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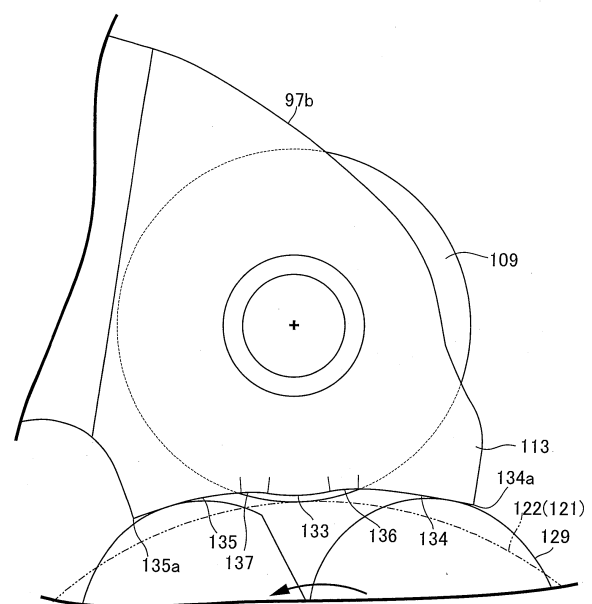
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(54) **INTERNAL COMBUSTION ENGINE**

(57) An internal combustion engine includes a decompression cam (112) that makes a curved protruding face (129) having a generatrix parallel to the rotational axis of the cam shaft project from an imaginary cylindrical face (122) coaxial with the cam shaft when the rotational speed is less than a preset value, a convex decompression follower face (133) with a convexly curved face that is provided on the exhaust side rocker arm (97b) on an outer side of the imaginary cylindrical face (122), that faces the imaginary cylindrical face (122) at a position closest to the imaginary cylindrical face (122), and that makes contact with the curved protruding face (129), and a concave decompression follower face (134) that is provided on the upstream of the convex decompression follower face (133) in a normal rotational direction of the cam shaft, that is formed as a concavely curved face having a generatrix parallel to the rotational axis of the cam shaft, and that makes contact with the curved protruding face (129). This provides an internal combustion engine that can further reduce the collision noise between a decompression cam and an exhaust side rocker arm and the seating noise of an exhaust valve.

FIG.6



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Description

TECHNICAL FIELD

[0001] The present invention relates to a decompression device of an internal combustion engine.

BACKGROUND ART

[0002] Patent Document 1 discloses a decompression device of an internal combustion engine. The decompression device includes a decompression cam having a partial cylindrical face with a small diameter having an axis parallel to the rotational axis of a cam shaft. The decompression cam has part of the partial cylindrical face projecting further than an imaginary cylindrical face coaxial with the cam shaft when the rotational speed is less than a preset value. A slipper of an exhaust side rocker arm makes contact with the projecting decompression cam to thus open an exhaust valve. Due to the exhaust valve opening during a compression stroke in a low rotational speed region, the drive resistance of a piston is reduced, and vibration of the internal combustion engine is suppressed.

RELATED ART DOCUMENTS

PATENT DOCUMENTS

[0003] Patent Document 1: Japanese Patent Application Laid-open No. 2014-129794

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0004] When a piston does not completely ride over compression top dead center and a cam shaft rotates in reverse, the noise of a collision between a decompression cam and an exhaust side rocker arm is reduced. There is a requirement not only to reduce such collision noise, but also to reduce the collision noise between the decompression cam and the exhaust side rocker arm when the cam shaft rotates normally and the seating noise of an exhaust valve.

[0005] The present invention has been accomplished in light of the above circumstances, and it is an object thereof to provide an internal combustion engine that can further reduce the collision noise between a decompression cam and an exhaust side rocker arm and the seating noise of an exhaust valve.

MEANS FOR SOLVING THE PROBLEMS

[0006] According to a first aspect of the present invention, there is provided an internal combustion engine comprising a base face having a shape with a partial cylindrical face that is coaxial with a rotational axis of a

cam shaft, a lift face that is provided on the cam shaft so as to be continuous from the base face in a rotational direction and that bulges further radially outward than the base face to define an amount of lift of an exhaust valve, a cam follower that is provided on an exhaust side rocker arm and causes the exhaust side rocker arm to swing while maintaining contact with the base face and the lift face, a decompression cam that makes a curved protruding face having a generatrix parallel to the rotational axis of the cam shaft project from an imaginary cylindrical face coaxial with the cam shaft when the rotational speed is less than a preset value, a convex decompression follower face with a convexly curved face that is provided on the exhaust side rocker arm on an outer side of the imaginary cylindrical face, that faces the imaginary cylindrical face at a position closest to the imaginary cylindrical face, and that makes contact with the curved protruding face, and a concave decompression follower face that is provided on the upstream of the convex decompression follower face in a normal rotational direction of the cam shaft, that is formed as a concavely curved face having a generatrix parallel to the rotational axis of the cam shaft, and that makes contact with the curved protruding face.

[0007] According to a second aspect of the present invention, in addition to the first aspect, an upstream end of the concave decompression follower face is provided at a position spaced from the rotational axis of the cam shaft compared with the curved protruding face.

[0008] According to a third aspect of the present invention, in addition to the first or second aspect, the concave decompression follower face is positioned remoter from the rotational axis of the cam shaft in going away from the convex decompression follower face.

[0009] According to a fourth aspect of the present invention, in addition to any one of the first to third aspects, the internal combustion engine further comprises an auxiliary concave decompression follower face that is formed between the convex decompression follower face and the concave decompression follower face and that is formed from a concavely curved face having a curvature smaller than a curvature of the curved protruding face.

[0010] According to a fifth aspect of the present invention, in addition to the fourth aspect, the auxiliary concave decompression follower face is formed from part of a cylindrical face having a curvature larger than a curvature of the concave decompression follower face.

[0011] According to a sixth aspect of the present invention, in addition to any one of the first to fifth aspects, the internal combustion engine further comprises a second concave decompression follower face that is provided on the downstream of the convex decompression follower face in the normal rotational direction of the cam shaft, that is formed as a concavely curved face having a generatrix parallel to the rotational axis of the cam shaft, and that makes contact with the curved protruding face.

[0012] According to a seventh aspect of the present invention, there is provided an internal combustion en-

gine comprising a base face having a shape with a partial cylindrical face that is coaxial with a rotational axis of a cam shaft, a lift face that is provided on the cam shaft so as to be continuous from the base face in a rotational direction and that bulges further radially outward than the base face to define an amount of lift of an exhaust valve, a cam follower that is provided on an exhaust side rocker arm and causes the exhaust side rocker arm to swing while maintaining contact with the base face and the lift face, a decompression cam that makes a curved protruding face having a generatrix parallel to the rotational axis of the cam shaft project from an imaginary cylindrical face coaxial with the cam shaft when the rotational speed is less than a preset value, a convex decompression follower face that is provided on the exhaust side rocker arm on an outer side of the imaginary cylindrical face, that faces the imaginary cylindrical face at a position closest to the imaginary cylindrical face, and that makes contact with the curved protruding face, and a concave decompression follower face that is provided on the downstream of the convex decompression follower face in a normal rotational direction of the cam shaft, that is formed as a concavely curved face having a generatrix parallel to the rotational axis of the cam shaft, and that makes contact with the curved protruding face.

[0013] According to an eighth aspect of the present invention, in addition to the seventh aspect, a downstream end of the concave decompression follower face is provided at a position spaced from the rotational axis of the cam shaft compared with the curved protruding face.

[0014] According to a ninth aspect of the present invention, in addition to the seventh or eighth aspect, the concave decompression follower face is positioned remoter from the rotational axis of the cam shaft in going away from the convex decompression follower face.

[0015] According to a tenth aspect of the present invention, in addition to any one of the seventh to ninth aspects, the internal combustion engine further comprises an auxiliary concave decompression follower face that is formed between the convex decompression follower face and the concave decompression follower face and that is formed from a concavely curved face having a curvature smaller than a curvature of the curved protruding face.

[0016] According to an eleventh aspect of the present invention, in addition to the tenth aspect, the auxiliary concave decompression follower face is formed from part of a cylindrical face having a curvature larger than a curvature of the concave decompression follower face.

[0017] According to a twelfth aspect of the present invention, in addition to any one of the first to eleventh aspects, the internal combustion engine further comprises an AC generator that is joined to a crankshaft, that generates electric power in response to rotation of the crankshaft, and that drives the crankshaft around a rotational axis thereof in response to electric power being supplied.

[0018] According to a thirteenth aspect of the present invention, there is provided an internal combustion engine comprising a base face having a shape with a partial cylindrical face that is coaxial with a rotational axis of a cam shaft, a lift face that is provided on the cam shaft so as to be continuous from the base face in a rotational direction and that bulges further radially outward than the base face to define an amount of lift of an exhaust valve, a cam follower that is provided on an exhaust side rocker arm and causes the exhaust side rocker arm to swing while maintaining contact with the base face and the lift face, a decompression cam that makes a curved protruding face having a generatrix parallel to the rotational axis of the cam shaft project from an imaginary cylindrical face coaxial with the cam shaft when the rotational speed is less than a preset value, and a convex decompression follower face with a convexly curved face that is provided on the exhaust side rocker arm on an outer side of the imaginary cylindrical face, that faces the imaginary cylindrical face, and that makes contact with the curved protruding face, the curved protruding face having a peak face that projects the furthest from the imaginary cylindrical face, and a buffer face that is provided on the upstream of the peak face in a normal rotational direction of the cam shaft, that is formed as a concavely curved face having a generatrix parallel to the rotational axis of the cam shaft, and that makes contact with the convex decompression follower face.

[0019] According to a fourteenth aspect of the present invention, in addition to the thirteenth aspect, the curved protruding face further has a second buffer face that is provided on the downstream of the peak face in the normal rotational direction of the cam shaft and that is formed as a concavely curved face having a generatrix parallel to the rotational axis of the cam shaft.

[0020] According to a fifteenth aspect of the present invention, there is provided an internal combustion engine comprising a base face having a shape with a partial cylindrical face that is coaxial with a rotational axis of a cam shaft, a lift face that is provided on the cam shaft so as to be continuous from the base face in a rotational direction and that bulges further radially outward than the base face to define an amount of lift of an exhaust valve, a cam follower that is provided on an exhaust side rocker arm and causes the exhaust side rocker arm to swing while maintaining contact with the base face and the lift face, a decompression cam that makes a curved protruding face having a generatrix parallel to the rotational axis of the cam shaft project from an imaginary cylindrical face coaxial with the cam shaft when the rotational speed is less than a preset value, and a convex decompression follower face with a convexly curved face that is provided on the exhaust side rocker arm on an outer side of the imaginary cylindrical face, that faces the imaginary cylindrical face, and that makes contact with the curved protruding face, the curved protruding face having a peak face that projects the furthest from the imaginary cylindrical face, and a buffer face that is provided on the down-

stream of the peak face in a normal rotational direction of the cam shaft, that is formed as a concavely curved face having a generatrix parallel to the rotational axis of the cam shaft, and that makes contact with the convex decompression follower face.

EFFECTS OF THE INVENTION

[0021] In accordance with the first aspect, in a low rotational speed region in which the rotational speed is less than a set value the curved protruding face of the decompression cam projects in the centrifugal direction of the cam shaft. While the cam shaft is rotating normally, the curved protruding face of the decompression cam makes contact with the concave decompression follower face and the convex decompression follower face of the exhaust side of the rocker arm one after another. Since the concave decompression follower face is formed as a concavely curved face, at the start of contact the curved protruding face of the decompression cam can slip against the concavely curved face in a tangential direction. Therefore, noise due to collision between the decompression cam and the exhaust side rocker arm can be suppressed.

[0022] In accordance with the second aspect, at the start of contact the curved protruding face of the decompression cam makes contact with the concavely curved face. Noise due to collision between the decompression cam and the exhaust side rocker arm can be suppressed.

[0023] In accordance with the third aspect, even if the position of the curved protruding face of the decompression cam is somehow displaced due to dimensional tolerance or assembly error, when starting contact the curved protruding face of the decompression cam can slip against the concavely curved face in a tangential direction. Therefore, noise due to collision between the decompression cam and the exhaust side rocker arm can be suppressed.

[0024] In accordance with the fourth aspect, since the concave decompression follower face, the auxiliary concave decompression follower face, and the convex decompression follower face are continuous, the curved protruding face of the decompression cam can smoothly follow the concave decompression follower face and then the convex decompression follower face. Noise due to collision between the decompression cam and the exhaust side rocker arm can be suppressed.

[0025] In accordance with the fifth aspect, in response to a change in the curvature the curved protruding face of the decompression cam can smoothly follow the concave decompression follower face and then the convex decompression follower face. Noise due to collision between the decompression cam and the exhaust side rocker arm can be suppressed.

[0026] In accordance with the sixth aspect, while the cam shaft is rotating normally, the curved protruding face of the decompression cam makes contact with the convex decompression follower face and the second con-

cave decompression follower face in succession. Since the second concave decompression follower face is formed as a concavely curved face, when the decompression cam disengages from the second concave decompression follower face, the amount of lift of the exhaust valve changes gently. As a result, the noise of seating of the exhaust valve (seating noise) is reduced. Moreover, while the cam shaft is rotating in reverse, the curved protruding face of the decompression cam makes contact with the second concave decompression follower face and the convex decompression follower face one after another. Since the second concave decompression follower face is formed as a concavely curved face, when starting contact the curved protruding face of the decompression cam can slip against the concavely curved face in a tangential direction. Therefore, when the piston cannot completely ride over compression top dead center and the cam shaft rotates in reverse, noise due to collision between the decompression cam and the exhaust side rocker arm can be suppressed.

