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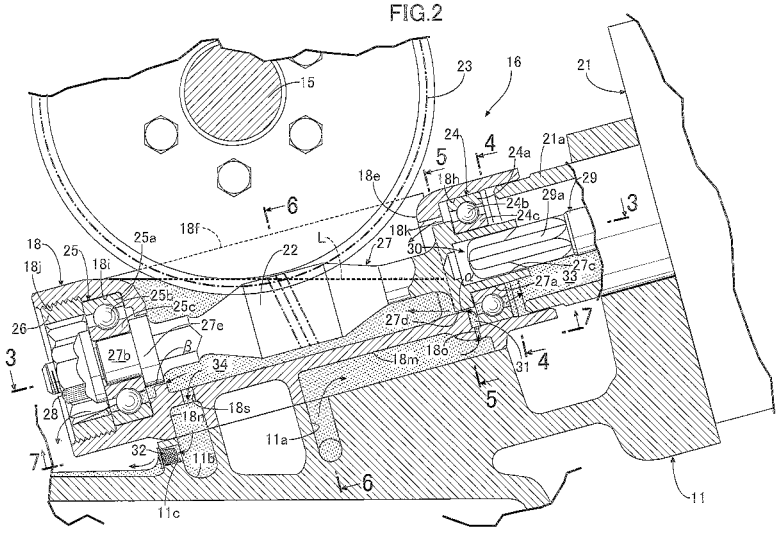
(54) ACTUATOR FOR VARIABLE VALVE MECHANISM

(57) A worm (22) and a worm wheel (23) are meshed in an oil storage chamber (34) formed in an actuator housing (18) which rotatably supports a worm shaft (27), a projecting portion (18p) which projects so as to surround the outer periphery of the worm (22) is formed on the inner wall surface of the oil storage chamber (34), an oil jet (18) is open to the inner peripheral surface of the projecting portion (18p) facing the outer periphery of the worm (22), and the opening of the oil jet (18r) is formed at a position overlapping with the worm (22) when viewed from above, whereby oil jetted from the oil jet (18r) flows down by gravity and touches the worm (22) and the oil is held between the worm and the projecting portion (18p) of the actuator housing (18) facing the outer periphery of the worm (22), so the lubricating effect can be improved by causing the oil to fully act on the meshed portion between the worm (22) and the worm wheel (23).

FIG.2



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Description

TECHNICAL FIELD

[0001] The present invention relates to an actuator for a variable valve operating mechanism in which a worm shaft is connected to a motor output shaft of an electric motor, a worm wheel is meshed with a worm provided on the worm shaft, and rotation of the motor output shaft is reduced in speed by the worm and the worm wheel to thus operate the variable valve operating mechanism, thereby changing at least one of valve lift and valve timing of an internal combustion engine.

BACKGROUND ART

[0002] An arrangement in which a ball screw mechanism and a threaded shaft, which operate a variable valve operating mechanism of an internal combustion engine by means of an electric motor, are housed in the interior of a housing, and a meshed part of the ball screw mechanism and a bearing for supporting the threaded shaft are lubricated by supplying oil to the interior of the housing is known from Patent Document 1.

Patent Document 1: Japanese Patent Application Laid-open No. 2006-144551

DISCLOSURE OF INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0003] However, in the above-mentioned conventional arrangement, since lubrication of the ball screw mechanism is carried out by oil supplied via a link member from the interior of a control shaft for operating the variable valve operating mechanism, it is difficult for oil to act sufficiently on a sliding part of the ball screw mechanism, and there is a possibility of inadequate lubrication occurring.

[0004] Furthermore, since the housing is provided in an inclined manner so that the electric motor side is high, and each of opposite ends of the threaded shaft is supported on the housing via the bearing, lubricating oil cannot spread through to the bearing that supports the end part on the high side of the threaded shaft in particular, and there is the problem that the lifespan of the bearing is short.

[0005] The present invention has been accomplished in light of the above-mentioned circumstances, and it is an object thereof to enhance durability by lubricating effectively a meshed part of a worm wheel and a worm of an actuator for a variable valve operating mechanism, and a bearing for supporting a worm shaft on an actuator housing.

MEANS FOR SOLVING THE PROBLEMS

[0006] In order to attain the above object, according to a first aspect of the present invention, there is provided an actuator for a variable valve operating mechanism in which a worm shaft is connected to a motor output shaft of an electric motor, a worm wheel is meshed with a worm provided on the worm shaft, and rotation of the motor output shaft is reduced in speed by the worm and the worm wheel to thus operate the variable valve operating mechanism, thereby changing at least one of valve lift and valve timing of an internal combustion engine, wherein the worm and the worm wheel mesh with each other in an interior of an oil storage chamber formed in an actuator housing rotatably supporting the worm shaft, a projecting portion is formed on an inner wall face of the oil storage chamber, the projecting portion projecting so as to surround an outer periphery of the worm, a first oil supply hole opens on an inner peripheral face of the projecting portion that opposes the outer periphery of the worm, and an opening of the first oil supply hole is formed at a position where the opening overlaps the worm when viewed from above.

[0007] Moreover, according to a second aspect of the present invention, in addition to the first aspect, there is provided an actuator for a variable valve operating mechanism, wherein a meshed part of the worm and the worm wheel is present within the width, in the axial direction, of the inner peripheral face of the projecting portion opposing the outer periphery of the worm.

[0008] Furthermore, according to a third aspect of the present invention, there is provided an actuator for a variable valve operating mechanism in which a worm shaft is connected to a motor output shaft of an electric motor, a worm wheel is meshed with a worm provided on the worm shaft, and rotation of the motor output shaft is reduced in speed by the worm and the worm wheel to thus operate the variable valve operating mechanism, thereby changing at least one of valve lift and valve timing of an internal combustion engine, wherein the worm and the worm wheel are meshed with each other in an interior of an oil storage chamber formed in an actuator housing rotatably supporting the worm shaft via a bearing, and a second oil supply hole for supplying oil to the oil storage chamber opens in a part of the actuator housing where the bearing is mounted.

[0009] Moreover, according to a fourth aspect of the present invention, in addition to the third aspect of the present invention, there is provided the actuator for a variable valve operating mechanism, wherein an annular oil reservoir surrounding the outer periphery of the worm shaft is defined by the worm shaft, the bearing, and the housing, the second oil supply hole opens in a lower part of the oil reservoir, and an oil passage supplying oil of the oil reservoir to the oil storage chamber is formed in a portion of the actuator housing that opposes an upper part of the oil reservoir.

[0010] Furthermore, according to a fifth aspect of the

present invention, in addition to any one of the first to fourth aspects, there is provided the actuator for a variable valve operating mechanism, wherein the worm shaft is coaxially connected to the motor output shaft of the electric motor via a coupling , the coupling being formed by relatively non-rotatably fitting, into an inner periphery of a tubular portion of one shaft among the motor output shaft and the worm shaft, an outer periphery of the other shaft, and an outer periphery of the tubular portion being rotatably supported on the actuator housing via the bearing.

[0011] Moreover, according to a sixth aspect of the present invention, in addition to the fifth aspect, there is provided the actuator for a variable valve operating mechanism, wherein the tubular portion is integrally formed with the one shaft.

[0012] Furthermore, according to a seventh aspect of the present invention, in addition to the sixth aspect, there is provided the actuator for a variable valve operating mechanism, wherein at least part of the other shaft overlaps the bearing when viewed from a direction perpendicular to the axis.

[0013] Moreover, according to an eighth aspect of the present invention, in addition to any one of the first to fourth aspects, there is provided the actuator for a variable valve operating mechanism, wherein the oil storage chamber is disposed in an inclined manner so that an end part, on the electric motor side, of the worm shaft is high, and a dust collection chamber communicating with the oil storage chamber is formed in an end part of the oil storage chamber on the side that is low.

[0014] Furthermore, according to a ninth aspect of the present invention, in addition to the eighth aspect, there is provided the actuator for a variable valve operating mechanism, wherein the actuator comprises a drain passage for discharging oil from the dust collection chamber, and the amount of oil discharged from the drain passage is set smaller than the amount of oil supplied to the oil storage chamber.

