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(54) Valve timing controller of an internal combustion engine

(57) Valve timing controller of an engine comprising internal and external rotors (26,28), being rotatable relative to each other, and at least one hydraulic chamber (43), which is arranged between the rotors and is divided into a timing-advance-side hydraulic chamber (44) and a timing-retard-side hydraulic chamber (45), wherein a timing-advance path (48) of a timing-advance-side oil path communicating with the timing-advance-side hydraulic chamber and a timing-retard path (49) of a timing-retard-side oil path communicating with the timing-retard-side hydraulic chamber are respectively provided on both sides relative to a layout position of the internal rotor and the external rotor.

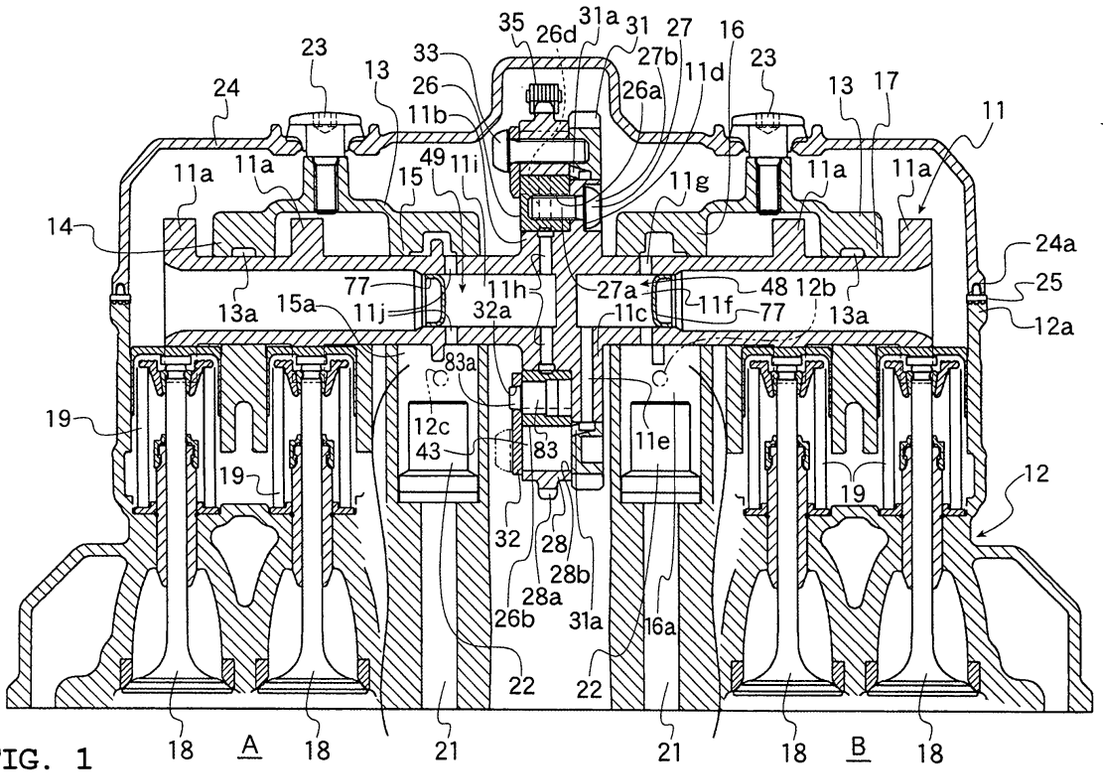

FIG. 1

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Description

[0001] This invention relates to a valve timing controller for engine for controlling timing to open/close intake and exhaust valves and to an engine.

[0002] One of the conventional type valve timing controllers is described in JP-A-H11-022426. This document discloses a valve timing controller with the following structure.

[0003] To be more specific, a camshaft is rotatably supported by a cylinder head in an internal combustion chamber. An internal rotor is provided at a tip end of the camshaft. Rotation transmitting members are also provided, including an external rotor, fitted on the outside of the internal rotor with the camshaft for relative rotation within a given range; a front plate; a cap; a rear plate and a timing pulley. Six vanes attached to the internal rotor and a lock mechanism attached to the external rotor also constitute the valve opening/closing timing controller.

[0004] It is known that the timing pulley receives rotational power transmitted from a crank pulley through a resin or rubber timing belt in a given direction.

[0005] The camshaft has well-known cams for opening/closing intake valves. Inside of the camshaft, a timing-advance path and a timing-retard path are provided, which extend in the axial direction of the camshaft. These paths are connected to their respective connection ports of a directional control valve. The directional control valve allows a spool to move against urging force of a spring by energizing a solenoid. When the solenoid is not energized, an oil delivery port connected to an oil pump driven by the internal combustion chamber is communicated with one of the connection ports while the other connection port is communicated with an oil drain port. In contrast to the above, when the solenoid is energized, moving the spool allows the oil delivery port to be communicated with the aforementioned other connection port, while allowing the aforementioned one connection port to be communicated with the oil drain port.

[0006] When the solenoid is not energized, operating oil, or lubricant oil in the internal combustion chamber, is delivered to the timing-retard path and then to a timing-retard oil chamber partitioned by each vane. When the solenoid is energized, the operating oil is delivered to the timing-advance path and then to a timing-advance oil chamber.

[0007] Thus, the internal rotor and the external rotor relatively rotate by a given angle between when the solenoid is energized and when the solenoid is not energized, thereby changing the phases of the crankshaft and the camshaft to control the opening/closing timing of the intake valves.

[0008] However, in such a conventional type valve timing controller, the internal rotor and the external rotor are provided at the end of the camshaft on which the timing-advance path and the timing-retard path extending in the axial direction are formed approximately parallel and adjacent to each other. These paths extend from a common journal toward the directional control valve so that it requires high accuracy in forming the timing-advance path and the timing-retard path approximately parallel and adjacent to each other, causing high production costs. Also, in some motorcycle engines, a head bolt could be positioned on the journal due to a problem with limited space. In this situation, it is difficult to form a pair of the timing-advance path and the timing-retard path and also undesirable in terms of securing strength.

[0009] The object of the present invention is to provide a valve timing controller for engine which facilitates forming of the oil paths on the camshaft as well as on the journal while securing strength for the journal with the head bolt.

[0010] This objective is solved in an inventive manner in that there is provided a valve timing controller of an engine comprising internal and external rotors, being rotatable relative to each other, and at least one hydraulic chamber, which is arranged between the rotors and is divided into a timing-advance-side hydraulic chamber and a timing-retard-side hydraulic chamber, wherein a timing-advance path of a timing-advance-side oil path communicating with the timing-advance-side hydraulic chamber and a timing-retard path of a timing-retard-side oil path communicating with the timing-retard-side hydraulic chamber are respectively provided on both sides relative to a layout position of the internal rotor and the external rotor.

[0011] According to a preferred embodiment, the timing-advance path of the timing-advance-side oil path and the timing-retard path of the timing-retard-side oil path are separately provided in and respectively extending along an axial direction of a camshaft.

[0012] Preferably, the internal rotor is provided on the camshaft and the external rotor is rotatably provided around the internal rotor, wherein lubricant delivered to the hydraulic chamber between the internal rotor and the external rotor allows the internal rotor and the external rotor to relatively rotate in a circumferential direction about the camshaft, wherein the external rotor is connected to the crankshaft side via a power transmission means, and wherein the relative rotation of the internal rotor and the external rotor allows controlling the opening/closing timing of intake valves and/or exhaust valves.

[0013] Further preferably, the internal rotor is provided on the camshaft either on the intake valve side or the exhaust valve side.

[0014] Still further preferably, the timing-advance-side hydraulic chamber and the timing-retard-side hydraulic chamber of the hydraulic chamber are separated by a vane.

[0015] Beneficially, when a pair of left and right paths, used as the timing-advance path and the timing-retard path, have different longitudinal dimensions, the shorter

one of them is used as the timing-advance path.

[0016] Furthermore, a stopper pin might be provided to lock/unlock the relative rotation of the internal rotor and the external rotor.

[0017] Still further preferably, the stopper pin is adapted to move under a hydraulic pressure in the timing-advance-side oil path, and is adapted to unlock the relative rotation under the hydraulic pressure in the timing-advance-side oil path.

[0018] According to another preferred embodiment, lubricant, in particular oil, is delivered to the journal of the camshaft, which is adjacent to the layout position of the internal rotor and the external rotor, and the lubricant, is delivered from this journal adjacent to the layout position to the timing-advance-side oil path or the timing-retard-side oil path in the camshaft.

[0019] Therein, the lubricant might be delivered from a cylinder head side to the journal of the camshaft, which is adjacent to the layout position of the internal rotor and the external rotor, and another journal of the camshaft, except the journal adjacent to the above layout position, might be lubricated from a cam cap side.

[0020] Furthermore, a drain opening connected to at least one of the timing-advance-side oil path and the timing-retard-side oil path, or a midsection positioned on the opposite side of the hydraulic chamber relative to the journal could be arranged higher than a bottom edge of the camshaft at the journal so as to prevent oil in the journal from completely flowing out.

[0021] Moreover, a hydraulic pressure lower than that in the oil delivery side might be applied to the journal in the path, set as the oil-drain-side, of the timing-advance-side oil path and the timing-retard-side oil path.

[0022] According to still another embodiment, the internal rotor and the external rotor are arranged between plural cylinders or are arranged outward of plural cylinders.

[0023] According to yet another embodiment, there are provided an intake-side gear member and a shield plate, wherein the external rotor, the intake-side gear member and the shield plate are integrally arranged for relative rotation about the internal rotor by a predetermined angle.

[0024] The above objective is also solved by an engine having a valve timing controller as specified above.

[0025] In the following, the present invention is explained in greater detail with respect to several embodiments thereof in conjunction with the accompanying drawings, wherein:

FIG. 1 is a vertical sectional view on a cylinder head side of a valve timing controller according to a first embodiment;

FIG. 2 is a cross sectional view on the cylinder head side of the valve timing controller according to the first embodiment;

FIG. 3 illustrates a timing chain and the like according to the first embodiment;

FIG. 4 is a sectional view showing internal and external rotors according to the first embodiment;

FIG. 5 is a sectional view showing an oil delivery structure to journals according to the first embodiment;

FIG. 6 is a sectional view showing a spool and the like according to the first embodiment;

FIG. 7 is a counterpart of FIG. 1, according to a second embodiment;

FIG. 8 is a counterpart of FIG. 1, according to a third embodiment;

FIG. 9 is a counterpart of FIG. 8, showing the exhaust side, according to the third embodiment;

FIG. 10 is a counterpart of FIG. 3, viewed from the side, according to the third embodiment;

FIG. 11 is a sectional view showing a spool and the like according to a fourth embodiment; and

FIG. 12 is a sectional view showing a spool and the like according to the fourth embodiment.

Description of the embodiments of the present invention is as follows.

