ACCELERATOR PEDAL MODULE**

**CROSS REFERENCE TO RELATED APPLICATION**

[0001] This application is based on and incorporates herein by reference Japanese Patent Application No. 2008-009070 filed on Jan. 18, 2008.

**BACKGROUND OF THE INVENTION**

[0002] 1. Field of the Invention

[0003] The present invention relates to an accelerator pedal module for vehicles.

[0004] 2. Description of Related Art

[0005] Conventionally, an accelerator pedal module, which is mounted on a vehicle to control a driving state of the vehicle in accordance with a pressing amount of an accelerator pedal that is foot-actuated by a driver, is known (see WO2006/100133A1 corresponding to US2008/0184843A1, hereafter referred to as patent document 1, for example). In such an accelerator pedal module, a support member pivotably supports the accelerator pedal that is foot-actuated by a driver, and a spring biases the accelerator pedal in a reverse of a pedaling direction of the accelerator pedal. When a pedal force actuating the accelerator pedal is released, a biasing force of the spring returns the accelerator pedal to its initial position.

[0006] In the accelerator pedal module disclosed in patent documents 1, the biasing force of the spring is transmitted to a rotor that is located on a counter-pedal portion side end portion of the accelerator pedal, via a holder, a movement of which is guided by a guide portion. When a driver presses the accelerator pedal, the rotor pushes up the holder against the biasing force of the spring. At this moment, a rotation surface of the rotor moves around an arc about a rotation axis of the accelerator pedal, a position of a contact point of the rotor and the holder shifts, and the holder is inclined to the guide portion. The holder slides on the guide portion, being inclined to the guide portion. Therefore, the holder is worn with time on one side by a sliding movement on the guide portion, to cause jerkiness in a pedal power characteristic. As a result, a pedal operation feeling becomes worse. Therefore, in order to keep the pedal operation feeling good with time, it is desirable that the holder moves without being guided by the guide portion to prevent the holder from being worn on one side.

[0007] In this regard, JPH11-37335A, which is hereafter referred to as patent document 2, discloses a construction of a flow control valve, in which a spherical projection member that is supported by a straight cylindrical valve shaft is in contact with a spherical concavity member, and the spherical projection member straightly pushes up the spherical concavity member against a biasing force of a spring. In this flow control valve, a part of the spherical concavity member and a part of the spherical projection member that are in contact with each other have spherical surfaces. Further, a position at which the biasing force of the spring acts on the spherical concavity member is below a contact point of the spherical concavity member and the spherical projection member. Thereby, an orientation of the spherical concavity member is highly stable while the spherical projection member is moving to push the spherical concavity member. Therefore, the flow control valve disclosed in patent document 2 does not require a guide portion as disclosed in patent document 1, in

order to guide a movement of the spherical concavity member. Therefore, the spherical concavity member is prevented from being worn on one side.

[0008] Thus, it is possible to eliminate the guide portion from the accelerator pedal module, by incorporating the above construction of the flow control valve into the accelerator pedal module, that is, by incorporating a construction of the spherical projection member into the rotor and a construction of the spherical concavity member into the holder, to locate a position at which the biasing force of the spring acts on the holder below a contact point of the holder and the rotor. However, in the accelerator pedal module, the rotation surface of the rotor moves around an arc, and the holder is pushed up against the biasing force of the spring to move along an arc when a driver presses the accelerator pedal. Therefore, a holder side end of the spring moves not along a straight path but along an arc while the spring is compressed. As a result, the operating efficiency of a spring falls, causing a problem to make the pedal operation feeling worse.

**SUMMARY OF THE INVENTION**

[0009] The present invention is made in view of the above-mentioned problem. Thus, it is an objective of the present invention to provide an accelerator pedal module that can minimize abrasion of parts and can keep a good pedal operation feeling.