[0027] In accordance with the seventh aspect, while the cam shaft is rotating normally, the curved protruding face of the decompression cam makes contact with the convex decompression follower face and the concave decompression follower face in succession. Since the concave decompression follower face is formed as a concavely curved face, when the decompression cam disengages from the concave decompression follower, the amount of lift of the exhaust valve changes gently. As a result, the noise of seating of the exhaust valve (seating noise) is reduced. Moreover, while the cam shaft is rotating in reverse, the curved protruding face of the decompression cam makes contact with the concave decompression follower face and the convex decompression follower face one after another. Since the concave decompression follower face is formed as a concavely curved face, when starting contact the curved protruding face of the decompression cam can slip against the concavely curved face in a tangential direction. Therefore, when the piston cannot completely ride over compression top dead center and the cam shaft rotates in reverse, noise due to collision between the decompression cam and the exhaust side rocker arm can be suppressed.

[0028] In accordance with the eighth aspect, the curved protruding face of the decompression cam moves away from the rocker arm via the concavely curved face in response to rotation of the cam shaft. When being seated the amount of lift of the exhaust valve reliably changes gently. In this way the noise of seating of the exhaust valve can be reduced.

[0029] In accordance with the ninth aspect, even if the position of the curved protruding face of the decompression cam is somehow displaced due to dimensional tolerance or assembly error, when being seated the amount of lift of the exhaust valve changes gently. In this way the noise of seating of the exhaust valve can be reduced.

[0030] In accordance with the tenth aspect, since the convex decompression follower face, the auxiliary con-

cave decompression follower face, and the concave decompression follower face are continuous, the curved protruding face of the decompression cam can smoothly follow the convex decompression follower face and then the concave decompression follower face. Noise due to collision between the decompression cam and the exhaust side rocker arm can be suppressed.

[0031] In accordance with the eleventh aspect, the curved protruding face of the decompression cam can smoothly follow the convex decompression follower face and then the concave decompression follower face in response to a change in the curvature. Noise due to collision between the decompression cam and the exhaust side rocker arm can be suppressed.

[0032] In accordance with the twelfth aspect, such an AC generator enables an idling state of an internal combustion engine to be established. During idling, the AC generator can make the piston move back and forth without going through the combustion stroke. Fuel consumption is suppressed and the exhaust noise of the internal combustion engine is reduced.

[0033] In accordance with the thirteenth aspect, in a low rotational speed region in which the rotational speed is less than a set value, the curved protruding face of the decompression cam projects in the centrifugal direction of the cam shaft. While the cam shaft is rotating normally, the curved protruding face of the decompression cam makes contact with the convex decompression follower face of the exhaust side rocker arm via the buffer face and the peak face one after another. Since the buffer face of the decompression cam is formed as a concavely curved face, when starting contact the convex decompression follower face can slip against the concavely curved face of the decompression cam in a tangential direction. Therefore, noise due to collision between the decompression cam and the exhaust side rocker arm can be suppressed.

[0034] In accordance with the fourteenth aspect, while the cam shaft is rotating normally, the curved protruding face of the decompression cam makes contact with the convex decompression follower face via the peak face and then via the second buffer face. Since the second buffer face is formed as a concavely curved face, when the convex decompression follower face disengages from the second buffer face, the amount of lift of the exhaust valve changes gently. As a result, the noise of seating of the exhaust valve (seating noise) is reduced. Moreover, while the cam shaft is rotating in reverse, the curved protruding face of the decompression cam makes contact with the second buffer face and the peak face one after another. Since the second buffer face is formed as a concavely curved face, when starting contact the convex decompression follower face can slip against the second buffer face in a tangential direction. Therefore, when the piston cannot completely ride over compression top dead center and the cam shaft rotates in reverse, noise due to collision between the decompression cam and the exhaust side rocker arm can be suppressed.

[0035] In accordance with the fifteenth aspect, in a low rotational speed region in which the rotational speed is less than a set value, the curved protruding face of the decompression cam projects in the centrifugal direction of the cam shaft. While the cam shaft is rotating normally, the curved protruding face of the decompression cam makes contact with the peak face and the buffer face one after another. Since the buffer face is formed as a concavely curved face, when the convex decompression follower face disengages from the buffer face, the amount of lift of the exhaust valve changes gently. As a result, the noise of seating of the exhaust valve (seating noise) is reduced. Moreover, while the cam shaft is rotating in reverse, the curved protruding face of the decompression cam makes contact with the buffer face and the peak face one after another. Since the buffer face is formed as a concavely curved face, when starting contact the convex decompression follower face can slip against the buffer face in a tangential direction. Therefore, when the piston cannot completely ride over compression top dead center and the cam shaft rotates in reverse, noise due to collision between the decompression cam and the exhaust side rocker arm can be suppressed.

BRIEF DESCRIPTION OF DRAWINGS

[0036]

[FIG. 1] FIG. 1 is a side view schematically showing a scooter type two-wheeled motor vehicle related to one embodiment of a saddle-ridden vehicle. (first embodiment)

[FIG. 2] FIG. 2 is a horizontal sectional view along line 2-2 in FIG. 1. (first embodiment)

[FIG. 3] FIG. 3 is an enlarged vertical sectional view of a cylinder head along line 3-3 in FIG. 2. (first embodiment)

[FIG. 4] FIG. 4 is a sectional view along line 4-4 in FIG. 3. (first embodiment)

[FIG. 5] FIG. 5 is a vertical sectional view in which part of FIG. 3 is enlarged. (first embodiment)

[FIG. 6] FIG. 6 is a vertical sectional view in which part of FIG. 5 is enlarged. (first embodiment)

[FIG. 7] FIG. 7 is a vertical sectional view, corresponding to FIG. 5, showing the position of a decompression cam when a cam pin is displaced from a first position to a second position in a decompression device related to a first embodiment. (first embodiment)

[FIG. 8] FIG. 8 is an enlarged vertical sectional view, corresponding to FIG. 6, schematically showing the arrangement of a decompression device related to a second embodiment. (second embodiment)

[FIG. 9] FIG. 9 is an enlarged vertical sectional view, corresponding to FIG. 6, schematically showing the arrangement of a decompression device related to a third embodiment. (third embodiment)

EXPLANATION OF REFERENCE NUMERALS AND SYMBOLS

[0037]

49	AC generator (AC generator starter)
89	Exhaust valve
95	Cam shaft
97b	Exhaust side rocker arm
101	Cam follower
108a	Base face
108b	Lift face
109	Roller (functioning as convex decompression follower face)
112	Decompression cam
122	Imaginary cylindrical face
129	Curved protruding face (partial cylindrical face)
133	Convex decompression follower face
134	Concave decompression follower face
134a	Upstream end
135	(Second) concave decompression follower face
135a	Downstream end
136	Auxiliary concave decompression follower face
137	(Second) auxiliary concave decompression follower face
143	Convex decompression follower face
144	Decompression cam
145	Curved protruding face
146	Peak face
147	Buffer face
148	(Second) buffer face
151	Decompression device
Xc	Rotational axis (of cam shaft)

MODES FOR CARRYING OUT THE INVENTION

[0038] One embodiment of the present invention is explained below by reference to the attached drawings. In the explanation below, the fore-and-aft, up-and-down, and left-and-right directions are directions as viewed by a person riding a two-wheeled motor vehicle.

FIRST EMBODIMENT

[0039] FIG. 1 schematically shows a scooter type two-wheeled motor vehicle related to one embodiment of a saddle-ridden vehicle. The two-wheeled motor vehicle 11 includes a body frame 12 and a body cover 13. The body frame 12 includes a head pipe 14 at the front end, a main frame 15 joined to the head pipe 14 via its front end, a cross pipe 16 joined to a rear part of the main frame 15 and extending in the vehicle width direction, and a pair of left and right rear frames 17 having front end parts connected to opposite end parts of the cross pipe 16 and extending in the vehicle fore-and-aft direction. A front fork 18 supporting a front wheel WF so that it can rotate around a horizontal axis and rod-shaped handlebars 19 are steerably supported on the head pipe

14.

[0040] The body cover 13 is fitted onto the body frame 12. A rider's seat 21 is mounted on the body cover 13 above the rear frame 17. The body cover 13 includes a front cover 22 that covers the head pipe 14 from the front, a leg shield 23 that is continuous from the front cover 22, and a step floor 24 that is continuous from the lower end of the leg shield 23 and is disposed above the main frame 15 between the rider's seat 21 and the front wheel WF.

[0041] A unit-swing type drive unit 25 is disposed in a space beneath the rear frame 17. The drive unit 25 is vertically swingably linked, via a link 27, to a bracket 26 joined to the front end of the rear frame 17. A rear wheel WR is supported by the rear end of the drive unit 25 so that it can rotate around a horizontal axis. A rear cushion unit 28 is disposed between the rear frame 17 and the drive unit 25 at a position spaced from the link 27 and the bracket 26. The drive unit 25 includes an air-cooled single-cylinder internal combustion engine 29 and a transmission device 31 that is connected to the internal combustion engine 29 and the rear wheel WR and transmits output from the internal combustion engine 29 to the rear wheel WR. A transmission case 31a of the transmission device 31 is joined to an engine main body 29a of the internal combustion engine 29.

[0042] The engine main body 29a of the internal combustion engine 29 includes a crankcase 33 that supports a crankshaft 32 so that it can rotate around a rotational axis, a cylinder block 34 that is joined to the crankcase 33, a cylinder head 35 that is joined to the cylinder block 34, and a head cover 36 that is joined to the cylinder head 35. An intake device 37 and an exhaust device 38 are connected to the cylinder head 35. The intake device 37 includes an air cleaner 39 that is supported on the transmission case 31a and a throttle body 41 that is disposed between the air cleaner 39 and the cylinder head 35. A fuel injection valve 42 is mounted on an upper side wall of the cylinder head 35. The exhaust device 38 includes an exhaust pipe 43 that extends rearward from a lower side wall of the cylinder head 35 while passing beneath the engine main body 29a, and an exhaust muffler (not illustrated) that is connected to the downstream end of the exhaust pipe 43 and is linked to the crankcase 33.

[0043] As shown in FIG. 2, a cylinder bore 44 is defined in the cylinder block 34. A piston 45 is slidably fitted into the cylinder bore 44 along a cylinder axis C. The cylinder axis C is inclined slightly upward to the front. The crankshaft 32 is linked to the piston 45. A rotational axis Xis of the crankshaft 32 is oriented in the vehicle width direction.

[0044] A combustion chamber 46 is defined in the cylinder head 35. The combustion chamber 46 is continuous from the cylinder bore 44. The piston 45 faces the cylinder head 35 and defines the combustion chamber 46 between itself and the cylinder head 35. An air-fuel mixture is introduced into the combustion chamber 46 via the intake device 37. Exhaust gas within the combustion chamber 46 is discharged via the exhaust device 38.

[0045] The crankcase 33 is divided into a first case half 33a and a second case half 33b. The first case half 33a and the second case half 33b define in cooperation a crank chamber 47. A crank of the crankshaft 32 is housed in the crank chamber 47. The first case half 33a has a bearing 48a that rotatably supports the crankshaft 32 whereas the second case half 33b has a bearing 48b that rotatably supports the crankshaft 32.

[0046] An AC generator starter 49 is joined to the crankcase 33. The AC generator starter 49 includes an outer rotor 51 that is fixed to the crankshaft 32, which extends through the first case half 33a of the crankcase 33 and protrudes out of the first case half 33a, and an inner stator 52 that is surrounded by the outer rotor 51 and is disposed around the crankshaft 32. The inner stator 52 is fixed to a support plate 53 fastened to the first case half 33a. An electromagnetic coil 52a is wound around the inner stator 52. A magnet 51a is fixed to the outer rotor 51. When the outer rotor 51 rotates relative to the inner stator 52, electric power is generated in the electromagnetic coil 52a. On the other hand, when current flows through the electromagnetic coil 52a, a magnetic force is generated in the electromagnetic coil 52a, thus causing the outer rotor 51 to rotate. In this process, the AC generator starter 49 functions as a motor. The AC generator starter 49 can rotate the crankshaft 32 without employing a gear, etc.

[0047] A control circuit (ECU) is connected to the AC generator starter 49. The control circuit controls the supply of electric power to the electromagnetic coil 52a. The driving force of the AC generator starter 49 may be used for example for rotating the crankshaft 32 as a starter when starting the internal combustion engine 29 or may be used when smoothly re-starting the two-wheeled motor vehicle 11 when idle stop is performed. Here, the control circuit has for example an idle stop determination part, an idle stop control part, and a motor idle drive processing part.

[0048] The idle stop determination part has a function of determining whether or not idle stop control is carried out when the vehicle temporarily stops during travel. Inputted into the idle stop determination part are a throttle degree of opening calculated by a throttle degree of opening calculation part and a travel speed of the vehicle calculated by a vehicle speed calculation part. When the throttle degree of opening and the travel speed attain a predetermined value or below, the idle stop determination part outputs a command signal for idle stop control to the idle stop control part. A command signal is supplied from an idle stop SW determination part to the idle stop determination part. If it is confirmed by the command signal that an idle stop switch is ON, then the idle stop determination part prompts the execution of idle stop control.