FIGs. 1 through 6 show a first embodiment.

[0026] A configuration is first described. An engine of the first embodiment, which is mounted to a motorcycle, a saddle-type vehicle, is a four-valve two-cylinder four-stroke engine. This engine, provided with a valve timing controller, is disposed with its crankshaft (not shown) arranged along a vehicle width direction.

[0027] To be more specific, FIG. 1 is a sectional view showing an upper side of the engine (intake side of a cylinder head), in which a reference numeral 11 denotes an intake-side camshaft, which is provided along the vehicle width direction. Cam caps 13 are secured to a cylinder head 12 with bolts 20 shown in FIG. 5 so that the camshaft 11 is rotatably supported by journals 14, 15, 16, 17 which are formed on the cam caps as shown in FIG. 1. The camshaft 11 has plural cams 11 a formed to push each of four intake valves 18 down against urging force of springs 19 in order to open their respective intake ports at a predetermined timing.

[0028] The cylinder head 12 is secured to a cylinder block (not shown) with stud bolts 21 and nuts 22 provided for the adjacent journals 15, 16 while a head cover 24 is attached to the cam caps 13 through screws 23.

A periphery 24a of the head cover 24 and an upper periphery 12a of the cylinder head 12 are sealed via a gasket 25.

[0029] The camshaft 11 has a valve timing controller disposed between two cylinders A, B.

[0030] More specifically, the camshaft 11 has a boss 11 b formed at its approximately middle section in the vehicle width direction, and a flange 11c with a predetermined diameter, formed on the right of the boss 11b in FIG. 1.

[0031] A ring-shaped inner rotor 26 of the valve timing controller is fitted onto the outside of the boss 11b of the camshaft 11 while the inner rotor 26 is mounted to the flange 11c with three mounting bolts 27 inserted parallel to the axial direction of the camshaft 11. These mounting bolts 27 are inserted from the flange 11 c side with a male thread 27a engaged with a female thread 26a of the inner rotor 26 and with a head 27a fitted into a recess 11d of the flange 11c.

[0032] An approximately ring-shaped external rotor 28 is fitted on the outside of the internal rotor 26 for relative rotation about the camshaft 11. An intake-side gear member 31 and a shield plate 32 are secured to the external rotor 28 on its right side and left side in FIG. 1, respectively, with a common bolt 33. Both side surfaces of the internal rotor 26 are slidably sandwiched between the intake-side gear member 31 and the shield plate 32. The external rotor 28, the intake-side gear member 31 and the shield plate 32 are integrally arranged for relative rotation about the internal rotor 26 by a predetermined angle.

[0033] A sprocket 28a is formed around the external rotor 28. As shown in FIG. 3, a timing chain 35 is installed on the sprocket 28a and a crank sprocket 34 provided on the crankshaft side. The timing chain 35 has a fixed chain guide 37 provided on one side, and a movable chain guide 38 provided on the other side. The movable chain guide 38 is moved by a chain tensioner 39 to adjust its tension to a predetermined value.

[0034] The intake-side gear member 31 engages with the exhaust-side gear member 41 as shown in FIGs. 2 and 3. An exhaust-side camshaft 91 rotates in synchronization with rotation of the exhaust-side gear member 41. The exhaust-side camshaft 91 has cams 91 a for opening and closing exhaust valves 93, as well as the exhaust-side gear member 41 and a scissors gear 42 mounted to an intermediate section in the longitudinal direction of this camshaft. The exhaust-side gear member 41 and the scissors gear 42 are mounted to the aforementioned camshaft with a stepped bolt 40. The exhaust-side gear member 41 has a chamfered section 41a formed for preventing interference with the external rotor 28.

[0035] Description of a hydraulic mechanism for allowing the internal rotor 26 and the external rotor 28 for relative rotation is as follows.

[0036] The external rotor 28 has total eight recess sections 28b as shown in FIGs. 3 and 4. There are total eight hydraulic chambers 43 formed between these recess sections 28b and an outer periphery 26b of the internal rotor 26. Each hydraulic chamber 43 is divided into a timing-advance-side hydraulic chamber 44 and a timing-retard-side hydraulic chamber 45 by a vane 46. The vane 46 has a base end 46a retained in a retaining slot 26c formed into the internal rotor 26. The vane is disposed so as to freely extend and retract in a radial direction of the internal rotor 26 while being urged toward the outside by an unillustrated spring disposed within the retaining slot 26c. A tip end 46b of the vane 46 therefore comes into contact with a bottom wall 28c of the recess section 28b of the external rotor 28.

[0037] A timing-advance-side oil path 48 communicating with the timing-advance-side hydraulic chamber 44 to deliver/drain oil, and a timing-retard-side oil path 49 communicating with the timing-retard-side hydraulic chamber 45 to deliver/drain oil are formed.

[0038] As shown in FIGs. 1, 3 and 4, the timing-advance-side oil path 48 has: a timing-advance path 31 a formed in the intake-side gear member 31 and facing the timing-advance-side hydraulic chamber 44; a timing-advance path 11e formed in the flange 11c of the camshaft 11 to communicate with the timing-advance path 31a; a timing-advance path 11f formed along the axial direction of the camshaft 11 to communicate with the timing-advance path 11e; a timing-advance path 11g formed on the camshaft 11 to communicated with the timing-advance path 11f; and a timing-advance path 16a formed in the journal 16 to communicate with the timing-advance path 11g. Furthermore, as shown in FIGs. 5 and 6, the timing-advance path 16a is communicated with a timing-advance path 12b formed extending outward of the cylinder head 12, which is connected to a directional control valve 76.

[0039] In contrast, the timing-retard-side oil path 49 has: a timing-retard path 26d formed in the internal rotor 26 and facing the timing-retard-side hydraulic chamber 45; a timing-retard path 11h formed in the boss 11b of the camshaft 11 to communicate with the timing-retard path 26d; a timing-retard path 11i formed along the axial direction of the camshaft 11 to communicate with the timing-retard path 11h; a timing-retard path 11j formed on the camshaft 11 to communicated with the timing-retard path 11i; and a timing-retard path 15a formed in the journal 15 to communicated with the timing-retard path 11j. Furthermore, as shown in FIGs. 5 and 6, the timing-retard path 15a is communicated with a timing-retard path 12c formed on the cylinder head 12, which is connected to a directional control valve 76.

[0040] As described above, the timing-advance path 11f and the timing-retard path 11i, which are formed in the axial direction of the camshaft 11, are separately provided on the right and left sides relative to the layout position of the internal rotor 26 and the external rotor 28 on the common axis of the camshaft 11. These timing-advance path 11f and timing-retard path 11i are formed by drilling a hole to the midsection of the camshaft 11

from its both ends and disposing their respective lids 77 thereto. If a pair of left and right paths, used as the timing-advance path 11f and the timing-retard path 11i, have different longitudinal dimensions, one of the paths with a shorter dimension would be used as the timing-advance path 11f.

[0041] As shown in FIGs. 5 and 6, the directional control valve 76 is configured such that a solenoid 79 causes a spool 80 more forward and backward in the left and right direction in FIG. 6. The spool 80 has a cylindrical-shaped column body 80a; a forward plate 80b provided on a tip end of the column body 80a to slide within a case 82; and a rearward plate 80c provided on a rear end of the column body to slide within the case 82.

[0042] The spool 80 is moved to a position shown by a chain double-dashed line in FIG. 6. Therefore, an oil delivery hole 81, to which oil is delivered from an oil pump driven by the engine, is communicated with the timing-advance path 12b of the timing-advance-side oil path 48. This allows the oil to be delivered to the timing-advance-side oil path 48. In turn, the timing-retard path 12c of the timing-retard-side oil path 49 is communicated with a drain opening 12d. As shown by the arrow of chain double-dashed line in FIG. 6, the oil in the timing-retard-side hydraulic chamber 45 is drained out into the cylinder head 12 from the drain opening 12d. The drain opening 12d is positioned higher than a bottom edge of the camshaft 11 at the journals 14, 15, 16, 17 as shown in FIG. 5. A reference symbol O in FIG. 5 denotes a horizontal line.

[0043] The spool 80 is further moved to a position shown by a solid line in FIG. 6. Therefore, the oil delivery hole 81 is communicated with the timing-retard path 12c of the timing-retard-side oil path 49 to which oil is delivered. In turn, the timing-advance path 12b of the timing-advance oil path 48 is communicated with the drain opening 12d. As shown by the arrow of solid line in FIG. 6, the oil in the timing-advance-side hydraulic chamber 44 is drained out into the cylinder head 12 from the drain opening 12d.

[0044] In contrast, the shield plate 32 mounted to the external rotor 28 shields the side of the retaining slot 26c of the internal rotor 26 in order to prevent the oil from leaking from a side opening of the retaining slot 26c. Between the shield plate 32 and the internal rotor 26, a stopper pin 83 for locking/unlocking relative rotation of the internal rotor 26 and the external rotor 28 is provided movably in the left and right direction in FIG. 1.

[0045] The stopper pin 83 is subject to hydraulic pressure by the oil in the timing-advance-side oil path 48 delivered through a communication passage 26e shown in FIG. 4, and then moved toward the right in FIG. 1 against the urging force of the unillustrated spring. This allows an engaging projection 83a of the stopper pin 83 to be disengaged from an engaging hole 32a of the shield plate 32, thereby unlocking the internal rotor 26 and the external rotor 28.

[0046] Each cam cap 13 is formed with an oil path 13a for the journals 14, 17, except the journals 15, 16 adjacent to the internal rotor 26. Oil is delivered to the journals 14, 17 through this oil path 13a and used as lubricant oil.

[0047] Effects of the invention are next described.

[0048] In the valve timing controller configured as above, in order to advance the valve timing in FIG. 4, the solenoid 79 moves the spool 80 to a position shown in the chain double-dashed line in FIG. 6. This allows the oil to be delivered to the timing-advance-side hydraulic chamber 44 through the timing-advance-side oil path 48, while allowing the oil in the timing-retard-side hydraulic chamber 45 to be drained out from the drain opening 12d through the timing-retard-side oil path 49.

[0049] The oil is delivered to the timing-advance-side oil path 48 and then to the stopper pin 83. The engaging projection 83a of the stopper pin 83 is therefore disengaged from the engaging hole 32a of the shield plate 32, resulting in the internal rotor 26 and the external rotor 28 being unlocked from each other.

[0050] This allows each vane 46 in the hydraulic chamber 43 to move to a position shown by the chain double-dashed line in FIG. 4, which increases the capacity of the timing-advance-side hydraulic chamber 44 while decreasing the capacity of the timing-retard-side hydraulic chamber 45.

[0051] Under this condition, the internal rotor 26 and the external rotor 28 relatively rotate, which changes the phases, or rotation angles, of the crankshaft and the camshaft 11, thereby advancing the valve timing.

