(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 207 276 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
22.05.2002 Bulletin 2002/21

(51) Int Cl.[7]: **F01L 1/04**, F01L 1/14, F01L 1/18

(21) Application number: **01121947.4**

(22) Date of filing: **12.09.2001**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE TR
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **16.11.2000 JP 2000349952**

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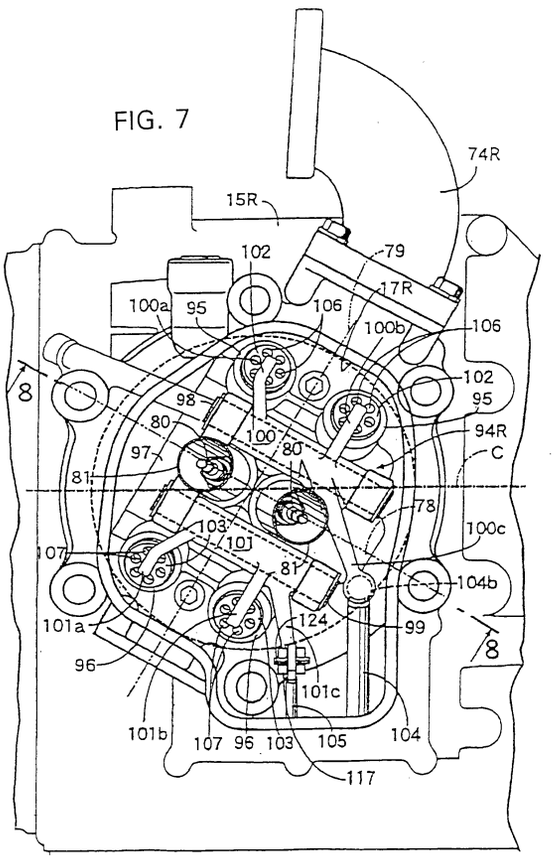
(54) Valve system for engine

(57) The invention provides avalve system for an engine, in which a rocker arm interlocked with an engine valve is supported on a rocker shaft fixedly mounted to a cylinder head in such a manner as to be rockable according to the rotation of a cam shaft, characterized by realizing the reduction in size and weight of the engine.

The posture of a rocker shaft (99) is set to have an axial line crossing an axial line of a crank shaft on the projection plane perpendicular to an axial line of a cylinder bore. A rocker arm(101)rockably supported by the rocker shaft(99)is provided with an input arm (101c) extending, on the above projection plane, from the rocker arm (101) to the cam shaft side, and a pull rod (105) reciprocating in the axial direction according to the rotation of the cam shaft is connected to the input arm (101c).

FIG. 7



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Description

[0001] The present invention relates to a valve system for an engine, and particularly to an improved valve system for an engine, in which a rocker arm interlocked with an engine valve is supported by a rocker shaft fixedly supported by a cylinder head in such a manner as to be rockable according to the rotation of a cam shaft.

[0002] A valve system of this type has been known, for example, from Japanese Patent Laid-open No. Hei 2000-110516.

[0003] The above-described related art valve system is of an overhead cam type in which a cam shaft is disposed over a cylinder head. In this valve system, to transmit a rotational power of a crank shaft to the cam shaft at a reduction ratio of 1/2, it is required to ensure a space on one end side of the crank shaft for disposing power transmission means such as a cam chain, with a result that the width of an engine becomes large in the direction along the axial line of the crank shaft, resulting in the increased weight of the engine.

[0004] In view of the foregoing, the present invention has been made, and an object of the present invention is to provide a valve system of an engine, which is capable of reducing the size and weight of the engine.

[0005] To achieve the above object, according to the invention described in claim 1, there is provided a valve system for an engine, in which a crank shaft is rotatably supported by a crank case in such a manner as to be connected to a piston slidably fitted in a cylinder bore; a cam shaft having an axial line parallel to an axial line of the crank shaft is interlocked with the crank shaft at a reduction ratio of 1/2; and a rocker arm interlocked with engine valves is supported by a rocker shaft fixedly supported by a cylinder head in such a manner as to be rockable according to the rotation of the cam shaft; characterized in that the cam shaft disposed on one side of the crank shaft is rotatably supported by the crank case; the posture of the rocker shaft is set to have an axial line crossing the axial line of the crank shaft on the projection plane perpendicular to an axial line of the cylinder bore; an input arm extending, on the projection plane, from the rocker arm to the cam shaft side is provided on side the rocker arm rockably supported by the rocker shaft; and a pull rod reciprocating in the axial direction according to the rotation of the cam shaft is connected to the input arm in order to rock the rocker arm in the valve opening direction when the pull rod is moved to the cam shaft side.

[0006] With this configuration, since the posture of the rocker shaft is set to have an axial line crossing the axial line of the crank shaft on the projection plane perpendicular to an axial line of the cylinder bore, a space required to be formed for disposing the rocker shaft, the rocker arm, and the like constituting part of the valve system can be set to be smaller in the direction along the axial line of the crank shaft. Also since the input arm extends from the rocker arm to the cam shaft disposed on one side of the crank shaft and the pull rod reciprocating in the axial direction according to the rotation of the cam shaft is connected to the input arm, it is not required to enlarge the width of the cylinder head in the direction along the axial line of the crank shaft for disposing the pull rod, with a result that it is possible to reduce the size and weight of the engine in the direction along the axial line of the crank shaft.

[0007] To achieve the above object, according to the invention described in claim 2, there is a valve system for an engine, in which a crank shaft is rotatably supported by a crank case in such a manner as to be connected to a piston slidably fitted in a cylinder bore; a cam shaft having an axial line parallel to an axial line of the crank shaft is interlocked with the crank shaft at a reduction ratio of 1/2; and a first rocker arm interlocked with first engine valves and a second rocker arm interlocked with second engine valves different in kind from the first engine valves are respectively supported by a first rocker shaft and a second rocker shaft, which are fixedly supported by a cylinder head, in such a manner as to be rockable according to the rotation of the cam shaft, characterized in that the cam shaft disposed on one side of the crank shaft is rotatably supported by the crank case; the first rocker arm corresponding to a pair of the first engine valves and the second rocker arm corresponding to a pair of the second engine valves are disposed in the cylinder head in such a manner as to face a combustion chamber, and are rockably supported by the first rocker shaft and the second rocker shaft, respectively, the first and second rocker shafts and having axial lines crossing the axial line of the crank shaft on the projection plane perpendicular to an axial line of the cylinder bore and being disposed in parallel to each other; an input arm and an input arm extending, on the projection plane, from the first rocker arm and the second rocker arm to the cam shaft side are provided on the first rocker arm and the second rocker arm, respectively; a push rod reciprocating in the axial direction according to the rotation of the cam shaft is connected to the input arm of the first rocker arm in order to rock the first rocker arm in the valve opening direction when the push rod is moved on the side opposite to the cam shaft; and a pull rod reciprocating in the axial direction according to the rotation of the cam shaft is connected to the input arm of the second rocker arm in order to rock the second rocker arm in the valve opening direction when the pull rod is moved on the cam shaft side.

[0008] With this configuration, since the pair of first engine valves and the pair of second engine valves are disposed in the cylinder head in such a manner as to face one combustion chamber, it is possible to improve the suction efficiency and increase the output torque in a low speed rotational range. Since the postures of the first and second rocker shafts are set to have the axial lines thereof crossing the axial line of the crank shaft on the projection plane perpendicular to the axial line of the cylinder bore, a space required to be formed in the cyl-

inder head for disposing the first and second rocker shafts, the first and second rocker arms, and the like constituting part of the valve system can be set to be smaller in the direction along the axial line of the crank shaft. Further, since both the input arms extend from the first and second rocker arms to the cam shaft disposed on one side of the crank shaft and the pull rod and the push rod reciprocating in the axial direction according to the rotation of the cam shaft are connected to the input arms of both the rocker arms, it is not required to enlarge the width of the cylinder head in the direction along the axial line of the crank shaft for disposing the pull rod and the push rod, so that a drive system between the cam shaft and both the rocker arms can be disposed in good balance, with a result that it is possible to reduce the size and weight of the engine in the direction along the axial line of the crank shaft.

[0009] Hereinafter, embodiments of the present invention will be described with reference to the accompanying drawings, in which:

FIG. 1 is a vertical sectional rear view of an engine.

FIG. 2 is an enlarged sectional view taken on line 2-2 of FIG. 1.

FIG. 3 is an enlarged sectional view taken on line 3-3 of FIG. 2.

FIG. 4 is an enlarged sectional view taken on line 4-4 of FIG. 2.

FIG. 5 is a sectional view taken on line 5-5 of FIG. 1 showing a cylinder head.

FIG. 6 is a sectional view taken on line 6-6 of FIG. 5 showing the cylinder head in a state in which a head cover is removed.

FIG. 7 is a view seen along an arrow 7 of FIG. 6.

FIG. 8 is a sectional view taken on line 8-8 of FIG. 7.

FIG. 9 is a sectional view taken on line 9-9 of FIG. 1.

FIG. 10 is an exploded perspective view of a structure for connecting a pull rod to a cam follower.

FIG. 11 is an exploded perspective view, corresponding to FIG. 10, showing another embodiment of the present invention.

[0010] FIGS 1 to 10 show one embodiment in which the present invention is applied to a four-cycle horizontal opposed type two-cylinder engine, wherein FIG. 1 is a vertical sectional rear view of the engine; FIG. 2 is an enlarged sectional view taken on line 2-2 of FIG. 1; FIG. 3 is an enlarged sectional view taken on line 3-3 of FIG. 2; FIG. 4 is an enlarged sectional view taken on line 4-4 of FIG. 2; FIG. 5 is a sectional view taken on line 5-5 of FIG. 1 showing a cylinder head; FIG. 6 is a sectional view taken on line 6-6 of FIG. 5 showing the cylinder head in a state in which a head cover is removed; FIG. 7 is a view seen along an arrow 7 of FIG. 6; FIG. 8 is a sectional view taken on line 8-8 of FIG. 7; FIG. 9 is a sectional view taken on line 9-9 of FIG. 1; and FIG. 10 is an exploded perspective view of a structure for connecting a pull rod to a cam follower.

[0011] Referring first to FIG. 1, there is shown a four-cycle horizontal opposed type engine E to be mounted on automobiles, motorcycles, aircraft, and the like. A main body 11 of the engine E includes a left engine block 12L disposed on the left side as seen from the rear side of the engine E and a right engine block 12R disposed on the right side as seen from the rear side of the engine E.

[0012] The left engine block 12L includes a left cylinder block 13L, a left crank case 14L formed integrally with the left cylinder block 13L, and a left cylinder head 15L connected to the side, opposite to the left crank case 14L, of the left cylinder block 13L. Similarly, the right engine block 12R includes a right cylinder block 13R, a right crank case 14R formed integrally with the right cylinder block 13R, and a right cylinder head 15R connected to the side, opposite to the right crank case 14R, of the right cylinder block 13R.

[0013] The cylinder block 13L (or 13R) has a cylinder bore 16L (or 16R). A piston 18L (or 18R) is slidably fitted in the cylinder bore 16L (or 16R) in such a manner as to form a combustion chamber 17L (or 17R) between the cylinder bore 16L (or 16R) and the cylinder head 15L (or 15R).

