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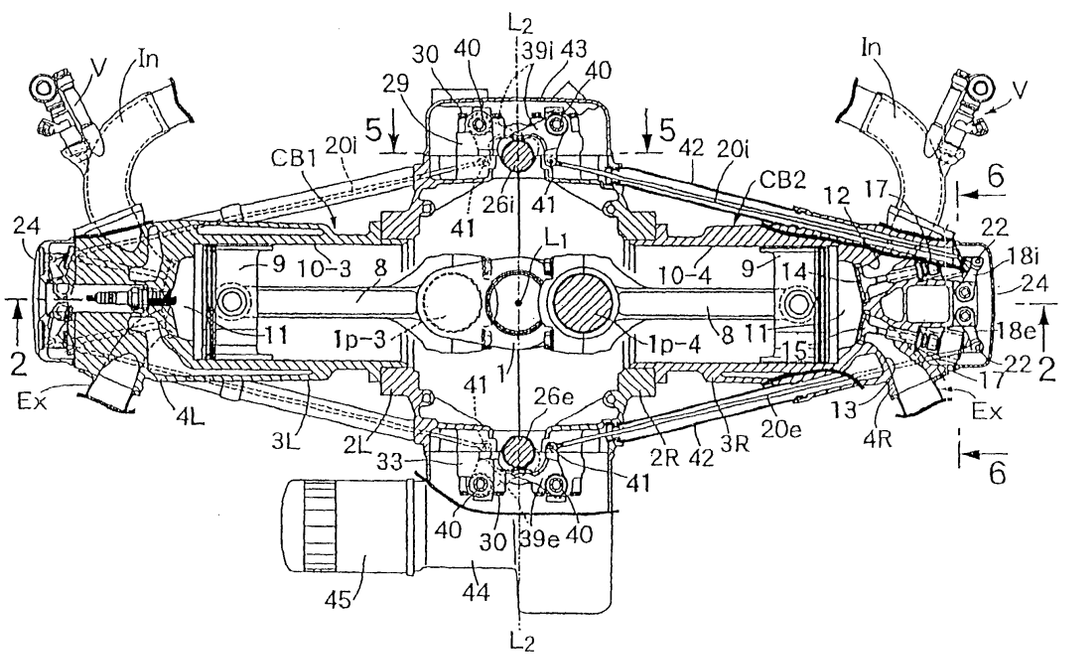
(54) Valve system for OHV-type four-cylinder internal combustion engine

(57) Problem: In a valve system for OHV-type horizontal opposed type four-cycle internal combustion engine, to contrive large reduction of the weight and size of piston heads at which intake and exhaust valves of the internal combustion engine are disposed.

Means of Solution: Valve camshafts (26i, 26e) are provided at crankcase portions (2L, 2R) for supporting a crankshaft(1), of left and right cylinder banks(CB1, CB2) disposed on opposite sides of the crankshaft(1). Intake and exhaust valves (14, 15)provided at cylinder heads (4L, 4R) are opened and closed by pull rods (20i, 20e) operated by the valve camshafts (26i, 26e).

FIG. 1



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Description

[0001] The present invention relates to a valve system suited for use with light-weight small OHV-type four-cycle internal combustion engines, particularly, horizontal opposed type and V-type internal combustion engines applicable to vehicles, to ships, to airplanes, to stationary use, and so on.

[0002] OHV (overhead valve)-type four-cycle internal combustion engines have been widely used for vehicles, for ships, for airplanes, for stational use, and so on because of such advantages as excellent thermal efficiency, low emission of HC and the like harmful components, low exhaust noise, and excellent drivability in a wide range of operation (See, for example, Japanese Patent Laid-open No. 2000-110516).

[0003] This type of internal combustion engines, however, have the problem that valve camshafts large in weight and valve mechanisms operating in connection therewith are disposed collectively at cylinder heads, namely, at head portions of the engine, leading to heavy head portions and large size, which tendency increases as the number of intake and exhaust valves is increased for raising the output of the engine. The above-mentioned publication discloses an example of application of an OHV-type valve mechanism to a horizontal opposed type four-cycle internal combustion engine. In the example disclosed, however, valve camshafts and valve systems are disposed in head portions located at left and right extreme ends farthest from a crankshaft and, necessarily, the left and right head portions are large in weight and size.

[0004] The present invention has been made in consideration of the above-mentioned circumstances. Namely, a principal purpose of the invention is to make it possible to dispose the large-weight valve camshafts as near to the crankshaft as possible, to thereby contrive reductions in weight and size of the head portions of the internal combustion engine, thus providing a novel valve system for OHV-type four-cycle internal combustion engine.