[0010] To achieve the objective of the present invention, there is provided an accelerator pedal module for a vehicle. A support member of the accelerator pedal module is adapted to be fixed to a body of the vehicle. A rotor is supported by the support member to be rotatable about a rotation axis. An accelerator pedal is engaged with the rotor so that the accelerator pedal is pivotable about the rotation axis in a first pivot direction upon application of a pedal force of a driver of the vehicle onto the accelerator pedal. A resilient biasing member has a first end that is received by the support member and is arranged to be compressible on a biasing axis that is generally tangential to an arc path, along which a protrusion of the rotor passes when the rotor rotates about the rotation axis. The resilient biasing member biases the accelerator pedal in a second pivot direction, which is opposite from the first pivot direction. A holder is interposed between the protrusion of the rotor and a second end of the resilient biasing member, which is opposite from the first end of the resilient biasing member. The holder has a concave surface that is located on a central portion of a first side of the holder and contacts a convex surface of the protrusion at a contact point, and a receiving portion that is located on a peripheral portion of a second side of the holder, which is opposite from the first side of the holder, and receives the second end of the resilient biasing member. The contact point is located between the second end and the first end of the resilient biasing member. The concave surface of the holder and the convex surface of the protrusion are curved to satisfy a relationship of  $r4 > r3 > r2 > r1$  where:

[0011]  $r1$  is a radius of curvature of the convex surface of the protrusion, which is measured in a first imaginary plane that contains the contact point and is perpendicular to the rotation axis;

[0012]  $r2$  is a radius of curvature of the concave surface of the holder, which is measured in the first imaginary plane;

[0013]  $r3$  is a radius of curvature of the convex surface of the protrusion, which is measured in a second imaginary plane that contains the biasing axis of the resilient biasing member and in parallel with the rotation axis; and

[0014]  $r_4$  is a radius of curvature the concave surface of the holder, which is measured in the second imaginary plane.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The invention, together with additional objectives, features and advantages thereof, will be best understood from the following description, the appended claims and the accompanying drawings in which:

[0016] FIG. 1 is a cross-sectional view showing an accelerator pedal module according to one embodiment of the present invention;

[0017] FIG. 2 is a cross-sectional view taken along a line II-II in FIG. 1;

[0018] FIG. 3A is a plan view showing a rotor of the accelerator pedal module according to the one embodiment;

[0019] FIG. 3B is a side view of the rotor of FIG. 3A seen in a direction IIIB in FIG. 2;

[0020] FIG. 3C is a side view of the rotor of FIG. 3A seen in a direction IIIC in FIG. 2;

[0021] FIG. 4A is a side view showing a holder of the accelerator pedal module according to the one embodiment;

[0022] FIG. 4B is a plan view of the holder of FIG. 4A seen in a direction IVB in FIG. 4A;

[0023] FIG. 4C is a bottom view of the holder of FIG. 4A seen in a direction IVB in FIG. 4A;

[0024] FIG. 4D is a cross-sectional view of the holder of FIG. 4A taken along a line IVD-IVD in FIG. 4C;

[0025] FIG. 4E is a cross-sectional view of the holder of FIG. 4A taken along a line IVE-IVE in FIG. 4C;

[0026] FIG. 5 is a schematic diagram of the accelerator pedal module according to the one embodiment;

[0027] FIG. 6A is an enlarged cross-sectional view of the rotor and the holder of the accelerator pedal module according to the one embodiment;

[0028] FIG. 6B is another enlarged cross-sectional view of the rotor and the holder of the accelerator pedal module according to the one embodiment; and

[0029] FIG. 7 is a partial cross-sectional view showing the accelerator pedal module according to the one embodiment.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0030] One embodiment of the present invention will be described hereafter, with reference to the accompanying drawings. FIGS. 1 and 2 depict an accelerator pedal module according to one embodiment of the present invention. The accelerator pedal module 1 is mounted on a vehicle, to control a driving state of the vehicle in accordance with a pressing amount of the accelerator pedal 2 that is foot-actuated by a driver. The accelerator pedal module 1 according to the present embodiment adopts drive-by-wire system, and the accelerator pedal 2 is not mechanically connected with a throttle body of the vehicle. Instead, the accelerator pedal module 1 transmits a rotation angle of the accelerator pedal 2 to an engine control unit (ECU) of the vehicle, and the ECU controls the throttle body in accordance with the rotation angle.

[0031] In the accelerator pedal module 1, the accelerator pedal 2 is supported by a housing 3 to be pivotable about a rotation axis O. Moreover, two return springs 4 and 5 bias the accelerator pedal 2 via a holder 90 in a reverse of a driver's pedaling direction of the accelerator pedal 2. The rotation angle of the accelerator pedal 2, which is pivotally moved by

a pedal force of the driver and biasing forces of the return springs 4 and 5, is detected by a rotation angle sensor 30, and is transmitted to the ECU.