[0014] Both the engine blocks 12L and 12R are oppositely disposed with axial lines of the cylinder bores 16L and 16R kept substantially in the horizontal direction. The left and right crank cases 14L and 14R are fastened to each other to form a crank case 19 in cooperation with each other. A crank shaft 21 connected to the pistons 18L and 18R via connecting rods 20L and 20R is rotatably supported between the left and right crank cases 14L and 14R.

[0015] Referring to FIG. 2, the crank case 19 is provided with a front journal wall 22F, an intermediate journal wall 22M, and a rear journal wall 22R, which are spaced from each other in the longitudinal direction. Three portions, spaced from each other in the axial direction, of the crank shaft 21 are rotatably supported by these journal walls 22F, 22M and 22R. The crank shaft 21 is housed in a crank chamber 24 formed in the crank case 19, and a partition wall 25 defining the bottom of the crank chamber 24 is provided on the inner wall of the crank case 19.

[0016] A rear end portion (left end portion in FIG. 2) of the crank shaft 21 projects rearwardly from the rear journal wall 22R. A rotor 27 of a generator 26 is coaxially connected to the rear end portion of the crank shaft 21,

and a stator 28 of the generator 26 is disposed behind the rear journal wall 22R and is fixedly supported by a supporting plate 29 fixed to the crank case 19. A cover 30 for covering the generator 26 is fastened to a rear portion of the crank case 19.

[0017] A drive gear 31 is fixed to the crank shaft'21 at a position between the rear journal wall 22R and the supporting plate 29. A rotating shaft 33, to which a first intermediate gear 32 meshing with the drive gear 31, is rotatably supported by the rear journal wall 22R and the supporting plate 29. A second intermediate gear 34, which is integrally provided on the rotating shaft 33, meshes with a gear 35 provided on a cam shaft 36. The cam shaft 36 having an axial line parallel to the crank shaft 21 is rotatably supported by the crank case 19 at a position under the partition wall 25.

[0018] In this way, a power is transmitted from the crank shaft 21 to the cam shaft 36, at a reduction ratio of 1/2, via the drive gear 31, first intermediate gear 32, second intermediate gear 34, and gear 35.

[0019] A water pump 37 is mounted to the cover 30. A pump shaft 38 of the water pump 37 is coaxially connected to the rotating shaft 33 in such a manner as not to be rotated relative to the rotating shaft 33, whereby a rotational power is transmitted from the crank shaft 21 to the water pump 37.

[0020] Referring to FIGS. 3 and 4, an oil pan 42 is connected to a lower portion of the crank case 19 in such a manner as to form an oil reservoir chamber 43 under the cam shaft 36. An oil pump 44 configured as a trochoide pump is housed in the oil pan 42.

[0021] A pump housing 45 of the oil pump 44 is formed by connecting a pair of housing halves 46 and 47 to each other. A drive shaft 48 having an axial line parallel to the crank shaft 21 and the cam shaft 36 is rotatably supported by the housing half 46. The drive shaft 48 is connected to a rotor 49 disposed between both the housing halves 46 and 47.

[0022] A partition wall 46a is integrally provided on the housing half 46, whereby a power transmission chamber 50 partitioned from the oil reservoir chamber 43 formed in the oil pan 42 is formed between the partition wall 46a and a side wall of the oil pan 42. A gear 51 meshing with the gear 35 of the cam shaft 36 rotated by a power transmitted from the crank shaft 21 is fixed to an end portion, on the power transmission chamber 50 side, of the drive shaft 48. In this way, a rotational power is transmitted from the crank shaft 21 to the oil pump 44.

[0023] The partition wall 46a has an approximately U-shaped transverse cross-section opened upwardly. The upper end of the partition wall 46a is located at a position higher than an oil level L of oil reserved in the oil reservoir chamber 43, so that oil does not flow from the oil reservoir chamber 43 side to the power transmission chamber 50 side. On the other hand, although oil flows from the crank chamber 24 side into the power transmission chamber 50 via a gear train disposed in the power transmission route from the crank shaft 21 to the gear 51, the oil in the power transmission chamber 50 is splashed to the oil reservoir chamber 43 side across the upper end of the partition wall 46a by rotation of the gear 51.

[0024] A pair of boss-like mounting portions 52 are integrally provided on a portion, corresponding to the housing half 46, of the bottom of the oil pan 42 in such a manner as to project therefrom. The housing half 46 is removably mounted on the mounting portions 52 with bolts 53. Similarly, a pair of boss-like mounting portions 52 are integrally provided on a portion, corresponding to the housing half 47, of the bottom of the oil pan 42 in such a manner as to project therefrom. The housing half 47 is removably mounted on the mounting portions 52 with bolts 53. That is to say, the pump housing 45 is removably mounted on the mounting portions 52 provided on the bottom of the oil pan 42.

[0025] An inlet 54 is provided in the housing half 46 of the pump housing 45, and an oil strainer 55 connected to the inlet 54 is fixedly held between the housing half 46 and the oil pan 42. To be more specific, an upper portion of the oil strainer 55 is inserted from below in a lower portion of the housing half 46 in such a manner as to be continuous to the inlet 54, and a lower peripheral edge of the oil strainer 55 is received on a receiving portion 56 provided on the bottom of the oil pan 42.

[0026] An outlet 57 is provided in the housing half 47 of the pump housing 45, and a relief valve 58 connected to the outlet 57 is fixedly held between the housing half 47 and the oil pan 42 while being kept in a posture parallel to that of the oil strainer 55. To be more specific, an upper portion of the relief valve 58 is inserted from below in a lower portion of the housing half 47 in such a manner as to be continuous to the outlet 57, and a lower end of the relief valve 58 is received by a raised portion 59 provided on the bottom of the oil pan 42.

[0027] An oil passage 61 communicated to the outlet 57 is provided in the housing half 47. An oil passage 62 communicated to the oil passage 61 is provided in the lower portion of the oil pan 42 when the pump housing 45 is mounted to the oil pan 42. An oil filter 63 connected to the oil passage 62 is removably mounted to an outer surface of a side wall of the oil pan 42. An oil passage 64 for leading oil cleaned through the oil filter 63 is provided in both the oil pan 42 and the crank case 19, which passage is communicated to a main gallery 65 provided in the crank case 19.

[0028] A front portion of the crank shaft 21 is formed into a cylindrical hollow shape for reducing the weight of the crank shaft 21. A cylindrical spacer 66, having an annular chamber 67 formed between the inner surface of the crank shaft 21 and the outer surface of the spacer 66, is fitted in the cylindrical hollow portion of the crank shaft 21. The annular chamber 67 extends at least between portions corresponding to the front and intermediate journal walls 22F and 22M of the crank case 19. Both axial ends of the annular chamber 67 are fluid-tightly sealed by mounting seal members to both ends

of the spacer 66 or press-fitting both the ends of the spacer 66 in the crank shaft 21.

[0029] An oil passage 68 for supplying oil to a portion to be lubricated between the intermediate journal wall 22M and the crank shaft 21 is provided in the crank case 19 in such a manner as to be communicated to the main gallery 65. The crank shaft 21 has a passage hole 69 for leading the oil from the portion to be lubricated between the intermediate journal wall 22M and the crank shaft 21 to the annular chamber 67, and a passage hole 70 for leading oil from the annular chamber 67 to a portion to be lubricated between the front journal wall 22F and the crank shaft 21.

[0030] The crank shaft 21 integrally includes a crank pin 21L connected to the connecting rod 20L on the left engine block 12L side and a crank pin 21R connected to the connecting rod 20R on the right engine block 12R side. An oil passage 71 for leading the oil from the annular chamber 67 to a portion to be lubricated between the connecting rod 20L and the crank pin 21L is provided in the crank shaft 21. Oil is supplied from the main gallery 65 to a portion to be lubricated between the rear journal wall 22R and the crank shaft 21. An oil passage 72 for leading the oil from the portion to be lubricated between the rear journal wall 22R and the crank shaft 21 to a portion to be lubricated between the connecting rod 20R and the crank pin 21R is provided in the crank shaft 21.

[0031] By the way, in order to lead oil to the portion to be lubricated between the connecting rod 20L and the crank pin 21L, the entire cylindrical hollow portion of the crank shaft 21 can be used as an oil passage; however, in this case, since the volume of the oil passage becomes excessively large, there may occur inconveniences that a hydraulic pressure rising time upon start-up of the engine E be retarded and a residual amount of oil upon oil exchange be increased. From this viewpoint, according to this embodiment, since the annular chamber 67 formed between the cylindrical hollow portion of the crank shaft 21 and the spacer 66 is, as described above, used as the oil passage, the passage volume can be set to a suitable value, to prevent the retardation of the hydraulic pressure rising time and to prevent the increase in residual amount of oil upon oil exchange. Also, since the inside diameter of the cylindrical hollow portion of the crank shaft 21 can be set to a relatively large value without increasing the passage volume, it is not required to increase the accuracies of penetrating depths of the passage holes 69 and 70. Further, by making the spacer 66 from a material lighter in weight than that of the crank shaft 21, the entire crank shaft 21 can be made lighter in weight.

[0032] The oil, which has lubricated the portion to be lubricated between the connecting rod 20L and the crank pin 21L and the portion to be lubricated between the connecting rod 20R and the crank pin 21R, is dropped in the crank chamber 24 and is once accumulated on the partition wall 25. Oil through-holes 73 for leading the oil accumulated on the partition wall 25 to portions of the crank case 19 for supporting both ends of the cam shaft 36 are provided in the partition wall 25. As a result, the oil is supplied even to portions to be lubricated between the cam shaft 36 and the crank case 19.

[0033] Referring to FIGS. 5 and 6, a pair of intake valve ports 76 and a pair of exhaust valve ports 77 are provided in the cylinder head 15R of the right engine block 12R in such a manner as to be positioned on both sides of a first virtual plane 78 containing the axial line of the cylinder bore 16R and passing through the center of the combustion chamber 17R, and to face to the combustion chamber 17R. The first virtual plane 78 crosses an axial line C of the crank shaft 21 at an angle α on the projection plane perpendicular to the axial line of the cylinder bore 16R (parallel to the paper plane of FIG. 5).

[0034] Referring to FIGS. 7 and 8, a pair of ignition plugs 80 are mounted in the cylinder head 15R in such a manner that the end portions thereof project in the combustion chamber 17R, and that the axial lines thereof pass through the center of the combustion chamber 17R and are disposed on the first virtual plane 78.

[0035] Both the ignition plugs 80 are disposed symmetrically with respect to the second virtual plane 79 perpendicular to the first virtual plane 78, and are mounted in the cylinder head 15R in such a manner as to be tilted with a distance therebetween becoming smaller toward the combustion chamber 17R. The end portions, projecting in the combustion chamber 17R, of both the ignition plugs 80 are disposed in a region surrounded by both the intake valve ports 76 and both the exhaust valve ports 77.

[0036] Both the ignition plugs 80 are connected to an ignition circuit (not shown) and are usually operated in synchronization with each other by the ignition circuit.

[0037] Inner ends of plug insertion cylinders 81 in which the ignition plugs 80 are to be inserted are fixedly fitted in the cylinder head 15R, and outer ends of the plug insertion cylinders 81 are located in opening portions 83 formed in a head cover 82R fastened to the cylinder head 15R. Spaces between the outer ends of the plug insertion cylinders 81 and the head cover 82R are sealed.