[0052] In contrast, in order to retard the valve timing, the solenoid 79 moves the spool 80 to a position shown in the solid line in FIG. 6. This allows the oil in the timing-retard-side hydraulic chamber 45 to be delivered through the timing-retard-side oil path 49, while allowing the oil in the timing-advance-side hydraulic chamber 44 to be drained out from the drain opening 12d through the timing-advance-side oil path 48.

[0053] This allows each vane 46 in the hydraulic chamber 43 to move to a position shown by the solid line in FIG. 4, which increases the capacity of the timing-retard-side hydraulic chamber 45 while decreasing the capacity of the timing-advance-side hydraulic chamber 44.

[0054] Under this condition, the internal rotor 26 and the external rotor 28 relatively rotate in the reverse direction to the above, which changes the phases, or rotation angles, of the crankshaft and the camshaft 11, thereby retarding the valve timing.

[0055] Advancing or retarding the valve timing as described above allows the intake valves 18 to be open/closed at a predetermined timing.

[0056] In this mechanism, the timing-advance path 11f in the timing-advance-side oil path 48 which is formed on the camshaft 11, and the timing-retard path 11i in the timing-retard-side oil path 49 which is formed on the camshaft 11 are provided respectively on the both sides relative to the layout position of the internal rotor

26 and the external rotor 28. It is therefore unnecessary to form two paths arranged adjacent and parallel to each other, which differs from the conventional configuration. This facilitates the forming. Also, in some motorcycle engines, the stud bolts 21 and the nuts 22 could be positioned on the journals 15, 16 due to a problem with limited space. However, in the present embodiment, the timing-advance path 11f and the timing-retard path 11i are separately provided on the right and left so that it is only necessary for the journal 15 to be provided with one of these paths as well as for the journal 16 to be provided with the other path. This can secure strength and facilitate the forming.

[0057] In the present embodiment, the timing-advance path 11f and the timing-retard path 11i are separately provided. In view of this as well as other circumstances, a pair of the left and right paths, used as the timing-advance path 11f and the timing-retard path 11i, may have different longitudinal dimensions. In such a case, using the path with a shorter dimension as the timing-advance path 11f results in improved response to hydraulic control to advance the valve timing.

[0058] Furthermore, the stopper pin 83 is provided in order to lock/unlock relative rotation of the internal rotor 26 and the external rotor 28. This can lock the internal rotor 26 and the external rotor 28 while the valve timing controller is not used, preventing both of the rotors from relative rotation until the hydraulic pressure increases, and preventing the phases, or rotation angles, of the crankshaft and the camshaft 11 from undesirably changing. In addition, the valve timing controller in use is operated by a hydraulic pressure from a shorter path, or the timing-advance path 11f, thereby advancing the unlock timing to speed up operations of the valve timing controller.

[0059] Furthermore, each cam cap 13 is formed with an oil path 13a for the journals 14, 17, except the journals 15, 16 adjacent to the internal rotor 26. Oil is delivered to the journals 14, 17 through this oil path 13a and used as lubricant oil. Therefore, this can avoid the impact of operations of the valve timing controller as well as the risk that the oil in the journals 14, 17, except the journals 15, 16 adjacent to the internal rotor, may flow out, thereby maintaining lubrication.

[0060] In addition, the drain opening 12d is positioned higher than the bottom edge of the camshaft 11 on the journals 14, 15, 16, 17. This therefore prevents the oil from completely flowing out of the journals 15, 16 even if either of the timing-advance-side oil path 48 and the timing-retard-side oil path 49 is set as the oil drain side, thereby maintaining lubrication.

[0061] The internal rotor 26 and the external rotor 28 (the valve timing controller) are provided between plural cylinders A, B. This results in improved appearance quality compared to the valve timing controller provided at the end of the camshaft. For example, providing the valve timing controller at the end of the camshaft 11 causes it to protrude from the edge side in a vehicle width direction. This results in portions of the engine, exposed to the both sides of the body, having different shapes, causing an unbalance. This adversely affects the appearance quality. In contrast to that, providing the internal rotor 26 and the external rotor 28 (the valve timing controller) between plural cylinders prevents this valve timing controller from protruding from the side, which secures a good balance as well as appearance quality.

[0062] Furthermore, the timing chain 35 is wound around the sprocket 28a of the intake-side external rotor 28 to transmit driving force from the intake-side gear member 31 to the exhaust-side gear member 41. This allows the intake-side camshaft 11 and an unillustrated exhaust-side camshaft to be arranged close to each other compared to the case of winding the timing chain 35 across the intake-side and the exhaust-side. This results in the axial directions of the intake valve 18 and an unillustrated exhaust valve being close and approximately parallel to each other, which can make the top surface of a combustion chamber approximately flat, thereby obtaining a good combustion chamber shape. In addition, in the case of winding the timing chain 35 across the intake side and the exhaust side, it is required to dispose respective sprockets on the intake side and exhaust side, as well as to make these sprockets apart to some extent not to interfere with each other. It is thus impossible to arrange the intake-side camshaft 11 and the unillustrated exhaust-side camshaft close to each other, which differs from the above case.

[0063] Fig. 7 shows a second embodiment.

[0064] In the second embodiment, an internal rotor 26 and an external rotor 28 (a valve timing controller) are provided outside of plural cylinders A, B.

[0065] To be more specific, a camshaft 11 extends outward of the cylinders to the right in the figure. A right-side end 11k outward of the internal rotor 26 and the external rotor 28 is rotatably supported by a journal 86 while a portion between these internal and external rotors 26, 28 and the cylinders A, B is rotatably supported by a journal 87. The journal 87 is provided with a stud bolt 21 and a nut 22.

[0066] As with the first embodiment, a timing-advance-side oil path 48 and a timing-retard-side oil path 49 are separately provided on the right and left for these journals 86, 87.

[0067] The rest of the second embodiment as well as its effects are the same as obtained in the first embodiment so the detailed descriptions will be omitted as appropriate.

[0068] FIGs. 8 through 10 show the third embodiment.

[0069] The third embodiment is different from the first embodiment in the point that a timing chain 35 is wound around an exhaust-side camshaft 91.

[0070] To be more specific, on the exhaust-side in FIG. 9, the exhaust-side camshaft 91 is rotatably supported on a cylinder head 12 by means of cam caps 13. Cams 91 a formed on the exhaust-side camshaft 91 al-

low their respective exhaust valves 93 to be open against urging force of each spring 94.

[0071] The camshaft 91 has a flange 91 b formed in its middle section between a pair of cylinders A, B. A sprocket member 92 is secured to the flange 91 b with plural bolts 95.

[0072] The sprocket member 92 has a sprocket 92a around which the timing chain 35 is wound, and a gear 92b formed adjacent to the sprocket 92a. A scissors gear 96 is secured to a side surface of the sprocket member 92 with a stepped bolt 98.

[0073] In contrast, on the intake side in FIG. 8, the external rotor 28 has a gear 28d on its outer periphery in place of the sprocket 28a, and a ring-shaped member 97 is disposed in place of the intake-side gear member 31 of the first embodiment. The ring-shaped member 97 is formed with a width smaller than the intake-side gear member 31 together with a timing-advance path 97a.

[0074] The gear 28d of the intake-side external rotor 28 and the gear 92b of the exhaust-side sprocket member 92 are engaged with each other.

[0075] In such a configuration, rotating the crankshaft allows the exhaust-side camshaft 91 to rotate via a timing chain 35. At the same time, this also allows the intake-side camshaft 11 to rotate via the sprocket member 92, the external rotor 28 and the like, since the gear 92b of the sprocket member 92 on the exhaust-side camshaft 91 and the gear 28d of the external rotor 28 on the intake-side camshaft 11 are engaged with each other.

[0076] In this mechanism, on the intake side on which the valve timing controller is provided, it is unnecessary to dispose the intake-side gear member 31 having a required predetermined width for strength on the side of the external rotor 28 having a required predetermined width to secure capacity of a hydraulic chamber 43. Instead, it is possible to provide the ring-shaped member 97 with a smaller width. This allows making a width of a flange 11c of the camshaft 11 smaller, thereby reducing a total width H of these elements. The entire engine can thus be made compact by its width reduced in the vehicle width direction.

[0077] The rest of the third embodiment as well as its effects are the same as obtained in the first embodiment so descriptions of overlapped parts between these embodiments will be omitted as appropriate.

[0078] FIGs. 11 and 12 show the fourth embodiment.

[0079] The fourth embodiment is different in a drain hole 12e shape from the first embodiment.

[0080] To be more specific, a pair of left and right drain holes 12e are formed as shown in FIG. 12. Oil is drained out from a drain opening 12f of each drain hole 12e into a cylinder head 12. The drain opening 12f is positioned higher than a bottom edge of the camshaft 11.

[0081] In such a configuration in which the drain opening 12f is positioned higher than the bottom edge of the camshaft 11, lubrication in journals 15, 16 can be maintained even if either of the journals 15, 16 is set as the oil drain side.

[0082] The rest of the fourth embodiment as well as its effects are the same as obtained in the first embodiment so descriptions of overlapped parts between these embodiments will be omitted as appropriate.

[0083] In this embodiment, a valve timing controller is provided on the intake side. However, it is understood that it may also be provided on the exhaust side.

[0084] The drain opening 12d is positioned higher than the bottom edge of the camshaft 11 to maintain lubrication in the journals 15, 16 thereof. However, the teaching of the present invention is not limited to that, and a midsection on the drain opening 12d side of the oil path may be positioned higher than the bottom edge of the camshaft 11. Furthermore, oil may be delivered to the journal 15 or 16 on the oil-drain side under pressure lower than that in the oil-delivery side to maintain lubrication.

[0085] The description above (amongst others) refers to a valve timing controller for engine having an internal rotor provided on a camshaft and an external rotor rotatably provided around the internal rotor, in which oil is delivered to a hydraulic chamber between the internal rotor and the external rotor, allowing the internal rotor and the external rotor to relatively rotate in a circumferential direction about the camshaft; the external rotor is connected to a crankshaft side via a power transmission means; and relative rotation of the internal rotor and the external rotor allows controlling the opening/closing timing of intake valves and/or exhaust valves, wherein the hydraulic chamber has a timing-advance-side hydraulic chamber and a timing-retard-side hydraulic chamber and; a timing-advance-side oil path communicating with the timing-advance-side hydraulic chamber and a timing-retard-side oil path communicating with the timing-retard-side hydraulic chamber are provided; and wherein the timing-advance-side oil path and the timing-retard-side oil path have a timing-advance path and a timing-retard path extending along the axial direction of the camshaft, respectively; and the timing-advance path and the timing-retard path are separately provided on both sides relative to layout position of the internal rotor and the external rotor.