[0032] A construction of the accelerator pedal module 1 is further described hereafter in detail. As shown in FIGS. 1 and 2, the housing 3, which serves as a support member, is formed of resin in a box-like shape. The housing 3 has a bottom plate 11, a top plate 12 that faces the bottom plate 11, and two side plates 13 and 14 that face each other and are perpendicular to the bottom plate 11 and to the top plate 12. The bottom plate 11 is fixed to a body of the vehicle with bolts, etc.

[0033] As shown in FIG. 2, a first side plate 13 has a bearing hole 131 and a sensor support hole 132. The bearing hole 131 and the sensor support hole 132 are approximately coaxially communicated with each other to pierce the first side plate 13. Both of the bearing hole 131 and the sensor support hole 132 have approximately cylindrical shapes. An inner diameter of the bearing hole 131 is smaller than an inner diameter of the sensor support hole 132. Thereby, a step portion 133 is formed between the bearing hole 131 and the sensor support hole 132. An inner circumference of the sensor support hole 132 supports the rotation angle sensor 30. The step portion 133 and a cover 15 sandwich the rotation angle sensor 30 therebetween, to prevent the rotation angle sensor 30 from coming off the sensor support hole 132. As shown in FIG. 1, a connector 16 in which a terminal (not shown) that is electrically connected with the rotation angle sensor 30 is embedded is formed on an outer wall of the housing 3.

[0034] As shown in FIG. 2, an approximately cylindrical bearing hole 141 is formed on a second side plate 14. Central axes of the bearing hole 141 and the bearing hole 131 are aligned with the rotation axis O.

[0035] As shown in FIGS. 1 and 2, the accelerator pedal 2 includes a pedal plate 40, a pedal arm 50, a pedal rotor 60, a spring rotor 70 and a shaft member 80. The pedal arm 50 is formed by bending a metal rod. The pedal plate 40, which is foot-actuated by the driver, is fixed to one end portion of the pedal arm 50.

[0036] The pedal rotor 60 is formed of resin, and has a large diameter hole 61 that pierces the pedal rotor 60. The large diameter hole 61 has an approximately cylindrical shape. The other end portion of the pedal arm 50 is bent at an approximately right angle, and is press fitted to a small diameter hole 62 and a groove 63 to be fixed to the pedal rotor 60.

[0037] The shaft member 80 is formed of resin in an approximately cylindrical shape. The shaft member 80 is inserted into the large diameter hole 61 of the pedal rotor 60. One end portion 81 of the shaft member 80 is supported by the bearing hole 131, and the other end portion 82 of the shaft member 80 is supported by the bearing hole 141. Thereby, the shaft member 80 is supported by the housing 3 to be rotatable about the rotation axis O. A groove 83 is formed on an outer circumferential wall of the shaft member 80, as shown in FIG. 1. A projection 64 that projects radially inward in a radial direction of the large diameter hole 61 is formed in the pedal rotor 60. The projection 64 is fitted to the groove 83 of the shaft member 80. Thereby, the pedal rotor 60 can rotate about the rotation axis O together with the shaft member 80. By such a construction, when the driver presses the pedal plate 40, the pedal arm 50, the pedal rotor 60 and the shaft member 80 integrally rotate about the rotation axis O.

[0038] As shown in FIG. 2, one end portion 81 of the shaft member 80 is formed in an approximately cylindrical hollow shape, to open to the rotation angle sensor 30 side. Magnet

portions **84** and **85** that are opposite in polarity from each other are embedded on an inner circumferential wall of the approximately cylindrical hollow of the one end portion **81** to rotate integrally, at two points to interpose the rotation axis **O** therebetween. A direction of a magnetic field generated by the two magnet portions **84** and **85** changes in accordance with a rotation angle of the shaft member **80**. The rotation angle sensor **30**, which is supported by the sensor support hole **132** of the first side plate **13**, has a Hall device or a magnetoresistive device at a tip end of a protruding portion **31** that protrudes toward the shaft member **80** side in a direction of the rotation axis **O**. The rotation angle sensor **30** detects the magnetic field in a noncontact manner, which is generated by the magnetic portions **84** and **85** that are located on a radially outer side of the protruding portion **31** to leave a clearance from the protruding portion **31**. The rotating angle sensor **30** outputs a detection signal to the ECU that is electrically connected with the terminal (not shown). The detection signal outputted from the rotation angle sensor **30** indicates the rotation angle of the shaft member **80**, i.e., the rotation angle of the accelerator pedal **2**.