[0038] A single intake port 84 commonly communicated to both the intake valve ports 76 and having its axial line disposed on the second virtual plane 79 is provided in the cylinder head 15R in such a manner as to be opened in an upper side surface of the cylinder head 15R. A single exhaust port 85 commonly communicated to both the exhaust valve ports 77 and having its axial line disposed on the second virtual plane 79 is provided in the cylinder head 15R in such a manner as to be opened in a lower side surface of the cylinder head 15R.

[0039] An intake pipe 74 is connected to the upper side surface of the cylinder head 15R in such a manner as to be communicated to the intake port 84, and a fuel injection valve 75R is additionally provided in the intake

pipe 74R.

[0040] Each of the intake valve ports 76 is openable/closable by an intake valve VI as a first engine valve. A valve stem 86 of the intake valve VI is slidably fitted in a guide cylinder 87 provided in the cylinder head 15R. The intake valve VI is elastically biased in the valve closing direction by a valve spring 89 provided between the cylinder head 15R and a retainer 88 fixed to an end, projecting from the guide cylinder 87, of the valve stem 86.

[0041] Each of the exhaust valve ports 77 is openable/closable by an exhaust valve VE as a second engine valve. A valve stem 90 of the exhaust valve VE is slidably fitted in a guide cylinder 91 provided in the cylinder head 15R. The exhaust valve VE is elastically biased in the valve closing direction by a valve spring 93 provided between the cylinder head 15R and a retainer 92 fixed to an end, projecting from the guide cylinder 91, of the valve stem 90.

[0042] Like the right cylinder head 15R, the left cylinder head 15L on the left engine block 12L side is provided with a pair of intake valves VI and a pair of exhaust valves VE, and also provided with a pair of ignition plugs. A head cover 82L is fastened to the cylinder head 15L, and an intake pipe 74L additionally provided with a fuel injection valve 75L is connected to an upper side surface of the cylinder head 15L.

[0043] The pair of the intake valves VI and the pair of the exhaust valves VE disposed in the right cylinder head 15R are opened/closed by a valve system 94R, and the pair of the intake valves VI and the pair of the exhaust valves VE disposed in the left cylinder head 15L are opened/closed by a valve system 94L. The configuration of the valve system 94R is the same as that of the valve system 94L, and therefore, only the configuration of the valve system 94R on the right cylinder head 15R side will be hereinafter described.

[0044] The valve system 94R includes a holder 97 which integrally includes cylindrical lifter housings 95 coaxial with valve stems 86 of both the intake valves VI and cylindrical lifter housings 96 coaxial with valve stems 90 of both the exhaust valves VE and which is fastened to the cylinder head 15R; an intake side rocker shaft 98 as a first rocker shaft and an exhaust side rocker shaft 99 as a second rocker shaft, which have axial lines parallel to each other and which are fixedly supported by the holder 97; an intake side rocker arm 100 as a first rocker arm rockably supported by the intake side rocker shaft 98 and an exhaust side rocker arm 101 as a second rocker arm rockably supported by the exhaust side rocker shaft 99; lifters 102 slidably fitted in the lifter housings 96 in such a manner as to be interposed between the intake rocker arm 100 and both the intake valves VI and lifters 103 slidably fitted in the lifter housings 97 in such a manner as to be interposed between the exhaust side rocker arm 101 and both the exhaust valves VE; the cam shaft 36 interlocked with the crank shaft 21 at a reduction ratio of 1/2; and a push rod 104 for imparting a valve opening force to the intake side rocker arm 100 according to the rotation of the cam shaft 36, and a pull rod 105 for imparting a valve opening force to the exhaust side rocker arm 101 according to the rotation of the cam shaft 36.

[0045] The intake side and exhaust side rocker shafts 98 and 99 are mounted to the cylinder head 15 in such a manner as to be disposed on both sides of the pair of ignition plugs 80. To be more specific, the intake side rocker shaft 98 is disposed between the pair of the intake valves VI, that is, the lifter housings 95 and both the ignition plugs 80, and the exhaust side rocker shaft 99 is disposed between the pair of exhaust valves VE, that is, the lifter housings 96 and both the ignition plugs 80. On the projection plane perpendicular to the axial line of the cylinder bore 16R (parallel to the paper plane of FIG. 7), postures of both the rocker shafts 98 and 99 are set such that axial lines thereof extend in parallel to the first virtual planes 78 on both sides of the first virtual plane 78 while crossing the axial line C of the crank shaft 21.

[0046] The lifter 102 (or 103) is formed into a cylindrical shape with its bottom closed, which has a diameter larger than an outside diameter of the valve stem 86 of the intake valve VI (or the valve stem 90 of the exhaust valve VE). The lifter 102 (or 103) is slidably fitted in the lifter housing 95 (or 96) with the closed end thereof directed to the rocker arm 101 (or 102) side. The closed end of the lifter 102 (or 103) has a plurality of through-holes 106 (or 107) arranged along a circular line for reducing the weight of the lifter 102 (or 103).

[0047] A pair of drive arms 100a and 100b extending to the lifters 102 are integrally provided on the intake side rocker arm 100. The leading ends of the drive arms 100a and 100b are in contact with the outer surfaces of the closed ends of the lifters 102 in order to impart drive forces for pressing the intake valves VI in the valve opening direction to the valve stems 86 of the intake valves VI via the lifters 102.

[0048] A pair of drive arms 100a and 100b extending to the lifters 103 are integrally provided on the exhaust side rocker arm 101. The leading ends of the drive arms 101a and 101b are in contact with the outer surfaces of the closed ends of the lifters 103 in order to impart drive forces for pressing the exhaust valves VE in the valve opening direction to the valve stems 90 of the exhaust valves VE via the lifters 103.

[0049] By the way, according to this embodiment, to adjust a tappet clearance, as shown in FIG. 6, a shim 121 is held between the valve stem 86 and the lifter 102 and a shim 122 is held between the valve stem 90 and the lifter 103. In place of the shim 121 (or 122), a tappet screw screwed in the leading end of the drive arm 100a (or 100b, 101a, or 101b) in such a manner as to be adjustable in its forward or backward movement position may be brought into contact with the lifter 102 (or 103).

[0050] An oil passage 108 to which the oil is lead from the oil pump 44 is provided in both the cylinder head 15R and the holder 97 connected to the cylinder head

15R. An oiling hole 109, which is communicated to the oil passage 108 and to annular recesses 110 and 111 provided in inner surfaces of the lifter housings 95 and 96, is provided in the holder 97 and in the lifter housings 95 and 96.

[0051] Referring to FIG. 9, the cam shaft 36 disposed under the crank shaft 21 is provided with an intake side cam 112R corresponding to the intake valves VI on the right engine block 12R side, an intake side cam 112L corresponding to the intake valves VI on the left engine block 12L side, an exhaust side cam 113R corresponding to the exhaust valves VE on the right engine block 12R side, and an exhaust side cam 113L corresponding to the exhaust valves VE on the left engine block 12L side.

[0052] Cam followers 114R and 114L following the intake side cams 112R and 112L and cam followers 115R and 115L following the exhaust side cams 113R and 113L are rockably supported by the crank case 19. The cam followers 114R and 115L are disposed on the right engine block 12R side with respect to the cam shaft 36, and are rockably supported by a common supporting shaft 118 mounted to the crank case 19. The cam followers 114L and 115R are disposed on the left engine block 12L side with respect to the cam shaft 36 and are rockably supported by a common supporting shaft 119 mounted to the crank case 19.

[0053] Referring to FIG. 7, input arms 100c and 101c extending, on the projection plane perpendicular to the axial line of the cylinder bore 16R, from the intake side rocker arm 100 and the exhaust side rocker arm 101 to the cam shaft 36 side (lower side of FIG. 7), are provided on the rocker arms 100 and 101, respectively. The input arm 100c of the intake side rocker arm 100 is connected to the cam follower 114R by means of a push rod 104, and the input arm 101c of the exhaust side rocker arm 101 is connected to the cam follower 115R by means of the pull rod 105. The push rod 104 acts, upon movement thereof in the direction opposite to the cam shaft 36, to push up the input arm 100c for rocking the intake side rocker arm 100 in the valve opening direction. The pull rod 105 acts, upon movement thereof on the cam shaft 36 side, to pull the input arm 101c for rocking the exhaust side rocker arm 101 in the valve opening direction.

[0054] A rod chamber 120 extending from the crank case 19 to both the cylinder heads 15R and 15L is formed under the engine main body 11. The push rod 104 and the pull rod 105 are contained and disposed in the rod chamber 120. In addition, since the tensile strength of a material for forming both the rods 104 and 105 is higher than the compression strength thereof, the diameter of the pull rod 105 is set to be smaller than that of the push rod 104.

[0055] Spherical portions 104a and 104b are provided on both ends of the push rod 104. The spherical portion 104a at one end of the push rod 104 is swingably received on the cam follower 114R, and the spherical portion 104b at the other end of the push rod 104 is swingably received on the leading end of the input arm 100c provided on the intake side rocker arm 100.

[0056] As shown in FIG. 10, an approximately U-shaped fork 116 opened to the side opposite to the cam shaft 36 is integrally provided on the cam follower 115R, and a pin 123 fixed in one end of the pull rod 105 by press-fitting or the like is engaged with the fork 116. Further, an approximately U-shaped fork 117 opened on the side opposite to the cam shaft 36 is integrally provided on the leading end of the input arm 101c provided on the exhaust side rocker arm 101, and a pin 124 fixed in the other end of the pull rod 105 is engaged with the fork 117. With this configuration, since both the ends of the pull rod 105 can be connected to the input arm 101c provided on the exhaust side rocker arm 101 and the cam follower 115R only by engaging both the ends of the pull rod 105 with the forks 116 and 117, one end of the pull rod 105 can be connected to the cam follower 115R from the cylinder head 15R side without disassembly of the oil pan 42, with a result that the workability upon maintenance work can be improved.

[0057] The function of this embodiment will be described below. Since the pump housing 45 of the oil pump 44 for supplying lubricating oil to various portions of the engine E is removably mounted on the mounting portions 52 provided on the bottom of the oil pan 42 connected to the lower portion of the crank case 19, it is possible to set the oil pump 44 at a relatively low position in the engine E, and hence to lower the center of gravity of the engine E and to improve the suction efficiency and maintenance performance of the oil pump 44.

[0058] Since the oil strainer 55 connected to the inlet 54 of the oil pump 44 is fixedly held between the oil pan 42 and the pump housing 45, it is possible to fix the oil strainer 55 between the oil pan 42 and the pump housing 45 without use of parts specialized for fixture thereof such as bolts, and hence to reduce the number of parts and the number of assembling steps. Further, since an oil suction passage between the inlet 54 of the oil pump 44 and the oil strainer 55 can be shortened, the pumping loss of the oil pump 44 can be reduced.

