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(54) CLUTCH OPERATION EFFORT REACTIVE FORCE GENERATOR

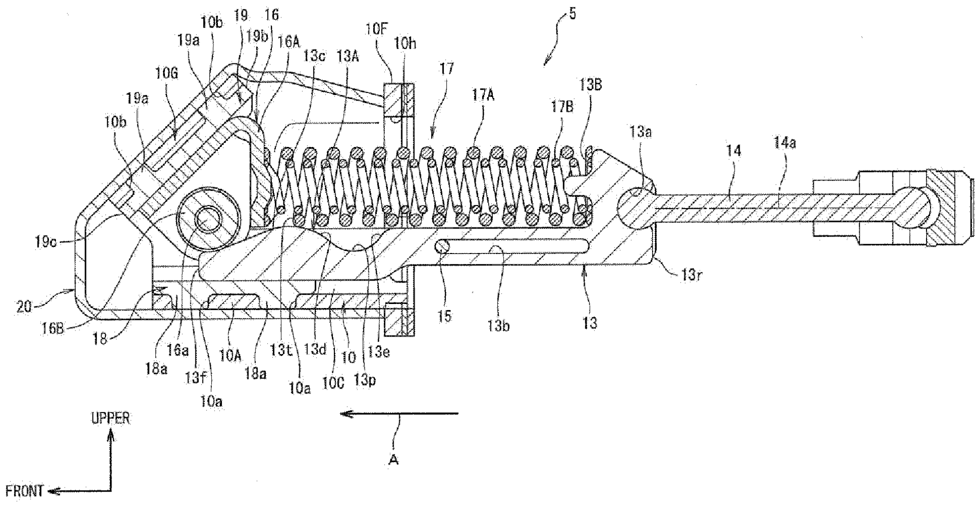
(57) OBJECT

It is an object to a clutch operation effort reactive force generator which can be reduced in size thereof, is capable of minimizing the volume of space for installation of the clutch operation effort reactive force generator, and developing a simulated reactive force as a function of an amount by which the clutch pedal is moved by an operator.

SOLVING MEANS

A clutch operation effort reactive force generator 5 includes a supporting member 10, a cam follower 16, and a coil spring 17. The supporting member 10 includes a cam plate 13 and a roller 16B. The cam plate 13 has a cam face 13A and is disposed to be movable on the supporting member 10. The roller 16B is arranged to make contact with the cam face 13A. The coil spring 17 is arranged between the cam follower 16 and the cam plate 13 and works to produce a biasing force to urge the cam follower 16 and the cam plate 13 away from each other in a direction of movement of the cam plate 13. The movement of the cam plate 13 causes a location of the contact between the roller 16B and the cam face 13A to be changed to move the cam follower 16 in the direction of movement of the cam plate 13. This structure enables the clutch operation effort reactive force generator 5 to be reduced in size thereof, minimizes the volume of space for installation of the clutch operation effort reactive force generator 5, and is capable of developing a simulated reactive force as a function of an amount by which the clutch pedal 4 is moved by an operator.

FIG. 4



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Description

1 Technical Field

[0001] The present invention generally relates to a clutch operation effort reactive force generator.

2 Background Art

[0002] Vehicles are known which are designed to engage or disengage a clutch using an actuator, for example, in a MT (i.e., Manual Transmission) employing a clutch-by-wire system.

[0003] The use of an actuator to operate the clutch will lead to difficulty for a vehicle operator to sense a reactive force which is usually generated as a function of a degree of effort exerted by a vehicle operator directly on a clutch pedal. It is, therefore, necessary to develop the reactive force as a function of the operator's effort on the clutch pedal.

[0004] Pedal actuating mechanism are known which work to generate a simulated reactive force opposing the degree of effort on a clutch pedal using a mechanical spring (see JP 1996-161069 A)

[0005] The pedal actuating mechanism, as taught in JP 1996-161069 A, is equipped with a bracket, an actuating pedal, and a return spring. The actuating pedal is attached to the bracket to be swingable around a single-swing axis. The actuating pedal starts to be depressed at an initial position and then moved to actuate a given operating member. The actuating pedal is also swung and returned to the initial position in response to a reactive force exerted by the operating member. The return spring is arranged to extend between a member attached to the bracket and the actuating pedal to urge or bias the actuating pedal to the initial position and hold the actuating pedal at the initial position.

[0006] The pedal actuating mechanism is also equipped with a biasing stopper working to stop exerting an opposing pressure, as produced by the spring, on the actuating pedal when the actuating pedal is depressed and moved over a preset intermediate position.

PRIOR ART DOCUMENT

PATENT LITERATURE

[0007] PATENT LITERATURE 1: JP 1996-161069 A

PROBLEM TO BE SOLVED BY THE INVENTION

[0008] The above type of pedal actuating mechanism, however, has a risk that the biasing stopper may require an undesirable additional installation space.

SUMMARY OF THE INVENTION

[0009] The present invention was made in view of the above problem. It is an object of the invention to provide a clutch operation effort reactive force generator which develops a simulated reactive force as a function of the degree of effort exerted by a vehicle operator on a clutch pedal.

MEANS FOR SOLVING THE PROBLEM

[0010] The present invention is to provide a clutch operation effort reactive force generator which works to produce a reactive force as a function of an amount by which a clutch pedal is operated by an operator. The clutch operation effort reactive force generator comprises: (a) a supporting member; (b) a cam follower which includes a cam plate and a contacting portion, the cam plate having a cam face and being disposed to be movable on the supporting member, the contacting portion being arranged to make contact with the cam face; and (c) a biasing member which is arranged between the cam follower and the cam plate and works to produce a biasing force to urge the cam follower and the cam plate away from each other in a direction of movement of the cam plate. The movement of the cam plate causes a location of the contact between the contacting portion and the cam face to be changed to move the cam follower in the direction of movement of the cam plate.

BENEFICIAL ADVANTAGE OF THE INVENTION

[0011] The above structure enables the clutch operation effort reactive force generator to be reduced in size thereof, minimizes the volume of space for installation of the clutch operation effort reactive force generator, and is capable of developing a simulated reactive force as a function of an amount by which the clutch pedal is moved by the operator.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012]

Fig. 1 is a cross sectional view which illustrates a clutch operation effort reactive force generator according to an embodiment of the invention which is attached to a dashboard panel.

Fig. 2 is a perspective view which illustrates a clutch operation effort reactive force generator according to an embodiment of the invention.

Fig. 3 is a left side view of a clutch operation effort reactive force generator according to an embodiment of the invention.

Fig. 4 is a longitudinal sectional view of a cam plate installed in a clutch operation effort reactive force generator according to an embodiment of the invention.

Fig. 5 is a view which represents a relation of a reactive force to an amount of stroke of a clutch pedal between depression and release of the clutch pedal in a clutch operation effort reactive force generator according to an embodiment of the invention.