[0086] In the preferred embodiment described directly above, the timing-advance path in the timing-advance-side oil path which is formed on the camshaft, and the timing-retard path in the timing-retard-side oil path which is formed on the camshaft are provided respectively on both side relative to the layout position of the internal rotor and external rotor. It is therefore unnecessary to form these two paths adjacent and parallel to each other, which differs from the conventional configuration. This facilitates the forming. Also, in some motorcycle engines, the stud bolts and the nuts could be positioned on the journals due to a problem with limited space. However, in the present embodiment, the timing-advance path and the timing-retard path are separately provided on the right and left so that it is only necessary for one journal to be provided with one of these paths

as well as for the other journal to be provided with the other path. This can secure strength and facilitate the forming.

[0087] Within the above embodiment of the valve timing controller for engine, it is beneficial if, when a pair of left and right paths, used as the timing-advance path and the timing-retard path, have different longitudinal dimensions, the shorter one of them is used as the timing-advance path.

[0088] As discussed above, the timing-advance path and the timing-retard path are separately provided. In view of this as well as other circumstances, a pair of the left and right paths, used as the timing-advance path and the timing-retard path, may have different longitudinal dimensions. In such a case, using the path with a shorter dimension as the timing-advance path results in improved response to hydraulic control to advance the valve timing.

[0089] Preferably, there is provided a stopper pin to lock/unlock relative rotation of the internal rotor and the external rotor, so that the stopper pin, when moved under hydraulic pressure in the timing-advance-side oil path, can unlock the relative rotation.

[0090] In this embodiment, the stopper pin is provided in order to lock/unlock relative rotation of the internal rotor and the external rotor. This can lock the internal rotor and the external rotor while the valve timing controller is not used, preventing both of the rotors from relative rotation until the hydraulic pressure increases, and preventing the phases, or rotation angles, of the crankshaft and the camshaft from undesirably changing. In addition, the valve timing controller in use is operated by a hydraulic pressure from a shorter path, or the timing-advance path, thereby advancing the unlock timing to speed up operations of the valve timing controller.

[0091] According to a preferred embodiment, oil is delivered from a cylinder head side to a journal of the camshaft, which is adjacent to the layout position of the internal rotor and the external rotor, and oil is delivered from the journal to the timing-advance-side oil path or the timing-retard-side oil path in the camshaft, while another journal of the camshaft except the journal adjacent to the above layout position is lubricated from a cam cap side.

[0092] Thus, each cam cap is formed with an oil path for the journals, except the journals adjacent to the internal rotor. Oil is delivered to the journals through this oil path and used as lubricant oil. Therefore, this can avoid the impact of operations of the valve timing controller as well as the risk that the oil in the journals, except the journals adjacent to the internal rotor, may flow out, thereby maintaining lubrication.

[0093] According to another preferred embodiment, oil is delivered to the journal of the camshaft, which is adjacent to the layout position of the internal rotor and the external rotor, and oil is delivered from the journal to the timing-advance-side oil path or the timing-retard-side oil path in the camshaft, while a drain opening connected to at least one of the timing-advance-side oil path and the timing-retard-side oil path, or a midsection positioned on the opposite side of the hydraulic chamber relative to the journal is arranged higher than a bottom edge of the camshaft at the journal so as to prevent oil in the journal from completely flowing out

[0094] In this embodiment, the drain opening of the oil path or a midsection of the oil path is positioned higher than the bottom edge of the camshaft on the journal. This therefore prevents the oil from completely flowing out of the journals even if either of the timing-advance-side oil path and the timing-retard-side oil path is set as the oil drain side, thereby maintaining lubrication.

[0095] According to yet another preferred embodiment, oil is delivered to the journal of the camshaft, which is adjacent to the layout position of the internal rotor and the external rotor, and oil is delivered from the journal to the timing-advance-side oil path or the timing-retard-side oil path in the camshaft, while a hydraulic pressure lower than that in the oil delivery side is applied to the journal in the path, set as the oil-drain-side, of the timing-advance-side oil path and the timing-retard-side oil path.

[0096] Thus, in this embodiment, oil may be delivered to the journal set as the oil-drain side under pressure lower than that in the oil-delivery side to maintain lubrication.

[0097] Beneficially, the internal rotor and the external rotor are arranged between plural cylinders.

[0098] If the internal rotor and the external rotor (the valve timing controller) are provided between plural cylinders, this results in improved appearance quality compared to the valve timing controller provided at the end of the camshaft.

[0099] However, the internal rotor and the external rotor may also be arranged outward of plural cylinders.

[0100] Briefly summarizing the above, there is particularly provided a valve timing controller for engine which facilitates forming of oil paths on a camshaft as well as on a journal while securing strength for the journal with a head bolt. Said valve timing controller for engine comprises an internal rotor 26 provided on a camshaft 11 and an external rotor 28 rotatably provided around the internal rotor 26, in which oil is delivered to a hydraulic chamber 43 between the internal rotor 26 and the external rotor 28, allowing the internal rotor 26 and the external rotor 28 to relatively rotate, wherein the hydraulic chamber 43 has a timing-advance-side hydraulic chamber 44 and a timing-retard-side hydraulic chamber 45; a timing-advance-side oil path 48 communicating with the timing-advance-side hydraulic chamber 44 and a timing-retard-side oil path 49 communicating with the timing-retard-side hydraulic chamber 45 are provided; the timing-advance-side oil path 48 and the timing-retard-side oil path 49 have a timing-advance path 11f and a timing-retard path 11i extending along the axial direction of the camshaft 11, respectively; and the timing-advance path 11f and the timing-retard path 11i are sepa-

rately provided on both sides relative to layout position of the internal rotor 26 and the external rotor 28.

Claims

1. Valve timing controller of an engine comprising internal and external rotors (26,28), being rotatable relative to each other, and at least one hydraulic chamber (43), which is arranged between the rotors (26,28) and is divided into a timing-advance-side hydraulic chamber (44) and a timing-retard-side hydraulic chamber (45), wherein a timing-advance path (48) of a timing-advance-side oil path communicating with the timing-advance-side hydraulic chamber (44) and a timing-retard path (49) of a timing-retard-side oil path communicating with the timing-retard-side hydraulic chamber (45) are respectively provided on both sides relative to a layout position of the internal rotor (26) and the external rotor (28).

2. Valve timing controller according to claim 1, **characterized in that** the timing-advance path (48) of the timing-advance-side oil path and the timing-retard path (49) of the timing-retard-side oil path are separately provided in and respectively extending along an axial direction of a camshaft (11).

3. Valve timing controller according to claim 1 or 2, **characterized in that** the internal rotor (26) is provided on the camshaft (11) and the external rotor (28) is rotatably provided around the internal rotor (26), wherein lubricant delivered to the hydraulic chamber (43) between the internal rotor (26) and the external rotor (28) allows the internal rotor (26) and the external rotor (28) to relatively rotate in a circumferential direction about the camshaft (11), wherein the external rotor (28) is connected to the crankshaft side via a power transmission means, and wherein the relative rotation of the internal rotor (26) and the external rotor (28) allows controlling the opening/closing timing of intake valves and/or exhaust valves.

4. Valve timing controller according to at least one of the claims 1 to 3, **characterized in that** the internal rotor (26) is provided on the camshaft (11) either on the intake valve side or the exhaust valve side.

5. Valve timing controller according to at least one of the claims 1 to 4, **characterized in that** the timing-advance-side hydraulic chamber (44) and the timing-retard-side hydraulic chamber (45) of the hydraulic chamber (43) are separated by a vane (46).

6. Valve timing controller according to at least one of the claims 1 to 5, **characterized in that** when a pair of left and right paths, used as the timing-advance path (48) and the timing-retard path (49), have different longitudinal dimensions, the shorter one of them is used as the timing-advance path (48).

7. Valve timing controller according to at least one of the claims 1 to 6, **characterized in that** a stopper pin (83) provided to lock/unlock the relative rotation of the internal rotor (26) and the external rotor (28).

8. Valve timing controller according to at least one of the claims 1 to 7, **characterized in that** the stopper pin (83) is adapted to move under a hydraulic pressure in the timing-advance-side oil path, and is adapted to unlock the relative rotation under the hydraulic pressure in the timing-advance-side oil path.

9. Valve timing controller according to at least one of the claims 1 to 8, **characterized in that** lubricant, in particular oil, is delivered to the journal (15,16) of the camshaft (11), which is adjacent to the layout position of the internal rotor (26) and the external rotor (28), and the lubricant, is delivered from this journal adjacent to the layout position to the timing-advance-side oil path or the timing-retard-side oil path in the camshaft (11).

10. Valve timing controller according to claim 9, **characterized in that** the lubricant is delivered from a cylinder head side to the journal (15,16) of the camshaft (11), which is adjacent to the layout position of the internal rotor (26) and the external rotor (28), and **in that** another journal (4,17) of the camshaft (11), except the journal (15,16) adjacent to the above layout position, is lubricated from a cam cap side.

11. Valve timing controller according to claim 9 or 10, **characterized by** a drain opening (12d) connected to at least one of the timing-advance-side oil path and the timing-retard-side oil path, or a midsection positioned on the opposite side of the hydraulic chamber (43) relative to the journal is arranged higher than a bottom edge of the camshaft (11) at the journal so as to prevent oil in the journal from completely flowing out.

12. Valve timing controller according to at least one of the claims 9 to 11, **characterized in that** a hydraulic pressure lower than that in the oil delivery side is applied to the journal in the path, set as the oil-drain-side, of the timing-advance-side oil path and the timing-retard-side oil path.

13. Valve timing controller according to at least one of the claims 1 to 12, **characterized in that** the internal rotor (26) and the external rotor (28) are arranged between plural cylinders (A,B) or are ar-

ranged outward of plural cylinders (A,B).

14. Valve timing controller according to at least one of the claims 1 to 13, **characterized by** an intake-side gear member (31) and a shield plate (32), wherein the external rotor (28), the intake-side gear member (31) and the shield plate (32) are integrally arranged for relative rotation about the internal rotor (26) by a predetermined angle.

15. Engine, in particular internal combustion engine, having a valve timing controller according to at least one of the preceding claims 1 to 14.