[0049] The idle stop control part carries out idle stop control based on the command signal of the idle stop determination part. The idle stop control part stops operation of the fuel injection valve 42 and operation of a

spark plug. Combustion of the internal combustion engine 29 is thereby suspended. When the two-wheeled motor vehicle 11 re-starts from a temporary stop, the idle stop control part carries out control so that, based on the rotational angle of the crankshaft 32, the crankshaft 32 is driven in reverse and ensures that the crankshaft 32 is driven normally.

[0050] The motor idle drive processing part carries out motor idle control in which the engine rotational speed is maintained at a predetermined rotational speed while the two-wheeled motor vehicle 11 is stopped in a state in which combustion of the internal combustion engine 29 is stopped by the idle stop determination part and the idle stop control part. The motor idle drive processing part stops motor idle control when an accelerator demand is not detected after a predetermined time has elapsed. If an accelerator demand is detected before a predetermined time has elapsed, the crankshaft 32 is rotated by the AC generator starter 49, and the two-wheeled motor vehicle 11 is started. At the same time as starting the two-wheeled motor vehicle 11 the combustion stroke of the internal combustion engine 29 is resumed.

[0051] A tubular generator cover 54 surrounding the AC generator starter 49 is joined to the first case half 33a. An air inlet 54a is defined at an open end of the generator cover 54. A radiator 55 is disposed in the air inlet 54a. A cooling fan 56 is joined to an outer face of the outer rotor 51. The cooling fan 56 rotates in response to rotation of the crankshaft 32, and cooling air flows toward the radiator 55.

[0052] The transmission device 31 includes an electronically controlled V-belt-type continuously variable transmission (hereinafter called a 'transmission') 57 that is housed within the transmission case 31a and steplessly changes the speed of rotational power transmitted from the crankshaft 32, and a reduction gear mechanism 59 that is housed within the transmission case 31a, reduces the speed of rotational power of the transmission 57, and transmits it to an axle 58 of the rear wheel WR. The rear wheel WR is disposed between the transmission case 31a and a support arm 61. The support arm 61 is continuous from the crankcase 33 and extends to the rear of the vehicle. The exhaust muffler described above is mounted on the support arm 61. The axle 58 of the rear wheel WR is doubly supported, on the transmission case 31a and on the support arm 61, so that it can rotate around its axis.

[0053] The transmission case 31a includes a case main body 62 that is continuous from the second case half 33b of the crankcase 33, a case cover 64 that is fastened to the case main body 62 and defines a transmission chamber 63 between itself and the case main body 62, and a gear cover 66 that is fastened to the case main body 62 and defines a gear chamber 65 between itself and the case main body 62. The transmission 57 is housed in the transmission chamber 63. The reduction gear mechanism 59 is housed in the gear chamber 65. The case main body 62 and the case cover 64 in coop-

eration form a transmission case.

[0054] The transmission 57 includes a drive pulley device 67 that is disposed within the transmission chamber 63 and is mounted on the crankshaft 32 as a drive shaft, and a driven pulley device 69 that is disposed within the transmission chamber 63 and is mounted on a driven shaft 68 protruding from the transmission chamber 63 into the gear chamber 65. In the drive pulley device 67, a V-belt 71 is wound around a fixed sheave 73 that is fixed to the crankshaft 32 and a movable sheave 74 that is supported on the crankshaft 32 so that it can move in the axial direction of the crankshaft 32 while facing the fixed sheave 73. Similarly, in the driven pulley device 69 the V-belt 71 is wound around a fixed sheave 78 that is coaxially fitted around the driven shaft 68 and a movable sheave 79 that is coaxially fitted around the driven shaft 68 while facing the fixed sheave 78. In the drive pulley device 67, the belt winding diameter is electronically controlled so as to be variable by the operation of an actuator unit 72. The belt winding diameter of the driven pulley device 69 changes in response to a change in the belt winding diameter of the drive pulley device 67.

[0055] In the drive pulley device 67, the movable sheave 74 is disposed between the second case half 33b of the crankcase 33 and the fixed sheave 73. The movable sheave 74 has a movable sheave boss 74a that receives the crankshaft 32. The movable sheave boss 74a extends from a sheave body that receives the V belt 71 toward the second case half 33b of the crankcase 24. The transmission 57 includes a first shift mechanism 75a, which includes a centrifugal weight and a cam plate, and a second shift mechanism 75b, which includes the actuator unit 72. Axial movement of the movable sheave 74 is realized in response to operation of the first shift mechanism 75a and the second shift mechanism 75b, and the winding radius of the V-belt 71 is changed.

[0056] The driven pulley device 69 includes an inner tube 76 that has a cylindrical shape coaxial with the driven shaft 68 and is coaxially fitted around the driven shaft 68, and an outer tube 77 that has a cylindrical shape coaxial with the driven shaft 68 and is coaxially fitted around the inner tube 76. The inner tube 76 is relatively rotatably supported on the driven shaft 68. The outer tube 77 is relatively rotatably and axially relatively displaceably supported on the inner tube 76. The fixed sheave 78 is coaxially fixed to the inner tube 76. The inner tube 76 and the fixed sheave 78 are formed as a unit from a material that is lighter than steel, such as for example aluminum. The movable sheave 79 is coaxially fixed to the outer tube 77. The outer tube 77 and the movable sheave 79 are formed as a unit from a material that is lighter than steel, such as for example aluminum. The movable sheave 79 moves closer to the fixed sheave 78 or moves away from the fixed sheave 78 according to relative displacement in the axial direction between the outer tube 77 and the inner tube 76.

[0057] A centrifugal clutch 81 is fitted around the driven shaft 68. The centrifugal clutch 81 includes a clutch plate

81a that is fixed to the inner tube 76. A coil spring 82 is disposed between the clutch plate 81a and the movable sheave 79. The coil spring 82 exhibits a resilient force that pushes the movable sheave 79 toward the fixed sheave 78. When the winding radius of the V-belt 71 increases for the drive pulley device 67, in the driven pulley device 69 the movable sheave 79 moves away from the fixed sheave 78 against the resilient force of the coil spring 82 and the winding radius of the V-belt 71 decreases.

[0058] The centrifugal clutch 81 includes an outer plate 81b that is fixed to the driven shaft 68. The outer plate 81b faces the clutch plate 81a. When the clutch plate 81a rotates, the outer plate 81b is joined to the clutch plate 81a by the action of centrifugal force. Rotation of the driven pulley device 69 is thus transmitted to the driven shaft 68. When the engine rotational speed exceeds a set rotational speed, the centrifugal clutch 81 establishes a power transmission state.

[0059] The reduction gear mechanism 59 includes a drive gear 83 fixed to the driven shaft 68 protruding into the gear chamber 65, a final gear 84 fixed to the axle 58 of the rear wheel WR, and idle gears 85a and 85b disposed between the drive gear 83 and the final gear 84. The idle gears 85a and 85b are fixed to a common intermediate shaft 86. The drive gear 83 meshes with the idle gear 85a, and the final gear 84 meshes with the idle gear 85b. In this way, rotation of the driven shaft 68 is reduced in speed and transmitted to the axle 58 of the rear wheel WR.

[0060] As shown in FIG. 3, the internal combustion engine 29 has a valve operating mechanism 87. The valve operating mechanism 87 includes an intake valve 88 that has a valve body 88a disposed within the combustion chamber 46 and is supported on the cylinder head 35 so that it can be displaced in the axial direction via a valve shaft 88b extending from the valve body 88a, and an exhaust valve 89 that has a valve body 89a disposed within the combustion chamber 46 and is supported on the cylinder head 35 so that it can be displaced in the axial direction via a valve shaft 89b extending from the valve body 89a. The valve body 88a of the intake valve 88 is seated on a valve seat 92a that is embedded in the cylinder head 35 at the opening of an intake port 91a communicating with the combustion chamber 46 and defines an intake aperture. The valve body 89a of the exhaust valve 89 is seated on a valve seat 92b that is embedded in the cylinder head 35 at the opening of an exhaust port 91b communicating with the combustion chamber 46 and defines an exhaust aperture.

[0061] The valve shafts 88b and 89b are axially slidably supported on the cylinder head 35. The valve shafts 88b and 89b extend through the cylinder head 35 and have one end (outer end) disposed outside the combustion chamber 46. A flange 93 is fixed to the outer ends of the valve shafts 88b and 89b. A coil spring 94, which is an elastic member, is sandwiched between the flange 93 and an outer face of the cylinder head 35. The coil spring

94 exerts a resilient force in an expansion direction in which the flange 93 moves away from the outer face of the cylinder head 35. The valve bodies 88a and 89a are seated on the valve seats 92a and 92b based on the resilient force of the coil spring 94.

[0062] The valve operating mechanism 87 includes a cam shaft 95 that is supported on the cylinder head 35 so that it can rotate around an axis Xc parallel to the rotational axis Xis of the crankshaft 32, a pair of rocker shafts 96 that have an axis Xk parallel to the rotational axis Xis of the crankshaft 32 and are supported on the cylinder head 35, and an intake side rocker arm 97a and an exhaust side rocker arm 97b that are supported on the rocker shaft 96 so that they can swing around the axis Xk. The individual rocker arms 97a and 97b include a first arm 99 that extends from the rocker shaft 96 in the centrifugal direction and has an action point 98 at the extremity, and a second arm 102 that extends from the rocker shaft 96 toward the side opposite to the first arm 99 in the centrifugal direction and has a cam follower 101 at the extremity. The rocker arms 97a and 97b make contact with the outer end of the intake valve 88 and the exhaust valve 89 respectively via the action point 98 of the first arm 99. The rocker arms 97a and 97b respectively make contact with the cam shaft 95 via the cam follower 101. Details of the cam shaft 95 and the rocker arms 97a and 97b are described later.

[0063] As shown in FIG. 4, the valve operating mechanism 87 includes a timing chain 103. The timing chain 103 is wound around a crank sprocket (not illustrated) fixed to the crankshaft 32 and a cam sprocket 104 fixed to the cam shaft 95. The timing chain 103 transmits rotation of the crankshaft 32 to the cam shaft 95. The cam shaft 95 rotates in synchronism with rotation of the crankshaft 32.

[0064] The internal combustion engine 29 includes a spark plug 105. The spark plug 105 is supported on the cylinder head 35. The spark plug 105 extends through the cylinder head 35 and has an electrode 105a at the extremity extending to the interior of the combustion chamber 46. The spark plug 105 ignites the air-fuel mixture within the combustion chamber 46 with a spark generated on the electrode 105a in response to a supplied electric signal.

[0065] The cam shaft 95 is rotatably supported on the cylinder head 35 via a pair of bearings 106. The bearing 106 employs for example a ball bearing. A first cam 107 for the intake side rocker arm 97a and a second cam 108 for the exhaust side rocker arm 97b are formed on the cam shaft 95 between the bearings 106. The first cam 107 and the second cam 108 are disposed so as to be displaced in the axial direction of the cam shaft 95.

[0066] Referring in addition to FIG. 5, the cam follower 101 includes a roller 109 that is supported on the second arm 102 so that it can rotate around a rotational axis parallel to the axis Xc of the cam shaft 95. An outer peripheral face of the roller 109 makes contact with the first cam 107 and the second cam 108 respectively. The rollers

109 receive rotation of the first cam 107 and the second cam 108 and can rotate. The roller 109 follows the profile of the first cam 107 and the second cam 108 while rotating. Moving the rollers 109 closer to or away from the axis Xc of the cam shaft 95 controls the opening and closing of the intake valve 88 and the exhaust valve 89.

[0067] The first cam 107 includes a base face 107a that has a partial cylindrical face shape that is coaxial with the axis Xc of the cam shaft 95, and a lift face 107b that is provided on the cam shaft 95 so as to be continuous from the base face 107a in the rotational direction and bulges further outward in the radial direction than the base face 107a so as to define an amount of lift of the intake valve 88. The cam follower 101 of the intake side rocker arm 97a maintains contact with the base face 107a and the lift face 107b and causes the intake side rocker arm 97a to swing.

[0068] The second cam 108 includes a base face 108a that has a partial cylindrical face shape that is coaxial with the axis Xc of the cam shaft 95, and a lift face 108b that is provided on the cam shaft 95 so as to be continuous from the base face 108a in the rotational direction and bulges further outward in the radial direction than the base face 108a so as to define a lift amount of the exhaust valve 89. The cam follower 101 of the exhaust side rocker arm 97b maintains contact with the base face 108a and the lift face 108b and causes the exhaust side rocker arm 97b to swing.

[0069] As shown in FIG. 4 and FIG. 5, the valve operating mechanism 97 includes a decompression device 111 related to the first embodiment. The decompression device 111 includes a decompression cam 112 that is attached to the cam shaft 95, a decompression follower 113 that is defined on the exhaust side rocker arm 97b so that it can make contact with the decompression cam 112, and a drive arm 114 that is attached to the cam shaft 95 and drives the decompression cam 112 between an operating position and a non-operating position.

[0070] The decompression cam 112 and the drive arm 114 are supported on a step face 115 formed on the cam shaft 95 between the second cam 108 and the bearing 106. The step face 115 is defined between a large diameter shaft 116a that defines the second cam 108 and a small diameter shaft 116b that is continuous from the large diameter shaft 116a, has a smaller diameter than that of the large diameter shaft 116a, and is received by the bearing 106, and is made to face the bearing 106. The step face 115 is orthogonal to the axis Xc of the cam shaft 95 and is connected to edges of the base face 108a and the lift face 108b of the second cam 108.

[0071] The decompression cam 112 includes a shaft body 117 that has an axis parallel to the axis Xc of the cam shaft 95. The shaft body 117 is received by a through hole 118 that is formed in the cam shaft 95 and defines a columnar space coaxial with the shaft body 117, so that the shaft body 117 can rotate around an axis (= rotational axis Xd). In this way, the decompression cam 112 is supported on the cam shaft 95 so that it can rotate around

the rotational axis Xd.