[0059] Since the relief valve 58 connected to the outlet 57 of the oil pump 44 is fixedly held between the oil pan 42 and the pump housing 45 while being kept in a posture parallel to that of the oil strainer 55, the relief valve 58 can be disposed by making effective use of a space which is formed on a side of the oil strainer 55 by holding the oil strainer 55 between the pump housing 45 and the oil pan 42. Also, since the relief valve is directly connected to the pump housing 45 of the oil pump 44, it is possible to shorten and simplify the oil discharge passage composed of the oil passages 61 and 62 extending from the oil filter 63 mounted on the outer surface of the side wall of the oil pan 42 to the oil pump 44. Further, since a relief port of the relief valve 58 can be easily set in oil in the oil pan 42, it is possible to prevent the oil from being bubbled.

[0060] By the way, the partition wall 46a forming the

power transmission chamber 50, which is partitioned from the oil reservoir chamber 43 formed in the oil pan 42, between the side wall of the oil pan 42 and the partition wall 46a, is formed on the housing half 46 constituting part of the pump housing 45, and the gear 51 rotated by a power transmitted from the crank shaft 21 is fixed to the end portion, on the power transmission chamber 50 side, of the drive shaft 48 rotatably supported by the pump housing 45. Accordingly, since the gear 51 rotated for transmitting a power from the crank shaft 21 to the drive shaft 48 does not agitate the oil reserved in the oil reservoir chamber 43 in the oil pan 42, it is possible to prevent the occurrence of friction loss and oil mist due to agitation of the oil.

[0061] The lifter 102 (or 103) formed into a cylindrical shape with its bottom closed, which has a diameter larger than that of the valve stem 86 (or 90) is interposed between the valve stem 86 of the intake valve VI (or the valve stem 90 of the exhaust valve VE) and the intake side rocker arm 100 (or exhaust side rocker arm 101) rocked in interlocking with the rotation of the cam shaft 36; and the lifter 102 (or 103) is slidably fitted in the cylindrical lifter housing 95 (or 96) which is integrally provided on the holder 97 fixed to the cylinder heads 15R and 15L and which is coaxial with the valve stem 86 (or 90).

[0062] With this configuration, a drive force from the intake side rocker arm 100 (or the exhaust side rocker arm 101) is applied to the valve stem 86 of the intake valve VI (or the valve stem 90 of the exhaust valve VE) via the lifter 102 (or 103), so that a bending load is not applied to the valve stem 86 (or 90) having a relatively small diameter. As a result, it is possible to prevent the occurrence of partial wear, galling, and the like in the guide cylinder 87 (or 91). Further, since the lifter 102 (or 103) has a relatively large diameter, even if a bending load is applied from the intake side rocker arm 100 (or exhaust side rocker arm 101), it is possible to minimize the occurrence of partial wear, galling, and the like between the lifter housing 95 (or 96) and the lifter 102 (or 103), and hence to improve the reliability of the valve systems 94R and 94L.

[0063] Since the oiling hole 109 opened in the inner surfaces of the lifter housings 95 and 96 are provided in the holder 97 and in the lifter housings 95 and 96, it is possible to make the sliding motion of the lifter 102 (or 103) in the lifter housing 95 (or 96) smoother, and hence to more certainly prevent the occurrence of partial wear, galling, and the like between the lifter housing 95 (or 96) and the lifter 102 (or 103).

[0064] In this case, if a point of the lifter 102 (or 103), to which a drive force is applied from the intake side rocker arm 100 (or 101), is offset from the center of the lifter 102 (or 103), the lifter 102 (or 103) can be rotated around its axial line and correspondingly the intake valve VI (or exhaust valve VE) can be rotated, to thereby prevent the occurrence of seize on one side of the intake valve VI (or exhaust valve VE). From this viewpoint, according to this embodiment, the intake valve VI (or exhaust valve VE) can be easily rotated by smoothly sliding the lifter 102 (or 103) in the lifter housing 95 (or 96).

[0065] The pair of the intake valve ports 76 and the pair of the exhaust valve ports 77 are provided in the cylinder head 15R (or 15L) in such a manner as to be located on both the sides of the first virtual plane 78 containing the axial line of the cylinder bore 16R (or 16L) and passing through an approximately center of the combustion chamber 17R (17L) and to face to the combustion chamber 17R (17L); and the pair of the ignition plugs 80 are mounted in the cylinder head 15R (or 15L). Both the ignition plugs 80, which are approximately symmetrical with respect to the second virtual plane 79 passing through the center of the combustion chamber 17R (or 17L) and being perpendicular to the first virtual plane 78, are disposed in the cylinder head 15R (or 15L) in such a manner that the axial lines thereof extend substantially along the first virtual plane 78 and that they are tilted with a distance therebetween becoming smaller toward the combustion chamber 17R (or 17L). The ends, projecting in the combustion chamber 17R (or 17L), of the ignition plugs 80 are disposed in the region surrounded by both the intake valve ports 76 and both the exhaust valve ports 77.

[0066] With this configuration, since the ends, projecting in the combustion chamber 17R (or 17L), of the pair of ignition plugs 80 are disposed in proximity to an approximately central portion in the combustion chamber 17R (or 17L), it is possible to ideally propagate flame in the combustion chamber 17R (or 17L), and further, even if there occurs accidental fire in either of both the ignition plugs 80, since the other ignition plug 80 is located at the approximately central portion of the combustion chamber 17R (or 17L), it is possible to minimize the deterioration of the flame propagation condition.

[0067] Since both the ignition plugs 80 are disposed, as seen from the direction perpendicular to the first virtual plane 78, in an approximately V-shape opened in the direction opposite to the combustion chamber 17R (or 17L), both the ignition plugs 80 can be easily mounted in the cylinder head 15R (or 15L) with the ends, projecting in the combustion chamber 17R (or 17L), of the ignition plugs 80 allowed to be disposed in proximity to an approximately central portion of the combustion chamber 17R (or 17L).

[0068] Since both the ignition plugs 80 are collectively disposed in the vicinity of the central portion of the combustion chamber 17R (or 17L), it is possible to enhance the degree of freedom of the shape of a water jacket on the cylinder head 15R (or 15L) side and the degree of freedom of disposition of fastening bolts for fastening the cylinder head 15R (or 15L) to the cylinder block 13R (or 13L), and hence to improve the sealing performance between the cylinder head 15R (or 15L) and the cylinder block 13R (or 13L) as well as improve the cooling performance.

[0069] The intake side and exhaust side rocker arms

100 and 101 are rockably supported by the intake side and exhaust side rocker shafts 98 and 99 having the axial lines extending along the first virtual plane 78, which plane contains the axial line of the cylinder bore 16R and passes through the center of the combustion chamber 17R, and which plane crosses the axial line of the crank shaft 21 at the angle α on the projection plane perpendicular to the axial line of the cylinder bore 16R; and the intake side and exhaust side rocker shafts 98 and 99 are mounted to the cylinder head 15R (or 15L) in such a manner as to be disposed on both the sides of both the ignition plugs 80. With this configuration, it is possible to set the width of the cylinder head 15R (or 15L) at a relatively small value in the direction along the second virtual plane 79, and hence to contribute to compactness of the engine E.

[0070] The input arm 101c extending, on the projection plane perpendicular to the axial line of the cylinder bore 16R (or 16L), from the rocker arm 101 to the cam shaft 36 side is provided on the exhaust side rocker arm 101, and the pull rod 105 reciprocating in the axial direction according to the rotation of the cam shaft 36 is connected to the input arm 101c in order to rock the exhaust side rocker arm 101 in the valve opening direction when the pull rod 105 is moved to the cam shaft 36 side. With this configuration, it is not required to enlarge the width of the cylinder head 15R (15L) in the direction along the axial line of the crank shaft 21 for disposing the pull rod 105, and hence to reduce the size and weight of the engine E in the direction along the axial line of the crank shaft 21.

[0071] The input arm 100c extending, on the projection plane perpendicular to the axial line of the cylinder bore 16R (or 16L), from the rocker arm 101 to the cam shaft 36 side is provided on the intake side rocker arm 100, and the push rod 104 reciprocating in the axial direction according to the rotation of the cam shaft 36 is connected to the input arm 100c in order to rock the intake side rocker arm 100 in the valve opening direction when the push rod 104 is moved to the cam shaft 36 side.

[0072] According to the configuration in which the intake and exhaust side rocker shafts 98 and 99 and the intake side and exhaust side rocker arms 100 and 101 are disposed as described above and also an opening/closing force is imparted to the intake side rocker arm 100 by the pull rod 105 and an opening/closing force is imparted to the exhaust side rocker arm 101 by the push rod 104, the space in the simulator 15R (or 15L), which space is necessary for disposing the rocker shafts 98 and 99 and the rocker arms 100 and 101 constituting parts of the valve system 94R (or 94L) can be made small in the direction along the axial line of the crank shaft 21.

[0073] Further, it is not required to enlarge the width of the cylinder head 15R (or 15L) in the direction along the axial line of the crank shaft 21 for disposing the pull rod 105 and the push rod 104, so that a drive system between the cam shaft 36 and both the rocker arms 100 and 101 can be disposed in good balance. This makes it possible to reduce the size and weight of the engine E in the direction along the axial line of the crank shaft 21.

[0074] Since the pair of the intake valves VI and the pair of the exhaust valves VE are disposed in the cylinder head 15R (or 15L) in such a manner as to face the combustion chamber 17R (or 17L), it is possible to improve the suction efficiency and thereby increase the output torque in a low speed rotational range of the engine E.

[0075] FIG. 11 shows another embodiment of the present invention. A spherical portion 105a is provided at one end of a pull rod 105, and an engagement portion 126 formed into a bowl shape having a slit 127 allowing the insertion of the pull rod 105 is provided on a cam follower 115R to be connected to the one end of the pull rod 105. The one end of the pull rod 105 is connected to the cam follower 115R by engaging the spherical portion 105a with the engagement portion 126.

[0076] Even in this embodiment, since the one end of the pull rod 105 can be connected to the cam follower 115R from the cylinder head 15R side without disassembly of the oil pan 42, it is possible to improve the workability upon maintenance work.

[0077] While the preferred embodiments have been described as described above, the present invention is not limited thereto, and it is to be understood that various changes in design may be made without departing from the scope of the claims.

[0078] For example, the present invention can be widely applied to engines other than the horizontal opposed type two-cylinder engine.

[0079] As described above, according to the invention described in claim 1, a space required to be formed for disposing the rocker shaft, the rocker arm, and the like constituting part of the valve system can be set to be smaller in the direction along the axial line of the crank shaft. Further, since it is not required to enlarge the width of the cylinder head in the direction along the axial line of the crank shaft for disposing the pull rod, it is possible to reduce the size and weight of the engine in the direction along the axial line of the crank shaft.

[0080] According to the invention described in claim 2, it is possible to improve the suction efficiency and increase the output torque in a low speed rotational range. Also, a space required to be formed in the cylinder head for disposing the first and second rocker shafts, the first and second rocker arms, and the like constituting part of the valve system can be set to be smaller in the direction along the axial line of the crank shaft. Further, since it is not required to enlarge the width of the cylinder head in the direction along the axial line of the crank shaft for disposing the pull rod and the push rod, a drive system between the cam shaft and both the rocker arms can be disposed in good balance, with a result that it is possible to reduce the size and weight of the engine in

the direction along the axial line of the crank shaft.

[0081] In summary it is an object to provide a valve system for an engine, in which a rocker arm interlocked with an engine valve is supported on a rocker shaft fixedly mounted to a cylinder head in such a manner as to be rockable according to the rotation of a cam shaft, characterized by realizing the reduction in size and weight of the engine.