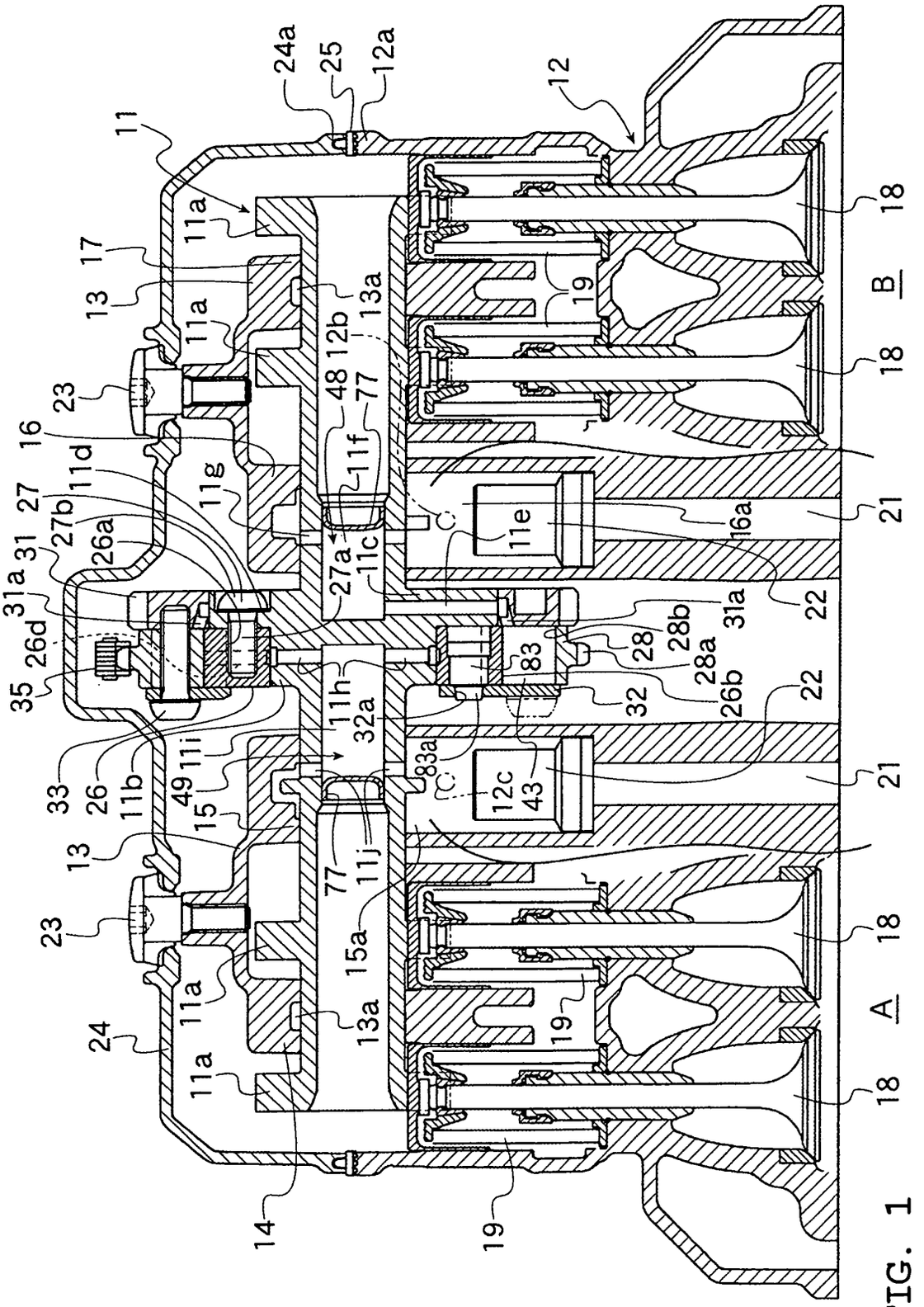
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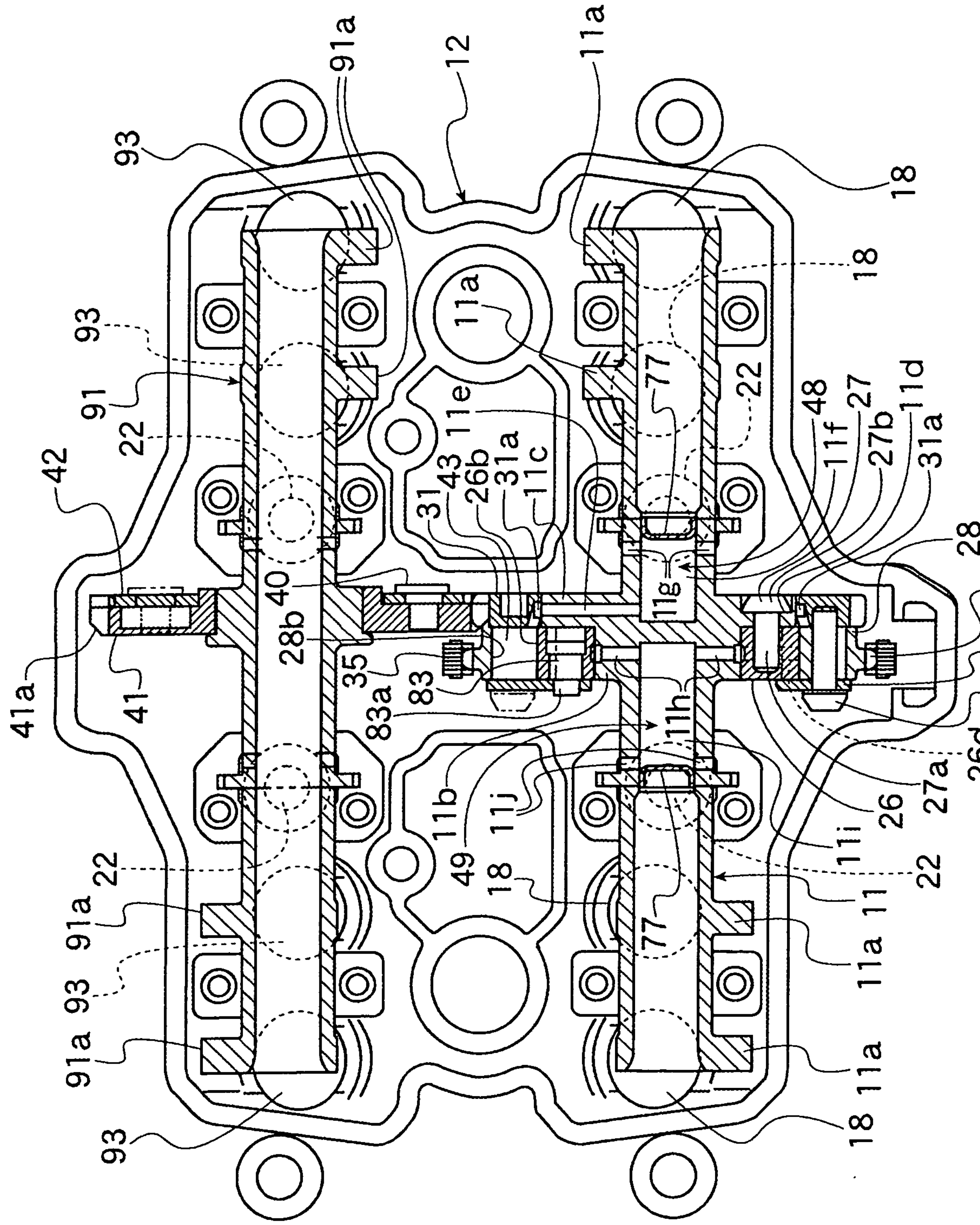
FIG. 1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11i
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FIG. 2

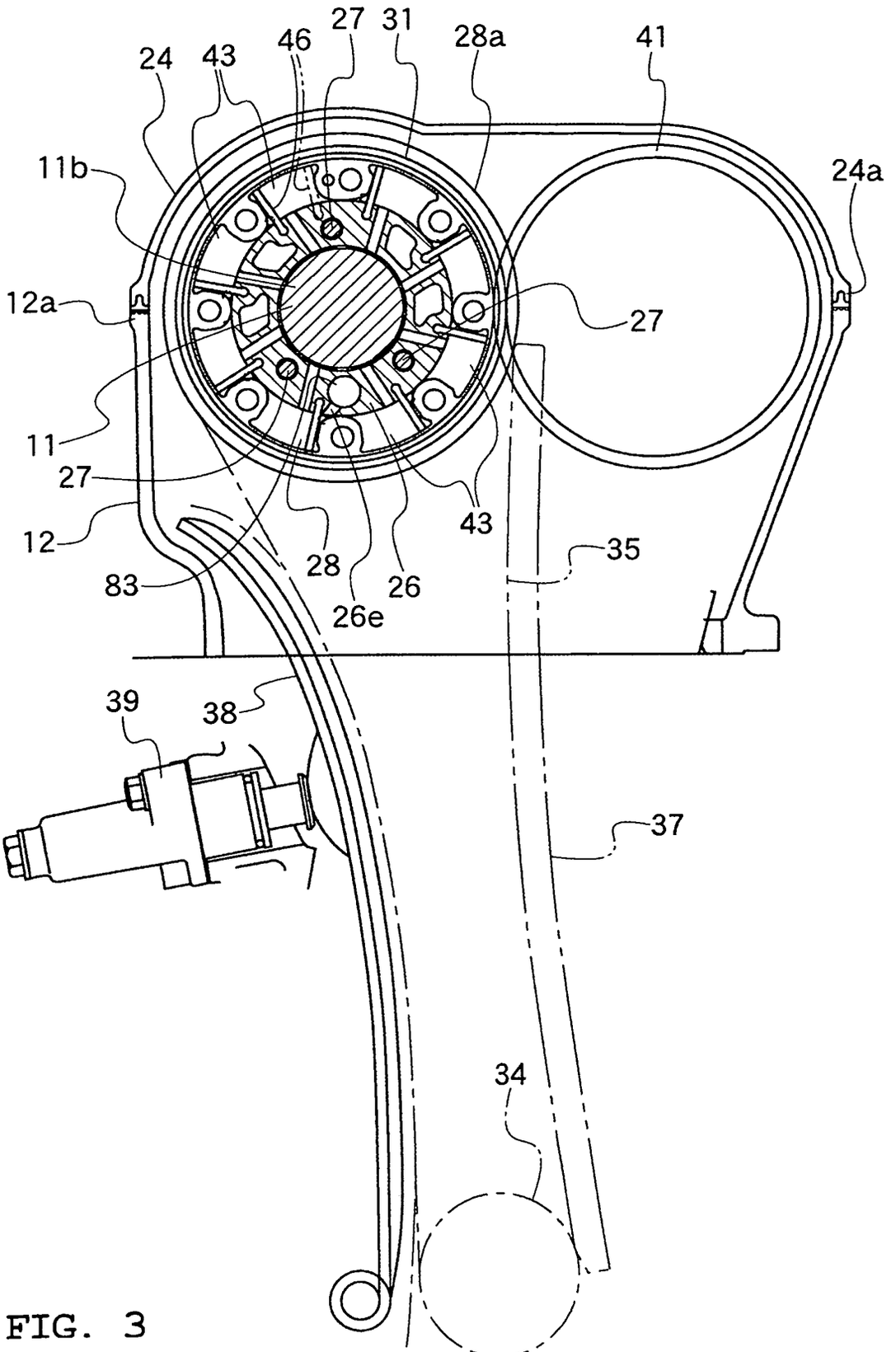
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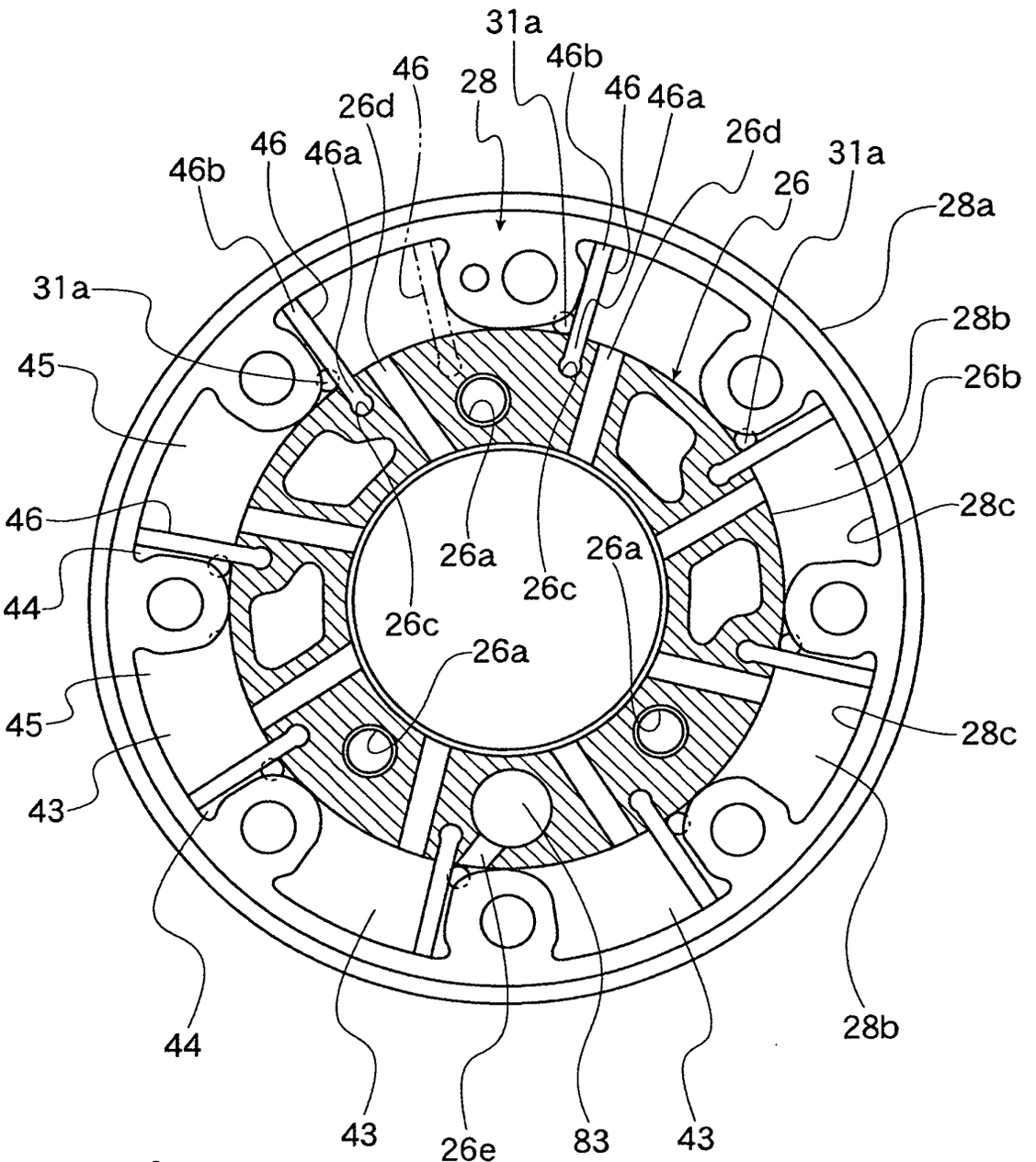
FIG. 3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44
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26e
83
43
28b