[0072] The decompression cam 112 includes a cam main body 119 that is coaxial with the shaft body 117. A cylindrical face 121 is defined on the cam main body 119, the cylindrical face 121 being coaxial with the shaft body 117 and continuous around the axis of the shaft body 117. The cylindrical face 121 is disposed at a position displaced, in the axial direction of the cam shaft 95, from an imaginary cylindrical face 122 that is drawn coaxially with the axis Xc of the cam shaft 95 and faces the decompression follower 113. Here, the imaginary cylindrical face 122 is a cylindrical face that is coaxial with the cylindrical face 121 and continuous from the cylindrical face 121 in the axial direction.

[0073] The decompression cam 112 has a cam groove 124 that receives a cam pin 123. The cam pin 123 is formed from a columnar body that has an axis parallel to the axis Xc of the cam shaft 95. The cam groove 124 is formed in an end face of the cam main body 119 and extends linearly from the cylindrical face 121 toward the axis. When the cam pin 123 moves in a peripheral direction around the axis Xc of the cam shaft 95, the decompression cam 112 changes its attitude around its axis between the operating position and the non-operating position.

[0074] The drive arm 114 is supported on the cam shaft 95 so that it can swing around a swing shaft 125. The swing shaft 125 has an axis parallel to the axis Xc of the cam shaft 95. The swing shaft 125 is pushed into the step face 115 by for example press fitting. A spacer 126 is fitted around the swing shaft 125 between the step face 115 and the drive arm 114. The dimension of the spacer 126 in the axial direction of the cam shaft 95 corresponds to the dimension of the imaginary cylindrical face 122. The imaginary cylindrical face 122 is thus disposed between the drive arm 114 and the step face 115.

[0075] The swing shaft 125 is disposed at a position spaced from the rotational axis Xd of the decompression cam 112 at least in the peripheral direction of the cam shaft 95. The swing shaft 125 is desirably separated from the decompression cam 112 as far as possible. Here, the swing shaft 125 and the rotational axis Xd of the decompression cam 112 are disposed on one diameter on opposite sides of the axis Xc.

[0076] The cam pin 123 is fixed to the extremity of the drive arm 114. The cam pin 123 moves between a first position where the operating position of the decompression cam 112 is established and a second position where the non-operating position of the decompression cam 112 is established. A torsion spring 127 is fitted onto the spacer 126. One end of the torsion spring 127 is latched to the drive arm 114. The other end of the torsion spring 127 is latched to the small diameter shaft 116b. The torsion spring 127 exerts a resilient force driving the cam pin 123 toward the first position.

[0077] The drive arm 114 curves so as to bypass the small diameter shaft 116b between the swing shaft 125 and the cam pin 123. A centrifugal weight 128 is mounted

on the drive arm 114 between the swing shaft 125 and the cam pin 123. When the rotation of the cam shaft 95 attains a preset rotational speed, the centrifugal weight 128 exerts a centrifugal force that moves the cam pin 123 from the first position to the second position against the resilient force of the torsion spring 127.

[0078] The cam main body 119 of the decompression cam 112 has a partial cylindrical face 129 that is disposed within a space on the inner side of the imaginary cylindrical face 122 and is continuous from the cylindrical face 121 coaxially with the shaft body 117, and a flat face 131 that connects generatrices of opposite ends of the partial cylindrical face 129 to each other. The decompression cam 112 has part of the partial cylindrical face 129 projecting to the outside from the imaginary cylindrical face 122 in the operating position. The partial cylindrical face 129 corresponds to a curved protruding face having a generatrix parallel to the axis Xc of the cam shaft 95.

[0079] As shown in FIG. 6, the decompression follower 113 includes a convexly curved convex decompression follower face 133 that is provided on the exhaust side rocker arm 97b on the outer side of the imaginary cylindrical face 122, opposes the imaginary cylindrical face 122 at a position closest to the imaginary cylindrical face 122, and makes contact with the partial cylindrical face 129, a first concave decompression follower face 134 that is provided on the upstream of the convex decompression follower face 133 in the normal rotational direction of the cam shaft 95, is formed as a concavely curved face having a generatrix parallel to the axis Xc of the cam shaft 95, and makes contact with the partial cylindrical face 129, and a second concave decompression follower face 135 that is provided on the downstream of the convex decompression follower face 133 in the normal rotational direction of the cam shaft 95, is formed as a concavely curved face having a generatrix parallel to the axis Xc of the cam shaft 95, and makes contact with the partial cylindrical face 129. Formed on the decompression follower 113 between the convex decompression follower face 133 and the first concave decompression follower face 134 is a first auxiliary concave decompression follower face 136 formed as a concavely curved face having a smaller curvature than that of the partial cylindrical face 129. Similarly, a second auxiliary concave decompression follower face 137 formed as a concavely curved face having a smaller curvature than that of the partial cylindrical face 129 is formed between the convex decompression follower face 133 and the second concave decompression follower face 135.

[0080] An upstream end 134a of the first concave decompression follower face 134 is disposed at a position further away from the axis Xc of the cam shaft 95 in the radial direction than the partial cylindrical face 129. A downstream end 135a of the second concave decompression follower face 135 is disposed at a position further away from the axis Xc of the cam shaft 95 in the radial direction than the partial cylindrical face 129. The first concave decompression follower face 134 moves

away from the axis Xc of the cam shaft 95 in going away from the convex decompression follower face 133 in the peripheral direction of the imaginary cylindrical face 122. The second concave decompression follower face 135 moves away from the axis Xc of the cam shaft 95 in going away from the convex decompression follower face 133 in the peripheral direction of the imaginary cylindrical face 122. The first concave decompression follower face 134 is formed from part of a cylindrical face having a smaller curvature than that of the partial cylindrical face 129. The second concave decompression follower face 135 is formed from part of a cylindrical face having a smaller curvature than that of the partial cylindrical face 129. The first auxiliary concave decompression follower face 136 is formed from part of a cylindrical face having a smaller curvature than that of the partial cylindrical face 129. The second auxiliary concave decompression follower face 137 is formed from part of a cylindrical face having a smaller curvature than that of the partial cylindrical face 129. The first auxiliary concave decompression follower face 136 is formed from part of a cylindrical face having a larger curvature than that of the first concave decompression follower face 134. The second auxiliary concave decompression follower face 137 is formed from part of a cylindrical face having a larger curvature than that of the second concave decompression follower face 135. The first auxiliary concave decompression follower face 136 and the second auxiliary concave decompression follower face 137 may be formed from part of a cylindrical face having a smaller curvature than that of the convex decompression follower face 133 or may be formed from part of a cylindrical face having a larger curvature than that of the convex decompression follower face 133.

[0081] Here, the convex decompression follower face 133 moves further away from the axis Xc of the cam shaft 95 than the outer peripheral face of the roller 109. Since the cylindrical face 121 and the imaginary cylindrical face 122 have the same diameter, a constant gap is maintained between the convex decompression follower face 133 and the imaginary cylindrical face 122. As shown in FIG. 7, when the decompression cam 112 is at the non-operating position, if the flat face 131, which is continuous from the partial cylindrical face 129, is disposed on the inner side of the imaginary cylindrical face 122, contact between the decompression cam 112 and the decompression follower 113 is avoided.

[0082] The operation of the decompression device 111 is now explained. In the internal combustion engine 29, the intake stroke, the compression stroke, the combustion stroke, and the exhaust stroke are repeated in sequence. In the intake stroke, the intake valve 88 opens. The piston 45 descends due to the inertial force of the crankshaft 32. The air-fuel mixture is introduced into the combustion chamber 46. Fuel is injected into air introduced from the air intake device 37 from the fuel injection valve 42 in the throttle body 41. In the compression stroke, the piston 45 ascends due to the inertial force of the crankshaft 32. The intake valve 88 and the exhaust

valve 89 are maintained in a closed state. The air-fuel mixture is compressed within the combustion chamber 46. In the combustion stroke, the air-fuel mixture is ignited within the combustion chamber 46. The intake valve 88 and the exhaust valve 89 are maintained in a closed state. The piston 45 descends due to the action of the explosion within the combustion chamber 46. The driving force is transmitted to the crankshaft 32. In the exhaust stroke the exhaust valve 89 is opened. The piston 45 ascends due to the inertial force of the crankshaft 32. Exhaust gas after combustion escapes into the exhaust pipe 43. In response to the subsequent descent of the piston 45 the intake stroke is carried out again. When the internal combustion engine 29 is started, a driving force is transmitted to the crankshaft 32 from the AC generator starter 49. The AC generator starter 49 generates a driving force for example in response to electric power supplied from a battery (not illustrated).

[0083] The valve operating mechanism 87 operates in association with rotation of the crankshaft 32. Opening and closing of the intake valve 88 is controlled by swinging of the intake side rocker arm 97a. The rocker arm 97a swings in response to contact between the roller 109 and the first cam 107. While the roller 109 is in contact with the base face 107a of the first cam 107, the rocker arm 97a maintains a valve-closed state of the intake valve 88. When the roller 109 follows the lift face 107b, the intake valve 88 opens. Opening and closing of the exhaust valve 89 is controlled by swinging of the exhaust side rocker arm 97b. The rocker arm 97b swings in response to contact between the roller 109 and the second cam 108. While the roller 109 is in contact with the base face 108a of the second cam 108, the rocker arm 97b maintains a valve-closed state of the exhaust valve 89. When the roller 109 follows the lift face 108b, the exhaust valve 89 opens.

[0084] When the engine rotational speed of the internal combustion engine 29 is less than a predetermined rotational speed, in the decompression device 111a sufficient centrifugal force is not generated by the centrifugal weight 128 in response to rotation of the cam shaft 95. The drive arm 114 therefore maintains the cam pin 123 at the first position in response to the resilient force of the torsion spring 127. The decompression cam 112 is positioned at the operating position. The partial cylindrical face 129 projects from an imaginary cylindrical face, including the imaginary cylindrical face 122. In response to rotation of the cam shaft 95 the partial cylindrical face 129 makes contact with the first concave decompression follower face 134, the first auxiliary concave decompression follower face 136, the convex decompression follower face 133, the second auxiliary concave decompression follower face 137, and the second concave decompression follower face 135 of the decompression follower 113 one after another. In this way the exhaust valve 89 is opened during the compression stroke. The pressure within the combustion chamber 46 is released. The drive resistance of the piston 45 is alleviated, and vibra-

tion of the internal combustion engine is suppressed.

[0085] When the engine rotational speed of the internal combustion engine 29 attains a predetermined rotational speed or greater, in the decompression device 111 a sufficient centrifugal force is generated by the centrifugal weight 128 in response to rotation of the cam shaft 95. The drive arm 114 therefore drives the cam pin 123 from the first position to the second position against the resilient force of the torsion spring 127. The decompression cam 112 changes its attitude to the non-operating position. The decompression cam 112 is contained inside the imaginary cylindrical face, including the imaginary cylindrical face 122. During rotation of the cam shaft 95 contact between the decompression follower 113 and the decompression cam 112 is avoided. During the compression stroke the exhaust valve 89 is maintained in a closed state. The driving force of the piston 45 due to explosion is exerted to the maximum. The internal combustion engine 29 generates power efficiently.

[0086] In accordance with the present embodiment, in a low rotational speed region in which the rotational speed is less than a set value the partial cylindrical face 129 of the decompression cam 112 projects in the centrifugal direction of the cam shaft 95. While the cam shaft 95 is rotating normally, the partial cylindrical face 129 of the decompression cam 112 makes contact with the first concave decompression follower face 134 and the convex decompression follower face 133 of the exhaust side of the rocker arm 97b one after another. Since the first concave decompression follower face 134 is formed as a concavely curved face, at the start of contact the partial cylindrical face 129 of the decompression cam 112 can slip against the concavely curved face in a tangential direction. Therefore, noise due to collision between the decompression cam 112 and the exhaust side rocker arm 97b can be suppressed.

[0087] The upstream end 134a of the first concave decompression follower face 134 is disposed at a position further away from the axis Xc of the cam shaft 95 than the partial cylindrical face 129 of the rocker arm 97b. At the start of contact the partial cylindrical face 129 of the decompression cam 112 reliably makes contact with the concavely curved face of the first concave decompression follower face 134. Noise due to collision between the decompression cam 112 and the exhaust side rocker arm 97b can be suppressed.

[0088] The first concave decompression follower face 134 related to the present embodiment moves away from the axis Xc of the cam shaft 95 in going away from the convex decompression follower face 133. Therefore, even if the position of the partial cylindrical face 129 of the decompression cam 112 is somehow displaced due to dimensional tolerance or assembly error, when starting contact the partial cylindrical face 129 of the decompression cam 112 can slip against the first concave decompression follower face 134 in a tangential direction. Therefore, noise due to collision between the decompression cam 112 and the exhaust side rocker arm 97b

can be suppressed.

[0089] In addition, in the decompression follower 113 the first auxiliary concave decompression follower face 136 is formed between the convex decompression follower face 133 and the first concave decompression follower face 134, the first auxiliary concave decompression follower face 136 being formed as a concavely curved face having a smaller curvature than that of the partial cylindrical face 129 of the decompression cam 112. Since the first concave decompression follower face 134, the first auxiliary concave decompression follower face 136, and the convex decompression follower face 133 are continuous, the partial cylindrical face 129 of the decompression cam 112 can smoothly follow the first concave decompression follower face 134 and then the convex decompression follower face 133. Noise due to collision between the decompression cam 112 and the exhaust side rocker arm 97b can be suppressed.