To achieve this, the posture of a rocker shaft 99 is set to have an axial line crossing an axial line of a crank shaft on the projection plane perpendicular to an axial line of a cylinder bore. A rocker arm 101 rockably supported by the rocker shaft 99 is provided with an input arm 101c extending, on the above projection plane, from the rocker arm 101 to the cam shaft side, and a pull rod 105 reciprocating in the axial direction according to the rotation of the cam shaft is connected to the input arm 101c.

Claims

1. A valve system for an engine, in which a crank shaft (21) is rotatably supported by a crank case (19) in such a manner as to be connected to a piston (18R, 18L) slidably fitted in a cylinder bore (16R, 16L); a cam shaft (36) having an axial line parallel to an axial line of said crank shaft (21) is interlocked with said crank shaft (21) at a reduction ratio of 1/2; and a rocker arm (101) interlocked with engine valves (VE) is supported by a rocker shaft (99) fixedly supported by a cylinder head (15R, 15L) in such a manner as to be rockable according to the rotation of said cam shaft (36); **characterized in that**

said cam shaft (36) disposed on one side of said crank shaft (21) is rotatably supported by said crank case (19);

the posture of said rocker shaft (99) is set to have an axial line crossing the axial line of said crank shaft (21) on the projection plane perpendicular to an axial line of said cylinder bore (16R, 16L);

an input arm (101c) extending, on said projection plane, from said rocker arm (101) to said cam shaft (36) side is provided on side said rocker arm (101) rockably supported by said rocker shaft (99); and

a pull rod (105) reciprocating in the axial direction according to the rotation of said cam shaft (36) is connected to said input arm (101c) in order to rock said rocker arm (101) in the valve opening direction when said pull rod (105) is moved to said cam shaft (36) side.

2. A valve system for an engine, in which a crank shaft (21) is rotatably supported by a crank case (19) in such a manner as to be connected to a piston (18R, 18L) slidably fitted in a cylinder bore (16R, 16L); a cam shaft (36) having an axial line parallel to an axial line of said crank shaft (21) is interlocked with said crank shaft (21) at a reduction ratio of 1/2; and a first rocker arm (100) interlocked with first engine valves (VI) and a second rocker arm (101) interlocked with second engine valves (VE) different in kind from said first engine valves (VI) are respectively supported by a first rocker shaft (98) and a second rocker shaft (99), which are fixedly supported by a cylinder head (15R, 15L), in such a manner as to be rockable according to the rotation of said cam shaft (36), **characterized in that**

said cam shaft (36) disposed on one side of said crank shaft (21) is rotatably supported by said crank case (19);

said first rocker arm (100) corresponding to a pair of said first engine valves (VI) and said second rocker arm (101) corresponding to a pair of said second engine valves (VE) are disposed in said cylinder head (15R, 16L) in such a manner as to face a combustion chamber (17R, 17L), and are rockably supported by said first rocker shaft (98) and said second rocker shaft (99), respectively, said first and second rocker shafts (98) and (99) having axial lines crossing the axial line of said crank shaft (21) on the projection plane perpendicular to an axial line of said cylinder bore (16R, 16L) and being disposed in parallel to each other;

an input arm (100c) and an input arm (101c) extending, on said projection plane, from said first rocker arm (100) and said second rocker arm (101) to said cam shaft (36) side are provided on said first rocker arm (100) and said second rocker arm (101), respectively;

a push rod (104) reciprocating in the axial direction according to the rotation of said cam shaft (36) is connected to said input arm (100c) of said first rocker arm (100) in order to rock said first rocker arm (100) in the valve opening direction when said push rod (104) is moved on the side opposite to said cam shaft (36); and

a pull rod (105) reciprocating in the axial direction according to the rotation of said cam shaft (36) is connected to said input arm (101c) of said second rocker arm (101) in order to rock said second rocker arm (101) in the valve opening direction when said pull rod (105) is moved on said cam shaft (36) side.

FIG. 1

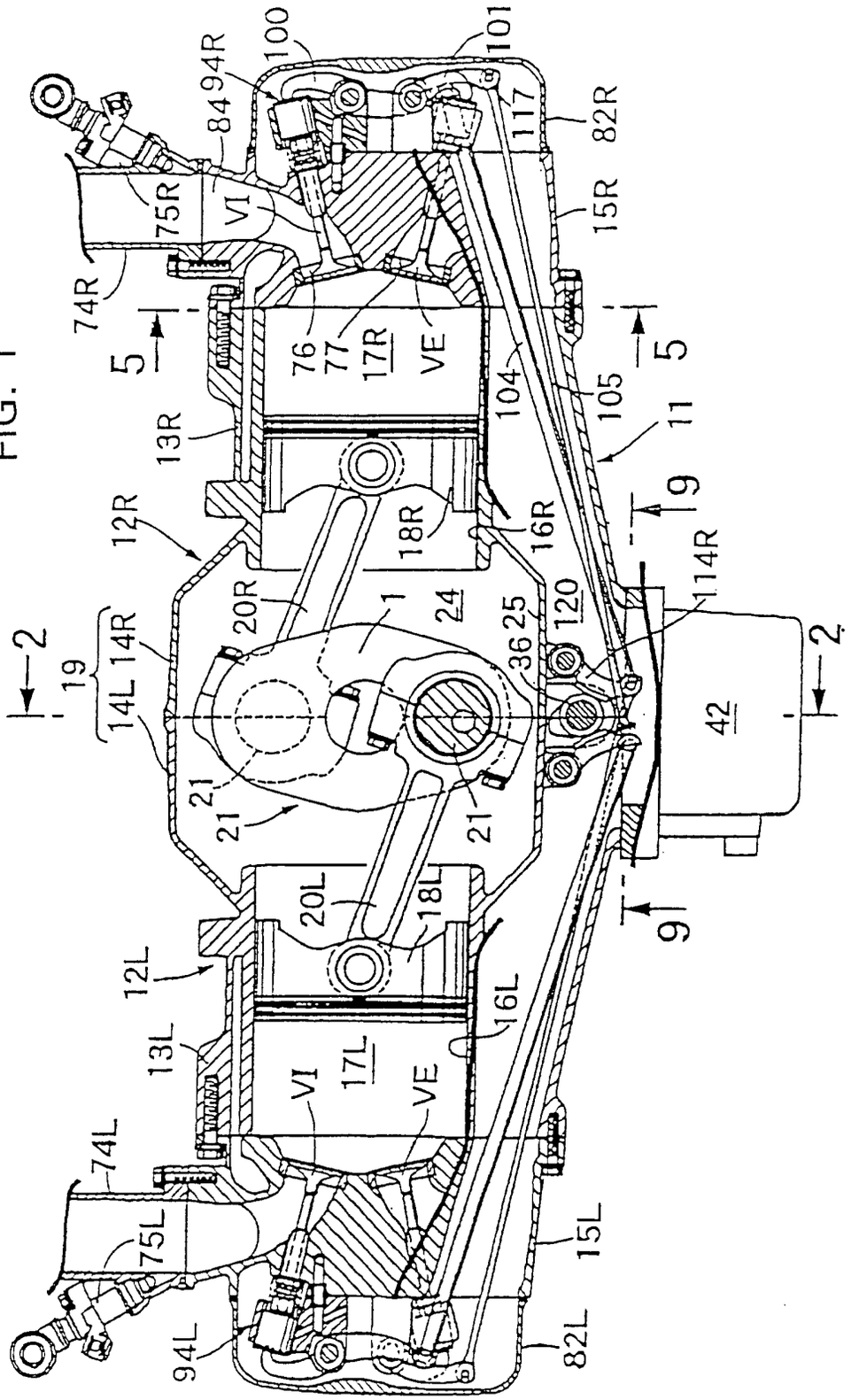

100
101
94R
84
117
82R
75R
VI
15R
74R
5
76
77
17R
VE
104
105
11
13R
9
12R
18R
16R
114R
20R
1
24
120
25
36
2
19
14R
14L
42
21
20L
18L
12L
16L
13L
17L
74L
75L
15L
94L
82L

FIG. 2

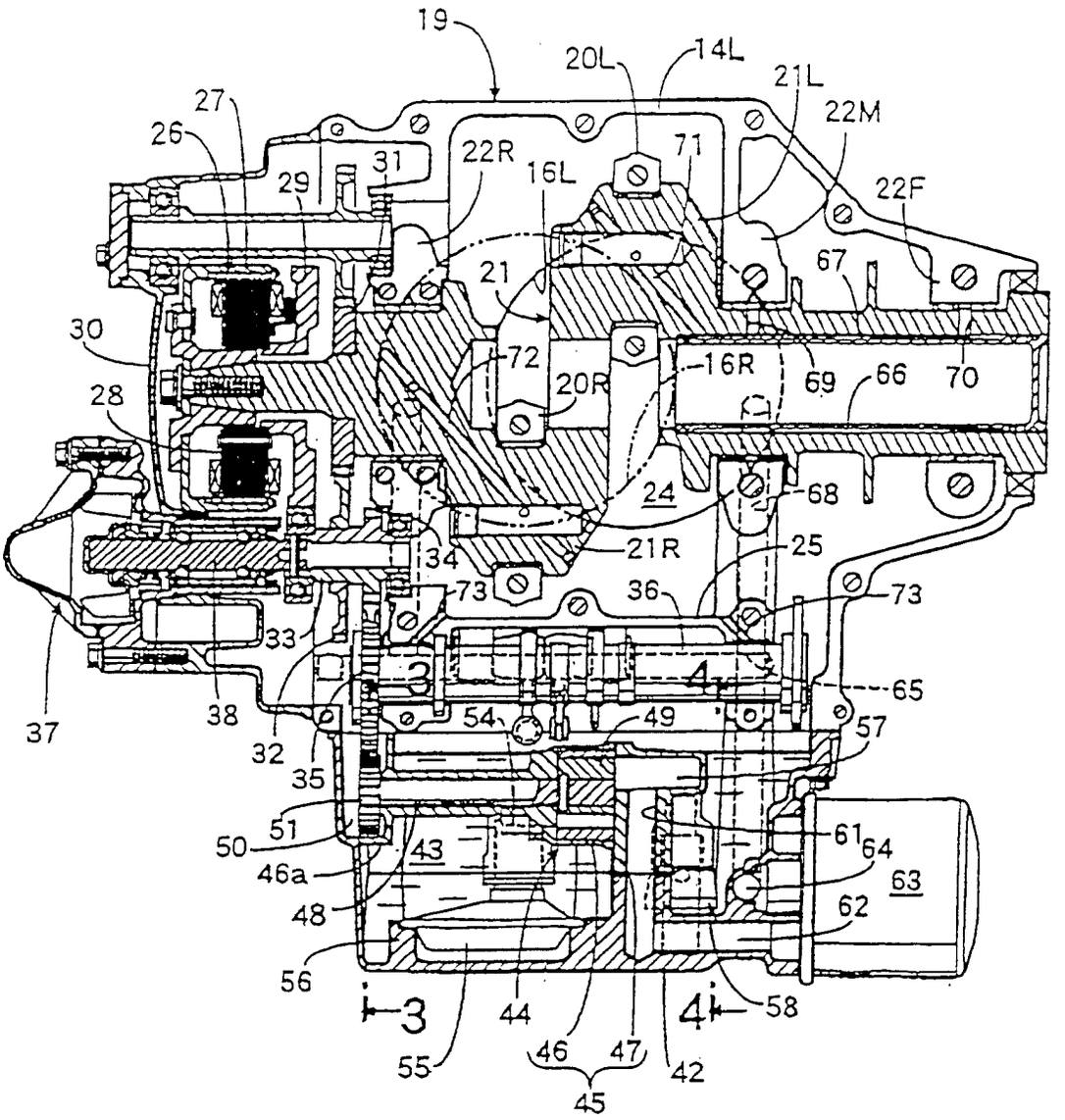

19
20L
14L
21L
22M
27
26
31
22R
16L
71
29
22F
67
21
30
72
16R
69
66
70
20R
28
24
68
34
21R
25
73
36
73
33
3
4
65
37
38
54
49
57
32
35
51
50
43
61
64
46a
63
48
62
56
3
44
4
58
55
46
47
42
45