[0005] In order to attain the above-mentioned object, the present invention as set forth in claim 1 is characterized in that, in an OHV-type four-cylinder internal combustion engine comprising a pair of cylinder banks disposed symmetrically on opposite sides of an imaginary line orthogonal to the axis line of a crankshaft, each of the cylinder banks comprises integrally a crankcase portion for rotatably supporting the crankshaft, a cylinder block portion on the outside of the crankcase portion, and a cylinder head portion on the outside of the cylinder block portion, valve camshafts operating in connection with the crankshaft are rotatably supported at the crankcase portions, while valve-operating members for operating intake and exhaust valves for opening and closing intake and exhaust ports of combustion chambers are provided at the cylinder head portions, and oscillating arms operating in connection with the valve camshafts are connected with the valve-operating members through pull rods disposed on lateral sides of the cylinder banks. The characteristic feature makes it possible to reduce greatly the weight and size of the head portions of the engine, and the adoption of the pull rods enables to narrow the valve mechanism as a whole notwithstanding that the valve camshafts are located away from the cylinder heads.

[0006] Besides, in order to attain the above object, the invention as set forth in claim 2 is characterized in that the intake and exhaust valve camshafts are disposed respectively on both sides of the crankcase portions with the crankshaft therebetween, and the oscillating arms operating in connection with the valve camshafts and the valve-operating members for operating the intake and exhaust valves are respectively connected to each other through the pull rods disposed on both sides of the cylinder banks. This characteristic feature makes it possible, in a system having valve camshafts disposed on both sides of a crankcase, to reduce greatly the weight and size of the head portions of the engine, and the adoption of the pull rods enables to narrow the valve mechanism as a whole notwithstanding that the valve camshafts are located away from the cylinder heads.

[0007] Now, modes for carrying out the present invention will be described based on the embodiments of the invention illustrated by the attached drawings, in which:

Fig. 1 is a sectional view taken along line 1-1 of Fig. 2 of a horizontal opposed type internal combustion engine according to the first embodiment of the invention

Fig. 2 is a sectional view taken along line 2-2 of Fig. 1.

Fig. 3 is a sectional view taken along line 3-3 of Fig. 2.

Fig. 4 is a sectional view taken along line 4-4 of Fig. 3.

Fig. 5 is a sectional view taken along line 5-5 of Fig. 1.

Fig. 6 is an enlarged sectional view taken along line 6-6 of Fig. 1.

Fig. 7 is a vertical sectional view of a V-type internal combustion engine according to the second embodiment of the invention.

[0008] First, referring to Figs. 1 to 6, a first embodiment of the invention will be described. The first embodiment pertains to application of the valve system for OHV-type four-cycle internal combustion engine of the invention to a horizontal opposed type four-valve four-cylinder engine. Fig. 1 is a sectional view taken along

line 1-1 of Fig. 2 of the horizontal opposed type internal combustion engine according to the first embodiment; Fig. 2 is a sectional view taken along line 2-2 of Fig. 1; Fig. 3 is a sectional view taken along line 3-3 of Fig. 2; Fig. 4 is a sectional view taken along line 4-4 of Fig. 3; Fig. 5 is a sectional view taken along line 5-5 of Fig. 1; and Fig. 6 is an enlarged sectional view taken along line 6-6 of Fig. 1.

[0009] In the description below, of a pair of cylinder banks disposed on opposite sides of a crankshaft 1, the one on the left side in Fig. 1 will be called left cylinder bank, and the other on the right side will be called right cylinder bank.

[0010] In Fig. 1, a pair of left and right cylinder banks CB1, CB2 are disposed symmetrically on the left and right sides of a vertical imaginary line L2-L2 orthogonal to the axis line L1-L1 of the crankshaft 1 which is disposed roughly horizontally in a direction orthogonal to the surface of paper. The left and right cylinder banks CB1 and CB2 have the same configuration, and are extended roughly horizontally in the left-right direction. Each of the cylinder banks CB1, CB2 comprises a crankcase portion 2L, 2R for receiving and rotatably supporting the crankshaft 1, a cylinder block portion 3L, 3R connected integrally to an outside surface of the crankcase portion 2L, 2R by a plurality of connecting bolts 5, and a cylinder head portion 4L, 4R provided integrally on the outside of the cylinder block portion 3L, 3R. The left and right crankcase portions 2L and 2R are coupled integrally to each other by coupling means such as coupling bolts.