FIG. 4

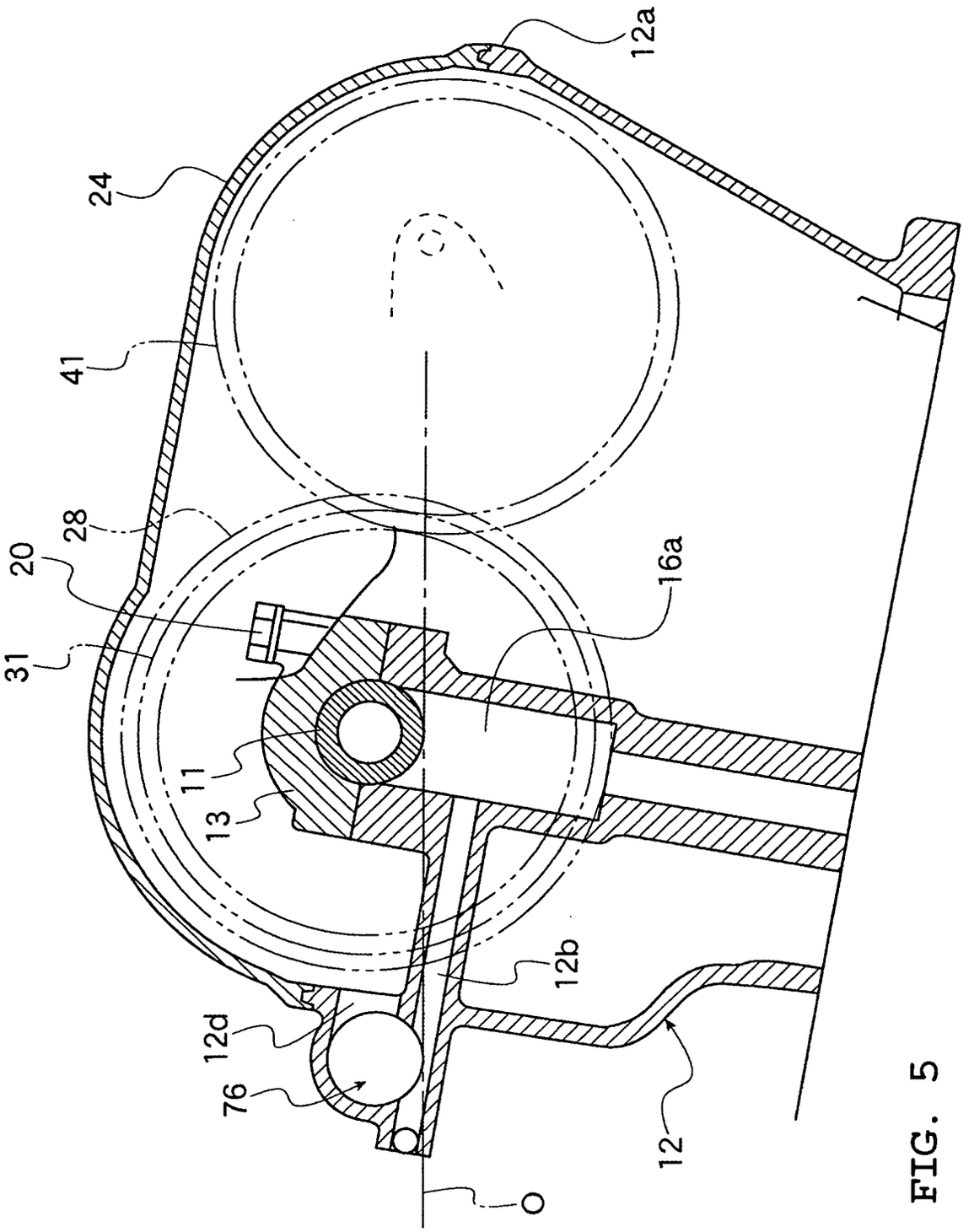


FIG. 5

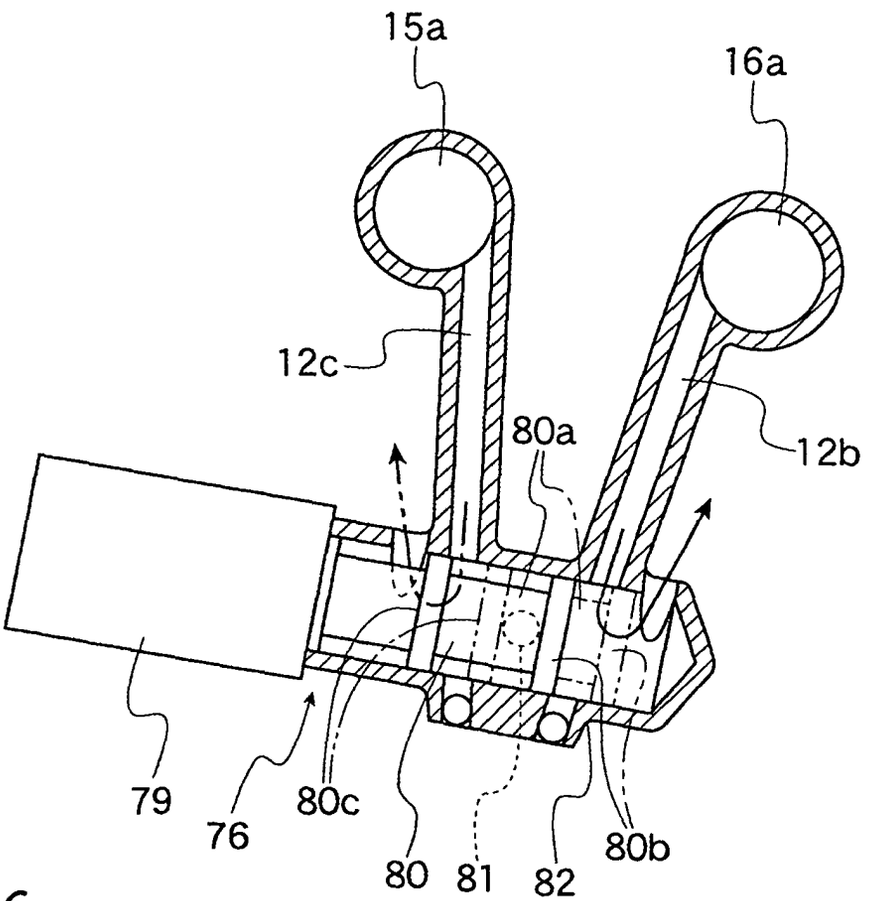
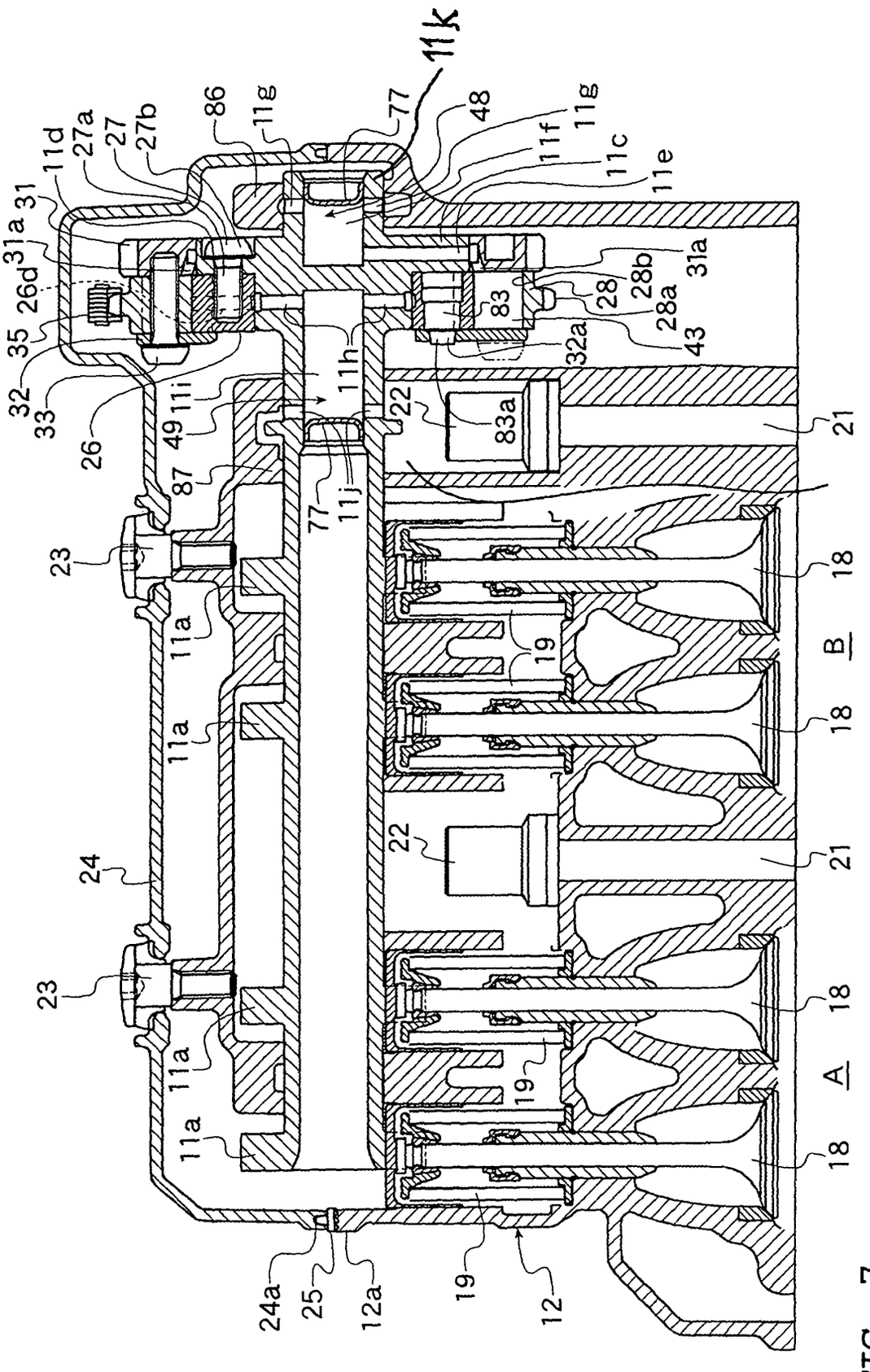