FIG. 3

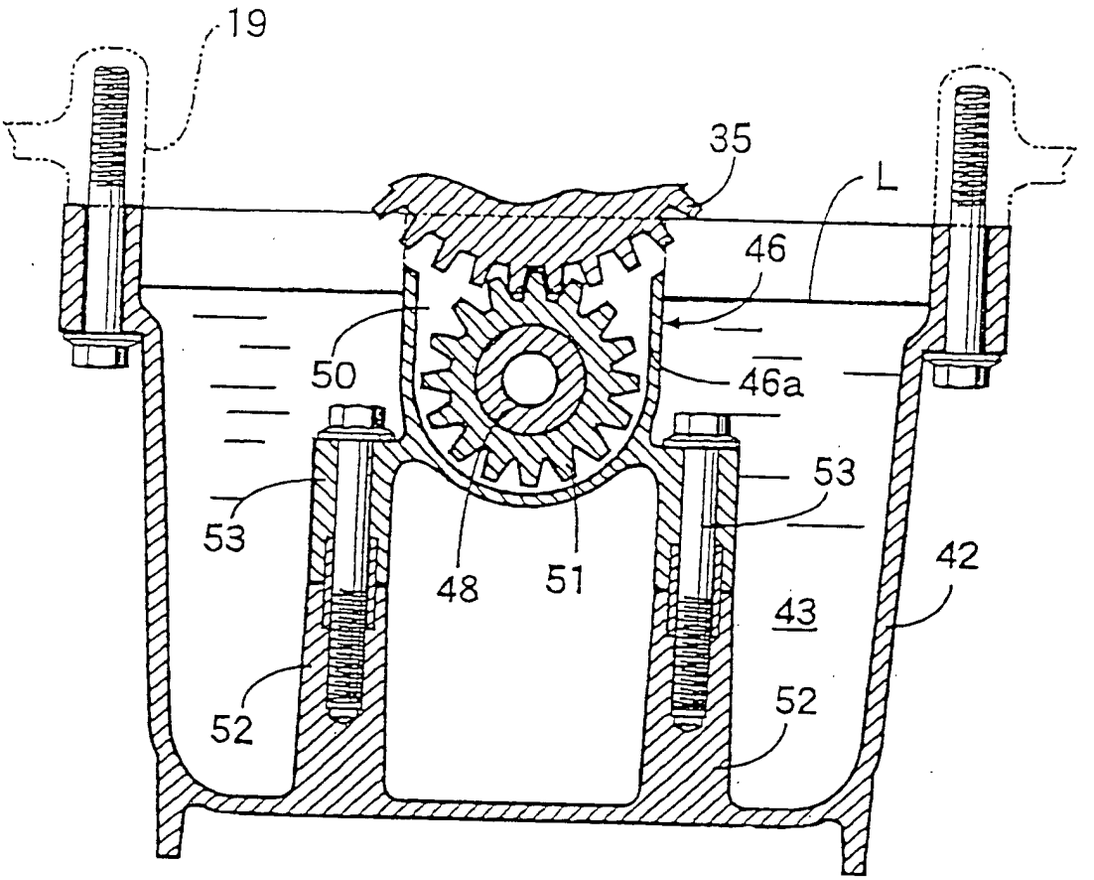
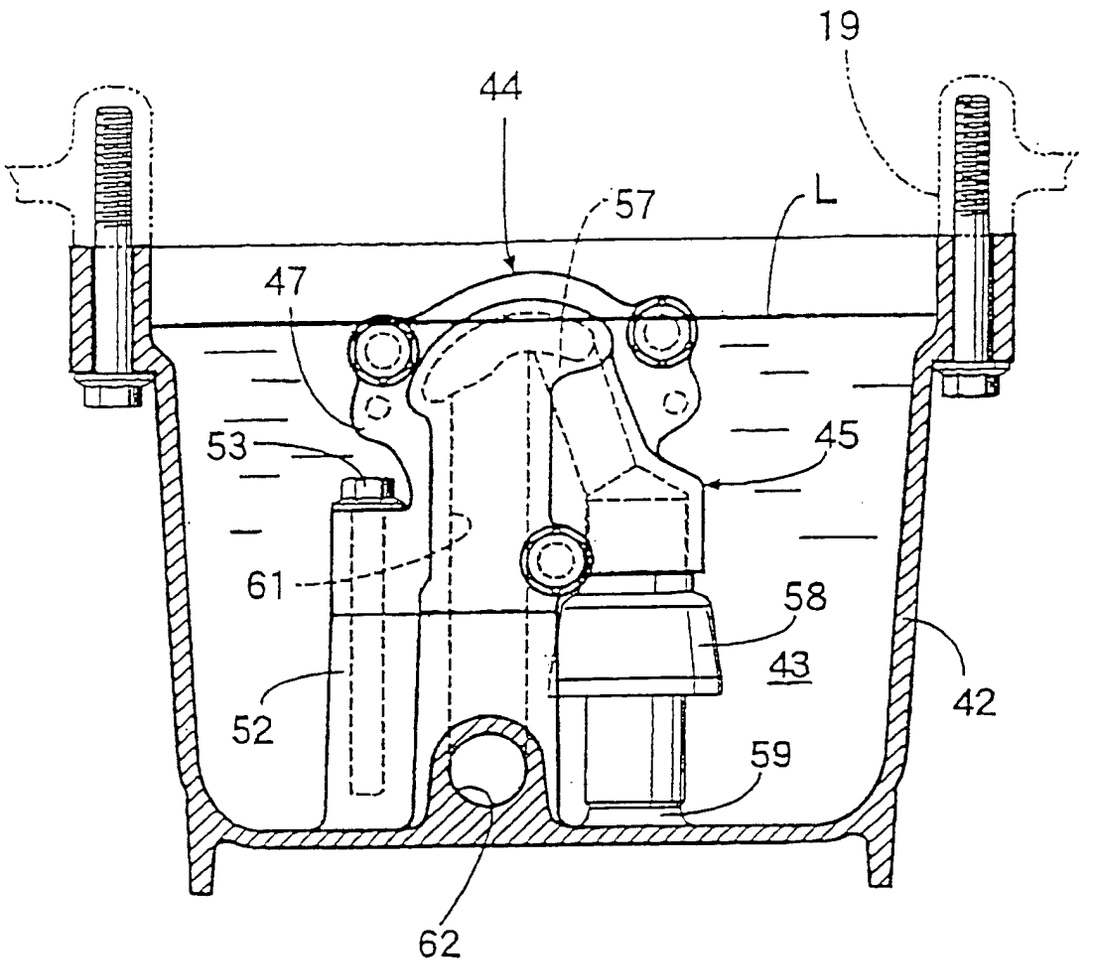