MODE FOR CARRYING OUT THE INVENTION

[0013] A clutch operation effort reactive force generator according to an embodiment of the invention is designed to produce a reactive force as a function of an amount by which a clutch pedal is operated by an operator. The clutch operation effort reactive force generator comprises: (a) a supporting member; (b) a cam follower which includes a cam plate and a contacting portion, the cam plate having a cam face and being disposed to be movable on the supporting member, the contacting portion being arranged to make contact with the cam face; and (c) a biasing member which is arranged between the cam follower and the cam plate and works to produce a biasing force to urge the cam follower and the cam plate away from each other in a direction of movement of the cam plate. The movement of the cam plate causes a location of the contact between the contacting portion and the cam face to be changed to move the cam follower in the direction of movement of the cam plate.

[0014] The above structure enables the clutch operation effort reactive force generator to be reduced in size thereof, minimizes the volume of space for installation of the clutch operation effort reactive force generator, and is capable of developing a simulated reactive force as a function of an amount by which the clutch pedal is moved by the operator.

EMBODIMENT

[0015] A clutch operation effort reactive force generator according to an embodiment of the invention will be described below with reference to the drawings. Figs. 1 to 5 are views which illustrates the clutch operation effort reactive force generator in the embodiment.

[0016] In Figs. 1 to 4, a vertical, longitudinal, and lateral directions are based on the orientation of the clutch operation effort reactive force generator installed in a vehicle, such as an automobile. The vertical, longitudinal, and lateral directions will also be referred to as a height-wise direction, a front-back direction, and a width-wise direction, respectively.

[0017] The structure will first be described. In Fig. 1, the vehicle 1 is equipped with the dashboard panel 2. The engine compartment 2A in which an engine or a transmission, not shown, are mounted is arranged in front of the dashboard panel 2. The passenger compartment 2B occupied by a driver and passengers is located in back of the dashboard panel 2.

[0018] The pedal bracket 3 is mounted on the dashboard panel 2. The pedal bracket 3 has disposed thereon the clutch pedal 4 which is swingable in the longitudinal direction of the vehicle 1.

[0019] The transmission in this embodiment is implemented by a MT (Manual Transmission) and works to engage or disengage a clutch device, not shown, using an actuator.

[0020] The actuator operates or drives the clutch device as a function of the position of the clutch pedal 4 depressed by the driver of the vehicle 1. The clutch pedal 4 is mechanically connected to the clutch device.

[0021] The vehicle 1 is equipped with the clutch operation effort reactive force generator 5. The clutch operation effort reactive force generator 5 works to produce an imitation of a reactive force, in other words, a counterforce which is expected to be actually developed as a function of the amount by which the clutch pedal 4 is operated or depressed by the driver of the vehicle 1 (i.e., pedal-exerted load).

[0022] Referring to Figs. 2 and 3, the clutch operation effort reactive force generator 5 includes the supporting member 10. The supporting member 10 is secured to the dashboard panel 2. Specifically, the dashboard panel 2 has formed therein a through-hole, not shown, through which the supporting member 10 passes to have a front portion disposed inside the engine compartment 2A and a rear portion disposed inside the passenger compartment 2B.

[0023] The supporting member 10 includes the front bottom wall 10A, the front left side wall 10B, the front right side wall 10C, the rear left side wall 10D, and the rear right side wall 10E. The front bottom wall 10A extends in the longitudinal direction of the vehicle 1. The front left side wall 10B extends upward from a left end of front bottom wall 10A. The front right wall 10C extends upward from a right end of the front bottom wall 10A. The rear left side wall 10D extends rearward from a rear end of the front left side wall 10B. The rear eight side wall 10E extends rearward from a rear end of the front right side wall 10C.

[0024] The front left side wall 10B and the front right side wall 10C face each other in the lateral direction (i.e., the width-wise direction of the vehicle 1) and are shaped to be bilaterally symmetrical. The rear left side wall 10D and the rear right side wall 10E face each other in the lateral direction and are shaped to be bilaterally symmetrical.

[0025] Although not illustrated, the rear right side wall 10E is located on the right side of the rear left side wall 10D, in other words, behind the rear left side wall 10D, as viewed in Fig. 3.

[0026] The supporting member 10 is, as illustrated in Fig. 2, equipped with the panel attachment 10F. The panel attachment 10F is arranged on connections between the rear ends of the front left side wall 10B and the front right side wall 10C and the front ends of the rear left side wall 10D and the rear right side wall 10E.

[0027] Specifically, the supporting member 10 has the front left side wall 10B and the front right side wall 10C arranged in front of the panel attachment 10F and also has the rear left side wall 10D and the rear right side wall 10E in back of the panel attachment 10F.

[0028] The panel attachment 10F has formed therein the through-hole 10h extending through a thickness of the panel attachment 10F. The coil spring 17 functioning as a biasing member, as will be described later in detail, extends through the through-hole 10h.

[0029] The rear surface 10r of the panel attachment 10F is, as clearly illustrated in Fig. 1, placed in direct contact with the front surface 2f of the dashboard panel 2. The rear surface 10r is firmly fastened to the dashboard panel 2 using a plurality of bolts 6 (only one is shown in Fig. 2), thereby securing the supporting member 10 to the dashboard panel 2.

[0030] The supporting member 10, as can be seen in Figs. 2 and 3, has the upper wall 10G. The upper wall 10G connects between upper ends of the front left side wall 10B and the front right side wall 10C and extends substantially vertical at an inclined angle relative to the direction A in which the cam plate 13, which will be described later in detail, is moved.

[0031] Specifically, the upper wall 10G is obliquely inclined relative to the direction A of the movement of the cam plate 13, in other words, extends forward from an upper end thereof obliquely downward to a lower end thereof.

[0032] The cam plate 13 is, as clearly illustrated in Fig. 4, disposed in the supporting member 10. The cam plate 13 is movable in the longitudinal direction relative to the supporting member 10.

[0033] The cam plate 13a has the joint groove 13a formed therein. The joint groove 13a has a font end of the rod 14 joined thereto. The pedal bracket 3 is, as can be seen in Fig. 1, equipped with the rod support 3A to which the rear end of the rod 14 is joined.

[0034] With the above arrangements, swing motion of the clutch pedal 4 relative to the pedal bracket 3 in the longitudinal direction causes the cam plate 13 to be moved with the aid of the rod 14.

[0035] Specifically, the cam plate 13 is moved or thrust forward by the rod 14 upon depression of the clutch pedal 4. When the depression of the clutch pedal 4 is released, the clutch pedal 4 is drawn by the rod 14 backward, so that it is returned back to a resting position thereof.

[0036] The cam plate 13 formed therein the elongated hole 13b extending in the longitudinal direction. The pin 15 is disposed in the elongated hole 13b. The pin 15 has a left end and a right end joined to the rear left side wall 10D and the rear right side wall 10E, respectively.

[0037] The elongated hole 13b is shaped to have a vertical dimension which is slightly larger than the diameter of the pin 15, thereby ensuring the stability in longitudinal smooth movement of the cam plate 13 relative to the supporting member 10 without oscillating in the vertical direction.

[0038] The supporting member 10 is equipped with the cam follower 16. The cam follower 16 is movable along the upper wall 10G.