[0015] Moreover, according to a tenth aspect of the present invention, in addition to the eighth or ninth aspect, there is provided the actuator for a variable valve operating mechanism, wherein the dust collection chamber and the oil storage chamber communicate with each other via a constricted portion.

[0016] A cutout 18k of an embodiment corresponds to the oil passage of the present invention, an oil jet 18o of the embodiment corresponds to the first oil supply hole of the present invention, an oil jet 18r of the embodiment corresponds to the second oil supply hole of the present invention, a first ball bearing 24 of the embodiment corresponds to the bearing of the present invention, a worm shaft 27 of the embodiment corresponds to the one shaft of the present invention, a first journal 27a of the embodiment corresponds to the tubular portion of the present invention, a motor output shaft 29 of the embodiment corresponds to the other shaft of the present invention, and a second oil storage chamber 34 of the embodiment corresponds to the oil storage chamber of the present invention.

EFFECTS OF THE INVENTION

[0017] In accordance with the first aspect of the present invention, since the worm and the worm wheel mesh with each other in the interior of the oil storage chamber formed in the actuator housing, which rotatably supports the worm shaft, the projecting portion is formed on the inner wall face of the oil storage chamber and projects so as to surround the outer periphery of the worm, the first oil supply hole is made to open on the inner peripheral face of the projecting portion that opposes the outer periphery of the worm, and the opening of the first oil supply hole is formed at a position that overlaps the worm when viewed from above, oil that comes out from the first oil supply hole drops downward due to gravity and contacts the worm, and the oil is retained between the worm and the projecting portion of the actuator housing that opposes the outer periphery of the worm, thereby enabling oil to act sufficiently on the meshed part between the worm and the worm wheel and the lubrication effect to be enhanced.

[0018] Furthermore, in accordance with the second aspect of the present invention, since the meshed part between the worm and the worm wheel is present within the width, in the axial direction, of the inner peripheral face of the projecting portion that opposes the outer periphery of the worm, it is possible to reliably supply oil to the meshed part between the worm and the worm wheel via the projecting portion.

[0019] Moreover, in accordance with the third aspect of the present invention, since the worm and the worm wheel mesh with each other in the interior of the oil storage chamber formed in the actuator housing rotatably supporting the worm shaft via the bearing, and the second oil supply hole for supplying oil to the oil storage chamber is made to open in the bearing mount portion of the actuator housing, not only is it possible to lubricate the bearing reliably even if it is disposed at a position higher than the oil level of the actuator housing, but it is also possible to supply clean oil having little contamination with abraded powder to the bearing and enhance the durability.

[0020] Furthermore, in accordance with the fourth aspect of the present invention, since the annular oil reservoir surrounding the outer periphery of the worm shaft is defined by the worm shaft, the bearing and the housing, the second oil supply hole is made to open in the lower part of the oil reservoir, and the oil passage is formed in the portion opposing the upper part of the oil reservoir, it is possible to reliably lubricate the bearing by retaining oil supplied from the second oil supply hole in the oil reservoir.

[0021] Moreover, in accordance with the fifth aspect of the present invention, since the coupling connecting the motor output shaft of the electric motor to the worm

shaft is formed by relatively non-rotatably fitting, into the inner periphery of the tubular portion formed on one shaft of the motor output shaft and the worm shaft, the outer periphery of the other shaft, and the outer periphery of the tubular portion is rotatably supported on the actuator housing via the bearing, it is possible to simultaneously support both the motor output shaft and the worm shaft by means of a single bearing at the position of the coupling, thus suppressing effectively vibration and wear of the connected parts thereof.

[0022] Furthermore, in accordance with the sixth aspect of the present invention, since the tubular portion is formed integrally with the one shaft, it becomes possible to reduce the number of components and the size of the coupling.

[0023] Moreover, in accordance with the seventh aspect of the present invention, since at least part of the other shaft overlaps the bearing when viewed in the direction perpendicular to the shaft, it is possible to reliably suppress run-out, in the radial direction, of the motor output shaft and the drive shaft by means of a single bearing.

[0024] Furthermore, in accordance with the eighth aspect of the present invention, since the oil storage chamber is disposed in an inclined manner so that the end part on the worm shaft-driving electric motor side is high, and the dust collection chamber is formed in the end part, on the low side, of the oil storage chamber, it is possible to guide oil supplied to the oil storage chamber by virtue of gravity to the dust collection chamber in order to lubricate the meshed part between the worm and the worm wheel and it is possible to suppress wear of the meshed part by collecting abraded powder contained in the oil, thereby enhancing the durability thereof.

[0025] Moreover, in accordance with the ninth aspect of the present invention, since the amount of oil discharged from the dust collection chamber via the drain passage is set smaller than the amount of oil supplied to the oil storage chamber, it is possible to always store a sufficient amount of oil in the oil storage chamber, thereby reliably lubricating the meshed part between the worm and the worm wheel.

[0026] Furthermore, in accordance with the tenth aspect of the present invention, since the dust collection chamber and the oil storage chamber communicate with each other via the constricted portion, not only is it possible to suppress the outflow of oil from the oil storage chamber by means of the constricted portion and thus retain the oil in the oil storage chamber, but it is also possible to prevent abraded powder, once it has entered the dust collection chamber from the oil storage chamber, from returning to the oil storage chamber by blocking it by means of the constricted portion.

BRIEF DESCRIPTION OF DRAWINGS

[0027]

[FIG. 1] FIG. 1 is a plan view of a cylinder head of a multi-cylinder engine equipped with a variable valve operating mechanism (first embodiment).

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

[FIG. 3] FIG. 3 is a sectional view along line 3-3 in FIG. 2 (first embodiment).

[FIG. 4] FIG. 4 is a sectional view along line 4-4 in FIG. 2 (first embodiment).

[FIG. 5] FIG. 5 is a sectional view along line 5-5 in FIG. 2 (first embodiment).

[FIG. 6] FIG. 6 is a sectional view along line 6-6 in FIG. 2 (first embodiment).

[FIG. 7] FIG. 7 is a view from anowed line 7-7 in FIG. 2 (first embodilnent).

[FIG. 8] FIG. 8 is a view from the direction of arrow 8 in FIG. 7 (first embodiment).

EXPLANATION OF REFERENCE NUMERALS AND SYMBOLS

[0028]

11b	Dust collection chamber
11c	Drain passage
14	Variable valve operating mechanism
18	Actuator housing
18k	Cutout (oil passage)
18n	Dust collection chamber
18o	Oil jet (second oil supply hole)
18p	Projecting portion
18r	Oil jet (first oil supply hole)
18s	Constricted portion
21	Electric motor
22	Worm
23	Worm wheel
24	First ball bearing (bearing)
27	Worm shaft (drive shaft, one shaft)
27a	First journal (tubular portion)
29	Motor output shaft (other shaft)
30	Coupling
31	Oil reservoir
34	Second oil storage chamber (oil storage chamber)

BEST MODE FOR CARRYING OUT THE INVENTION

[0029] A mode for carrying out the present invention is explained below by reference to the attached drawings.

FIRST EMBODIMENT

[0030] FIG. 1 to FIG. 8 show a mode for carrying out the present invention.

[0031] As shown in FIG. 1, a cylinder head 11 of an in-line multi-cylinder engine has provided therein two intake valves 13 for opening and closing each of combustion chambers 12 formed in a lower face of the cylinder head 11, and the valve lift and/or valve timing of these intake

valves 13 are controlled by variable valve operating mechanisms 14 provided for each of the cylinders. Various structures are known for the variable valve operating mechanisms 14, and the variable valve operating mechanisms 14 employed by the invention of the present application may have any structure. A control shaft 15 is disposed on an upper face of the cylinder head 11 along the direction in which the plurality of variable valve operating mechanisms 14 are arranged, and operation of the variable valve operating mechanisms 14 is controlled by cams 15a provided on the control shaft 15 at predetermined intervals.