FIG. 4



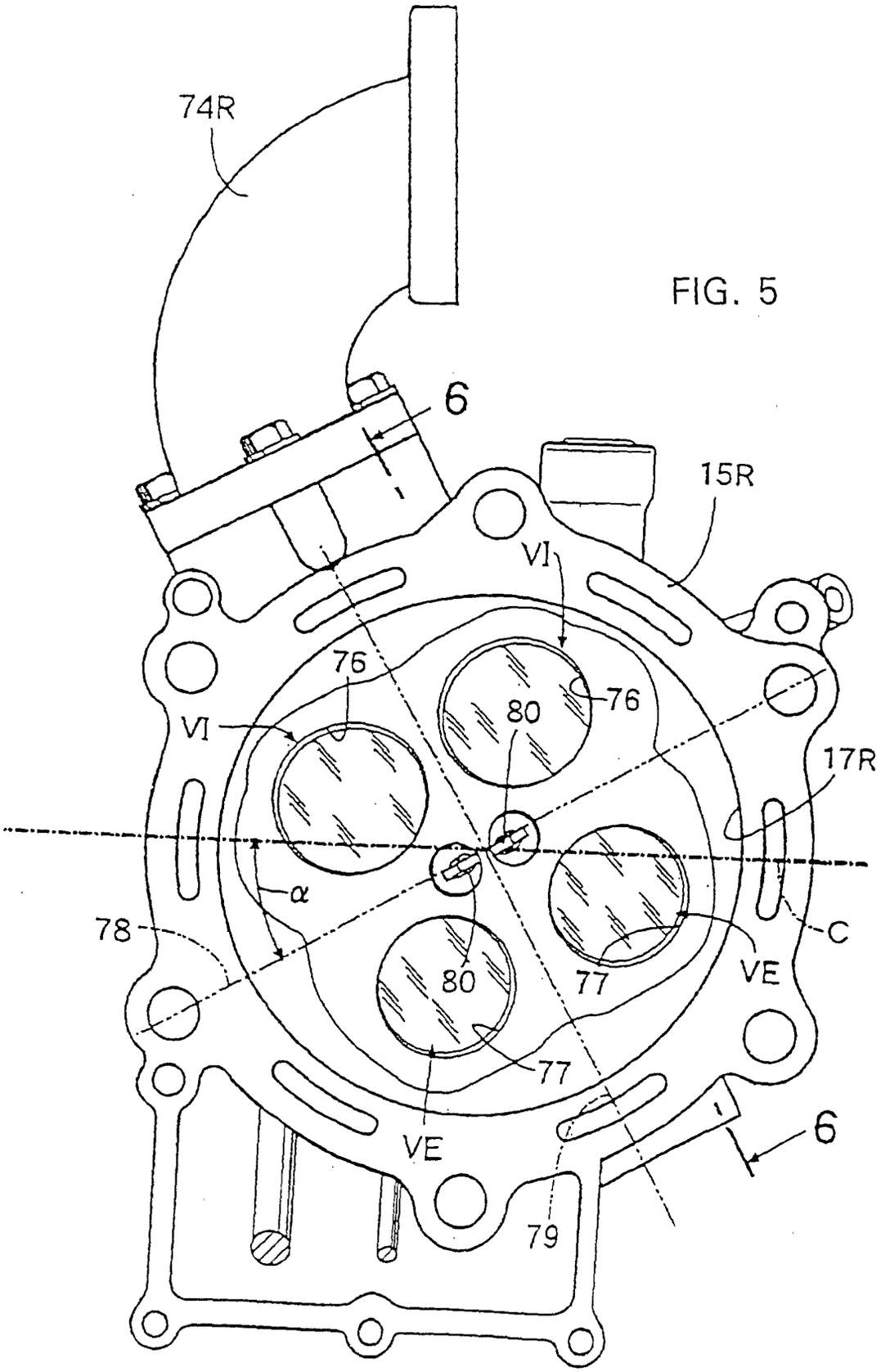


FIG. 5

FIG. 6

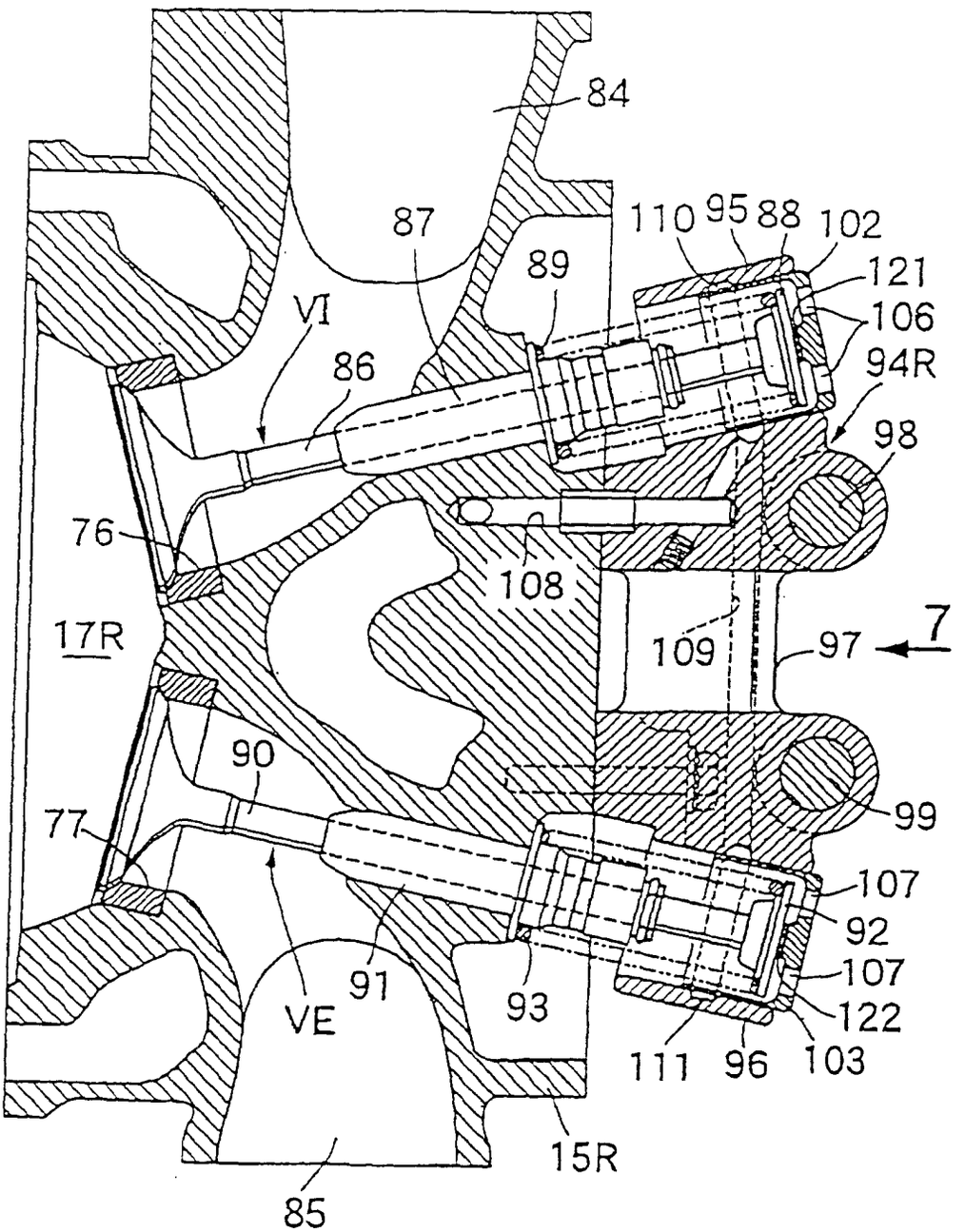

84
87
110
95
88
102
121
89
106
VI
86
94R
98
76
108
17R
109
97
7
90
99
77
107
92
91
93
107
VE
122
111
96
103
15R
85

FIG. 7

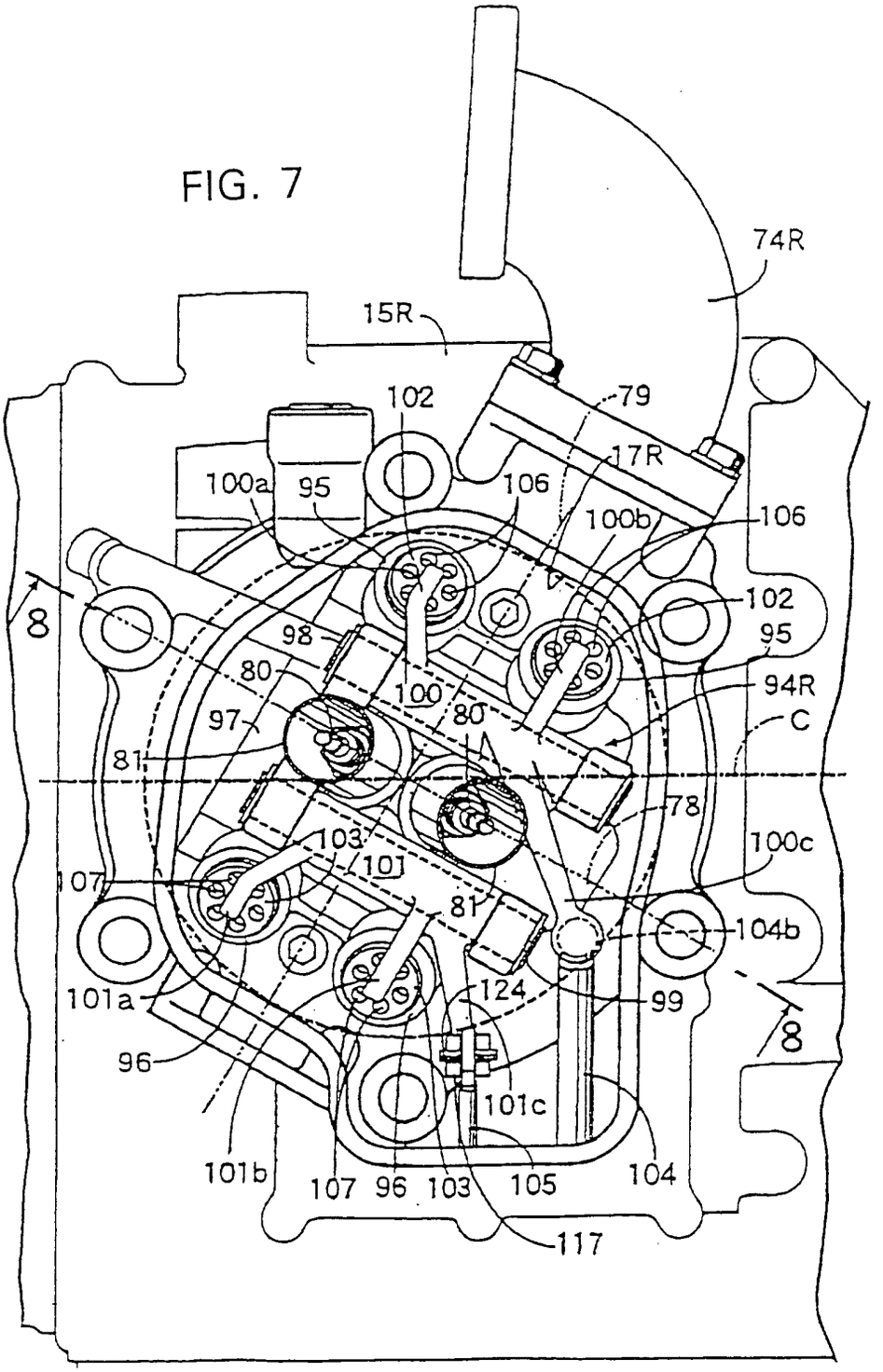

74R
15R
102
79
17R
100a
95
106
100b
106
102
95
94R
C
98
80
100
80
97
81
78
103
101
100c
107
81
104b
124
99
101a
96
101c
101b
107
96
103
105
104
117
8
8