[0090] The first auxiliary concave decompression follower face 136 is formed from part of a cylindrical face having a larger curvature than that of the first concave decompression follower face 134. As a result, in response to a change in the curvature the partial cylindrical face 129 of the decompression cam 112 smoothly follows the first concave decompression follower face 134 and then the convex decompression follower face 133. Noise due to collision between the decompression cam 112 and the exhaust side rocker arm 97b can be suppressed.

[0091] Furthermore, while the cam shaft 95 is rotating normally, the partial cylindrical face 129 of the decompression cam 112 makes contact with the convex decompression follower face 133 and the second concave decompression follower face 135 in succession. Since the second concave decompression follower face 135 is formed as a concavely curved face, when the decompression cam 112 disengages from the second concave decompression follower face 135, the amount of lift of the exhaust valve 89 changes gently. As a result, the noise of seating of the exhaust valve 89 (seating noise) is reduced. Moreover, when the piston 45 cannot completely ride over compression top dead center and the cam shaft 95 rotates in reverse, the partial cylindrical face 129 of the decompression cam 112 makes contact with the second concave decompression follower face 135 and the convex decompression follower face 133 one after another. Since the second concave decompression follower face 135 is formed as a concavely curved face, when starting contact the partial cylindrical face 129 of the decompression cam 112 can slip against the concavely curved face in a tangential direction. Therefore, when the piston 45 cannot completely ride over compression top dead center and the cam shaft 95 rotates in reverse, noise due to collision between the decompression cam 112 and the exhaust side rocker arm 97b can be suppressed.

[0092] The downstream end 135a of the second concave decompression follower face 135 is disposed at a position further away from the axis Xc of the cam shaft

95 than the partial cylindrical face 129 of the decompression cam 112. The partial cylindrical face 129 of the decompression cam 112 moves away from the rocker arm 97b via the concavely curved face in response to rotation of the cam shaft 95. When being seated the amount of lift of the exhaust valve 89 changes gently. In this way the noise of seating of the exhaust valve 89 can be reduced.

[0093] The second concave decompression follower face 135 related to the present embodiment moves away from the axis Xc of the cam shaft 95 in going away from the convex decompression follower face 133. Therefore, even if the position of the partial cylindrical face 129 of the decompression cam 112 is somehow displaced due to dimensional tolerance or assembly error, when being seated the amount of lift of the exhaust valve 89 changes gently. In this way the noise of seating of the exhaust valve 89 can be reduced.

[0094] In the decompression follower 113, the second auxiliary concave decompression follower face 137 formed as a concavely curved face having a smaller curvature than that of the partial cylindrical face 129 of the decompression cam 112 is formed between the convex decompression follower face 133 and the second concave decompression follower face 135. Since the convex decompression follower face 133, the second auxiliary concave decompression follower face 137, and the second concave decompression follower face 135 are continuous, the partial cylindrical face 129 of the decompression cam 112 can smoothly follow the convex decompression follower face 133 and then the second concave decompression follower face 135. Noise due to collision between the decompression cam 112 and the exhaust side rocker arm 97b can be suppressed.

[0095] The second auxiliary concave decompression follower face 137 is formed from part of a cylindrical face having a larger curvature than that of the second concave decompression follower face 135. As a result, the partial cylindrical face 129 of the decompression cam 112 can smoothly follow the convex decompression follower face 133 and then the second concave decompression follower face 135 in response to a change in the curvature. Noise due to collision between the decompression cam 112 and the exhaust side rocker arm 97b can be suppressed.

[0096] In the present embodiment the internal combustion engine 29 employs motor idling control. In motor idling control, fuel is not injected from the fuel injection valve 42 into air introduced from the air intake device 37 into the combustion chamber 46 when the accelerator is OFF (a state in which the accelerator is not operated). When maintaining idling, a driving force is transmitted from the AC generator starter 49 to the crankshaft 32. The AC generator starter 49 generates a driving force in response to electric power supplied from for example a battery (not illustrated). During idling, the AC generator starter 49 can make the piston 45 move back and forth without going through the combustion stroke. Fuel con-

sumption is suppressed and the exhaust noise of the internal combustion engine 29 is reduced.

SECOND EMBODIMENT

[0097] FIG. 8 schematically shows the arrangement of a decompression device 141 related to a second embodiment. In the decompression device 141, a decompression follower 142 has a convex decompression follower face 143 that is a single convexly curved face instead of the first concave decompression follower face 134, the first auxiliary concave decompression follower face 136, the convex decompression follower face 133, the second auxiliary concave decompression follower face 137, and the second concave decompression follower face 135 described above. On the other hand, a curved protruding face 145 of a decompression cam 144 has a peak face 146 that project furthest from the imaginary cylindrical face 122, a first buffer face 147 that is provided on the upstream of the peak face 146 in the normal rotational direction of the cam shaft 95 and is formed as a concavely curved face having a generatrix parallel to the axis Xc of the cam shaft 95, and a second buffer face 148 that is provided on the downstream of the peak face 146 in the normal rotational direction of the cam shaft 95 and is formed as a concavely curved face having a generatrix parallel to the axis Xc of the cam shaft 95. The arrangement is otherwise the same as that of the preceding embodiment.

[0098] Here, the convex decompression follower face 143 of the decompression follower 142 is formed from part of a cylindrical face that is coaxial with the rotational axis of the roller 109 and has a smaller diameter than that of the roller 109. Therefore, the convex decompression follower face 143 is made to face the imaginary cylindrical face 122 across a set gap. On the other hand, the peak face 146 of the decompression cam 144 is formed from part of a cylindrical face having the same diameter as that of the partial cylindrical face 129. The first buffer face 147 and the second buffer face 148 of the decompression cam 144 are each formed as a partial cylindrical face having a smaller curvature than that of the convex decompression follower face 143. An upstream end 147a of the first buffer face 147 is disposed at a position closer to the axis Xc of the cam shaft 95 than the convex decompression follower face 143 when the decompression cam 144 is positioned at an operating position. A downstream end 148a of the second buffer face 148 is disposed at a position closer to the axis Xc of the cam shaft 95 than the convex decompression follower face 143 when the decompression cam 144 is positioned at an operating position.

[0099] While the cam shaft 95 is rotating normally, the curved protruding face 145 of the decompression cam 144 makes contact with the convex decompression follower face 143 of the exhaust side rocker arm 97b via the first buffer face 147 and the peak face 146 one after another. Since the first buffer face 147 of the decompression

sion cam 144 is formed as a concavely curved face, when starting contact the convex decompression follower face 143 can slip against the first buffer face 147 of the decompression cam 144 in a tangential direction. Therefore, noise due to collision between the decompression cam 114 and the exhaust side rocker arm 97b can be suppressed.

[0100] While the cam shaft 95 is rotating normally, the curved protruding face 145 of the decompression cam 144 makes contact with the convex decompression follower face 143 via the peak face 146 and then via the second buffer face 148. Since the second buffer face 148 is formed as a concavely curved face, when the convex decompression follower face 143 disengages from the second buffer face 148, the amount of lift of the exhaust valve 89 changes gently. As a result, the noise of seating of the exhaust valve 89 (seating noise) is reduced. Moreover, while the cam shaft 95 is rotating in reverse, the curved protruding face 145 of the decompression cam 144 makes contact with the second buffer face 148 and the peak face 146 one after another. Since the second buffer face 148 is formed as a concavely curved face, when starting contact the convex decompression follower face 143 can slip against the second buffer face 148 in a tangential direction. Therefore, when the piston 45 cannot completely ride over compression top dead center and the cam shaft 95 rotates in reverse, noise due to collision between the decompression cam 114 and the exhaust side rocker arm 97b can be suppressed.

THIRD EMBODIMENT

[0101] FIG. 9 schematically shows the arrangement of a decompression device 151 related to a third embodiment. In the decompression device 151 the cam follower 101 also functions as the decompression follower 142. That is, the roller 109 of the cam follower 101 functions, over the entire periphery of the cylindrical face, as the convex decompression follower face 143 having the convexly curved face described above. The roller 109 is made to face the imaginary cylindrical face 122 across a set gap. The peak face 146 of the decompression cam 144 is formed as part of a cylindrical face having the same diameter as that of the partial cylindrical face 129. The first buffer face 147 and the second buffer face 148 of the decompression cam 144 are each formed as a partial cylindrical face having a smaller curvature than that of the cylindrical face of the roller 109. The upstream end 147a of the first buffer face 147 is disposed at a position closer to the axis Xc of the cam shaft 95 than the roller 109 when the decompression cam 144 is positioned at the operating position. The downstream end 148a of the second buffer face 148 is disposed at a position closer to the axis Xc of the cam shaft 95 than the roller 109 when the decompression cam 144 is positioned at the operating position. The arrangement is otherwise the same as that of the second embodiment described above.

[0102] While the cam shaft 95 is rotating normally, the curved protruding face 145 of the decompression cam 144 makes contact with the roller 109 of the exhaust side rocker arm 97b via the first buffer face 147 and the peak face 146 one after another. Since the first buffer face 147 of the decompression cam 144 is formed as a concavely curved face, when starting contact the roller 109 can slip against the first buffer face 147 of the decompression cam 144 in a tangential direction. Therefore, noise due to collision between the decompression cam 144 and the exhaust side rocker arm 97b can be suppressed.

[0103] While the cam shaft 95 is rotating normally, the curved protruding face 145 of the decompression cam 144 makes contact with the roller 109 via the peak face 146 and then via the second buffer face 148. Since the second buffer face 148 is formed as a concavely curved face, when the roller 109 disengages from the second buffer face 148, the amount of lift of the exhaust valve 89 changes gently. As a result, the noise of seating of the exhaust valve 89 (seating noise) is reduced. Moreover, while the cam shaft 95 is rotating in reverse, the curved protruding face 145 of the decompression cam 144 makes contact with the second buffer face 148 and the peak face 146 one after another. Since the second buffer face 148 is formed as a concavely curved face, when starting contact the roller 109 can slip against the second buffer face 148 in a tangential direction. Therefore, when the piston 45 cannot completely ride over compression top dead center and the cam shaft 95 rotates in reverse, noise due to collision between the decompression cam 144 and the exhaust side rocker arm 97b can be suppressed.

Claims

1. An internal combustion engine comprising
 - a base face (108a) having a shape with a partial cylindrical face that is coaxial with a rotational axis (Xc) of a cam shaft (95),
 - a lift face (108b) that is provided on the cam shaft (95) so as to be continuous from the base face (108a) in a rotational direction and that bulges further radially outward than the base face (108a) to define an amount of lift of an exhaust valve (89),
 - a cam follower (101) that is provided on an exhaust side rocker arm (97b) and causes the exhaust side rocker arm (97b) to swing while maintaining contact with the base face (108a) and the lift face (108b),
 - a decompression cam (112) that makes a curved protruding face (129) having a generatrix parallel to the rotational axis (Xc) of the cam shaft (95) project from an imaginary cylindrical face (122) coaxial with the cam shaft (95) when the rotational speed is less than a preset value,
 - a convex decompression follower face (133) with a convexly curved face that is provided on the exhaust side rocker arm (97b) on an outer side of the imag-

- inary cylindrical face (122), that faces the imaginary cylindrical face (122) at a position closest to the imaginary cylindrical face (122), and that makes contact with the curved protruding face (129), and a concave decompression follower face (134) that is provided on the upstream of the convex decompression follower face (133) in a normal rotational direction of the cam shaft (95), that is formed as a concavely curved face having a generatrix parallel to the rotational axis (Xc) of the cam shaft (95), and that makes contact with the curved protruding face (129).
2. The internal combustion engine according to Claim 1, wherein an upstream end (134a) of the concave decompression follower face (134) is provided at a position spaced from the rotational axis (Xc) of the cam shaft (95) compared with the curved protruding face (129).
 3. The internal combustion engine according to Claim 1 or 2, wherein the concave decompression follower face (134) is positioned remoter from the rotational axis (Xc) of the cam shaft (95) in going away from the convex decompression follower face (133).
 4. The internal combustion engine according to any one of Claims 1 to 3, further comprising an auxiliary concave decompression follower face (136) that is formed between the convex decompression follower face (133) and the concave decompression follower face (134) and that is formed from a concavely curved face having a curvature smaller than a curvature of the curved protruding face (129).
 5. The internal combustion engine according to Claim 4, wherein the auxiliary concave decompression follower face (136) is formed from part of a cylindrical face having a curvature larger than a curvature of the concave decompression follower face (134).
 6. The internal combustion engine according to any one of Claims 1 to 5, further comprising a second concave decompression follower face (135) that is provided on the downstream of the convex decompression follower face (133) in the normal rotational direction of the cam shaft (95), that is formed as a concavely curved face having a generatrix parallel to the rotational axis (Xc) of the cam shaft (95), and that makes contact with the curved protruding face (129).
 7. An internal combustion engine comprising a base face (108a) having a shape with a partial cylindrical face that is coaxial with a rotational axis (Xc) of a cam shaft (95), a lift face (108b) that is provided on the cam shaft (95) so as to be continuous from the base face (108a) in a rotational direction and that bulges further radially outward than the base face (108a) to define an amount of lift of an exhaust valve (89), a cam follower (101) that is provided on an exhaust side rocker arm (97b) and causes the exhaust side rocker arm (97b) to swing while maintaining contact with the base face (108a) and the lift face (108b), a decompression cam (112) that makes a curved protruding face (129) having a generatrix parallel to the rotational axis (Xc) of the cam shaft (95) project from an imaginary cylindrical face (122) coaxial with the cam shaft (95) when the rotational speed is less than a preset value, a convex decompression follower face (133) that is provided on the exhaust side rocker arm (97b) on an outer side of the imaginary cylindrical face (122), that faces the imaginary cylindrical face (122) at a position closest to the imaginary cylindrical face (122), and that makes contact with the curved protruding face (129), and a concave decompression follower face (135) that is provided on the downstream of the convex decompression follower face (133) in a normal rotational direction of the cam shaft (95), that is formed as a concavely curved face having a generatrix parallel to the rotational axis (Xc) of the cam shaft (95), and that makes contact with the curved protruding face (129).
 8. The internal combustion engine according to Claim 7, wherein a downstream end (135a) of the concave decompression follower face (135) is provided at a position spaced from the rotational axis (Xc) of the cam shaft (95) compared with the curved protruding face (129).
 9. The internal combustion engine according to Claim 7 or 8, wherein the concave decompression follower face (135) is positioned remoter from the rotational axis (Xc) of the cam shaft (95) in going away from the convex decompression follower face (133).
 10. The internal combustion engine according to any one of Claims 7 to 9, further comprising an auxiliary concave decompression follower face (137) that is formed between the convex decompression follower face (133) and the concave decompression follower face (135) and that is formed from a concavely curved face having a curvature smaller than a curvature of the curved protruding face (129).
 11. The internal combustion engine according to Claim 10, wherein the auxiliary concave decompression follower face (137) is formed from part of a cylindrical face having a curvature larger than a curvature of the concave decompression follower face (135).
 12. The internal combustion engine according to any one

of Claims 1 to 11, further comprising an AC generator (49) that is joined to a crankshaft (32), that generates electric power in response to rotation of the crankshaft (32), and that drives the crankshaft (32) around a rotational axis (Xis) thereof in response to electric power being supplied.