[0032] Provided on an upper face of one end part in the longitudinal direction of the cylinder head 11 is an actuator 16 for driving the control shaft 15. The actuator 16 includes an actuator housing 18 fixed to the upper face of the cylinder head 11 by four bolts 17, and one end part of the control shaft 15 is rotatably supported on a bearing part 19 provided in the vicinity of the actuator housing 18. Provided at an extremity of the control shaft 15 that projects from an end wall of the cylinder head 11 is a resolver 20 for detecting the rotational position thereof.

[0033] An electric motor 21 is supported on a side wall of the cylinder head 11 in a direction perpendicular to the control shaft 15 when viewed in a direction vertical to the plane of the paper, and a worm 22 provided on a motor output shaft 29 of the electric motor 21 meshing with a worm wheel 23 provided on the control shaft 15 rotatingly drives the control shaft 15 by virtue of the driving force of the electric motor 21.

[0034] The structure of the actuator 16 for driving the control shaft 15 is now explained in detail by reference to FIG. 2, FIG. 3, FIG. 7, and FIG. 8.

[0035] As is clear from FIG. 2, the upper face of the cylinder head 11 is inclined relative to the horizontal plane, and the actuator housing 18 is fixed by the four bolts 17 along the inclined direction. The actuator housing 18 is basically a cylindrical member; boss portions 18a to 18d for the four bolts 17 to extend through are formed in a lateral part thereof, and an opening 18e for a lower part of the worm wheel 23 to be fitted into is formed in an upper face thereof. One edge 18f of the opening 18e is formed in a linear shape, and the other edge 18g is formed in a V shape.

[0036] A step portion 18h having an enlarged inner diameter is formed on an inner peripheral face of the higher end of the actuator housing 18, and an outer race 24a of a first ball bearing 24 and a connecting tubular portion 21a of a casing of the electric motor 21 are fitted into the step portion 18h. A step portion 18i having an enlarged inner diameter and a female threaded portion 18j are formed on an inner peripheral face of the lower end of the actuator housing 18, and an outer race 25a of a second ball bearing 25 fitted into the step portion 18i is fixed by a lock nut 26 screwed into the female threaded portion 18j.

[0037] With regard to a worm shaft 27 disposed in the interior of the actuator housing 18, a first journal 27a at one end thereof is press-fitted into an inner race 24c relatively rotatably supported on the outer race 24a of the first ball bearing 24 via a plurality of balls 24b. Furthermore, with regard to the worm shaft 27, a second journal 27b at the other end thereof is fitted into an inner race 25c relatively rotatably supported on the outer race 25a of the second ball bearing 25 via a plurality of balls 25b, and fixed by a lock nut 28.

[0038] An extremity part of the motor output shaft 29, which extends in the interior of the connecting tubular portion 21a of the casing of the electric motor 21, has an interlocking portion 29a having six peaks and six valleys that alternate in the circumferential direction, and this interlocking portion 29a engages with an interlocking portion 27c, formed on the inner periphery of the first journal 27a of the worm shaft 27, having six peaks and six valleys that alternate in the circumferential direction (see FIG. 4). The interlocking portion 29a of the motor output shaft 29 of the electric motor 21 and the interlocking portion 27c of the worm shaft 27, which form a coupling 30, engage in a splined manner and transmit rotation, a slight gap is formed between contacting faces thereof, and rotation is transmitted while thereby absorbing displacement in the radial direction between the axis of the motor output shaft 29 and the axis of the worm shaft 27.

[0039] A large-diameter portion 27d is formed on the inside in the axial direction of the first journal 27a of the worm shaft 27, and the inner peripheral face of the actuator housing 18 opposes the outer periphery of the large-diameter portion 27d across a slight gap a (see FIG. 2, FIG. 3, and FIG. 5). Furthermore, a crescent-shaped cutout 18k (see FIG. 2 and FIG. 5), through which oil can pass, is formed in an inner peripheral face of the actuator housing 18 opposing an upper part of the large-diameter portion 27d. Moreover, a large-diameter portion 27e is formed on the inside in the axial direction of the second journal 27b of the worm shaft 27, and the inner peripheral face of the of the actuator housing 18 opposes the outer periphery of the large-diameter portion 27e across a slight gap β (see FIG. 2 and FIG. 3).

[0040] The worm wheel 23 provided at the shaft end of the control shaft 15 meshes with the worm 22 formed in a middle part of the worm shaft 27 via the opening 18e of the actuator housing 18.

[0041] As is clear from FIG. 2 and FIG. 7, an oil supply groove 18m and a dust collection chamber 18n open on the lower face of the actuator housing 18, and the oil supply groove 18m communicates with an oil pump, which is not illustrated, via an oil supply passage 11a formed in the cylinder head 11. An oil jet 18o is formed in an end part, distant from the oil supply passage 11a, of the oil supply groove 18m, and this oil jet 18o communicates, in the interior of the actuator housing 18, with an annular oil reservoir 31 defined by the actuator housing 18, the outer race 24a and balls 24b of the first ball bearing 24, and the large-diameter portion 27d of the worm shaft 27. The cutout 18k opens at the highest position of

the upper part of the oil reservoir.

[0042] As is clear from FIG. 3 and FIG. 6, a projecting portion 18p is formed from the linear edge 18f defining the opening 18e of the actuator housing 18 along the inner face of the actuator housing 18. This projecting portion 18p opposes the outer peripheral face of the worm 22 and one side face of the worm wheel 23 across a slight gap γ so as to oppose a meshed part of the worm 22 and the worm wheel 23. In particular, a bottom wall of the actuator housing 18 is formed so as to have an arc-shaped cross section along the outer peripheral face of the worm 22, thereby making the outer peripheral face of the worm 22 be surrounded by the gap γ throughout a range of 180° or greater.

[0043] An oil jet 18r directed to an upper part of the meshed part of the worm 22 and the worm wheel 23 is formed at the upper end of an oil guide groove 18q branching upward from the oil supply groove 18m of the actuator housing 18 opposing the oil supply passage 11 a of the cylinder head 11. A width W2 in the axial direction of the projecting portion 18p of the actuator housing 18 is set larger than a width W1 in the in the axial direction of the meshed part of the worm 22 and the worm wheel 23.

[0044] A small-diameter constricted portion 18s is formed on the lowest side of the bottom wall of the actuator housing 18, and this constricted portion 18s communicates with the dust collection chamber 18n. A dust collection chamber 11b is formed in the upper face of the cylinder head 11 so as to be connected integrally to the dust collection chamber 18n. A drain passage 11c extending from a side wall on the lower side of the dust collection chamber 11b communicates with the internal space of the cylinder head 11 via an oil filter 32.

[0045] The operation of the embodiment of the present invention having the above-mentioned arrangement is now explained.

[0046] When the electric motor 21 is driven and the motor output shaft 29 rotates, the rotation is reduced in speed and transmitted to the worm wheel 23 from the worm 22 formed on the worm shaft 27 connected to the motor output shaft 29 via the coupling 30, the control shaft 15 rotates, and the variable valve operating mechanisms 14 operate, thus changing valve lift and valve timing of the intake valves 13.

[0047] In this process, since the coupling 30 connecting the motor output shaft 29 of the electric motor 21 to the worm shaft 27 is formed by relatively non-rotatably fitting, via the interlocking portions 27c and 29a, the outer periphery of the motor output shaft 29 into the inner periphery of the tubular first journal 27a formed integrally with the worm shaft 27, and the outer periphery of the tubular first journal 27a is rotatably supported on the inner periphery of the actuator housing 18 via the first ball bearing 24, both the motor output shaft 29 and the worm shaft 27 can be simultaneously supported by the single first ball bearing 24 at the position of the coupling 30, thus suppressing effectively vibration and wear of the connected part.

[0048] Moreover, since the tubular first journal 27a is formed integrally with the worm shaft 27, not only is it possible to reduce the number of components and the size of the coupling 30, but it is also possible to reliably suppress run-out, in the radial direction, of the motor output shaft 29 and the worm shaft 27 by the single first ball bearing 24 because at least part of the motor output shaft 29 overlaps the first ball bearing 24 when viewed from a direction perpendicular to the axis.