[0039] As shown in FIGS. 1 to 3C, the spring rotor **70**, which serves as a rotor, is formed of resin, and has a circular rotating portion **71**. The rotating portion **71** has a rotation hole **72** that pierces the rotating portion **71** in the direction of the rotation axis **O**. The rotating portion **71** is in contact with the pedal rotor **60** to be coaxially aligned with the rotation hole **72** and the large diameter hole **61**. The shaft member **80** is inserted in the rotation hole **72** so that the spring rotor **70** can rotate about the rotation axis **O**.

[0040] As shown in FIGS. 2 and 3C, several helical gear cogs **73** are formed on a pedal rotor **60** side surface of the rotating portion **71** of the spring rotor **70**. The several helical gear cogs **73** are arranged at regular intervals around the rotation axis **O**. Several helical gear cogs **65** are formed on a rotating portion **71** side wall surface of the pedal rotor **60**. The several helical gear cogs **65** are arranged at regular intervals around the rotation axis **O**, to be engaged with either of the helical gear cogs **73** that face the helical gear cogs **65** in the direction of the rotation axis **O**. By this engagement, the pedal rotor **60** and the spring rotor **70** can rotate together. For example, when the driver presses the pedal plate **40**, the spring rotor **70** rotates in the pedaling direction. A friction washer **32** is interposed between a second side plate **14** side surface of the rotating portion **71** and a rotating portion **71** side wall surface of the second side plate **14**. The friction washer **32** is fixed to the side plate **14** not to rotate on the second side plate **14**. The friction washer **32** is in sliding contact with the rotating portion **71** to produce a frictional force. Moreover, a groove **66** is formed on a first side plate **13** side of the pedal rotor **60**, and a circular friction ring **67** is press fitted in this groove **66**. The friction ring **67** is in sliding contact with the first side plate **13** to produce a frictional force.

[0041] The spring rotor **70** further has a protruding portion **74** that is formed of resin integrally with the rotating portion **71**. As shown in FIGS. 1 and 3A to 3C, the protruding portion **74** protrudes in a generally tangential direction from a rim portion of the rotating portion **71**. The protruding portion **74** has a convex surface **75** on its top plate **12** side.

[0042] As shown in FIGS. 1, 2 and 4A to 4E, the holder **90** is formed of resin in an approximately disk-like shape, and has a concave surface **91** on its protruding portion **74** side. A material that has a low coefficient of friction such as a fluo-

ropolymer, for example, is applied to the concave surface **91**. The concave surface **91** of the holder **90** and the convex surface **75** of the spring rotor **70** are in contact with each other. A first return spring **4** and a second return spring **5**, which serve as a resilient biasing member, are interposed between a top plate **12** side surface of the holder **90** and an inner wall surface of the top plate **12**.

[0043] Both of the first and the second springs **4** and **5** are compression coil springs. A coil diameter of the second return spring **5** is smaller than a coil diameter of the first return spring **4**. The second return spring **5** is installed inside an inner circumference of the first return spring **4**.

[0044] A spherical projection **92** that spherically projects toward the top plate **12** is formed on the top plate **12** side surface of the holder **90**. An annular projection **93** that annularly projects toward the top plate **12** is formed on a radially outer side of the spherical projection **92**. Thereby, an annular first receiving surface **94** is formed on a radially outer side of the annular projection **93** and a second receiving surface **95** is formed between the spherical projection **92** and the annular projection **93** on the top plate **12** side surface of the holder **90**.

[0045] A spherical projection **121** that spherically projects toward the holder **90** is formed on the inner wall surface of the top plate **12**. An annular projection **122** that annularly projects toward the holder **90** is formed on a radially outer side of the spherical projection **121**. Thereby, an annular first receiving surface **123** is formed on a radially outer side of the annular projection **122** and an annular second receiving surface **124** is formed between the spherical projection **121** and the annular projection **122** on the inner wall surface of the top plate **12**.

[0046] One end portions **4a** and **5a** of the return springs **4** and **5** are received by the first receiving surface **123** and the second receiving surface **124** of the top plate **12**, respectively. The other end portions **4b** and **5b** of the return springs **4** and **5** are received by the first receiving surface **94** and the second receiving surface **95** of the holder **90**, respectively. In this way, the return springs **4** and **5** bias the pedal arm **50** and the spring rotor **70**, which has been rotated in the pedaling direction, via the holder **90** in the reverse of the pedaling direction. The spring rotor **70** receives a total biasing force  $F_s$  of the return springs **4** and **5** at the protruding portion **74**, to rotate.