13. An internal combustion engine comprising
 - a base face (108a) having a shape with a partial cylindrical face that is coaxial with a rotational axis (Xc) of a cam shaft (95),
 - a lift face (108b) that is provided on the cam shaft (95) so as to be continuous from the base face (108a) in a rotational direction and that bulges further radially outward than the base face (108a) to define an amount of lift of an exhaust valve (89),
 - a cam follower (101) that is provided on an exhaust side rocker arm (97b) and causes the exhaust side rocker arm (97b) to swing while maintaining contact with the base face (108a) and the lift face (108b),
 - a decompression cam (144) that makes a curved protruding face (145) having a generatrix parallel to the rotational axis (Xc) of the cam shaft (95) project from an imaginary cylindrical face (122) coaxial with the cam shaft (95) when the rotational speed is less than a preset value, and
 - a convex decompression follower face (143) with a convexly curved face that is provided on the exhaust side rocker arm (97b) on an outer side of the imaginary cylindrical face (122), that faces the imaginary cylindrical face (122), and that makes contact with the curved protruding face (145),
 - the curved protruding face (145) having a peak face (146) that projects the furthest from the imaginary cylindrical face (122), and a buffer face (147) that is provided on the upstream of the peak face (146) in a normal rotational direction of the cam shaft (95), that is formed as a concavely curved face having a generatrix parallel to the rotational axis (Xc) of the cam shaft (95), and that makes contact with the convex decompression follower face (143).
14. The internal combustion engine according to Claim 13, wherein the curved protruding face (145) further has a second buffer face (148) that is provided on the downstream of the peak face (146) in the normal rotational direction of the cam shaft (95) and that is formed as a concavely curved face having a generatrix parallel to the rotational axis (Xc) of the cam shaft (95).
15. An internal combustion engine comprising
 - a base face (108a) having a shape with a partial cylindrical face that is coaxial with a rotational axis (Xc) of a cam shaft (95),
 - a lift face (108b) that is provided on the cam shaft (95) so as to be continuous from the base face (108a) in a rotational direction and that bulges further radi-

ally outward than the base face (108a) to define an amount of lift of an exhaust valve (89),

a cam follower (101) that is provided on an exhaust side rocker arm (97b) and causes the exhaust side rocker arm (97b) to swing while maintaining contact with the base face (108a) and the lift face (108b),

a decompression cam (144) that makes a curved protruding face (145) having a generatrix parallel to the rotational axis (Xc) of the cam shaft (95) project from an imaginary cylindrical face (122) coaxial with the cam shaft (95) when the rotational speed is less than a preset value, and

a convex decompression follower face (143) with a convexly curved face that is provided on the exhaust side rocker arm (97b) on an outer side of the imaginary cylindrical face (122), that faces the imaginary cylindrical face (122), and that makes contact with the curved protruding face (145),

the curved protruding face (145) having a peak face (146) that projects the furthest from the imaginary cylindrical face (122), and a buffer face (148) that is provided on the downstream of the peak face (146) in a normal rotational direction of the cam shaft (95), that is formed as a concavely curved face having a generatrix parallel to the rotational axis (Xc) of the cam shaft (95), and that makes contact with the convex decompression follower face (143).