[0039] The cam follower 16 includes the cam follower body 16A, the roller shaft 16a firmly secured to the cam follower body 16A, and the roller 16B retained by the roller shaft 16a to be rotatable. The roller 16B works as a rotating member and will also be referred to below as a contacting portion.

[0040] The cam plate 13 has the cam face 13A formed on an upper surface thereof. The roller 16B is placed in contact with the cam face 13A.

[0041] The cam face 13A extends substantially in the direction A of movement of the cam plate 13. The direction A is identical with the longitudinal direction of the vehicle 1. The direction A of movement of the cam plate 13 is also identical with a direction in which the axis line 14a of the rod 14 extends.

[0042] The cam face 13A includes the convex cam face 13c. The cam plate 13 has a length with the front end 13f and the rear end 13r which are opposed to each other in the direction A of movement of the cam plate 13. The front end 13f is located closer to the cam follower 16 than the rear end 13r is. The convex cam surface 13c extends from the front end 13f toward the rear end 13r and gradually protrudes in a direction perpendicular to the direction A of movement of the cam plate 13.

[0043] The cam face 13A also includes the first S-shaped cam face 13d and the second S-shaped cam face 13e. The first S-shaped cam face 13d extends from the top 13t of the convex cam face 13c toward the rear end 13r of the cam plate 13 and is gently curved downward from the top 13t in a direction substantially perpendicular to the direction A of movement of the cam plate 13. The second S-shaped cam face 13e extends from the lowest point or bottom 13p of the first S-shaped cam face 13d toward the rear end 13r of the cam plate 13 and is gently curved upward from the bottom 13p in a direction perpendicular to the direction A of movement of the cam plate 13. A combination of the first S-shaped cam face 13d and the second S-shaped cam face 13e will also be referred to below as a concave cam face which is recessed gradually in a direction (i.e., inward direction) perpendicular to the direction A.

[0044] The front end 13f of the cam plate 13 will also be referred to below as a first end of the cam plate 13, while the rear end 13r will also be referred to below as a second end of the cam plate 13 opposed to the first end in a direction of movement of the cam plate 13.

[0045] When the clutch pedal 4 is not depressed, so that it is located at an initial or resting position (i.e., a fully engaged clutch position), the roller 16B is located to be lower than the top 13t of the convex cam face 13c and higher than the bottom 13p of the first S-shaped cam face 13d. The bottom 13p is the deepest portion of the first S-shaped cam face 13d.

[0046] The longitudinal movement of the cam plate 13 upon depression of the clutch pedal 4 causes a location of contact between the roller 16B and the cam face 13A to change.

[0047] The coil spring 17 is disposed between the cam follower 16 and the cam plate 13. The coil spring 17 has a front end placed in contact with the cam follower body 16A and a rear end placed in contact with the springbearing portion 13B provided on a rear end portion of the cam plate 13.

[0048] The coil spring 17 is made of a double-coil spring including the outer coil spring 17A and the inner coil spring 17B disposed inside the outer coil spring 17A.

[0049] The coil spring 17 produces a biasing pressure to urge the cam follower 16 and the cam plate 13 away from each other in the direction A of movement of the cam plate 13.

[0050] The clutch operation effort reactive force generator 5 works to change an amount by which the coil spring 17 is compressed as a function of a location of contact of the roller 16B with the cam face 13A during longitudinal movement of the cam plate 13 when the clutch pedal 4 is being depressed or released back to the resting position, thereby developing a simulated reactive force opposing the movement of the clutch pedal 4 and exerting it on the clutch pedal 4.

[0051] The supporting member 10 includes the resinous friction members 18 and 19. The friction member 18 is disposed between the front bottom wall 10A of the supporting member 10 and the cam plate 13.

[0052] The friction member 18 has the fitting protrusions 18a formed on a surface thereof which faces the front bottom wall 10A of the friction member 18. The front bottom wall 10A has formed therein the fitting grooves 10a in which the fitting protrusions 18a are fit.

[0053] With the above arrangements, the friction member 18 is held from moving in the longitudinal direction in which the front bottom wall 10A extends. The friction member 18 frictionally contacts the cam plate 13 when the cam plate 13 is moved in the longitudinal direction. The friction member 18 will also be referred to below as a first friction member.

[0054] The friction member 19 is disposed between the upper wall 10G of the supporting member 10 and the cam follower body 16A.

[0055] The friction member 19 is inclined relative to the direction in which the cam plate 13 moves. Specifically, the friction member 19 is obliquely oriented to have the upper end 19b facing the cam plate 13 in the direction A of movement of the cam plate 13 and the lower end 19c facing away from the cam plate 13 in the direction A of movement of the cam plate 13.

[0056] The friction member 19 has the fitting protrusions 19a formed on a surface thereof which faces the upper wall 10G. The upper wall 10G has formed in an inner wall thereof the fitting grooves 19b in which the fitting protrusions 19a are fit.

[0057] With the above arrangements, the friction member 19 is held from moving in a direction of inclination of the upper wall 10G. When the cam follower 16 moves in the direction of inclination, the friction member 19 frictionally contacts the cam follower 16. The friction member 19 will also be referred to below as a second friction member.

[0058] The cover member 20 is arranged in front of the supporting member 10. The cover member 20 is, as clearly illustrated in Fig. 1, arranged away from the dashboard panel 2 within the engine compartment 2A and covers the supporting member 10 from outside it.

[0059] The vehicle 1 is equipped with a position sensor, not shown, which detects a position of the clutch pedal 4, in other words, an amount by which the clutch pedal 4 is operated. The position sensor works to detect a depressed position of the clutch pedal 4, i.e., an amount by which the cam plate 13 is moved and output a signal indicative thereof to a controller, not shown.

[0060] The controller analyzes the output from the position sensor to control an operation of the actuator to engage or disengage the clutch device.

[0061] The operation of the clutch operation effort reactive force generator 5 will be described below.

[0062] When the driver of the vehicle 1 does not depress the clutch pedal 4, the clutch device is engaged. The roller 16B of the cam follower 16 is riding on a portion of the cam face 13A of the cam plate 13 which is close to the front end 13f.

[0063] When the driver is depressed from the resting position to disengage the clutch device, it causes the cam plate 13 to be moved forward by the rod 14 in frictional contact with the friction member 18, thereby compressing the coil spring 17.

[0064] The forward movement of the cam plate 13 causes the roller 16B to rotate on the convex cam face 13c of the cam face 13A, so that the cam follower 16 is moved obliquely upward in the rearward direction. Simultaneously, the cam follower body 16A moves toward the rod 14 in the direction A of movement of the cam plate 13 in frictional contact with the friction member 19

[0065] When the cam plate 13 is further moved forward, so that the roller 16B rides on the top 13t of the convex cam face 13c, it causes the cam follower 16 to be located closest to the rod 14 in the direction A of movement of the cam plate 13. In other words, the distance between the lower end 19c of the friction member 19 of the supporting member 10 and the cam follower 16 is maximized in the direction A of movement of the cam plate 13.