[0049] Oil that is supplied from the oil pump, which is not illustrated, to the oil supply groove 18m of the lower face of the actuator housing 18 via the oil supply passage 11a of the cylinder head 11 is ejected into the oil reservoir 31 of the actuator housing 18 via the oil jet 18o communicating with the oil supply groove 18m, thus lubricating the first ball bearing 24 facing the oil reservoir 31. Oil that has lubricated the first ball bearing 24 flows into a first oil storage chamber 33 and lubricates the coupling 30 disposed therein, and surplus oil passes through the cutout 18k (see FIG. 2 and FIG. 5) formed in the upper part of the actuator housing 18 and flows into a second oil storage chamber 34. Oil that has passed from the oil reservoir 31 through the gap α of the outer periphery of the large-diameter portion 27d of the worm shaft 27 also flows into the second oil storage chamber 34, and lubricates the meshed part of the worm 22 and the worm wheel 23.

[0050] In this arrangement, since the worm 22 and the worm wheel 23 mesh with each other in the interior of the second oil storage chamber 34 formed in the actuator housing 18 rotatably supporting the worm shaft 27 via the first ball bearing 24, and the oil jet 18o supplying oil indirectly to the second oil storage chamber 34 opens in the part of the actuator housing 18 where the first ball bearing 24 is mounted, even though part of the first ball bearing 24 is disposed at a position higher than an oil level L (see FIG. 3) of the actuator housing 18, not only is it possible to reliably lubricate the first ball bearing 24, but it is also possible to supply clean oil that is little contaminated with abraded powder to the first ball bearing 24, thus enhancing the durability.

[0051] Moreover, since the annular oil reservoir 31, which surrounds the outer periphery of the worm shaft 27, is defined by the worm shaft 27, the first ball bearing 24, and the actuator housing 18, the oil jet 18o is made to open in the lower part of the oil reservoir 31, and the cutout 18k is formed in the portion opposing the upper part of the oil reservoir 31, it is possible to retain in the oil reservoir 31 oil that has been supplied from the oil jet 18o to thus reliably lubricate the first ball bearing 24, and then supply surplus oil from the first oil storage chamber 33 to the second oil storage chamber 34 via the cutout 18k.

[0052] Furthermore, oil flows in the interior of the second oil storage chamber 34 from the first ball bearing 24 side, which is at a high position, to the second ball bearing 25 side, which is at a low position, and as is clear from FIG. 6 since the narrow gap γ is formed around the

meshed part of the worm 22 and the worm wheel 23 by the projection 18p of the actuator housing 18, it is possible to reliably make oil that passes through the gap act on the meshed part, thus enhancing the lubrication effect. Moreover, since oil that has been supplied to the oil supply groove 18m of the lower face of the actuator housing 18 issues from the oil guide groove 18q toward the upper part of the meshed part of the worm 22 and the worm wheel 23 via the oil jet 18r, it is possible to further enhance the effect of lubrication of the meshed part by the oil.

[0053] In particular, since the opening of the oil jet 18r is formed at a position where it overlaps the worm 22 when viewed from above (see FIG. 6), and the meshed part of the worm 22 and the worm wheel 23 is provided within the width, in the axial direction, of the inner peripheral face of the projecting portion 18p opposing the outer periphery of the worm 22 (see FIG. 3), oil that has been discharged from the oil jet 18r flows down under gravity and is retained by the projecting portion 18p of the actuator housing 18 opposing the outer periphery of the worm 22, and it is possible to make the oil act sufficiently on the meshed part of the worm 22 and the worm wheel 23, thus enhancing the lubrication effect.

[0054] Part of the oil that has lubricated the meshed part of the worm 22 and the worm wheel 23 passes through the gap β on the outer periphery of the large-diameter portion 27e of the worm shaft 27, lubricates the second ball bearing 25, and is then returned from the upper face of the cylinder head 11 to an oil pan, which is not illustrated, by gravity. Furthermore, another part of the oil that has lubricated the meshed part flows into the dust collection chambers 18n and 11b from the constricted portion 18s provided at the lowest position of the second oil storage chamber 34, and foreign matter such as abraded powder contained in the oil is collected in the dust collection chambers 18n and 11b. When oil of the dust collection chambers 18n and 11b passes through the oil filter 32 provided in the drain passage 11c and is discharged, abraded powder contained in the oil is filtered by the filter 32. Oil that has been filtered and flowed out from the oil filter 32 is returned to the oil pan from the upper face of the cylinder head 11.

[0055] Since abraded powder contained in the oil is collected by the dust collection chambers 18n and 11b in this way, it is possible to suppress wear of the meshed part of the worm 22 and the worm wheel 23 due to the abraded powder biting in, thus enhancing the durability thereof. In this arrangement, since the constricted portion 18s is provided between the second oil storage chamber 34 and the dust collection chambers 18n and 11b, it is possible to regulate the flow rate of the oil by means of the constricted portion 18s and store a sufficient amount of oil in the second oil storage chamber 34 and, moreover, since the constricted portion 18s is formed so as to have a smaller diameter than that of the cross sectional area of the dust collection chambers 18n and 11b, once abraded powder has been collected by the dust collection chambers 18n and 11b, it will not return to the second oil storage chamber 34 by passing through the constricted portion 18s.

[0056] Furthermore, since the amount of oil that is discharged from the dust collection chambers 18n and 11b via the drain passage 11c is set smaller than the final amount of oil supplied to the second oil storage chamber 34 from the oil jets 18o and 18r, it is possible for a sufficient amount of oil to always be stored in the second oil storage chamber 34, thus reliably lubricating the meshed part of the worm 22 and the worm wheel 23.

[0057] A mode for carrying out the present invention is explained above, but the present invention may be modified in a variety of ways as long as the modifications do not depart from the spirit and scope thereof.

[0058] For example, in the embodiment the projecting portion 18p is formed on one inner wall face of the second oil storage chamber 34, but projecting portions 18p and 18p may be formed on both inner wall faces.

[0059] Furthermore, the bearing of the present invention is not limited to the ball bearing 24 of the embodiment, and any bearing such as a roller bearing, a needle bearing, or a plain bearing may be used.

[0060] Moreover, in the embodiment, among the worm shaft 27 and the motor output shaft 29, which are connected via the coupling 30, the worm shaft 27 is supported on the actuator housing 18 via the first ball bearing 24, but the connecting relationship between the worm shaft 27 and the motor output shaft 29 may be reversed in terms of which is inside and which is outside, and the motor output shaft 29 may be supported on the actuator housing 18 via the first ball bearing 24.

[0061] Furthermore, in the embodiment oil is supplied to the second oil storage chamber 34 via the two oil jets 18o and 18r, but the oil supply hole of the present invention is not necessarily an oil jet, and the number thereof is not necessarily two.

Claims

1. An actuator for a variable valve operating mechanism in which a worm shaft (27) is connected to a motor output shaft (29) of an electric motor (21), a worm wheel (23) is meshed with a worm (22) provided on the worm shaft (27), and rotation of the motor output shaft (29) is reduced in speed by the worm (22) and the worm wheel (23) to thus operate the variable valve operating mechanism (14), thereby changing at least one of valve lift and valve timing of an internal combustion engine,
wherein the worm (22) and the worm wheel (23) mesh with each other in an interior of an oil storage chamber (34) formed in an actuator housing (18) rotatably supporting the worm shaft (27), a projecting portion (18p) is formed on an inner wall face of the oil storage chamber (34), the projecting portion (18p) projecting so as to surround an outer periphery of the worm (22), a first oil supply hole (18r) opens on

an inner peripheral face of the projecting portion (18p) that opposes the outer periphery of the worm (22), and an opening of the first oil supply hole (18r) is formed at a position where the opening overlaps the worm (22) when viewed from above.

2. The actuator for a variable valve operating mechanism according to Claim 1, wherein a meshed part of the worm (22) and the worm wheel (23) is present within the width, in the axial direction, of the inner peripheral face of the projecting portion (18p) opposing the outer periphery of the worm (22).