[0011] The crankcase portion 2L, 2R and the cylinder block portion 3L, 3R may be formed integrally with each other, while the cylinder block portion 3L, 3R and the cylinder head portion 4L, 4R may be formed as separate bodies and connected integrally by known connecting means.

[0012] As shown in Figs. 2 and 3, the crankshaft 1 has a portion thereof formed hollow in order to contrive a reduction in weight. Journal shaft portions 1j of the crankshaft 1 are rotatably supported by a plurality of bearing halves provided respectively at the crankcase portions 2L, 2R of the left and right cylinder banks CB1, CB2. Large end portions of connecting rods 8 are rotatably connected to four crank pins of the crankshaft 1, namely, first to fourth crank pins 1p-1 to 1p-4. Concretely, as shown in Fig. 2, small end portions of the connecting rods 8 connected to the first and third crank pins 1p-1, 1p-3 are connected to pistons 9 on the side of the left cylinder bank CB1, whereas small end portions of the connecting rods 8 connected to the second and fourth crank pins 1p-2, 1p-4 are connected to pistons 9 on the side of the right cylinder bank CB2.

[0013] As shown in Figs. 1 and 2, the left and right cylinder block portions 3L, 3R are each provided with two cylinder barrels disposed side by side. The cylinder barrels of the left cylinder block portion 3L are provided with first and third cylinders 10-1 and 10-3, whereas the cylinder barrels of the right cylinder block portion 3R are provided with second and fourth cylinders 10-2 and 10-4. The pistons 9 connected with the small end portions of the connecting rods 8 are slidably fitted in the cylinders.

[0014] As clearly shown in Figs. 1 and 2, the cylinder head portions 4L, 4R formed integrally with the left and right cylinder block portions 3L, 3R are respectively provided with combustion chambers 11 corresponding to the first and third cylinders 10-1, 10-3 and the second and fourth cylinders 10-2, 10-4. Two intake ports 12 and two exhaust ports 13 which are communicated to the combustion chambers 11 via valve ports are respectively communicated with each of the combustion chambers 11. The two intake ports 12 and two exhaust ports 13 are opened and closed respectively by intake and exhaust valves 14, 15 which are provided slidably in the cylinder head portions 4L, 4R. In addition, the intake and exhaust valves 14, 15 are energized in a closing direction by valve springs 17 as usual. The cylinder head portions 4L, 4R comprise valve-operating members, namely, swing arms 18i and 18e on the intake and exhaust sides, which are supported swingably through shafts. Slipper surfaces at tip ends of the swing arms 18i, 18e are disposed adjacently to end faces of the intake and exhaust valves 14 and 15. Pull rods 20i and 20e which will be detailed later are respectively connected by connection pins 22 to the tip ends of the swing arms 18i and 18e on the intake and exhaust sides. The intake and exhaust valves 14 and 15 are respectively opened when the swing arms 18i and 18e are swung to the inside against the springy force of the valve springs 17 by the pulling operation of the pull rods 20i and 20e.

[0015] The intake ports 12 are each connected to an intake system In disposed on the upper side of the left and right cylinder banks CB1 and CB2 collectively, whereas the exhaust ports 13 are each connected to an exhaust system Ex disposed on the lower side of the left and right cylinder banks CB1 and CB2 collectively. As shown in Fig. 1, fuel injection valves V are connected to downstream portions of the intake system In. An ignition plug P is screwed to a central portion of an upper wall of each of the combustion chambers 11.

[0016] Portions of the valve mechanism described later are provided on the left and right cylinder head portions 4L, 4R, and the portions of the valve mechanism are covered by head covers 24 disposed on top surfaces of the cylinder head portions 4L, 4R.

[0017] As shown in Figs. 1 and 3 to 5, on the vertical imaginary line L2-L2 orthogonal to the axis line L1-L1 of the crankshaft 1 mentioned above, two valve camshafts 26i and 26e on the intake side and exhaust side parallel with the crankshaft 1 are rotatably supported at an upper portion and a lower portion of the left and right crankcase portions 2L, 2R. The valve camshaft 26i on the intake side is rotatably supported at an upper portion of the left and right crankcase portions 2L, 2R by a plurality of bearing halves 28 which are provided at the faying sur-