[0047] Next, cross-sectional shapes of the spring rotor **70** and the holder **90** will be described in detail. As shown in FIG. 5, a coordinate system is defined in which z-axis is in parallel with the rotation axis **O** of the accelerator pedal **2**, y-axis is in parallel with a direction in which the return springs **4** and **5** can be expanded and compressed, and x-axis is perpendicular to both of z-axis and y-axis. FIG. 6A depicts cross sections of the spring rotor **70** and the holder **90** on xy plane that contains a contact point **P** of the spring rotor **70** and the holder **90**. FIG. 6B depicts cross sections of the spring rotor **70** and the holder **90** on yz plane that contains the contact point **P**.

[0048] As shown in FIG. 6A, on the xy plane that contains the contact point **P**, a radius of curvature **r1** of the cross section of the convex surface **75** of the spring rotor **70** in a proximity of the contact point **P** is smaller than a radius of curvature **r2** of the cross section of the concave surface **91** of the holder **90** in the proximity of the contact point **P**. Moreover, as shown in FIG. 6B, on the yz plane that contains the contact point **P**, a radius of curvature **r3** of the cross section of the convex surface **75** of the spring rotor **70** in the proximity of the contact point **P** is smaller than a radius of curvature **r4** of the cross section of the concave surface **91** of the holder **90** in the proximity of the contact point **P**. Furthermore, the radius of

curvature  $r_2$  is smaller than the radius of curvature  $r_3$ . That is, the curvature radii  $r_1$  to  $r_4$  satisfy a relationship of  $r_4 > r_3 > r_2 > r_1$ .

[0049] Moreover, as shown in FIGS. 6A and 6B, the first receiving surface 94 of the holder 90 is located closer to the bottom plate 11 than the contact point P is, by a height  $\delta$ . That is, the other end portion 4b of the return spring 4 is located closer to the bottom plate 11 than the contact point P is. The second receiving surface 95 of the holder 90 is located approximately as close to the bottom plate 11 as the contact point P is, or is located closer to the bottom plate 11 than the contact point P is.

[0050] Next, an operation of the accelerator pedal module 1 will be described.

[0051] As shown in FIG. 1, before the driver presses the pedal plate 40 of the accelerator pedal 2, the biasing forces of the return springs 4 and 5 bias the accelerator pedal 2 in the reverse of the pedaling direction. At this time, a contact portion 68 of the pedal rotor 60 is in contact with a stopper 125 that is formed on the top plate 12.

[0052] When the driver presses the pedal plate 40 of the accelerator pedal 2 and adjusts a pressing amount of the accelerator pedal 2, the pedal rotor 60 and the spring rotor 70, of which the helical gear cogs 65 and the helical gear cogs 73 are engaged with each other, integrally rotate, so that the spring rotor 70 is in sliding contact with the friction washer 32 and the first side plate 13 is in sliding contact with the friction ring 67. At this time, the rotation angle sensor 30 detects the rotation angle of the shaft member 80 that rotates integrally with the pedal rotor 60, in accordance with the magnetic field that is generated by the magnet portions 84 and 85.

[0053] When the driver increases the pedal force, the pedal rotor 60 and the spring rotor 70 rotate in the pedaling direction. In accordance with the rotation of the pedal rotor 60 and the spring rotor 70, the total biasing force  $F_s$  of the return springs 4 and 5 and the frictional force  $F_{11}$  produced by the friction between the spring rotor 70 and the friction washer 32 act on the spring rotor 70 in the reverse of the pedaling direction. The frictional force  $F_{12}$  produced by the friction between the friction ring 67 and the first side plate 13 acts on the pedal rotor 60 in the reverse of the pedaling direction. At this time, the total biasing force  $F_s$  of the return springs 4 and 5 increases as the return springs 4 and 5 are compressed in accordance with the pressing amount of the accelerator pedal 2. At this time, an engagement of the helical gear cogs 65 and the helical gear cogs 73 increases a force to separate the pedal rotor 60 from the rotating portion 71 of the spring rotor 70 in the direction of the rotation axis O, to increase the frictional forces  $F_{11}$  and  $F_{12}$ .