3. An actuator for a variable valve operating mechanism in which a worm shaft (27) is connected to a motor output shaft (29) of an electric motor (21), a worm wheel (23) is meshed with a worm (22) provided on the worm shaft (27), and rotation of the motor output shaft (27) is reduced in speed by the worm (22) and the worm wheel (23) to thus operate the variable valve operating mechanism (14), thereby changing at least one of valve lift and valve timing of an internal combustion engine,
wherein the worm (22) and the worm wheel (23) are meshed with each other in an interior of an oil storage chamber (34) formed in an actuator housing (18) rotatably supporting the worm shaft (27) via a bearing (24), and a second oil supply hole (18o) for supplying oil to the oil storage chamber (34) opens in a part of the actuator housing (18) where the bearing (24) is mounted.

4. The actuator for a variable valve operating mechanism according to Claim 3, wherein an annular oil reservoir (31) surrounding the outer periphery of the worm shaft (27) is defined by the worm shaft (27), the bearing (24), and the housing (18), the second oil supply hole (18o) opens in a lower part of the oil reservoir (31), and an oil passage (18k) supplying oil of the oil reservoir (31) to the oil storage chamber (34) is formed in a portion of the actuator housing (18) that opposes an upper part of the oil reservoir (31).

5. The actuator for a variable valve operating mechanism according to any one of Claim 1 to Claim 4, wherein the worm shaft (27) is coaxially connected to the motor output shaft (29) of the electric motor (21) via a coupling (30),
the coupling (30) being formed by relatively non-rotatably fitting, into an inner periphery of a tubular portion (27a) of one shaft (27) among the motor output shaft (29) and the worm shaft (27), an outer periphery of the other shaft (29), and an outer periphery of the tubular portion (27a) being rotatably supported on the actuator housing (18) via the bearing (24).

6. The actuator for a variable valve operating mechanism according to Claim 5, wherein the tubular portion (27a) is integrally formed with said one shaft (27).

7. The actuator for a variable valve operating mechanism according to Claim 6, wherein at least part of said other shaft (29) overlaps the bearing (24) when viewed from a direction perpendicular to the axis.

8. The actuator for a variable valve operating mechanism according to any one of Claim 1 to Claim 4, wherein the oil storage chamber (34) is disposed in an inclined manner so that an end part, on the electric motor (21) side, of the worm shaft (27) is high, and a dust collection chamber (11b, 18n) communicating with the oil storage chamber (34) is formed in an end part of the oil storage chamber (34) on the side that is low.

9. The actuator for a variable valve operating mechanism according to Claim 8, wherein the actuator comprises a drain passage (11c) for discharging oil from the dust collection chamber (11b, 18n), and the amount of oil discharged from the drain passage (11c) is set smaller than the amount of oil supplied to the oil storage chamber (34).

10. The actuator for a variable valve operating mechanism according to Claim 8 or Claim 9, wherein the dust collection chamber (11b, 18n) and the oil storage chamber (34) communicate with each other via a constricted portion (18s).

FIG.1

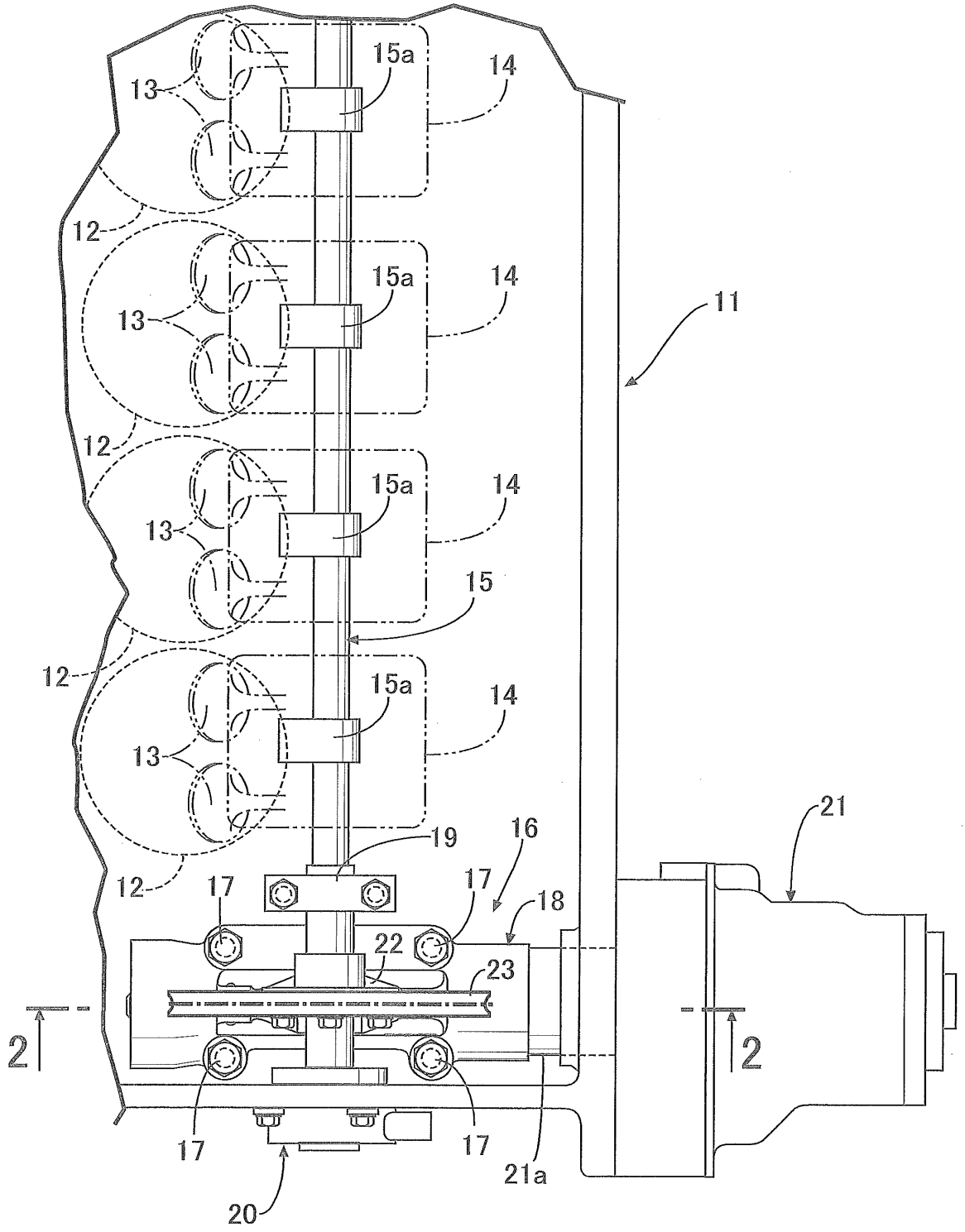
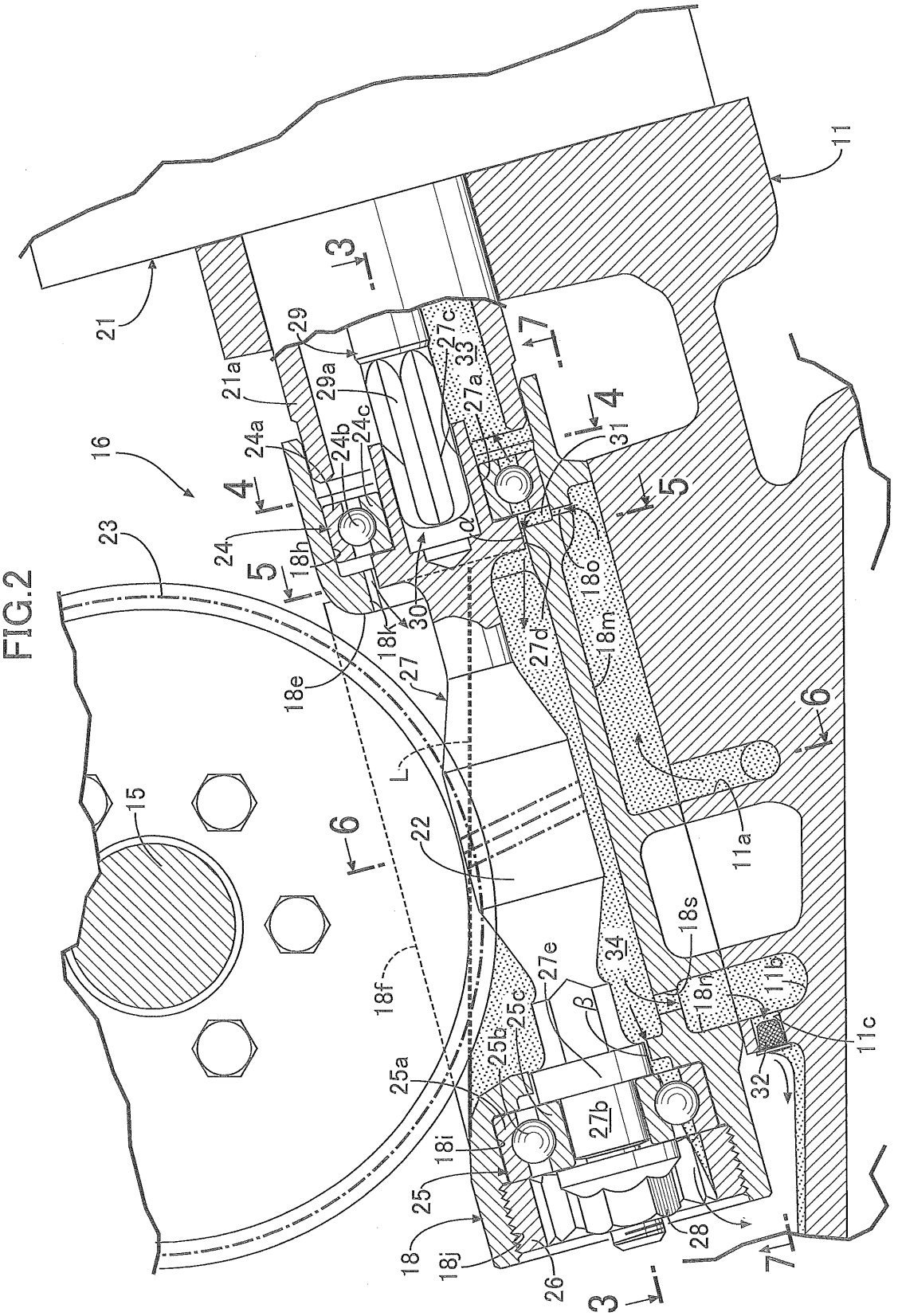