FIG. 1

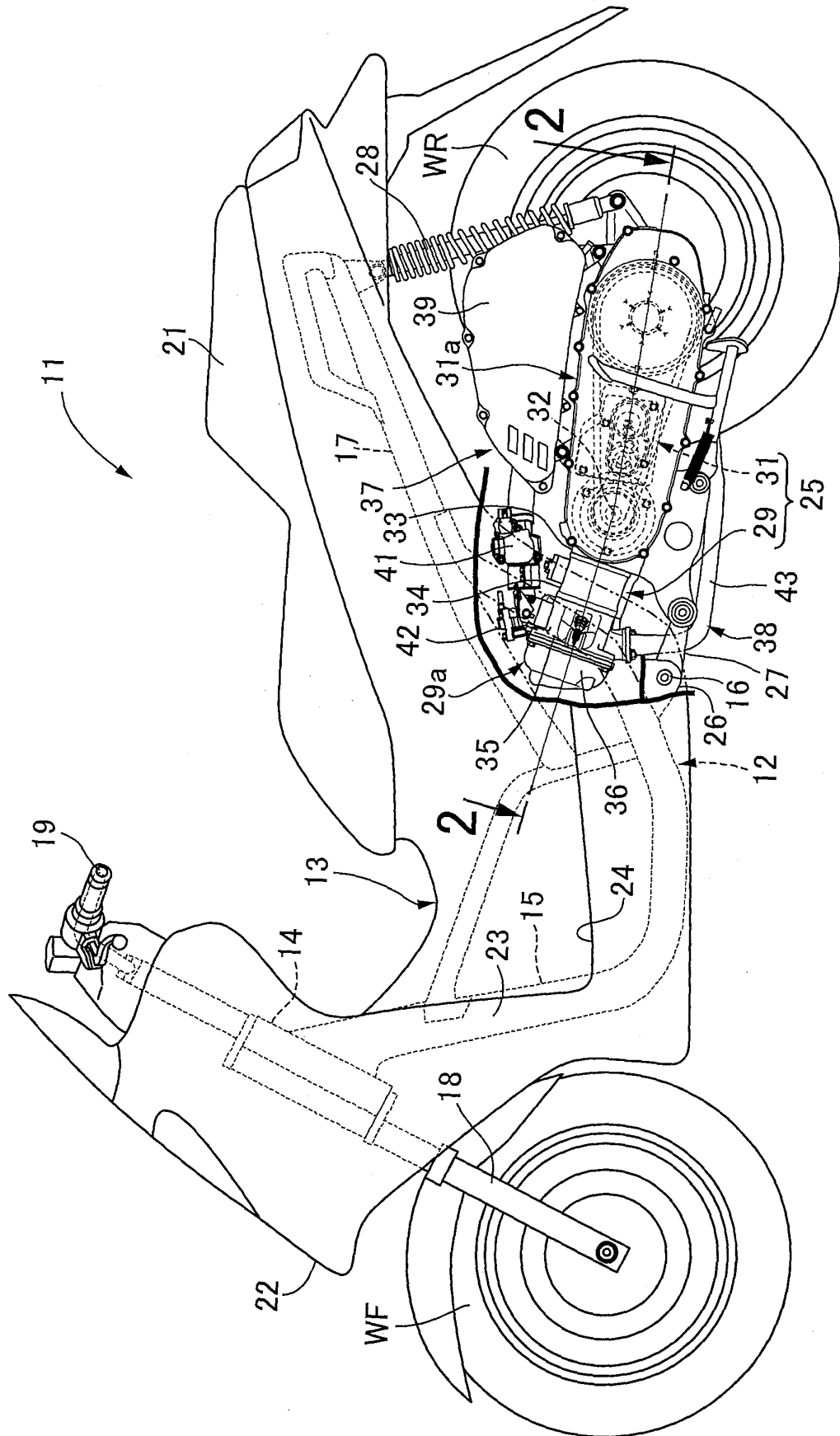


FIG.2

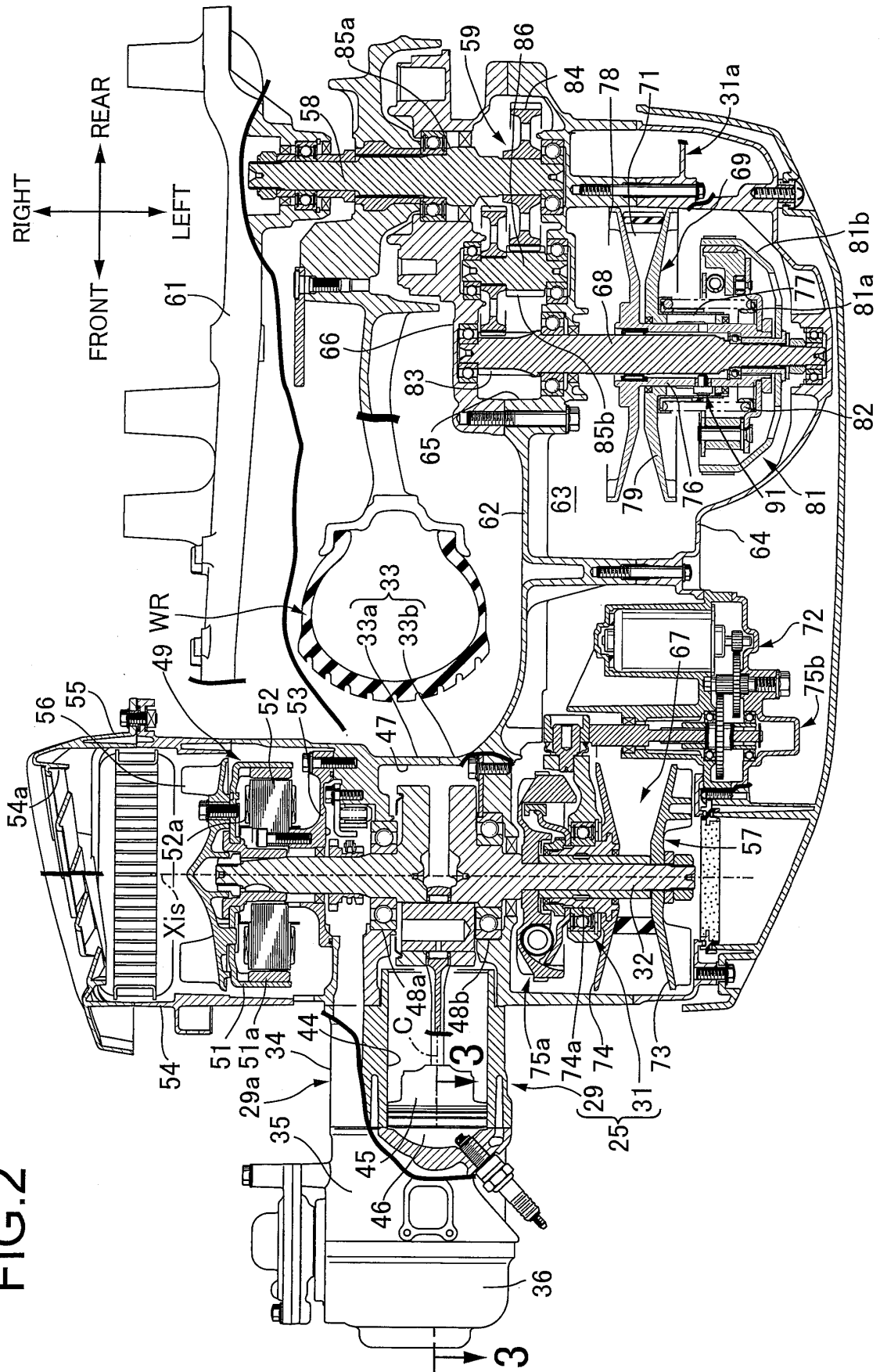


FIG.3

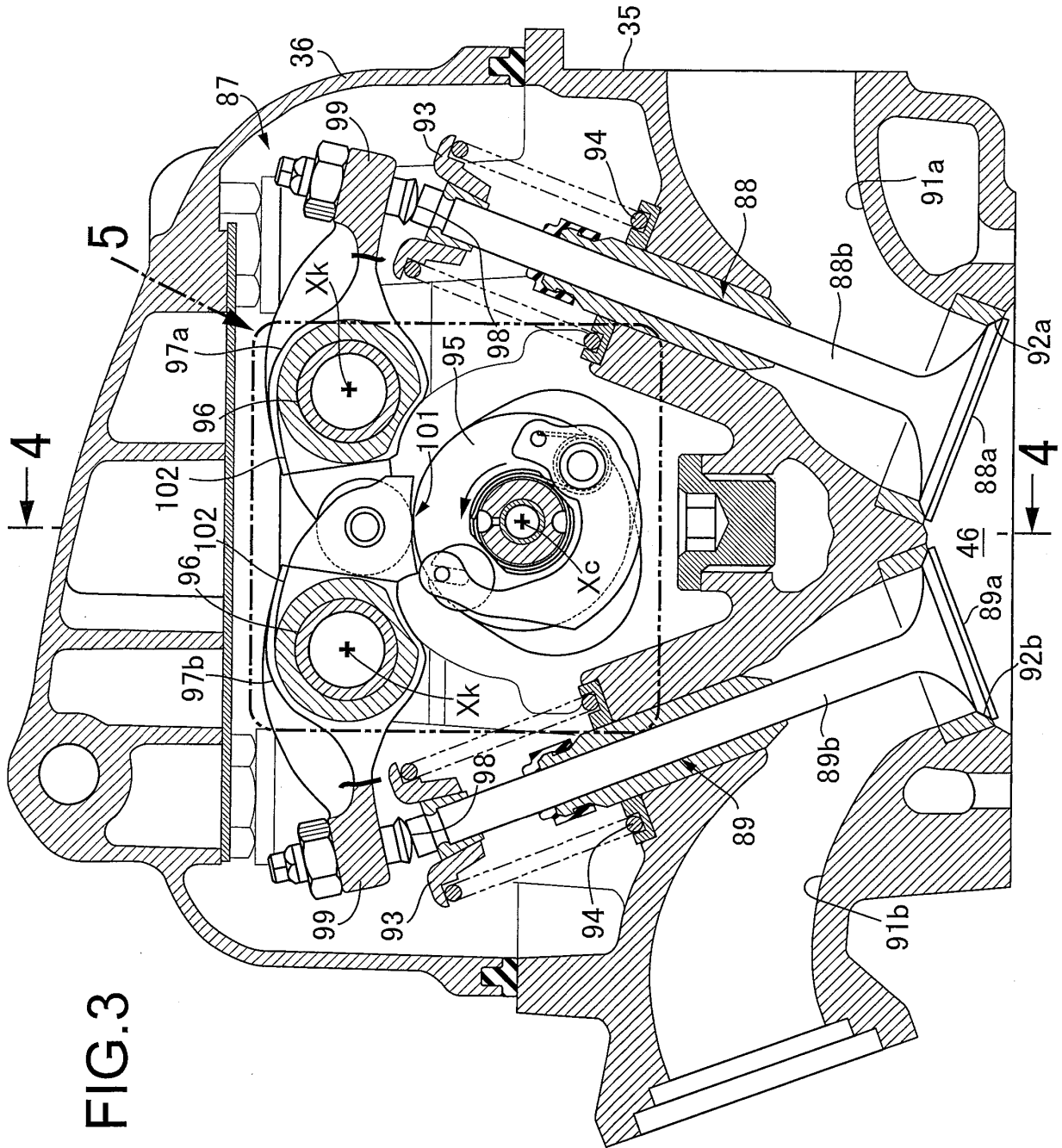


FIG.4

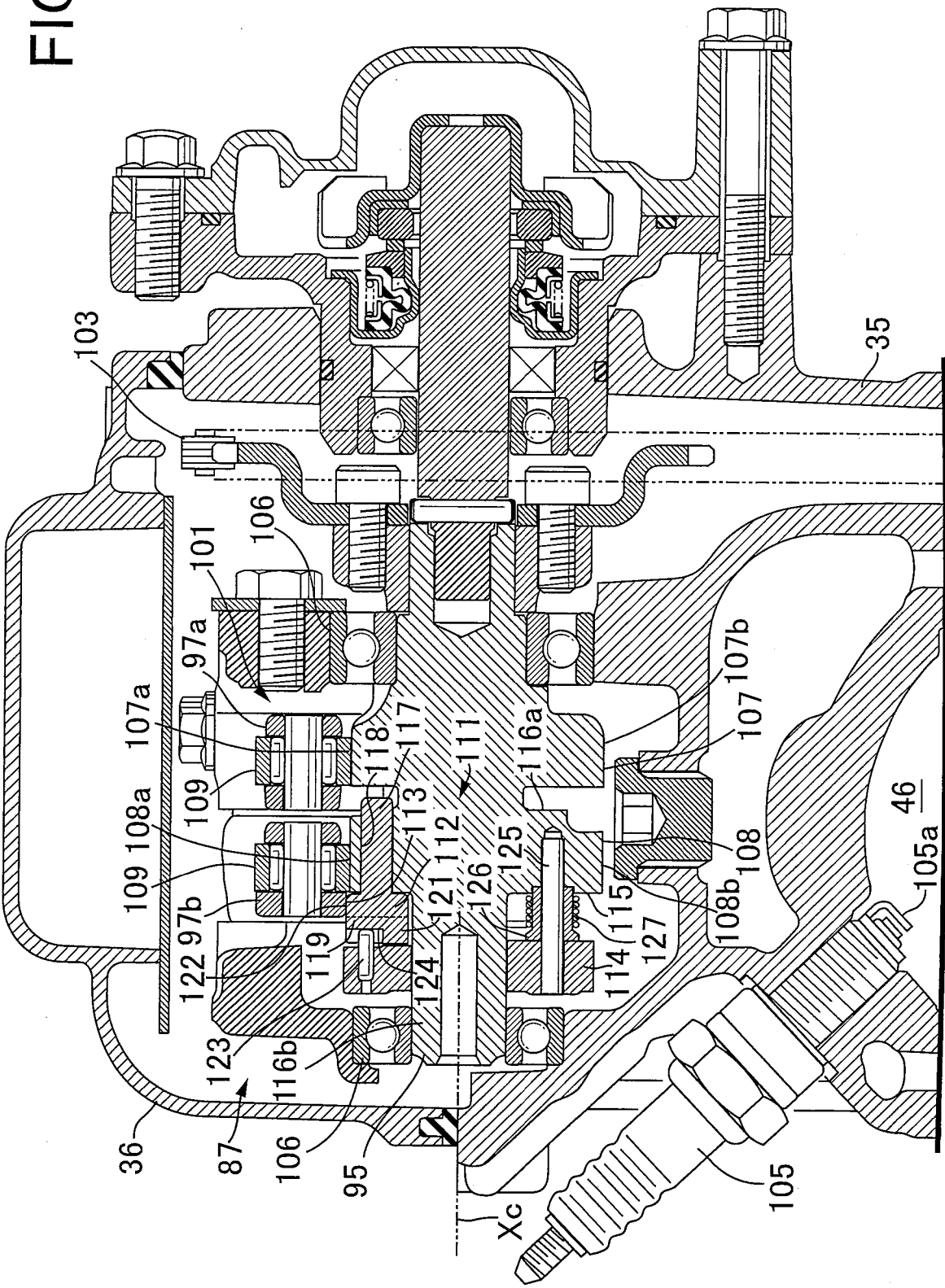


FIG.5

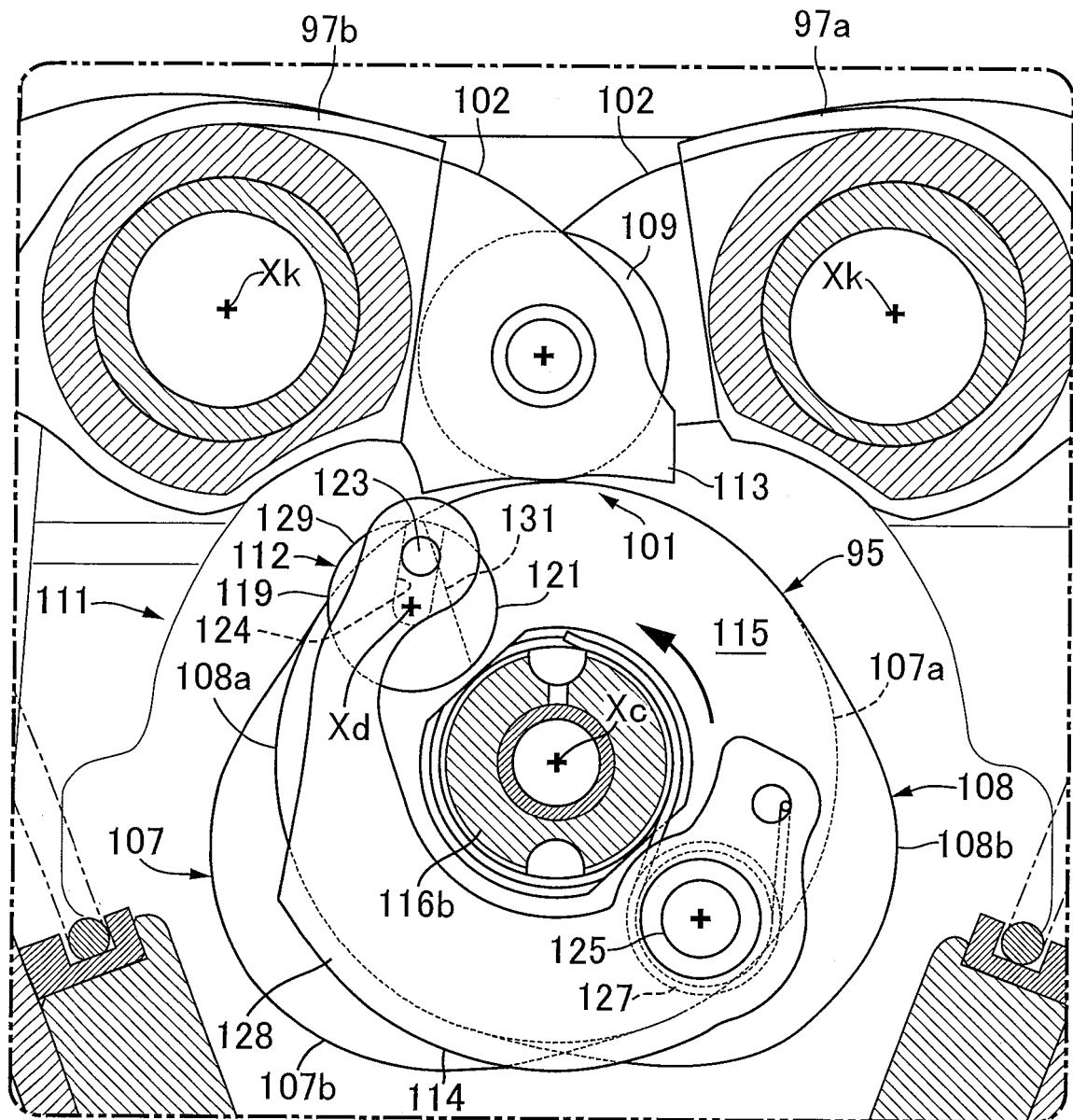


FIG.6

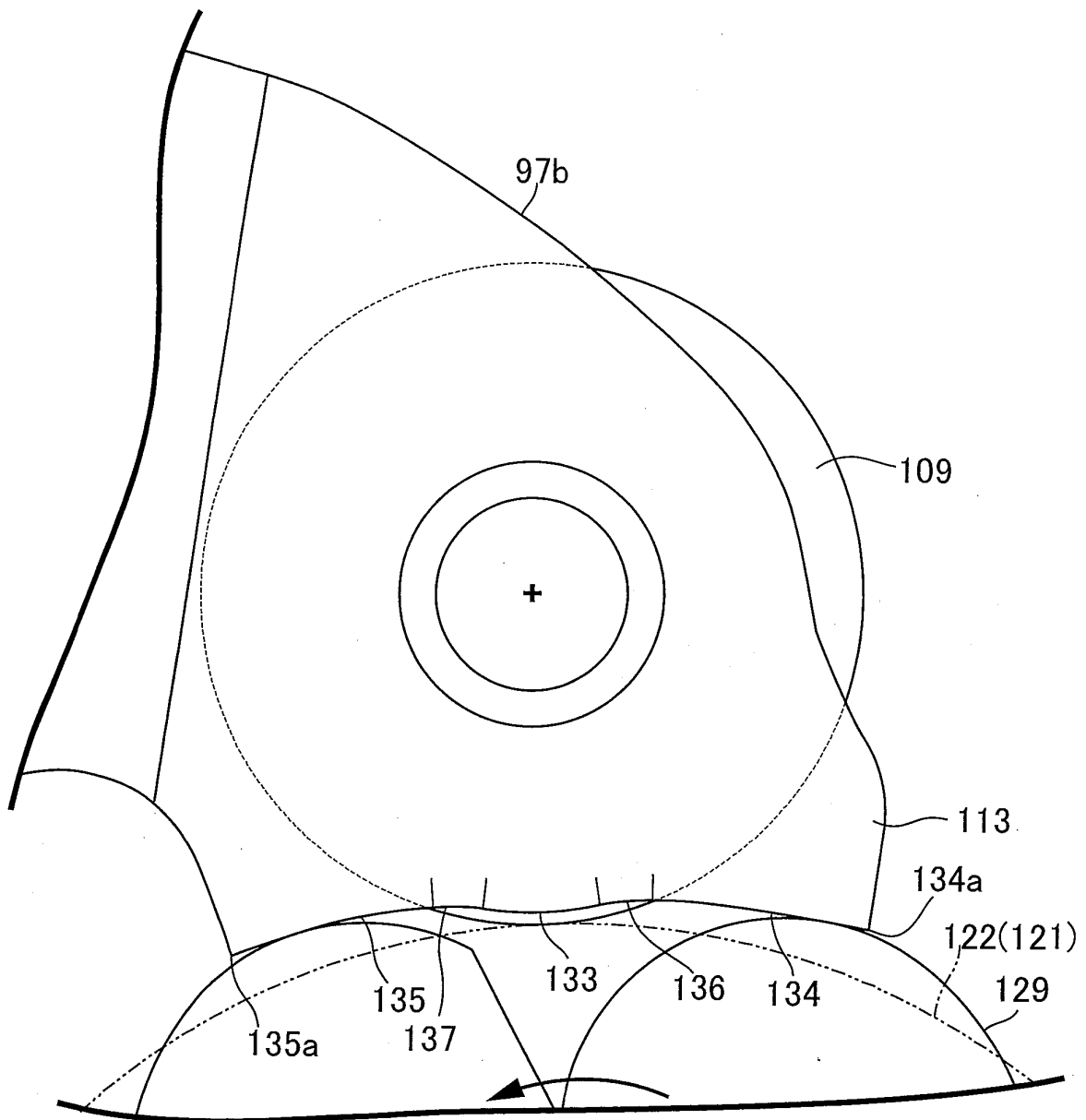


FIG.7

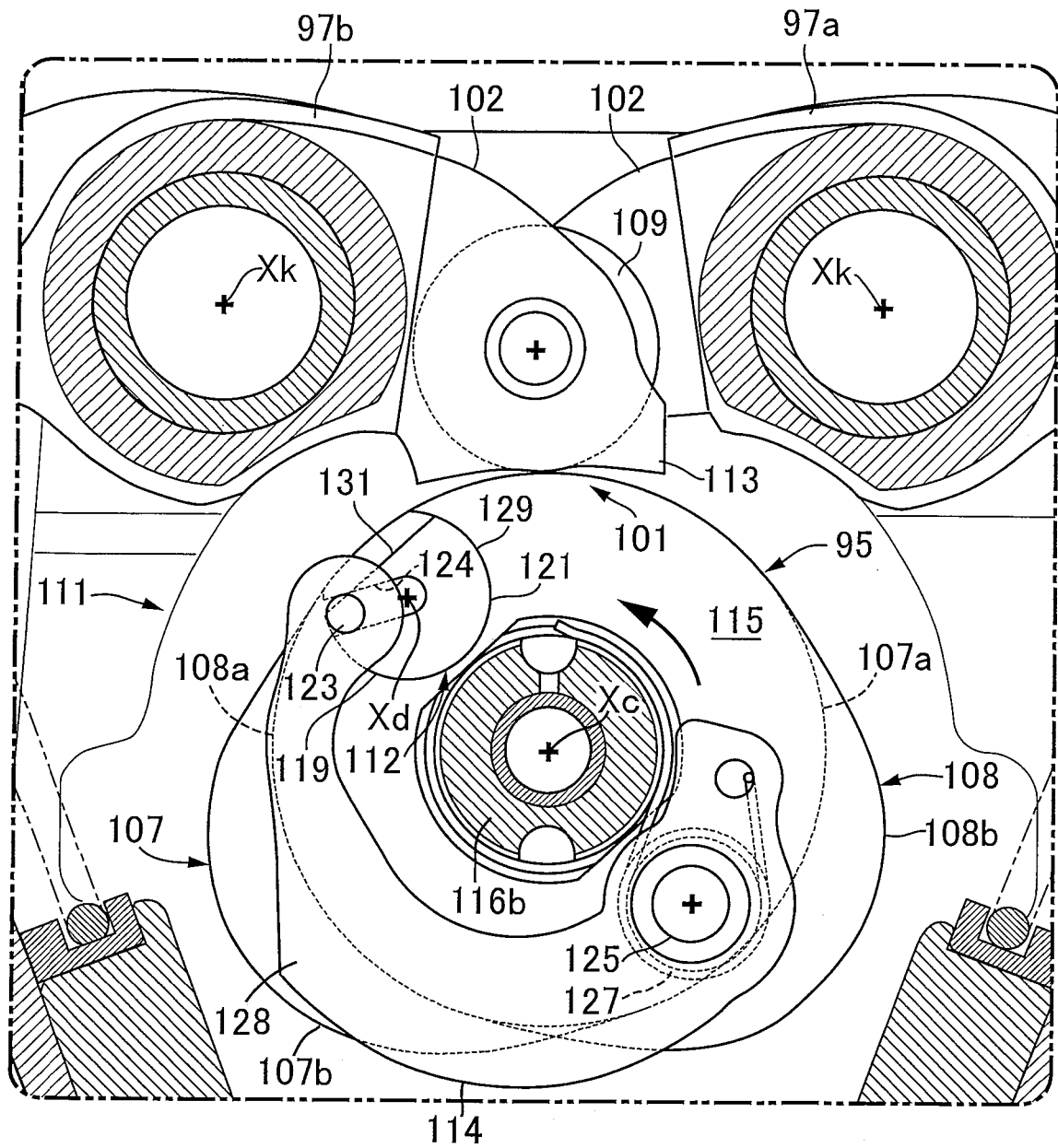


FIG.8

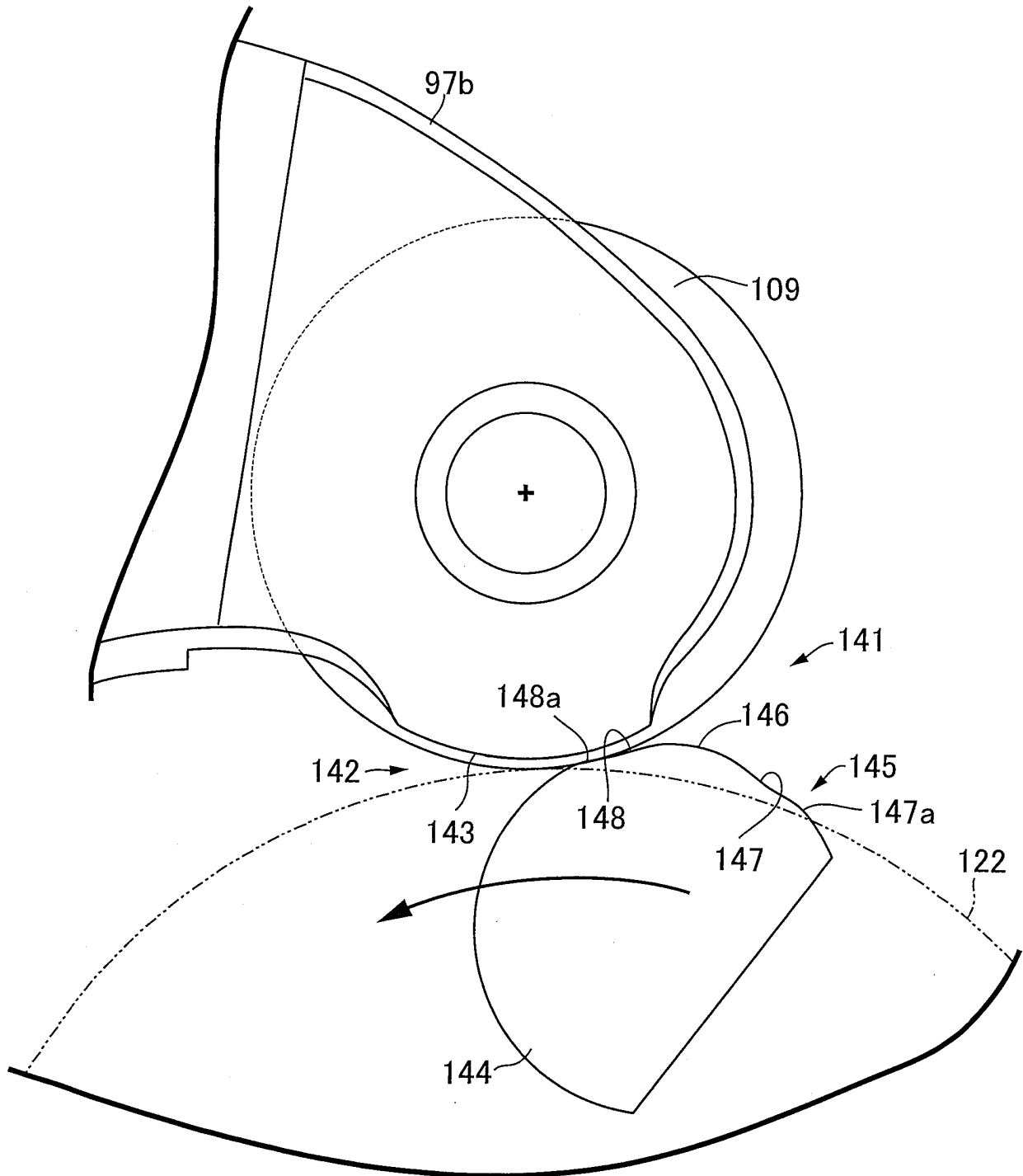
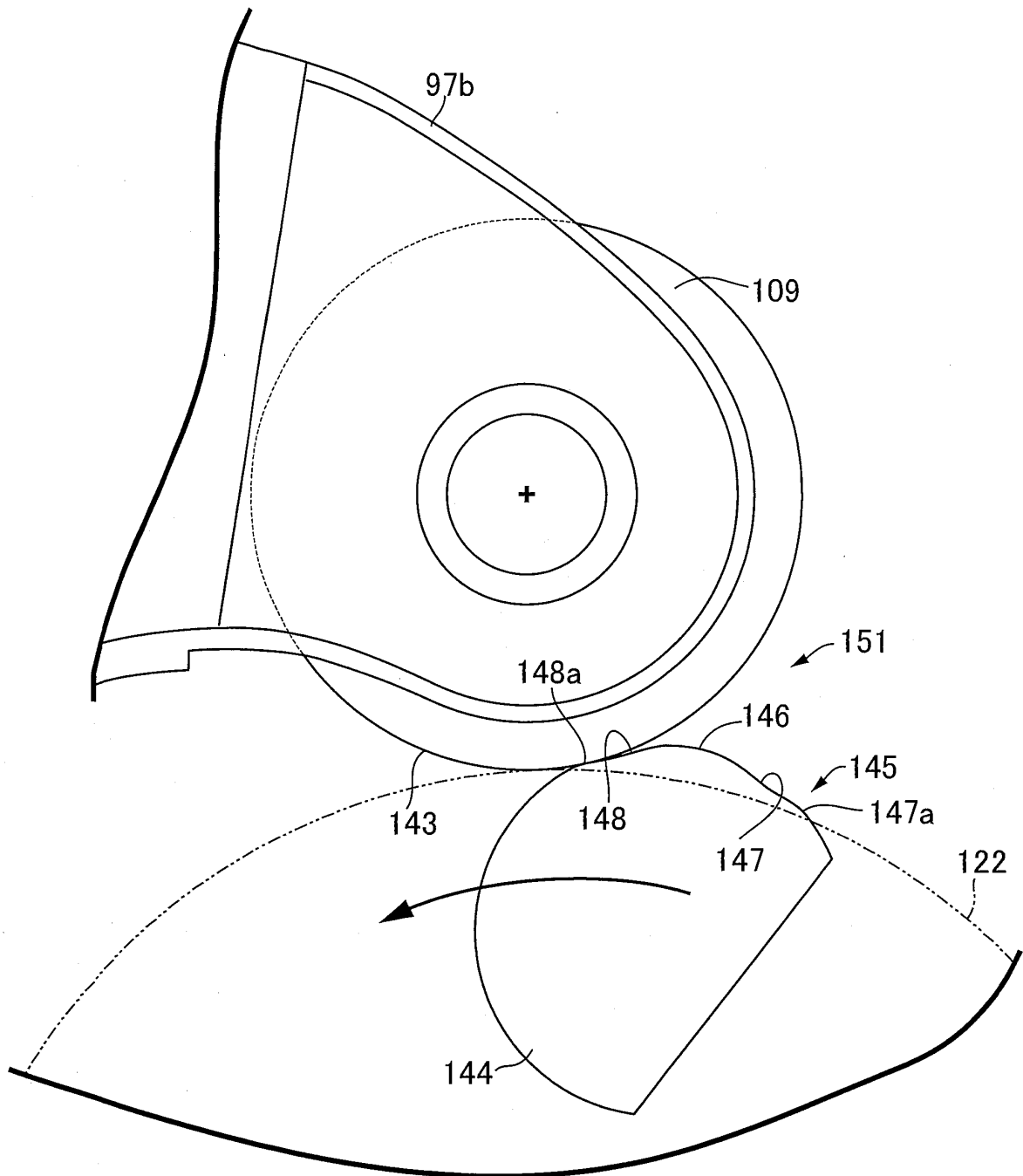


FIG.9



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2018/010294

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl. F01L13/08 (2006.01) i

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)
Int.Cl. F01L13/08

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

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2018
Registered utility model specifications of Japan	1996-2018
Published registered utility model applications of Japan	1994-2018

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2012-163057 A (HONDA MOTOR CO., LTD.) 30 August 2012, paragraphs [0038]-[0048], fig. 6-9 & US 2012/0199087 A1, paragraphs [0058]-[0068], fig. 6-9	1-15
A	JP 2014-129794 A (HONDA MOTOR CO., LTD.) 10 July 2014, paragraphs [0050]-[0066], fig. 6-8, 11 (Family: none)	1-15
A	JP 6002269 B1 (HONDA MOTOR CO., LTD.) 05 October 2016, paragraphs [0043], [0082]-[0086], fig. 10 & CN 106014745 A	12

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search
11 June 2018 (11.06.2018)

Date of mailing of the international search report
19 June 2018 (19.06.2018)

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Patent documents cited in the description

- JP 2014129794 A [0003]