[0054] When the driver increases the pedal force further, the pedal rotor 60 rotates further in the pedaling direction, and a contact portion 69 of the pedal rotor 60 comes in contact with a stopper 111 that is formed on the bottom plate 11. The contact portion 69 comes in contact with the stopper 111, to prevent the accelerator pedal 2 from rotating further.

[0055] When the driver decreases the pedal force, the pedal rotor 60 and the spring rotor 70 rotate in the reverse of the pedaling direction, due to the total biasing force  $F_s$  of the return springs 4 and 5. In accordance with the rotation of the pedal rotor 60 and the spring rotor 70, the frictional force  $F_{11}$  between the spring rotor 70 and the friction washer 32 acts on the spring rotor 70 in a reverse of the total biasing force  $F_s$ , i.e., in the pedaling direction. The frictional force  $F_{12}$  between the friction ring 67 and the first side plate 13 acts on the pedal

rotor 60 in the pedaling direction. In accordance with a return of the accelerator pedal 2, the return springs 4 and 5 expands, decreasing the total biasing force  $F_s$ . At this time, the engagement of the helical gear cogs 65 and the helical gear cogs 73 decreases the force to separate the pedal rotor 60 from the rotating portion 71 of the spring rotor 70 in the direction of the rotation axis O, to decrease the frictional forces  $F_{11}$  and  $F_{12}$ . As explained above, the accelerator pedal module 1 has a pedal force characteristic with hysteresis, that is, the pedal force in pedaling time is not equal to the pedal force in returning time. Therefore, it is easy to hold the accelerator pedal 2 at a certain position.

[0056] A referential numeral S1 in FIG. 7 denotes a state of the holder 90 in which the contact portion 68 is in contact with the stopper 125 before the accelerator pedal 2 is pressed by the driver. A referential numeral S2 in FIG. 7 denotes a state of the holder 90 in which the accelerator pedal 2 is pressed partway by the driver. A referential numeral S3 in FIG. 7 denotes a state of the holder 90 in which the contact portion 69 is in contact with the stopper 111 after the accelerator pedal 2 is pressed to the maximum by the driver. In this way the accelerator pedal 2 can rotate within a range from a position at which the contact portion 68 is in contact with the stopper 125 to a position at which the contact portion 69 comes in contact with the stopper 111.

[0057] As shown in FIG. 6A, the radius of curvature  $r_1$  of the cross section of the convex surface 75 of the spring rotor 70, which is taken on the xy plane, is set to be relatively small. Therefore, as shown in FIG. 7, while the protruding portion 74 of the spring rotor 70 moves along an arc to push up the holder 90 in accordance with a driver's pedaling operation of the accelerator pedal 2, the contact point P of the spring rotor 70 and the holder 90 deviates little in a direction of x-axis. Thereby, the holder 90 is linearly pushed up by the protruding portion 74. As a result, the return springs 4 and 5 are compressed linearly.

[0058] In the accelerator pedal module 1 according to the above-described embodiment of the present invention, the radius of curvature  $r_1$  of the cross section of the convex surface 75 of the spring rotor 70, which is taken on the xy plane, is set to be relatively small. Thereby, although the protruding portion 74 of the spring rotor 70 moves along an arc, the contact point P of the spring rotor 70 and the holder 90 deviates little in the direction of x-axis. Therefore, the holder 90 is linearly pushed up by the spring rotor 70 while the driver performs a pedaling operation. As a result, the return springs 4 and 5 are linearly compressed, to improve operating efficiencies of the return springs 4 and 5. Therefore, a pedal operation feeling of the accelerator pedal 2 becomes good.

[0059] Moreover, while the spring rotor 70 pushes up the holder 90 in accordance with the pedaling operation of the accelerator pedal 2, the protruding portion 75 of the spring rotor 70 is in sliding contact with the concave surface 91 of the holder 90 to push up the holder 90. In the accelerator pedal module 1 according to the above embodiment of the present invention, the radius of curvature  $r_3$  of the cross section of the convex surface 75 of the spring rotor 70, which is taken on the yz plane, in the proximity of the contact point P, is set to be larger than the radius of curvature  $r_1$ . Thereby, a contact pressure of the holder 90 and the spring rotor 70 can be relatively small. Therefore, local wears of the holder 90 and the spring rotor 70 due to the sliding contact of the holder 90 and the spring rotor 70 can be reduced.