FIG.2


11
21
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27c
33
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29a
27a
7
4
24a
24b
24c
31
16
4
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24
5
18h
18o
18k
30
27
27d
18m
18e
L
6
15
6
22
11a
18s
34
18f
27e
β
18n
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27b
18i
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18j
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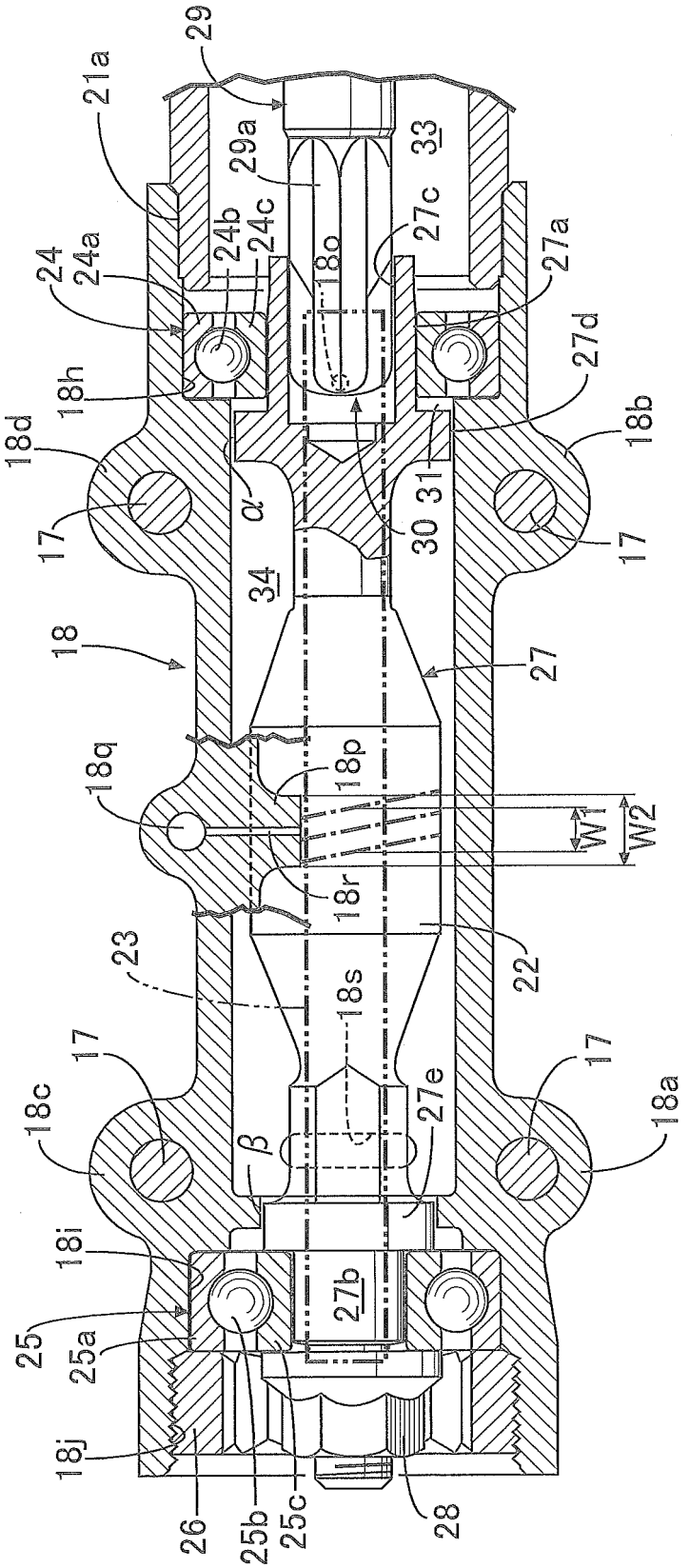
7
3

FIG.3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24a
24b
24c
18o
27c
27a
18h
27d
18d
18b
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30
31
17
34
18
27
18q
18p
W1
W2
18r
23
22
18s
17
17
18c
β
27e
18a
18i
27b
25
25a
18j
26
25b
25c
28