[0066] Consequently, the movement of the roller 16B from a portion of the cam face 13A close to the front end 13f of the cam plate 13 until the roller 16B arrives at or contacts the top 13t of the convex cam face 13c causes an amount by which the coil spring 17 is compressed to be increased by the distance the cam follower 16 travels toward the rod 14.

[0067] When the roller 16B is moving along the convex cam face 13c, a reactive force which is produced by the coil spring 17 and, as demonstrated by *W1* in Fig. 5, gradually increased in level as a function of the amount by which the clutch pedal 4 is depressed, i.e., an amount of stroke of the clutch pedal 4 is applied to the clutch pedal 4 as a counter pressure.

[0068] When the cam plate 13 is further moved forward, the roller 16B travels from the top 13t of the convex cam face 13c to the bottom 13p of the first S-shaped cam face 13d in contact with the first S-shaped cam face 13d, in other words, the roller 16B moves downward along the first S-shaped cam face 13d.

[0069] When the roller 16B moves along the first S-shaped cam face 13d, it causes the cam follower 16 to move obliquely downward, forward along the friction member 19 away from the rod 14 in the direction A of movement of the cam plate 13, thereby decreasing the amount by which the coil spring 17 is compressed.

[0070] Consequently, a reactive force which is produced by the coil spring 17 and, as demonstrated by *W2* in Fig. 5, gradually decreased in level as a function of the amount by which the clutch pedal 4 is depressed, i.e., an amount of stroke of the clutch pedal 4 is applied to the clutch pedal 4 as a counter pressure.

[0071] When the cam plate 13 is further moved forward, the roller 16B travels upward from the bottom 13p of the first S-shaped cam face 13d in contact with the second S-shaped cam face 13e, thereby causing the cam follower 16 to move obliquely upward, rearward toward the rod 14 in the direction A of movement of the cam plate 13, thereby increasing the amount by which the coil spring 17 is compressed.

[0072] Consequently, a reactive force which is produced by the coil spring 17 and, as demonstrated by *W3* in Fig. 5, gradually increased in level as a function of the amount by which the clutch pedal 4 is depressed, i.e., an amount of stroke of the clutch pedal 4 is applied to the clutch pedal 4 as a counter pressure.

[0073] After the clutch pedal 4 is depressed until the clutch device is disengaged, and then a shift operation of the transmission is been completed, the release of the clutch pedal 4 will cause the pressure exerted by the driver on the clutch pedal 4 to be lower than that applied to the clutch pedal 4 during the depression of the clutch pedal 4.

[0074] The release of the clutch pedal 4 causes the cam plate 13 to be urged by the coil spring 17, so that it is moved backward along with the rod 14.

[0075] When the cam plate 13 is urged by the coil spring 17 backward, it causes the roller 16B to move from the first S-shaped cam face 13d to the convex cam face 13c in contact therewith. The cam follower 16 is, therefore, moved in the direction A of movement of the cam plate 13 with a change in location of contact of the roller 16B with the first S-shaped cam face 13d or the convex cam face 13c.

[0076] The above movement of the cam follower 16 regulates the amount of compression of the coil spring 17, which develops a mechanical pressure as a function of the amount of compression of the coil spring 17 and exerts it to the clutch pedal 4 as a simulated counter force.

[0077] When the clutch pedal 4 is being returned back to the resting position, a reactive force which is, as can be seen in Fig. 5, lower in level than that developed when the clutch pedal 4 is being depressed is exerted on the clutch pedal 4.

[0078] Specifically, when the clutch pedal 4 is depressed, friction which resists the depression of the clutch pedal 4 is developed between the friction member 18 and the cam plate 13 and between the friction member 19 and the cam follower 16. The degree of such friction is increased with an increase in amount of compression of the coil spring 17.

[0079] Alternatively, when the clutch pedal 4 is released, so that it is returned back to the resting position, friction which resists the backward movement of the clutch pedal 4, in other words, which is oriented opposite the direction in which the clutch pedal 4 is depressed is developed between the friction member 18 and the cam plate 13 and between the friction member 19 and the cam follower 16. The degree of such friction is decreased with a decrease in amount by which the coil spring 17 is compressed.

[0080] The degree of effort exerted on the clutch pedal 4 when the clutch pedal 4 is released by the driver of the vehicle 1 is usually lower than that when the clutch pedal 4 is depressed by the driver, thus, as represented in Fig. 5, resulting in hysteresis of the reactive force acting on the clutch pedal 4.

[0081] The above hysteresis causes the clutch operation effort reactive force generator 5 to produce a higher degree of reactive force during the depression of the clutch pedal 4 and a lower degree of reactive force during the release of the clutch pedal 4.

[0082] The clutch operation effort reactive force generator 5 in this embodiment is, as described above, equipped with the supporting member 10, the cam face 13A, the cam plate 13 which is arranged in the supporting member 10 to be movable, and the cam follower 16 which is movable in the supporting member. The cam follower 16 is equipped with the roller 16B which is arranged in contact with the cam face 13A.

[0083] The clutch operation effort reactive force generator 5 is also equipped with the coil spring 17 which is disposed between the cam follower 16 and the cam plate 13 and generates a biasing force which urges the cam follower 16 and the cam plate 13 away from each other in the direction A in which the cam plate 13 is moved. The movement of the cam plate 13 results in a change in location of contact between the roller 16B and the cam face 13A to move the cam follower 16 in the direction A of the movement of the cam plate 13.

[0084] Accordingly, when the clutch pedal 4 is operated, the clutch operation effort reactive force generator 5 works to change the amount by which the coil spring 17 is compressed as a function of the distance by which the cam plate 13, i.e., the cam follower 16 is moved and apply, to the clutch pedal 4, a reactive force which resists the operation of the clutch pedal 4 and is developed as a function of the amount of the compression of the coil spring 17.

[0085] The configuration of the cam face 13A of the cam plate 13 may be changed to control the distance by which the cam follower 16 moves in the direction A of movement of the cam plate 13, thereby regulating the degree of reactive force produced by the coil spring 17 to a desired level.

[0086] As apparent from the above discussion, the clutch operation effort reactive force generator 5 is capable of creating a simulated reactive force as a function of the amount by which the clutch pedal 4 is operated by the driver of the vehicle 1 and providing the driver with a comfortable feeling of operation of the clutch pedal 4.

[0087] The cam plate 13 is shaped to have the cam face 13A. The cam follower 16 is equipped with the roller 16B riding directly on the cam face 13A. This eliminates the need for an additional biasing mechanism required in the prior art structure, thereby enabling the clutch operation effort reactive force generator 5 to be reduced in size thereof, which leads to a decreased volume of space for installation of the clutch operation effort reactive force generator 5.

[0088] The supporting member 10, the cam plate 13, the cam follower 16, and the coil spring 17 constitute the clutch operation effort reactive force generator 5, thereby simplifying the structure of the clutch operation effort reactive force generator 5. The clutch pedal 4 is joined to the cam plate 13 through the rod 14, thereby facilitating transmission of the simulated reactive force from the clutch operation effort reactive force generator 5 to the clutch pedal 4.