FIG. 6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28
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12a
12
A
B

FIG. 7

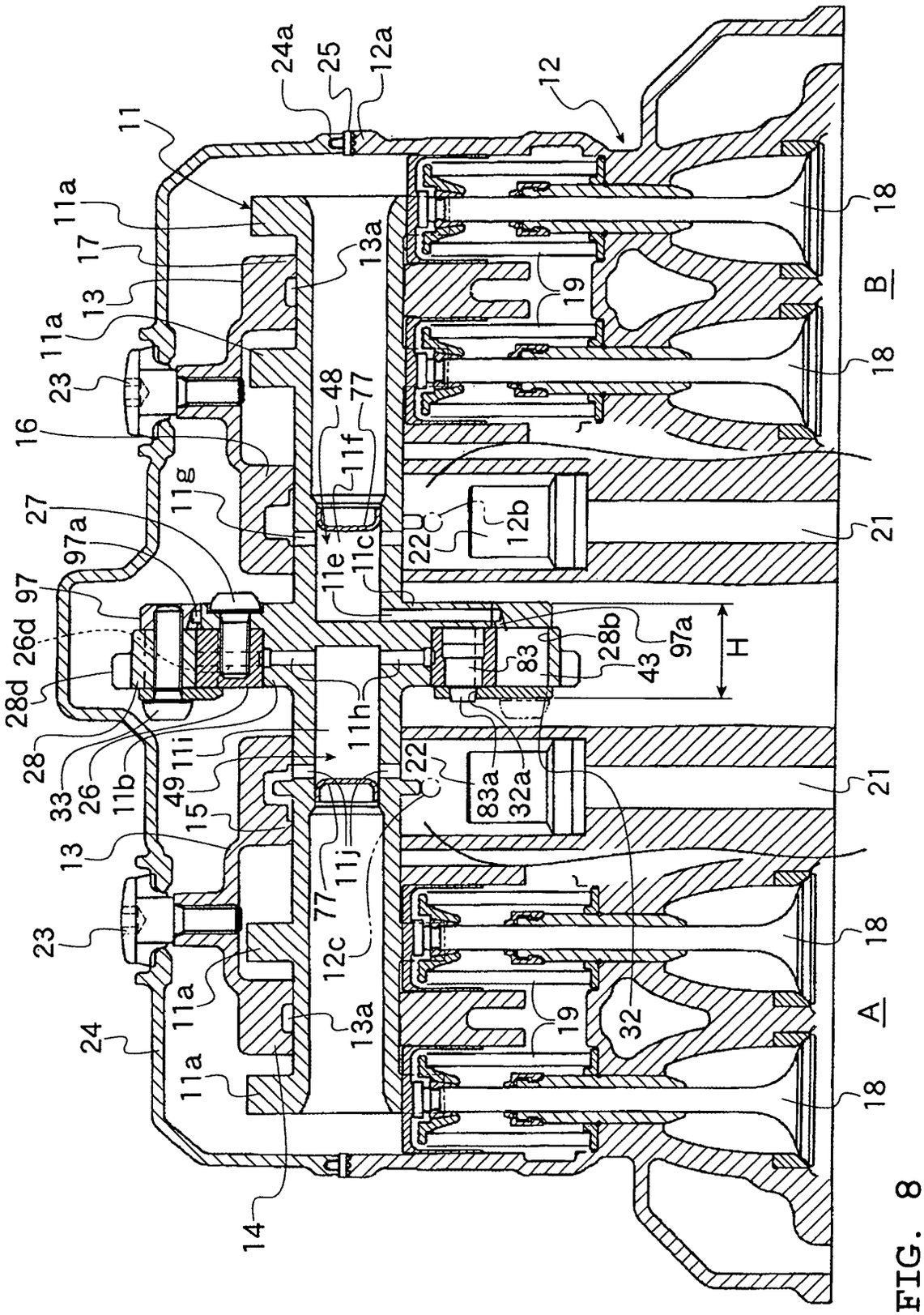
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FIG. 8

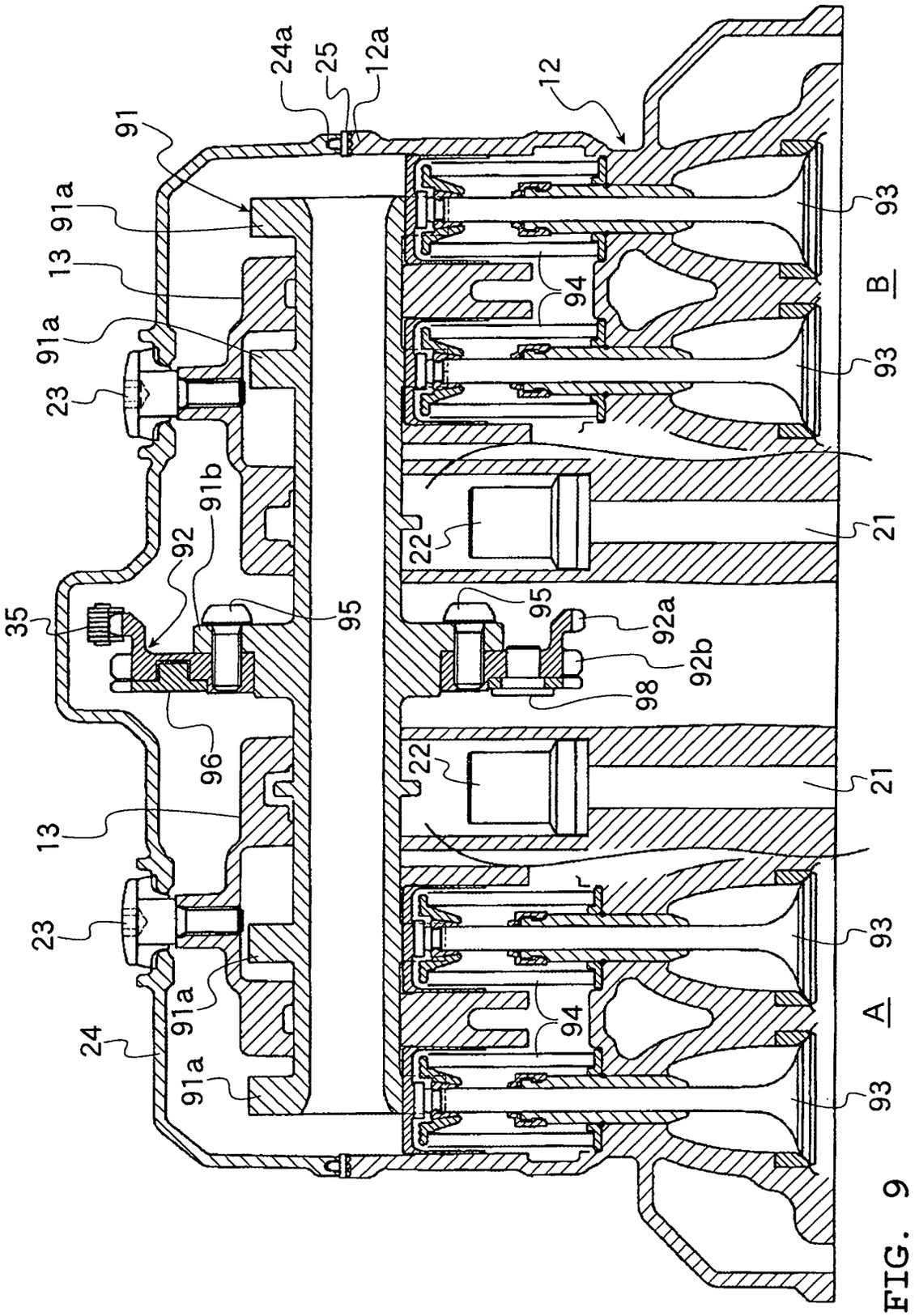
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FIG. 9