FIG.4

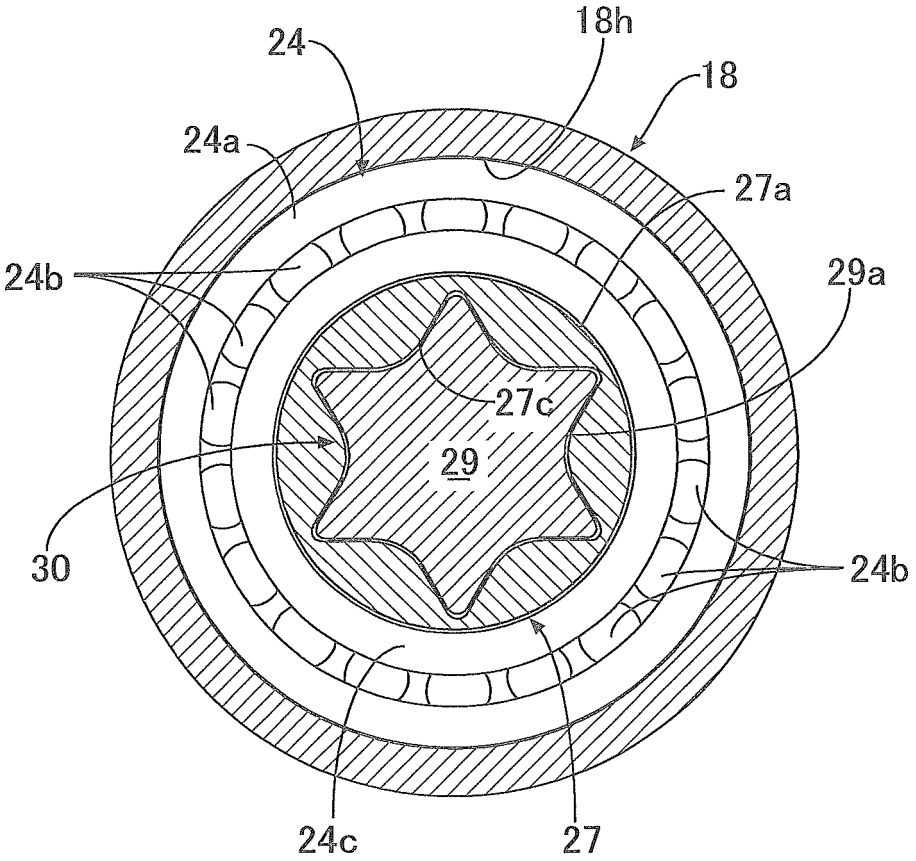


FIG.5

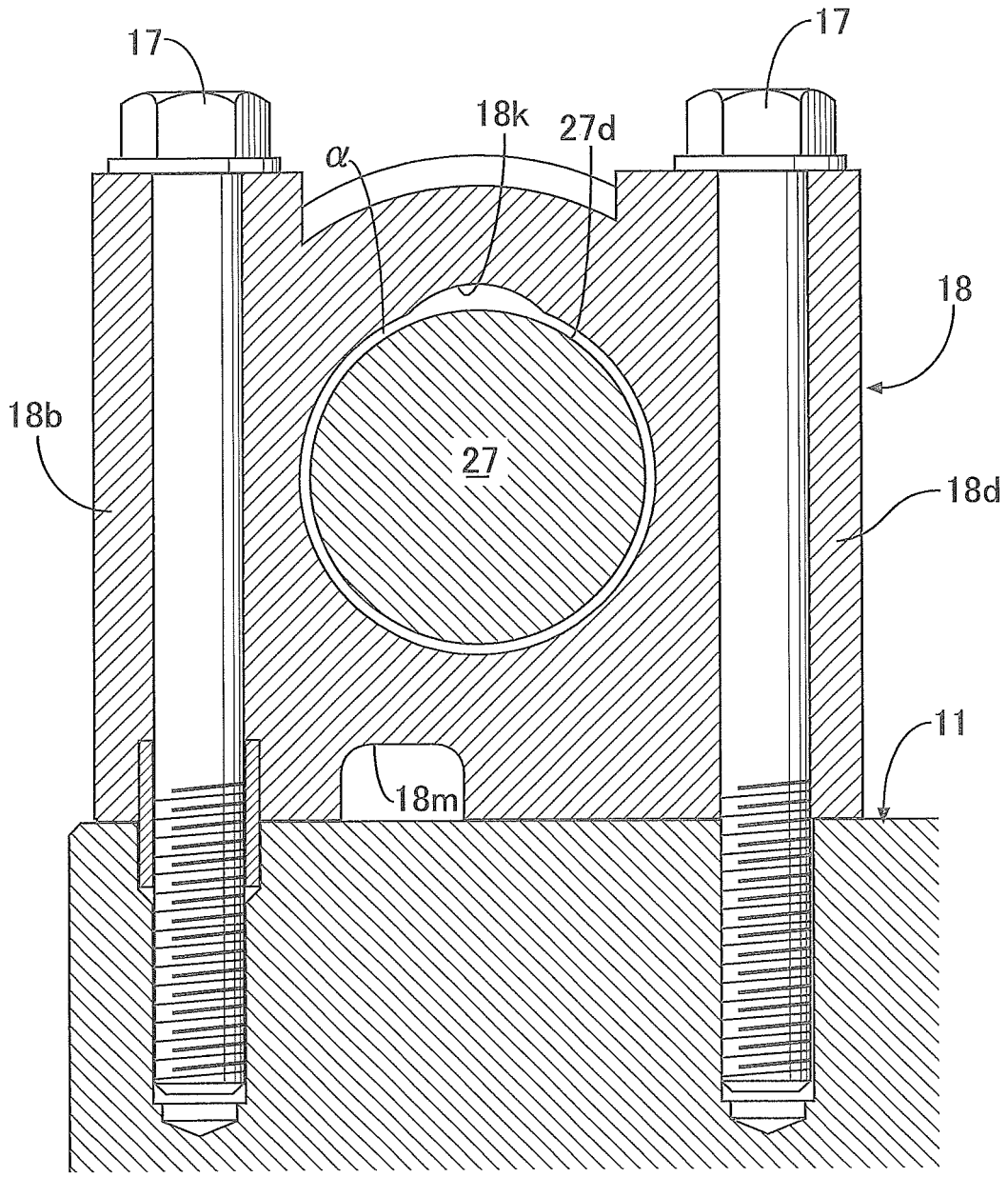


FIG.6

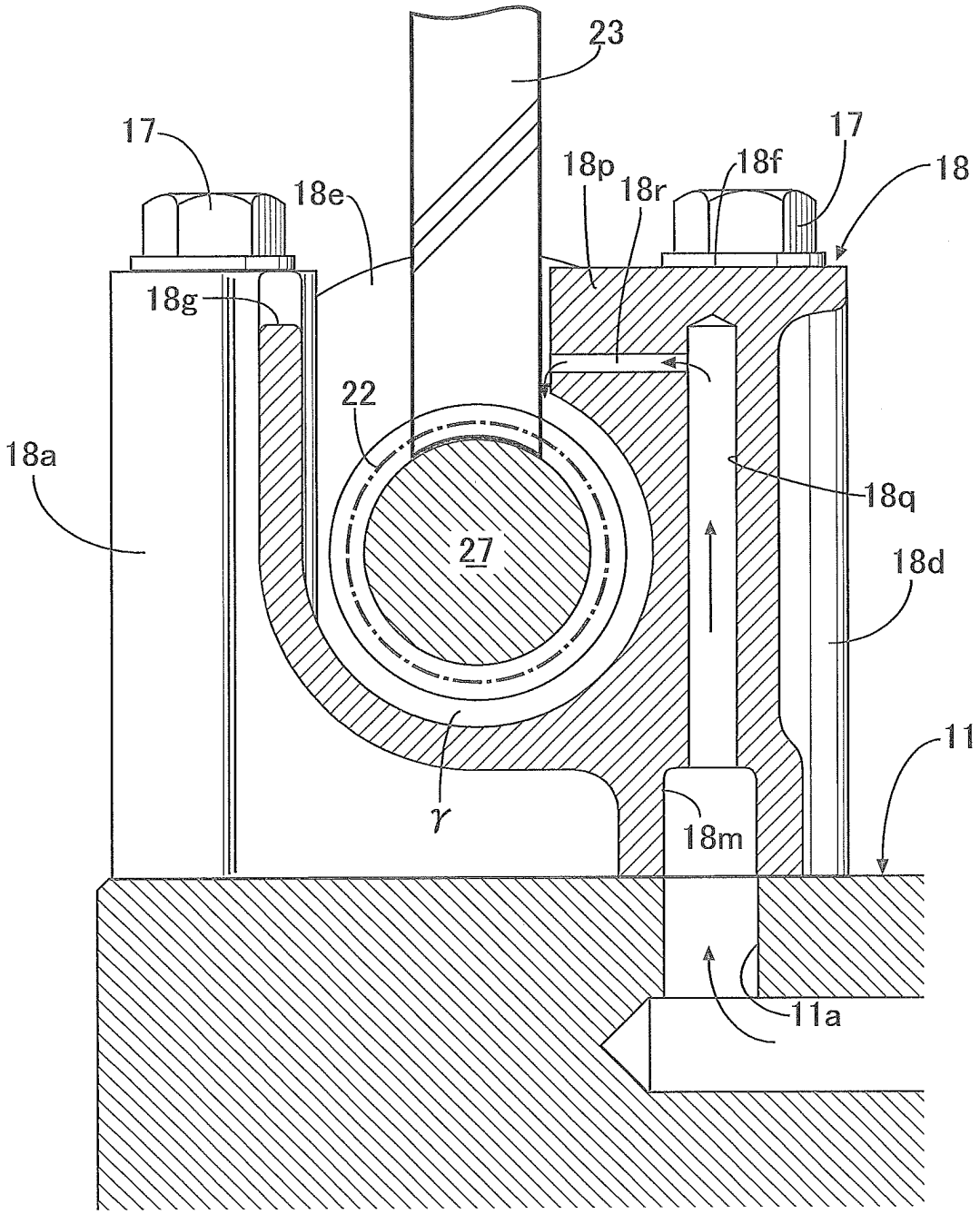


FIG.7

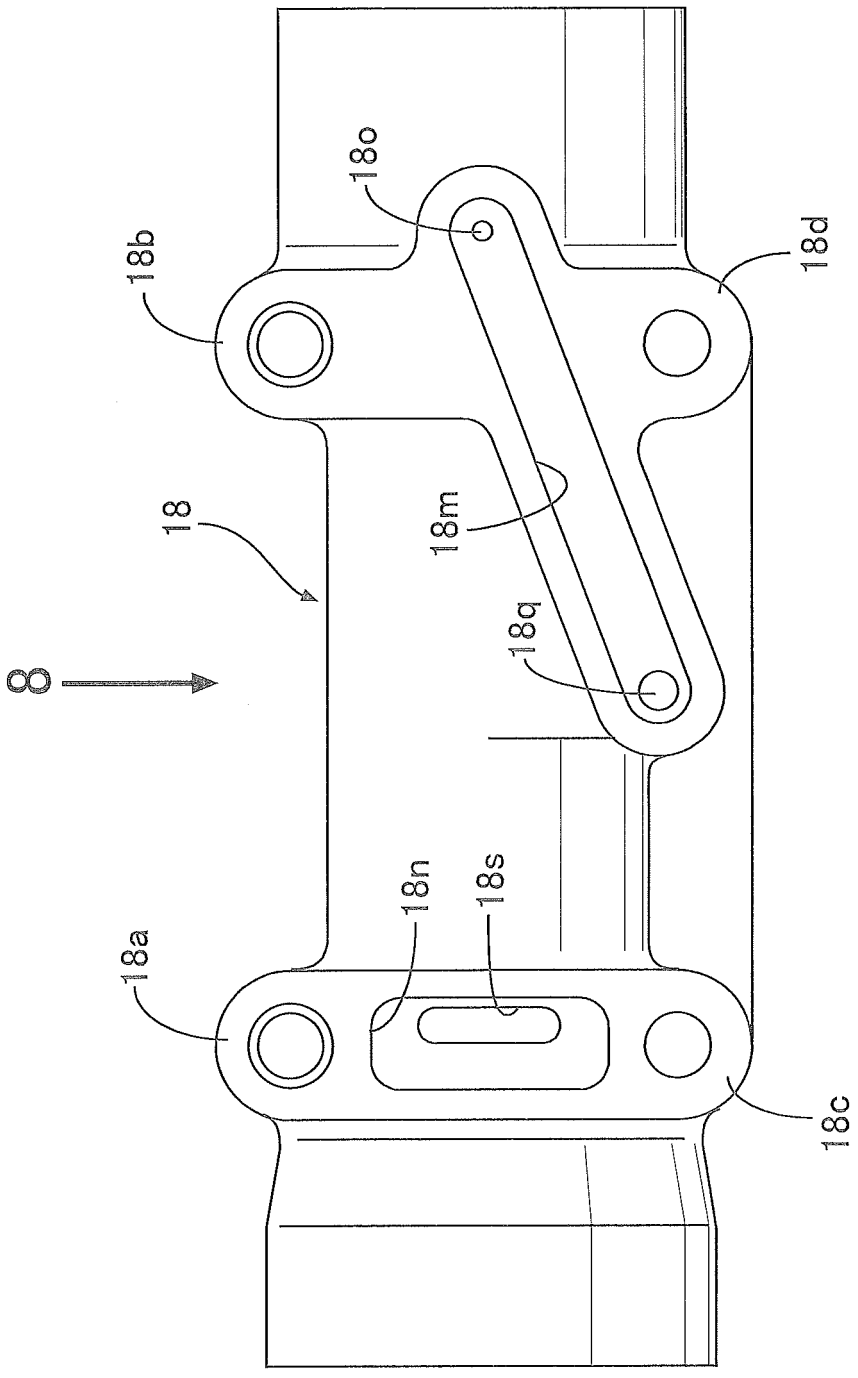
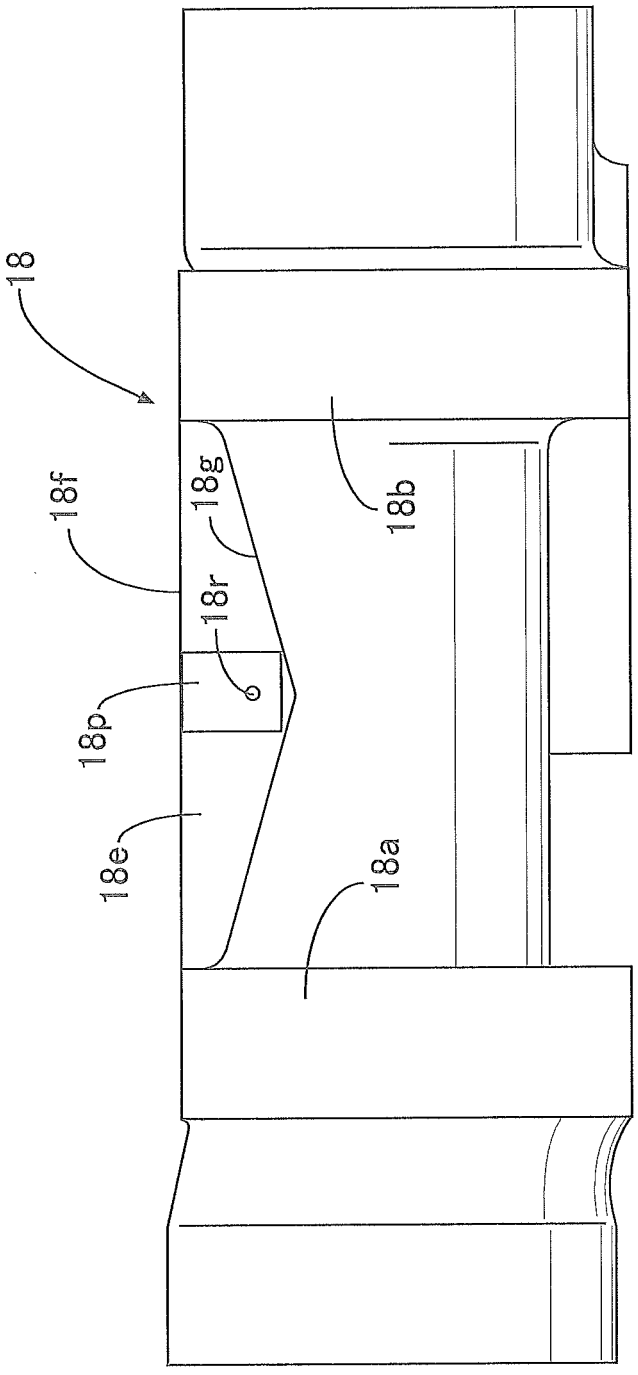


FIG.8



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/051101

A. CLASSIFICATION OF SUBJECT MATTER
F01L13/00(2006.01)i, *F01L1/34*(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)
F01L13/00, F01L1/34

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2009
Kokai Jitsuyo Shinan Koho	1971-2009	Toroku Jitsuyo Shinan Koho	1994-2009

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 2000-234507 A (Unisia Jecs Corp., Nissan Motor Co., Ltd.), 29 August, 2000 (29.08.00), Full text; all drawings (Family: none)	1-10
A	JP 2006-144551 A (Hitachi, Ltd.), 08 June, 2006 (08.06.06), Full text; all drawings (Family: none)	1-10
A	JP 2008-14290 A (Toyota Motor Corp.), 24 January, 2008 (24.01.08), Full text; all drawings (Family: none)	1-10

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 February, 2009 (10.02.09)	24 February, 2009 (24.02.09)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

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Patent documents cited in the description

- JP 2006144551 A **[0002]**