[0089] The above arrangements eliminate the need for designing the clutch pedal 4 especially for the clutch operation effort reactive force generator 5 or shaping the dashboard panel 2 especially for the clutch operation effort reactive force generator 5, which minimizes the cost for production of the vehicle 1.

[0090] The clutch operation effort reactive force generator 5 in this embodiment has the cam face 13A shaped to have the convex cam face 13c which extends from the front end 13f of the cam plate 13 facing the cam follower 16 toward the rear end 13r and protrudes gradually in a direction perpendicular to the direction A of movement of the cam plate 13.

[0091] The cam face 13A also has the first S-shaped cam face 13d which extends from the top 13t of the convex cam face 13c toward the rear end 13r of the cam plate 13 and is curved gently downward from the top 13t in a direction perpendicular to the direction A of movement of the cam plate 13.

[0092] With the above arrangements, the roller 16B makes contact with the convex cam face 13c upon start of depression of the clutch pedal 4, thereby producing the reactive force whose level, as demonstrated in Fig. 5, increases gradually.

[0093] The roller 16B is also moved from the convex cam face 13c to the first S-shaped cam face 13d in contact therewith, thereby gradually decreasing the degree of reactive force acting on the clutch pedal 4.

[0094] Accordingly, the clutch operation effort reactive force generator 5 works to produce the reactive force which gradually increases in the early half or first half (i.e., *W1* in Fig. 5) from start of depression of the clutch pedal 4 to approximately half of the total amount by which the clutch pedal 4 is depressed (i.e., total amount of stroke of the clutch pedal 4), and also produce the reactive force which gradually decreases in the last half or second half (i.e., *W2* to *W3* in Fig. 5) of the depression of the clutch pedal 4.

[0095] The driver of the vehicle 1, therefore, feels a strong resistance to the movement of the clutch pedal 4 in the first half of the depression of the clutch pedal 4 and then feels a decreased degree of resistance to the movement of the clutch pedal 4 in the second half of the depression of the clutch pedal 4.

[0096] When the clutch pedal 4 is released, the clutch operation effort reactive force generator 5 also works to produce a first level of reactive force in the first half of the release of the clutch pedal 4. The first level of reactive force is lower than that during the second half of the depression of the clutch pedal 4. The enables the driver of the vehicle 1 to physically feel the sense of release of the clutch pedal 4.

[0097] The clutch operation effort reactive force generator 5 in this embodiment also has the supporting member 10 equipped with the friction member 18 and the friction member 19.

[0098] The friction member 18 is disposed between the supporting member 10 and the cam plate 13 and makes frictional contact with the cam plate 13 during movement of the cam plate 13.

[0099] The friction member 19 is arranged between the supporting member 10 and the cam follower 16 and makes frictional contact with the cam follower 16 during movement of the cam follower 16.

[0100] The frictional contact between the friction member 18 and the cam plate 13 and between the friction member 19 and the cam follower 16 results in hysteresis of the reactive force acting on the clutch pedal 4 between the depression and the release of the clutch pedal 4.

[0101] The clutch operation effort reactive force generator 5 in this embodiment has the friction member 19 inclined relative to the direction A of movement of the cam plate 13 to have the upper end 19b facing the cam plate 13 and the lower end 19c facing away from the cam plate 13.

[0102] With the above arrangements, when the roller 16B of the cam follower 16 slides on the convex cam face 13c and the first S-shaped cam face 13d, it causes the cam follower 16 to be moved upward along the upper wall 10G and simultaneously travel in the direction A of movement of the cam plate 13.

[0103] The upward movement of the cam follower 16 results in inclination of the coil spring 17 relative to the direction A of movement of the cam plate 13. The inclination of the coil spring 17 during the movement of the cam plate 13 may, however, be minimized by increasing the inclination of the friction member 19 relative to the direction A of movement of the cam plate 13, thereby achieving a smooth movement of the clutch pedal 4 and ensuring the durability of the coil spring 17.

[0104] The inclination of the friction member 19 relative to the direction A of movement of the cam plate 13 also avoids an increase in dimension of the supporting member 10 in a direction perpendicular to the direction A of movement of the cam plate 13, thereby enabling the clutch operation effort reactive force generator 5 to be reduced in size thereof.

[0105] The inclination of the friction member 19 relative to the direction A of movement of the cam plate 13 also results in an increased level of pressure acting on a surface-to-surface contact between the cam follower 16 and the friction member 19, thereby increasing the hysteresis of the reactive force between the depression and release of the clutch pedal 4.

[0106] The development of the hysteresis between the depression and release of the clutch pedal 4 requires increasing the pressure exerted on surface-to-surface contacts between the friction member 18 and the cam plate 13 and between the friction member 19 and the cam follower 16 and also achieving frictional sliding motion of the cam plate 13 and the cam follower 16 on the friction members 18 and 19.

[0107] However, in case of use of metal as material of the friction members 18 and 19, the increase in pressure acting on the surface-to-surface contacts between the friction member 18 and the cam plate 13 and between the friction member 19 and the cam follower 16 will result in mechanical wear thereof due to roughness of the surfaces of the friction members 18 and 19, which leads to a change in load acting on the cam plate 13 and the cam follower 16 during movement thereof.

[0108] The clutch operation effort reactive force generator 5 in this embodiment has the friction member 18 and the friction member 19 made from resin material.

[0109] The resin material usually has a smooth or slick surface, is excellent in wear resistance, and has an even coefficient of friction. The use of resin material, thus, minimizes the mechanical wear of the surfaces of the friction members 18 contacting the cam plate 13 and the cam follower 16, respectively, as compared with metallic material.

[0110] It is, therefore, possible to keep the reactive force resisting the operation of the clutch pedal 4 at a constant level, which provides the stability for the driver to feel a suitable level of reactive force opposing the movement of the clutch pedal 4 over an extended period of time.

[0111] The clutch operation effort reactive force generator 5 has the cam follower 16 equipped with the roller 16B arranged to be rotatable in contact with the cam face 13A.

[0112] The above structure minimizes the mechanical wear of the cam face 13A of the cam plate 13, thereby improving the durability of the cam plate 13 and keeping the level of the reactive force resisting the movement of the clutch pedal 4 at a constant level. This enables the driver of the vehicle 1 to feel a suitable level of the reactive force for a long period of time.

[0113] The clutch operation effort reactive force generator 5 has the cam plate 13 connected to the clutch pedal 4 through the rod 14, but however, the cam plate 13 may alternatively be joined directly to the clutch pedal 4.

[0114] While the present invention has been disclosed in terms of the preferred embodiment in order to facilitate better understanding thereof, it should be appreciated that the invention can be embodied in various ways without departing from the principle of the invention. Therefore, the invention should be understood to include all possible equivalents or modifications to the shown embodiment which can be embodied without departing from the principle of the invention as set forth in the appended claims.