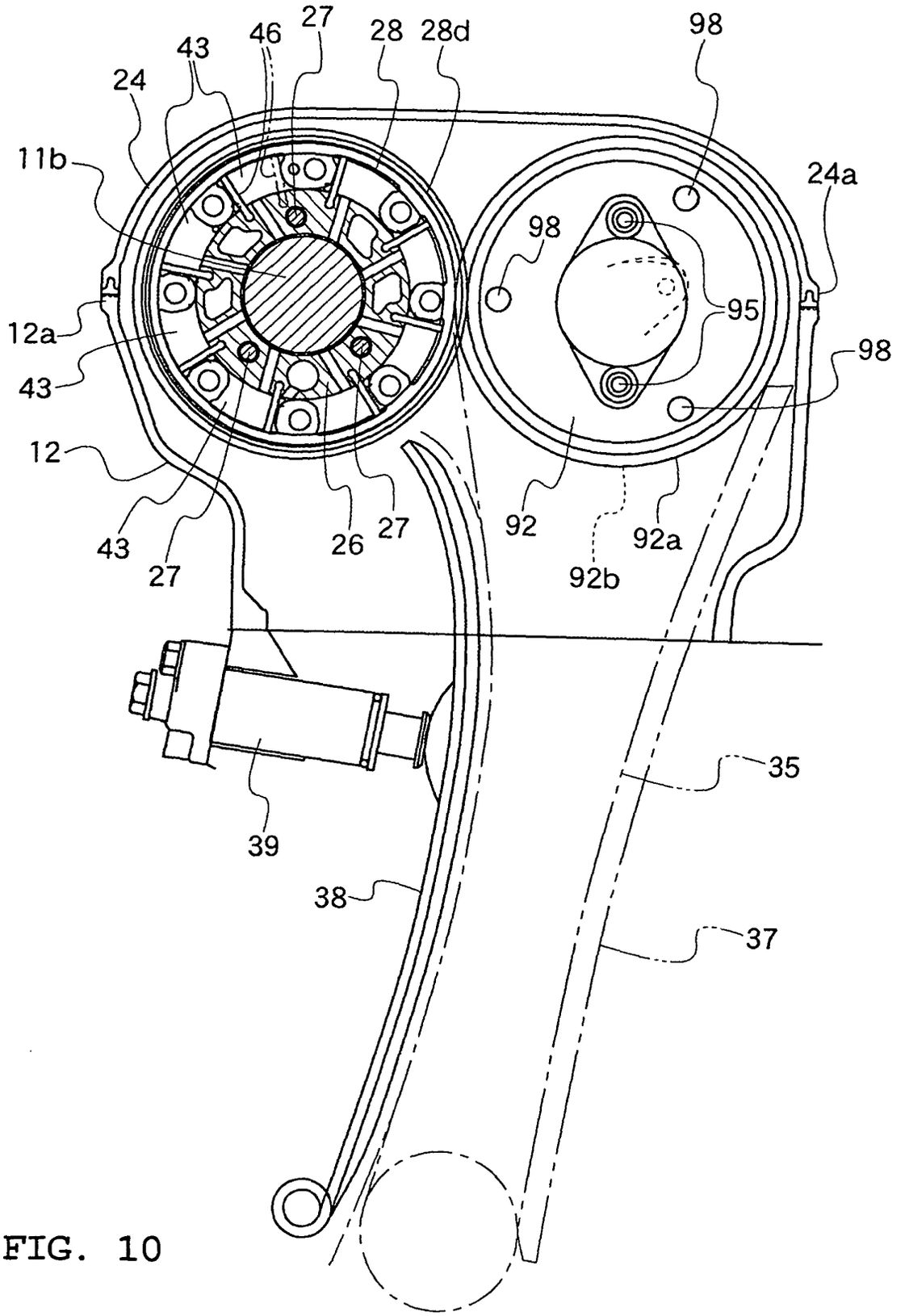
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FIG. 10

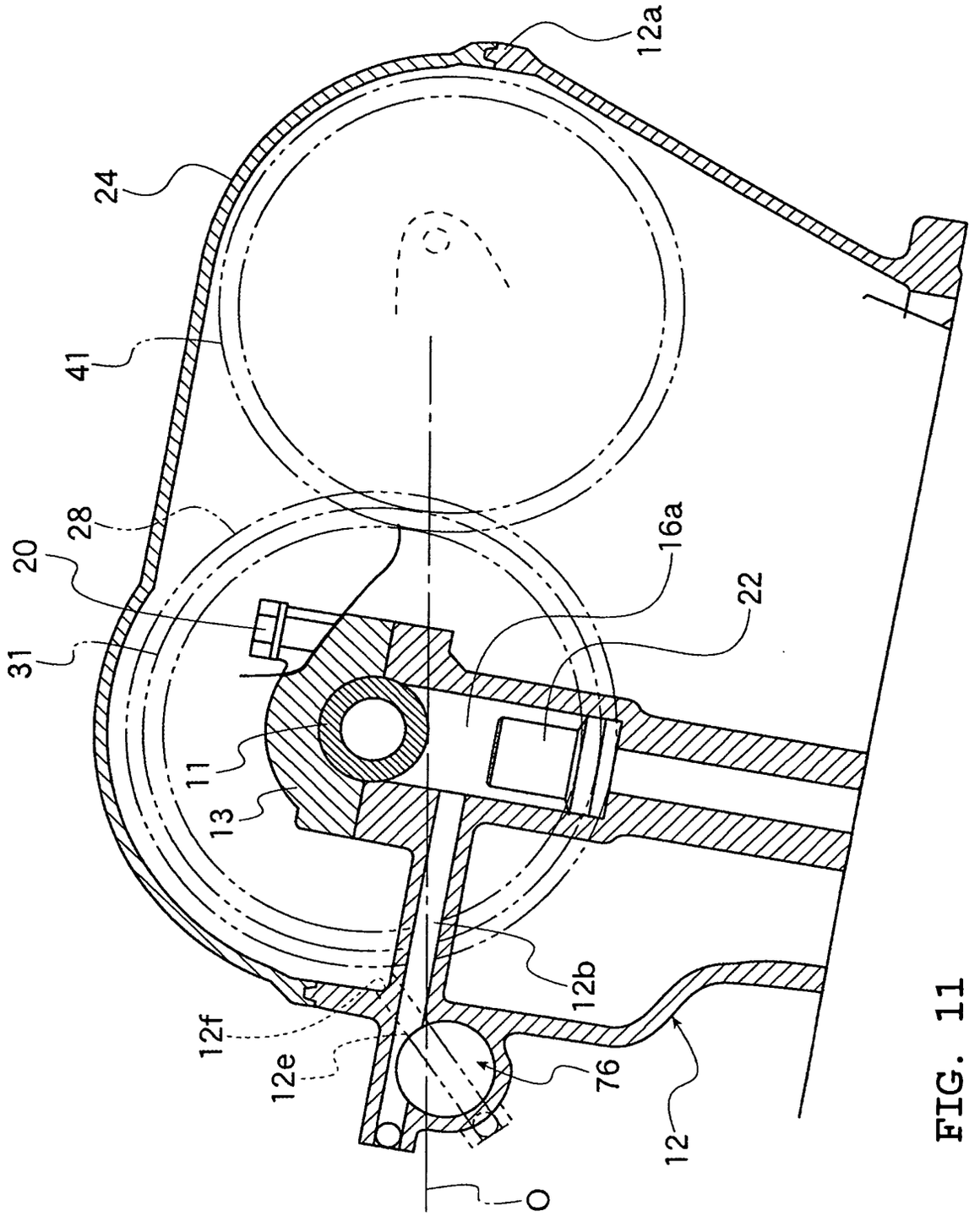

FIG. 11

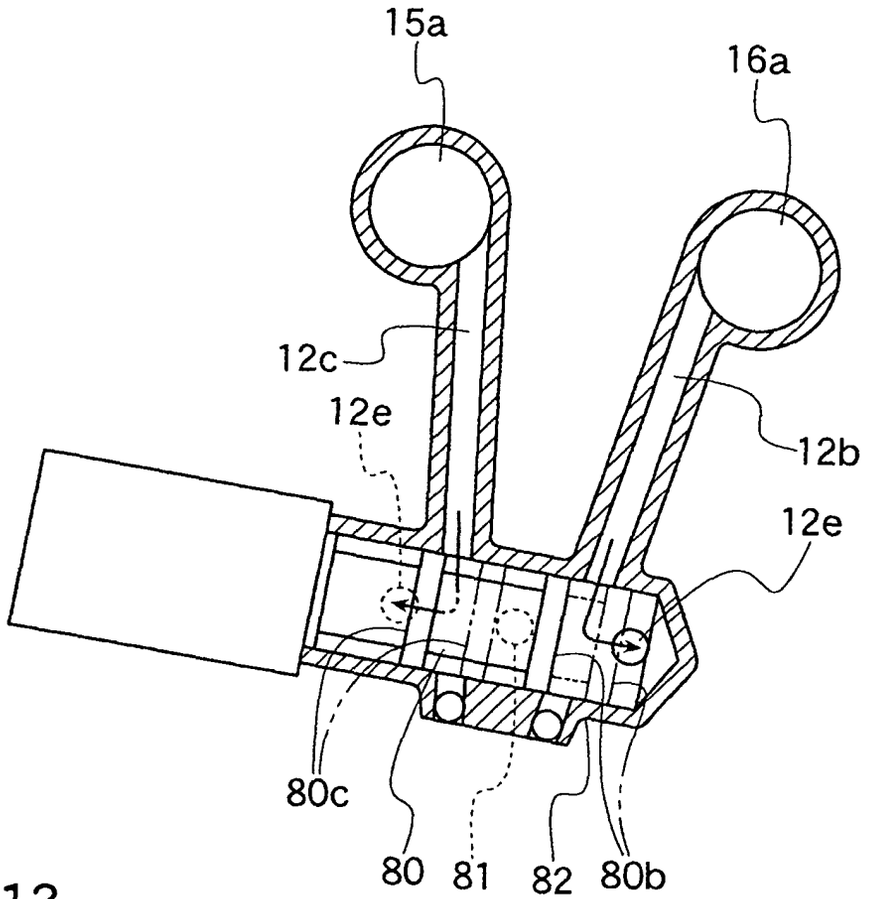

FIG. 12

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 04 01 8491

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	US 2002/104497 A1 (SCHREECK NICO ET AL) 8 August 2002 (2002-08-08) * figures 2,6-8,12-14 * * column 2 *	1-5,9, 13-15	F01L1/053 F01L1/344 F01L1/047
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F01L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	16 November 2004	Paulson, B

CATEGORY OF CITED DOCUMENTS

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16-11-2004

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