FIG. 8

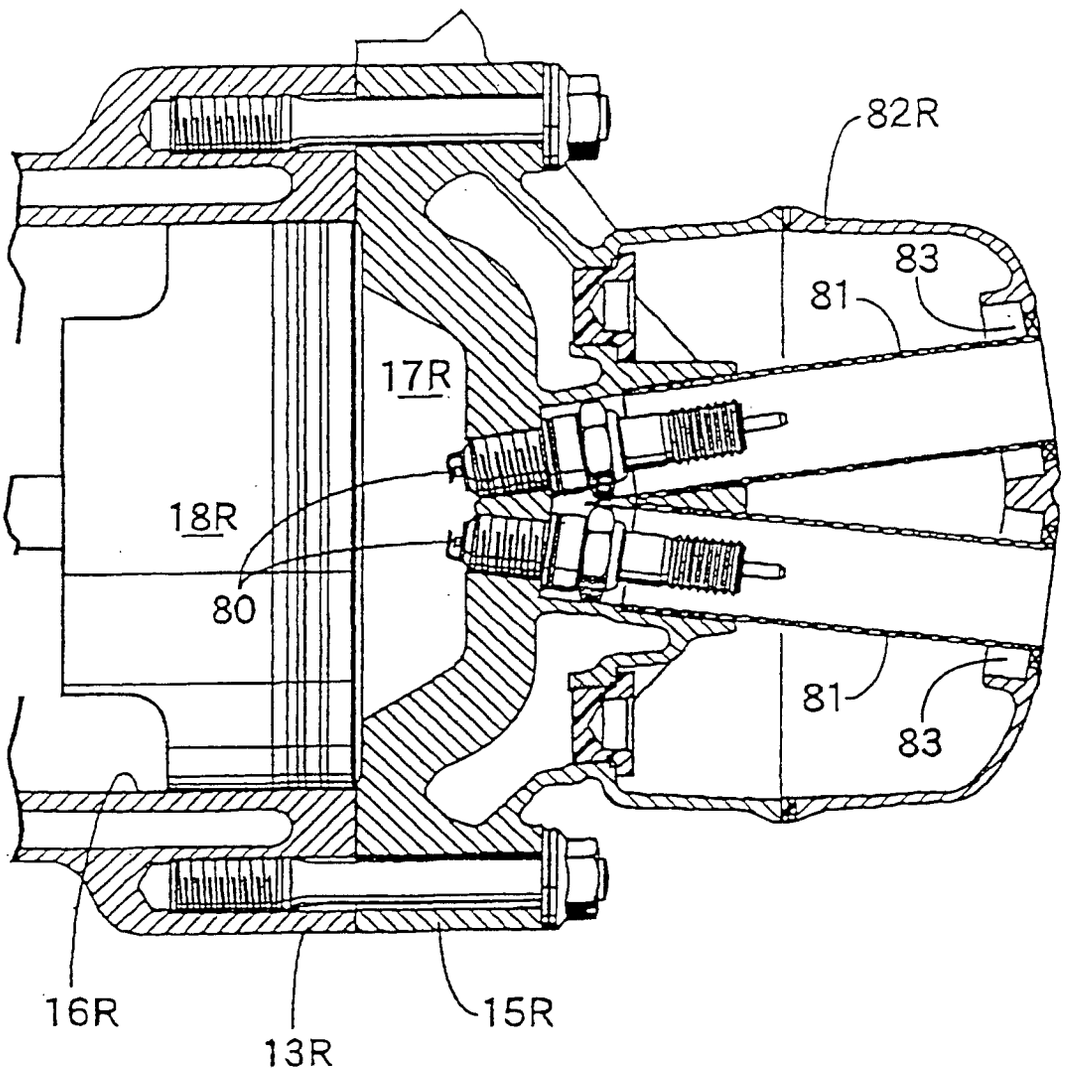


FIG. 9

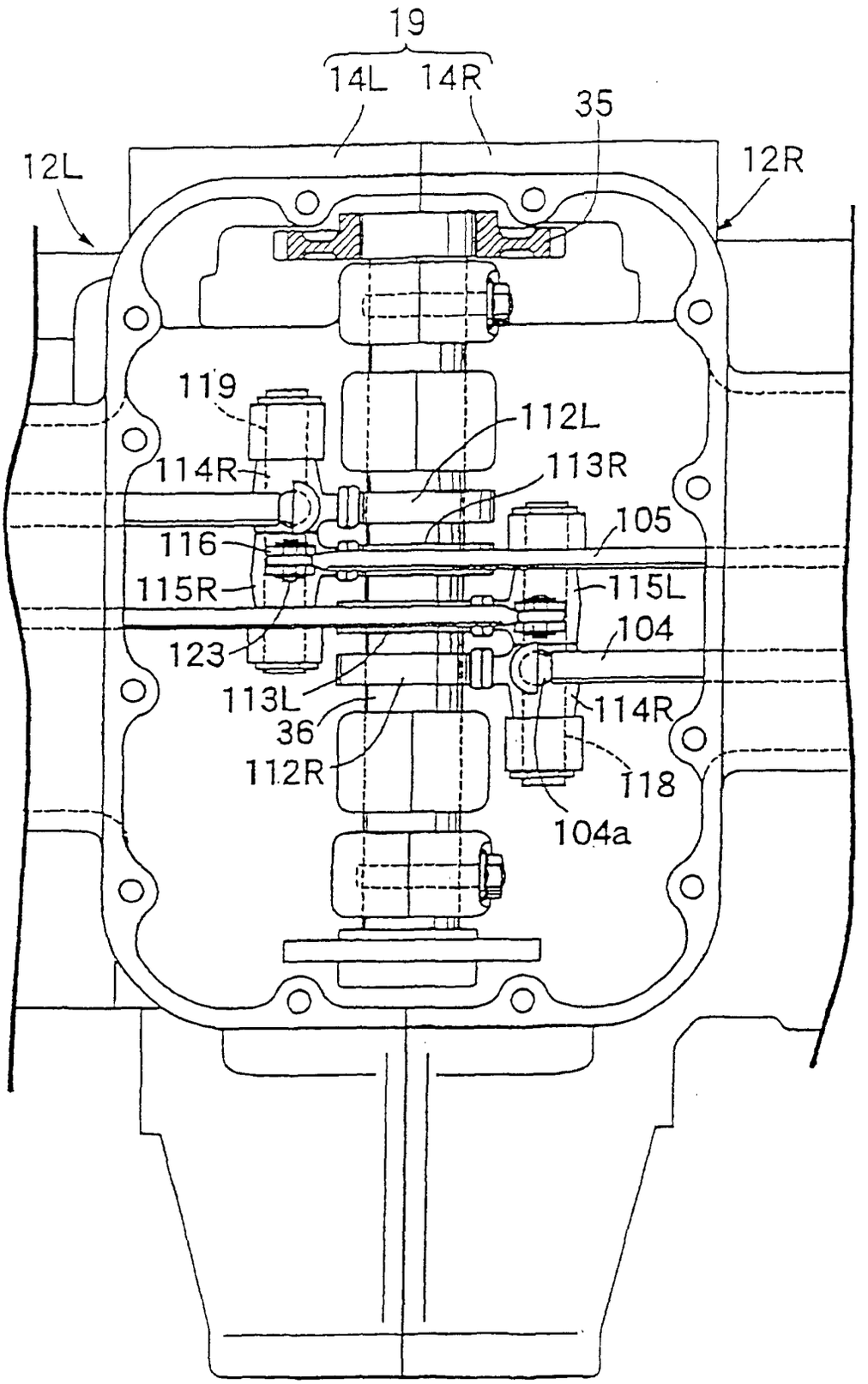
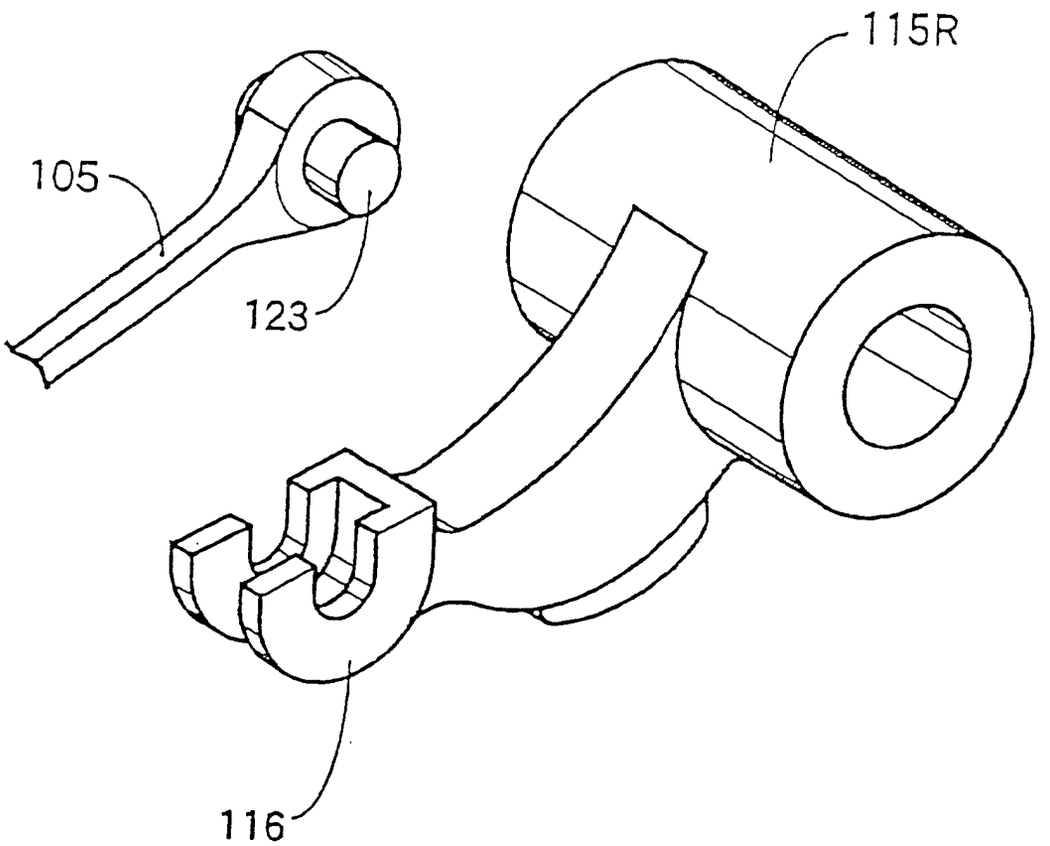

19
14L
14R
35
12L
12R
119
112L
114R
113R
105
116
115R
115L
104
123
113L
36
114R
112R
118
104a

FIG. 10



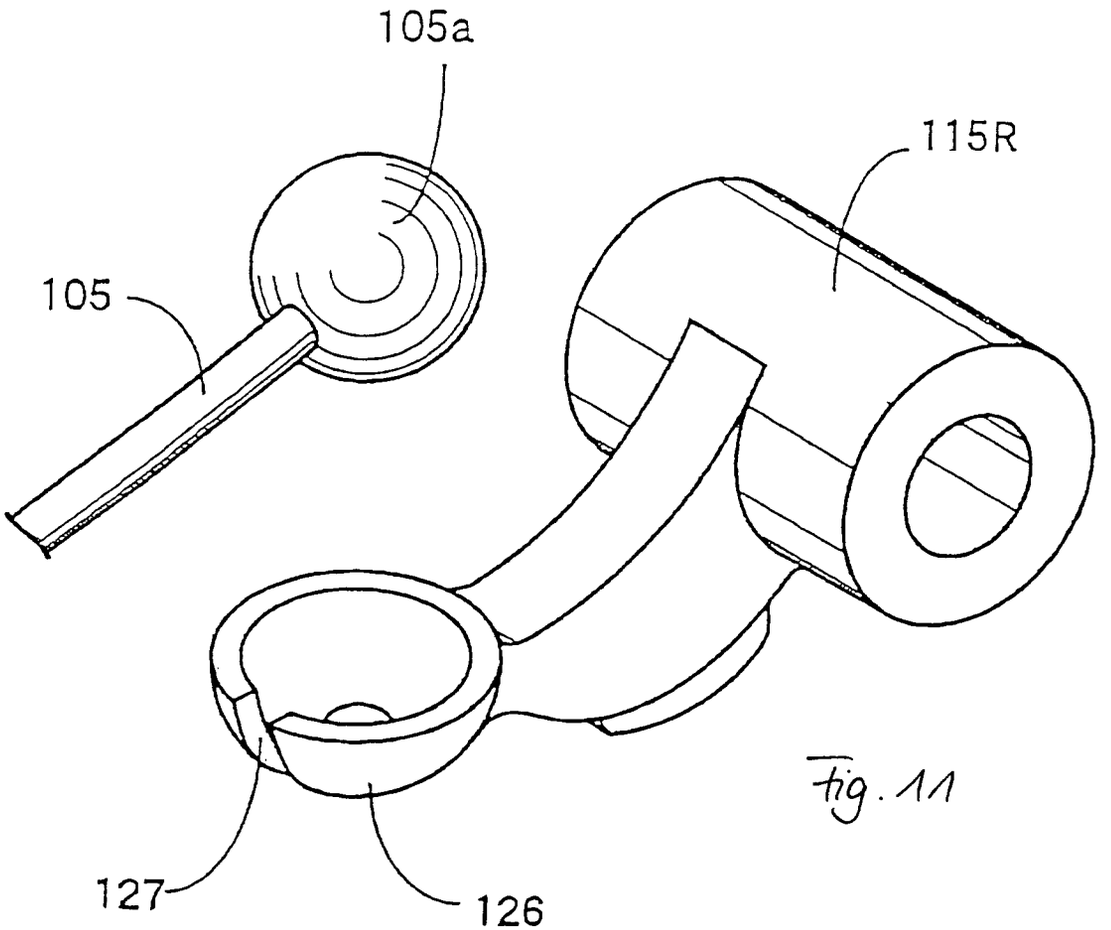


fig. 11