Claims

1. A clutch operation effort reactive force generator (5) which works to produce a reactive force as a function of an amount by which a clutch pedal (4) is operated by an operator, comprising:

a supporting member (10);
a cam follower (16) which includes a cam plate (13) and a contacting portion (16B), the cam plate (13) having a cam face (13A) and being disposed to be movable on the supporting member (10), the contacting portion (16B) being arranged to make contact with the cam face (13A); and
a biasing member (17) which is arranged between the cam follower (16) and the cam plate (13) and works to produce a biasing force to urge the cam follower (16) and the cam plate (13) away from each other in a direction of movement of the cam plate (13), **characterized in that**
the movement of the cam plate (13) causes a location of the contact between the contacting portion (16B) and the cam face (13A) to be changed to move the cam follower (16) in the direction of movement of the cam plate (13).

2. The clutch operation effort reactive force generator as claimed in claim 1, wherein the cam face (13A) includes a convex cam face (13c) and a concave cam face (13d, 13e), the convex cam face (13c) extending from a first end portion (13f) of the cam plate (13) which is located close to the cam follower (16) toward a second end portion (13r) of the cam plate (13) facing away from the cam follower (16) in the direction of movement of the cam plate (13), the convex cam face (13c) gradually protruding in a direction perpendicular to the direction of movement of the cam plate (13), the concave cam face (13d, 13e) extending from a top of the convex cam face (13c) toward the second end portion of the cam plate (13) in the direction of movement of the cam plate (13), the concave cam face (13d, 13e) gradually recessed in a direction perpendicular to the direction of movement of the cam plate (13).

3. The clutch operation effort reactive force generator as claimed in claim 1 or 2, wherein the supporting member includes a first friction member (18) and a second friction member (19), the first friction member (18) being disposed between the supporting member (10) and the cam plate (13), the second friction member (19) being disposed between the supporting member (10) and the cam follower (16),

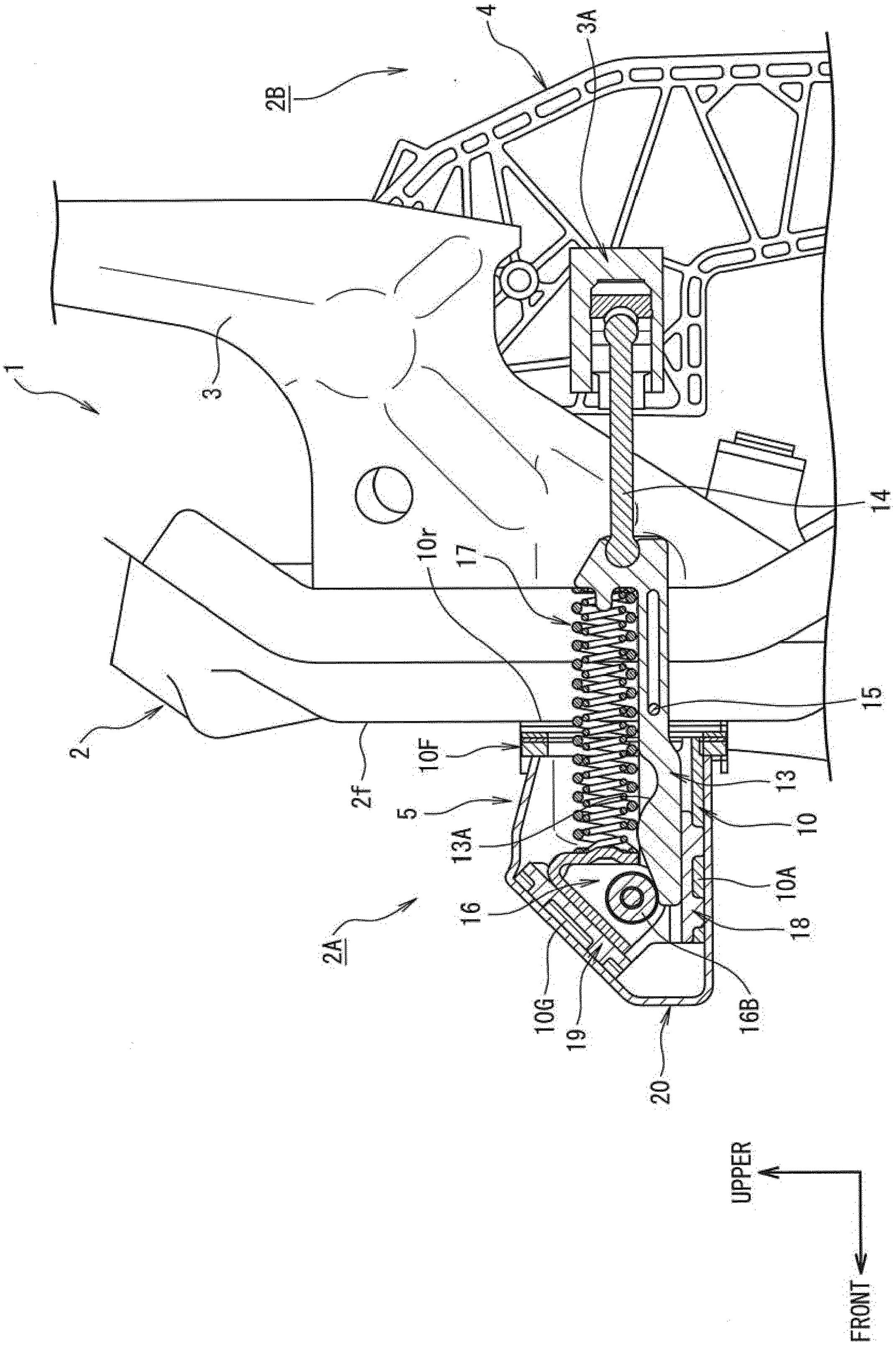
    the first friction member (18) makes frictional contact with the cam plate (13) during movement of the cam plate (13), and
    the second friction member (19) makes frictional contact with the cam follower (16) during movement of the cam follower (16).

4. The clutch operation effort reactive force generator as claimed in claim 3, wherein the second friction member (19) is inclined relative to the direction of movement of the cam plate (13) to have an upper end (19b) which faces the cam plate (13) in the direction of movement of the cam plate (13).

5. The clutch operation effort reactive force generator as claimed in claim 3 or 4, wherein the first friction member (18) and the second friction member (19) are made from resin material.

6. The clutch operation effort reactive force generator as claimed in any one of claims 1 to 5, wherein the contacting portion (16B) is made of a roller which is rotatable in contact with the cam face (13A).