face of the crankcase portions 2L, 2R and a bearing cap 29 which is fixed to flat top surfaces of the left and right crankcase portions 2L, 2R by a plurality of bolts 30. On the other hand, the valve camshaft 26e on the exhaust side is also rotatably supported at a lower portion of the left and right crankcase portions 2L, 2R by a plurality of bearing halves 32 which are provided at the faying surface of the crankcase portions 2L, 2R and a bearing cap 33 which is fixed to flat top surfaces of the left and right crankcase portions 2L, 2R by a plurality of bolts 30. The two valve camshafts 26i, 26e on the intake and exhaust sides are each rotationally driven by the crankshaft 1 through a timing gear transmission mechanism T. Namely, as clearly shown in Fig. 4, driven gears 35 are respectively fixed to end portions (a right end portion in Fig. 5) of the two valve camshafts 26i, 26e, while a driving gear 37 is fixed to an end portion of the crankshaft 1, and idle reduction gears 36 respectively meshed with the gears 35, 37 are rotatably supported on the left and right crankcase portions 2L, 2R. Therefore, when the crankshaft 1 is rotated, the upper and lower valve camshafts 26i and 26e can be driven to rotate in the same direction with a speed reduction rate of 1/2 through the driving gear 37, the idle reduction gears 36 and the driven gear 35.

[0018] As shown in Figs. 1 and 5, on the left and right sides of the bearing cap 29 supporting the intake-side valve camshaft 26i disposed at upper portions of the left and right cylinder banks CB1 and CB2, base ends of a plurality (two for each cylinder) of forked oscillating arms 39i are oscillatably supported with supporting shafts 40 at intervals along the direction of the crankshaft 1. One free end of each of the oscillating arms 39i is provided with a slipper, which is in contact with an intake cam formed on the valve camshaft 26i on the intake side. The other free end of each of the oscillating arms 39i is connected by a connection pin 41 with one end of the pull rod 20i. In Fig. 1, the left and right pull rods 20i penetrate through the crankcase portions 2L, 2R of the left and right cylinder banks CB1, CB2, and are extended downward toward the head portions of the cylinder banks CB1, CB2, namely, the cylinder head portions 4L, 4R. Tips of the left and right pull rods 20i are connected by connection pins 22 to free ends of the intake-side swing arms 18i which are shaft-supported on the cylinder head portions 4L, 4R. Those portions of the pull rods 20i which are exposed outside the cylinder banks CB1, CB2 are covered by tubular rod covers 42 bridgingly connected between the crank case portions 2L, 2R and the cylinder head portions 4L, 4R. Also, on the left and right sides of the bearing cap 33 supporting the exhaust-side valve camshaft 26e disposed at lower portions of the left and right cylinder banks CB1 and CB2, base ends of a plurality (two for each cylinder) of forked oscillating arms 39e are oscillatably supported with supporting shafts 40 at intervals along the direction of the crankshaft 1. Slippers of the oscillating arms 39e are in contact with exhaust cams formed on the valve camshaft 26e on the exhaust side. The left and right pull rods 20e connected by connection pins 41 to the other free ends of the oscillating arms 39e penetrate through the crankcase portions 2L, 2R of the left and right cylinder banks CB1, CB2, and are extended upward toward the head portions of the cylinder banks CB1, CB2, namely, the cylinder head portions 4L, 4R. Tips of the left and right pull rods 20e are connected by connection pins 22 to free ends of the exhaust-side swing arms 18e which are shaft-supported on the cylinder head portions 4L, 4R. The intake-side bearing cap 29 supporting the oscillating arm 39i by the supporting shaft 40 is covered by a cover 43 fixed to an upper surface of the faying part of the crankcase portions 2L, 2R, while the exhaust-side bearing cap 33 supporting the oscillating arm 39e by the supporting shaft 40 is covered by an oil pan 44 fixed to a lower surface of the faying part of the crankcase portions 2L, 2R. Incidentally numeral 45 in the figure denotes an oil filter supported on the oil pan 44.

[0019] The oscillating arms 39i, 39e, the pull rods 20i, 20e, and the swing arms 18i, 18e as valve-operating members constitute the valve mechanism.

[0020] Now, the operation of the first embodiment will be described. When the crankshaft 1 is rotated by operation of the internal combustion engine, the upper-lower pair of the intake-side and exhaust-side valve camshafts 26i, 26e are respectively rotated in the same direction with a reduction ratio of 1/2 through the timing gear transmission mechanism T composed of a group of gears. Then, the intake-side and exhaust-side oscillating arms 39i, 39e in adjacent contact with cam surfaces of valve cams of the valve camshafts 26i, 26e are respectively forcedly oscillated. When the pull rods 20i, 20e in connection with the oscillating arms 39i, 39e are pulled toward the valve camshafts 26i, 26e, the intake and exhaust valves 14, 15 are opened through the swing arms 18i, 18e functioning as the valve-operating members. On the other hand, when pulling of the pull rods 20i, 20e is released, the intake and exhaust valves 14, 15 are closed by springy force of the valve springs 17. When rotation of the intake-side and exhaust-side valve camshafts 26i, 26e is continued, the intake and exhaust valves 14, 15 are opened and closed with predetermined timings, whereby the engine operation is continued repeating predetermined intake, compression, expansion and exhaust strokes.