[0060] Furthermore, in the accelerator pedal module 1 according to the above embodiment of the present invention, the other end portion 4b of the return spring 4 is located closer to the bottom plate 11 than the contact point P is. That is, a point of application of the biasing force of the return spring 4 to the holder 90 is located closer to the bottom plate 11 than the contact point P is. Therefore, while the spring rotor 70 pushes up the holder 90 against the biasing force of the spring in accordance with the pedaling operation of the accelerator pedal 2, an orientation of the holder 90 is stable. Thereby, the accelerator pedal module 1 according to the present embodiment does not especially require a member for guiding a movement of the holder 90. Therefore, it is possible to prevent a one-sided wear of the holder 90, which is caused by a guide member of the holder 90 with time. Therefore, it is possible to keep a good pedal operation feeling of the accelerator pedal 2.

[0061] In the accelerator pedal module 1 according to the above embodiment of the present invention, a material that has a low coefficient of friction such as a fluoropolymer is applied to the concave surface 91 of the holder 90. That is, the concave surface 91 of the holder 90 is surface treated to make its coefficient of friction smaller than a coefficient of friction of a material that forms the spring rotor 70. Therefore, when the convex surface 75 of the spring rotor 70 slides on the concave surface 91 of the holder 90, a frictional resistance that acts between the convex surface 75 and the concave surface 91 is small. Therefore, local wears of the spring rotor 70 and the holder 90 can be reduced.

Other Embodiments

[0062] As other embodiments of the present invention, a pedal plate, a pedal arm, a pedal rotor and a shaft member may be formed of resin, etc. in a single piece, and an accelerator pedal may be formed by assembling the single piece with a separate spring rotor, for example. Instead, it is also possible to form all the parts that compose the accelerator pedal in a single piece of resin.

[0063] Furthermore, as still another embodiment of the present invention, the material that has a low coefficient of friction such as a fluoropolymer may be applied not only to the concave surface of the holder but also to the convex surface of the spring rotor. It is also possible to apply fluoropolymer, etc. not to the concave surface but only to the convex surface. Moreover, it is also possible to make any one of the holder and the spring rotor of a fluoropolymer, etc.

[0064] Additional advantages and modifications will readily occur to those skilled in the art. The invention in its broader terms is therefore not limited to the specific details, representative apparatus, and illustrative examples shown and described.

What is claimed is:

- 1. An accelerator pedal module for a vehicle, comprising: a support member that is adapted to be fixed to a body of the vehicle;

- a rotor that is supported by the support member to be rotatable about a rotation axis;
- an accelerator pedal that is engaged with the rotor so that the accelerator pedal is pivotable about the rotation axis in a first pivot direction upon application of a pedal force of a driver of the vehicle onto the accelerator pedal;
- a resilient biasing member that has a first end that is received by the support member and is arranged to be compressible on a biasing axis that is generally tangential to an arc path, along which a protrusion of the rotor passes when the rotor rotates about the rotation axis, to bias the accelerator pedal in a second pivot direction, which is opposite from the first pivot direction; and
- a holder that is interposed between the protrusion of the rotor and a second end of the resilient biasing member, which is opposite from the first end of the resilient biasing member, wherein:

the holder has:

- a concave surface that is located on a central portion of a first side of the holder and contacts a convex surface of the protrusion at a contact point; and
- a receiving portion that is located on a peripheral portion of a second side of the holder, which is opposite from the first side of the holder, and receives the second end of the resilient biasing member;

the contact point is located between the second end and the first end of the resilient biasing member; and

the concave surface of the holder and the convex surface of the protrusion are curved to satisfy a relationship of  $r4 > r3 > r2 > r1$  where:

- r1 is a radius of curvature of the convex surface of the protrusion, which is measured in a first imaginary plane that contains the contact point and is perpendicular to the rotation axis;
- r2 is a radius of curvature of the concave surface of the holder, which is measured in the first imaginary plane;
- r3 is a radius of curvature of the convex surface of the protrusion, which is measured in a second imaginary plane that contains the biasing axis of the resilient biasing member and in parallel with the rotation axis; and
- r4 is a radius of curvature the concave surface of the holder, which is measured in the second imaginary plane.

2. The accelerator pedal module according to claim 1, wherein a material that has a coefficient of friction smaller than coefficients of friction of the rotor and the holder is applied to at least one of the convex surface of the protrusion and the concave surface of the holder.

3. The accelerator pedal module according to claim 1, wherein one of the rotor and the holder is made of a material that has a coefficient of friction smaller than a coefficient of friction of a material of which the other of the rotor and the holder is made.

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