FIG. 1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2B
2f
3
3A
4
5
10
10A
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10G
10r
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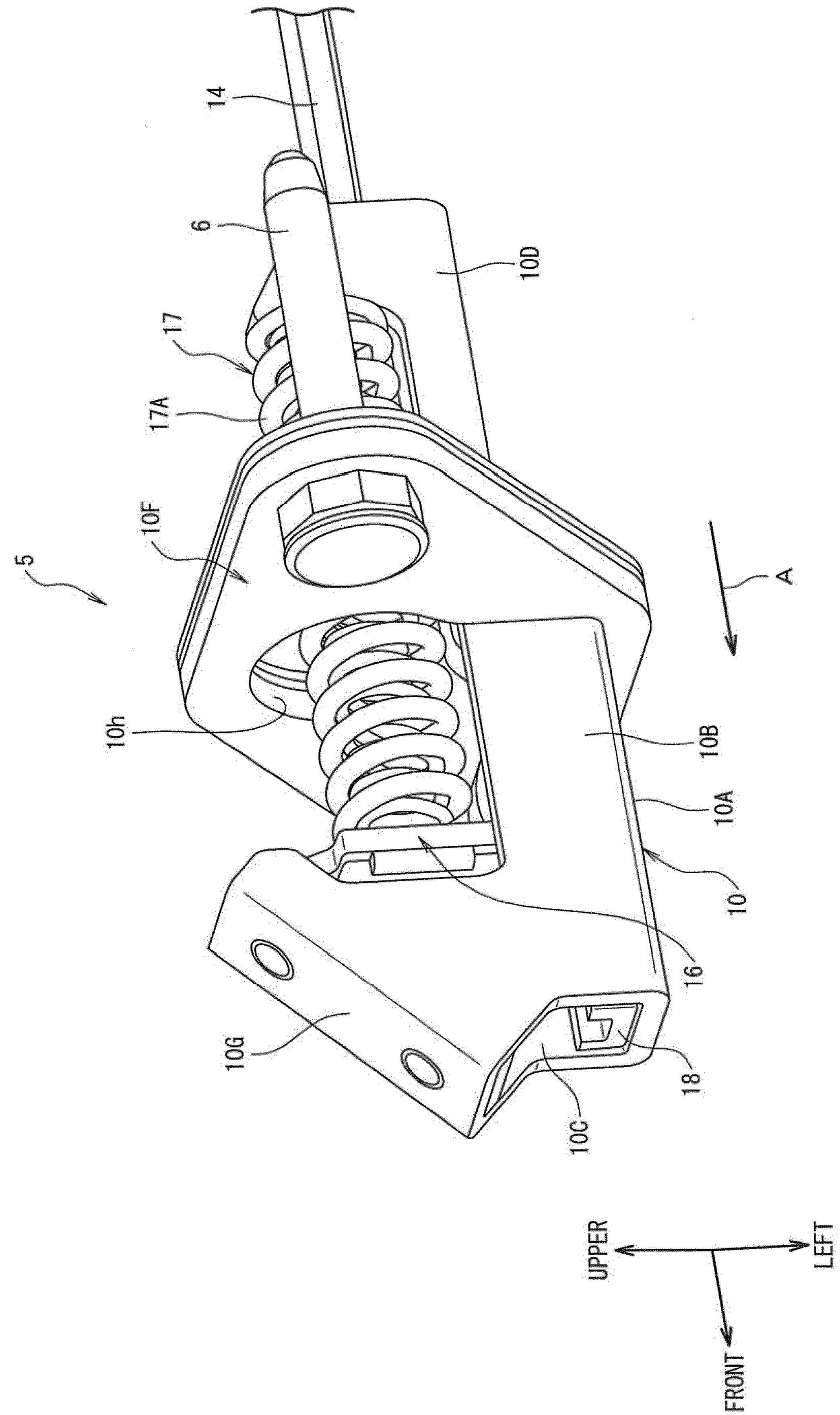
15
16
16B
17
18
19
20
UPPER
FRONT

FIG. 2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14
6
10D
17
17A
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10h
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10
16
10G
18
10C
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UPPER
LEFT
FRONT

FIG. 3

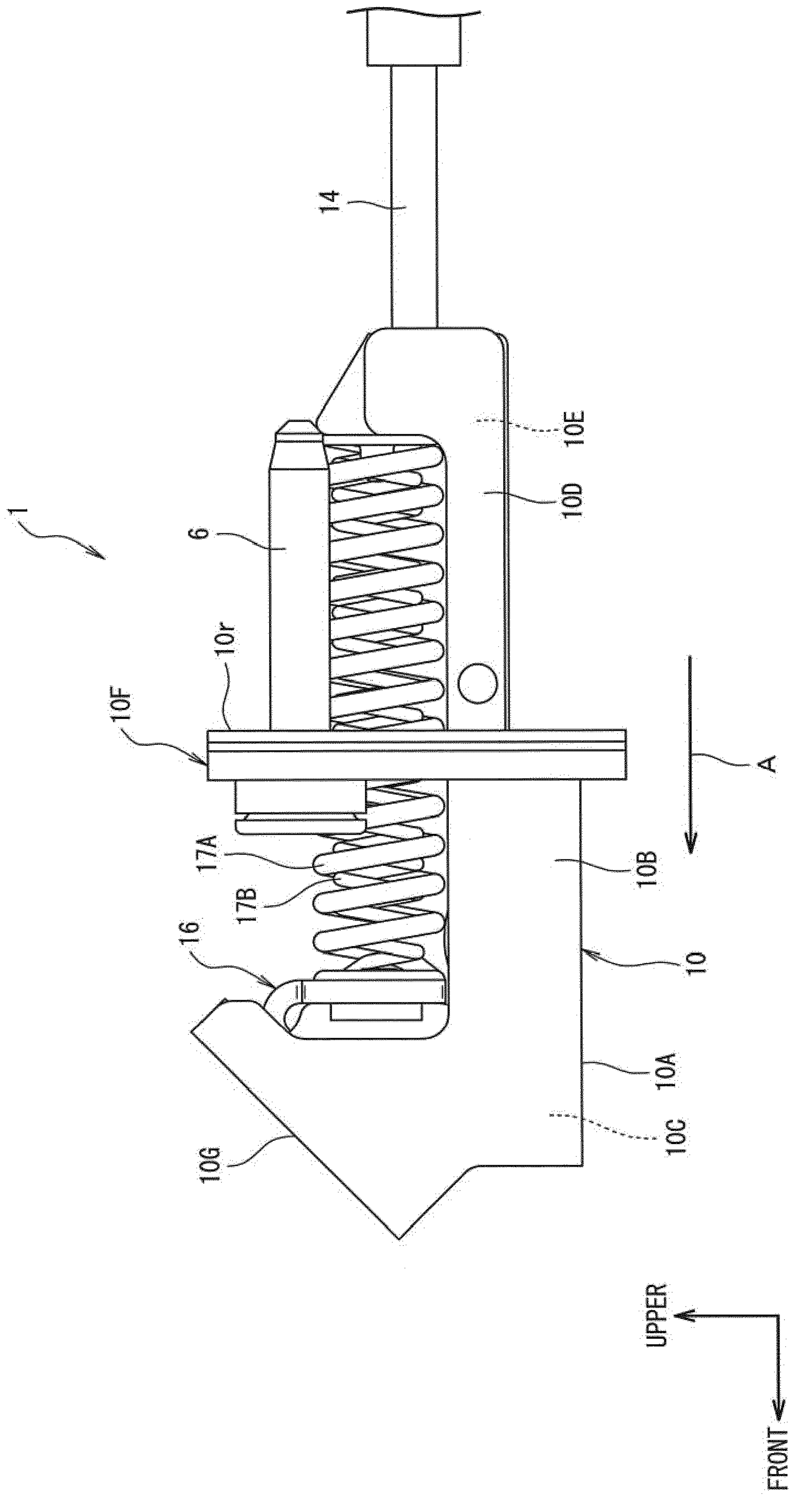
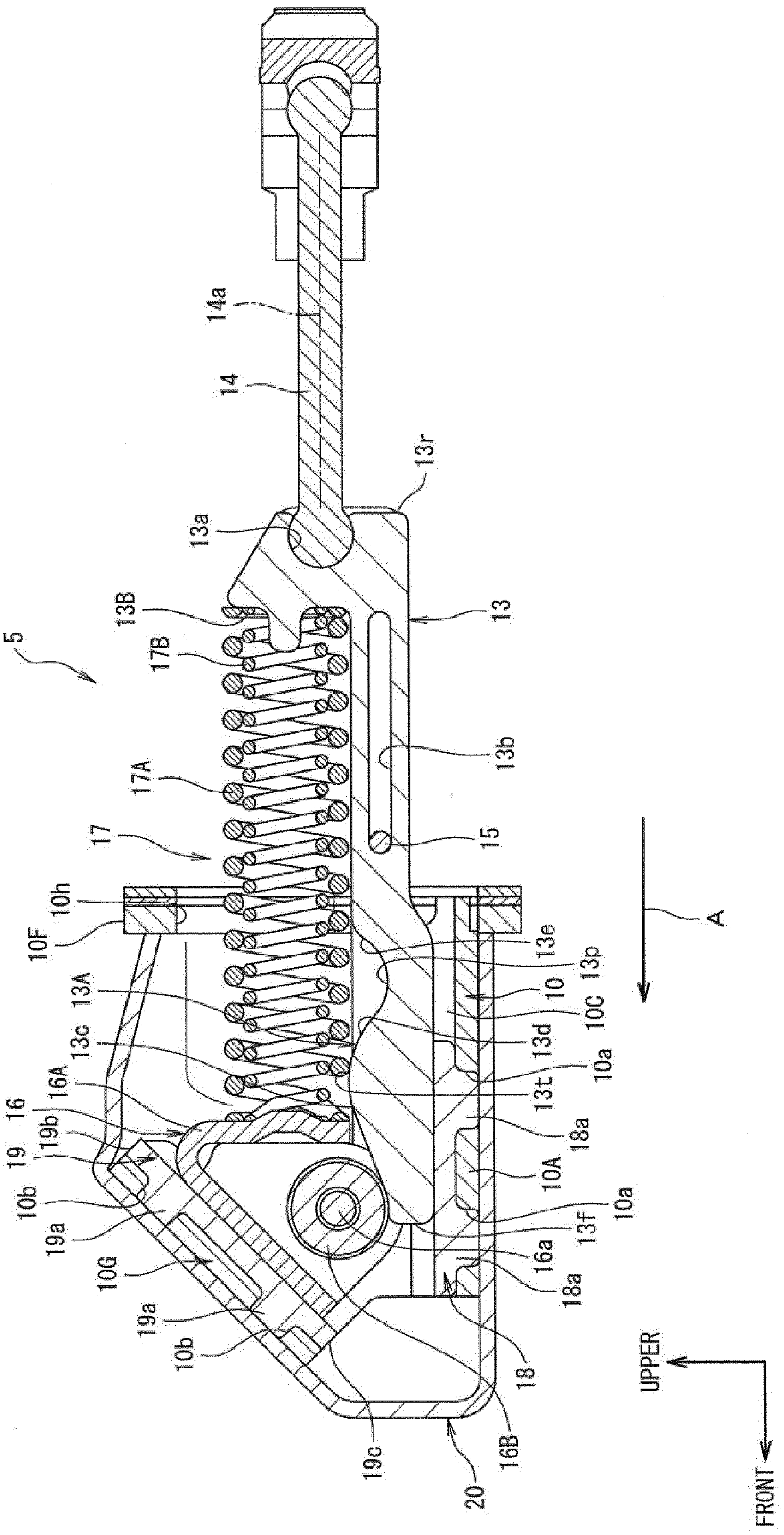


FIG. 4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13A
10C
13c
13d
16A
10a
13t
16
19b
18a
19
10A
10b
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13f
16a
10G
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10b
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UPPER
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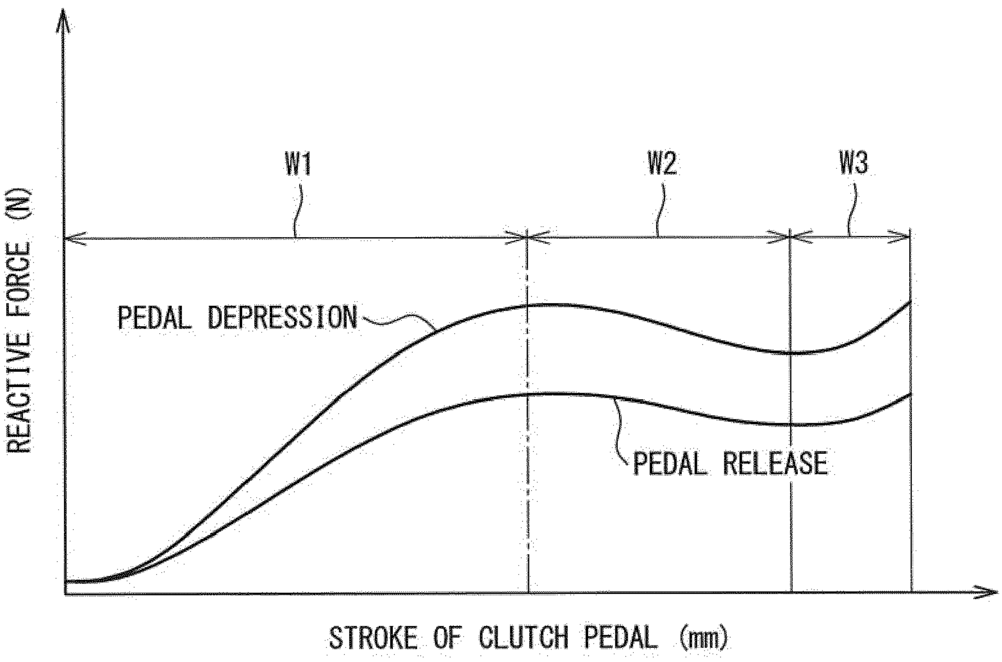
19c
16B
20

FIG. 5


W1
W2
W3
REACTIVE FORCE (N)
PEDAL DEPRESSION
PEDAL RELEASE
STROKE OF CLUTCH PEDAL (mm)

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EUROPEAN SEARCH REPORT

Application Number
EP 22 17 4238

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1

Place of search	Date of completion of the search	Examiner
Munich	11 November 2022	García y Garmendia

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