[0021] According to the valve system, the valve camshafts 26i, 26e which are large in weight and mounting of which requires space for mounting bearings and other component members are provided at the crankcase portions 2L, 2R near the crankshaft 1. As a result, cylinder head portions 4L, 4R, i.e. the head portions, of the cylinder banks CB1, CB2 can be formed as light and small as possible.

[0022] Next, a second embodiment of the invention will be described.

[0023] Fig. 7 is a vertical sectional view of a V-type internal combustion engine according to the second em-

bodiment of the invention, wherein the same elements as those in the first embodiment are denoted by the same symbols as above. The second embodiment is application of the valve system of the invention to an OHV-type four-cycle and V-type four-cylinder internal combustion engine. In Fig. 7, a pair of left and right cylinder banks CB1, CB2 are disposed symmetrically on the left and right sides of an imaginary line L2-L2 orthogonal to the axis line L1 of the crankshaft 1 disposed in a roughly horizontal direction orthogonal to the surface of paper. The structures of the left and right cylinder banks CB1, CB2 are the same as those of the left and right cylinder banks CB1, CB2 in the first embodiment above, except for the V-type layout; and, accordingly, description of the same structures will be omitted.

[0024] A single valve camshaft 26 is rotatably supported by left and right crankcase portions 2L, 2R on the imaginary line L2-L2 directly below the crankshaft 1. Pull rods 20i, 20e connected with intake-side and exhaust-side oscillating arms 39i, 39e in adjacent contact with intake and exhaust cams of the valve camshaft 1 are extended upward respectively on the lateral sides of the left and right crankcase portions 2L, 2R, and top ends of the pull rods 20i, 20e are connected to valve-operating members, i.e. swing arms 18i, 18e on the intake and exhaust sides.

[0025] When the pull rods 20i, 20e are pulled via oscillating arms 39i, 39e by rotation of the valve camshaft 1, intake and exhaust valves 14, 15 in the left and right cylinder banks CB1, CB2 are opened with predetermined timings. When the pulling of the pull rods 20i, 20e is released due to continued rotation of the valve camshaft 26, the intake and exhaust valves are closed by springy force of valve springs with predetermined timings, as usual.

[0026] The system according to the second embodiment makes the same effects as the system according to the first embodiment above. It is possible to largely reduce the weight and size of the cylinder head portions 4L, 4R, i.e. head portions, of the pair of cylinder banks CB1, CB2 disposed in a V-type configuration.

[0027] Incidentally, the left and right crankcase portions 2L, 2R may be split into upper and lower portions with respect to a line in a direction intersecting the imaginary line L2-L2, or may be split into left, right, front and rear portions in forward and rearward directions with respect to the surface of paper.

[0028] Although the embodiments of the present invention have been described above, the invention is not limited to or by the embodiments, and various embodiments can be made within the scope of the invention. For example, although the above embodiments have been described as application of the invention to horizontal opposed type and V-type internal combustion engines, the invention can also be applied to other types of internal combustion engines. Further, although the invention has been described referring to application to four-valve type internal combustion engines, the invention can naturally be applied to other valve types of internal combustion engines, e.g. two- or three-valve type.

[0029] As has been described above, according to the invention as set forth in the claims, it is possible to largely reduce the weight and size of the head portions of an internal combustion engine. In addition, adoption of pull rods for operating intake and exhaust valves promises narrowing of the valve mechanism for connecting the operation of the valve camshaft and the operations of intake and exhaust valves.

[0030] Problem: In a valve system for OHV-type horizontal opposed type four-cycle internal combustion engine, to contrive large reduction of the weight and size of piston heads at which intake and exhaust valves of the internal combustion engine are disposed.

[0031] Means of Solution: Valve camshafts 26i, 26e are provided at crankcase portions 2L, 2R for supporting a crankshaft 1, of left and right cylinder banks CB1, CB2 disposed on opposite sides of the crankshaft 1. Intake and exhaust valves 14, 15 provided at cylinder heads 4L, 4R are opened and closed by pull rods 20i, 20e operated by the valve camshafts 26i, 26e.

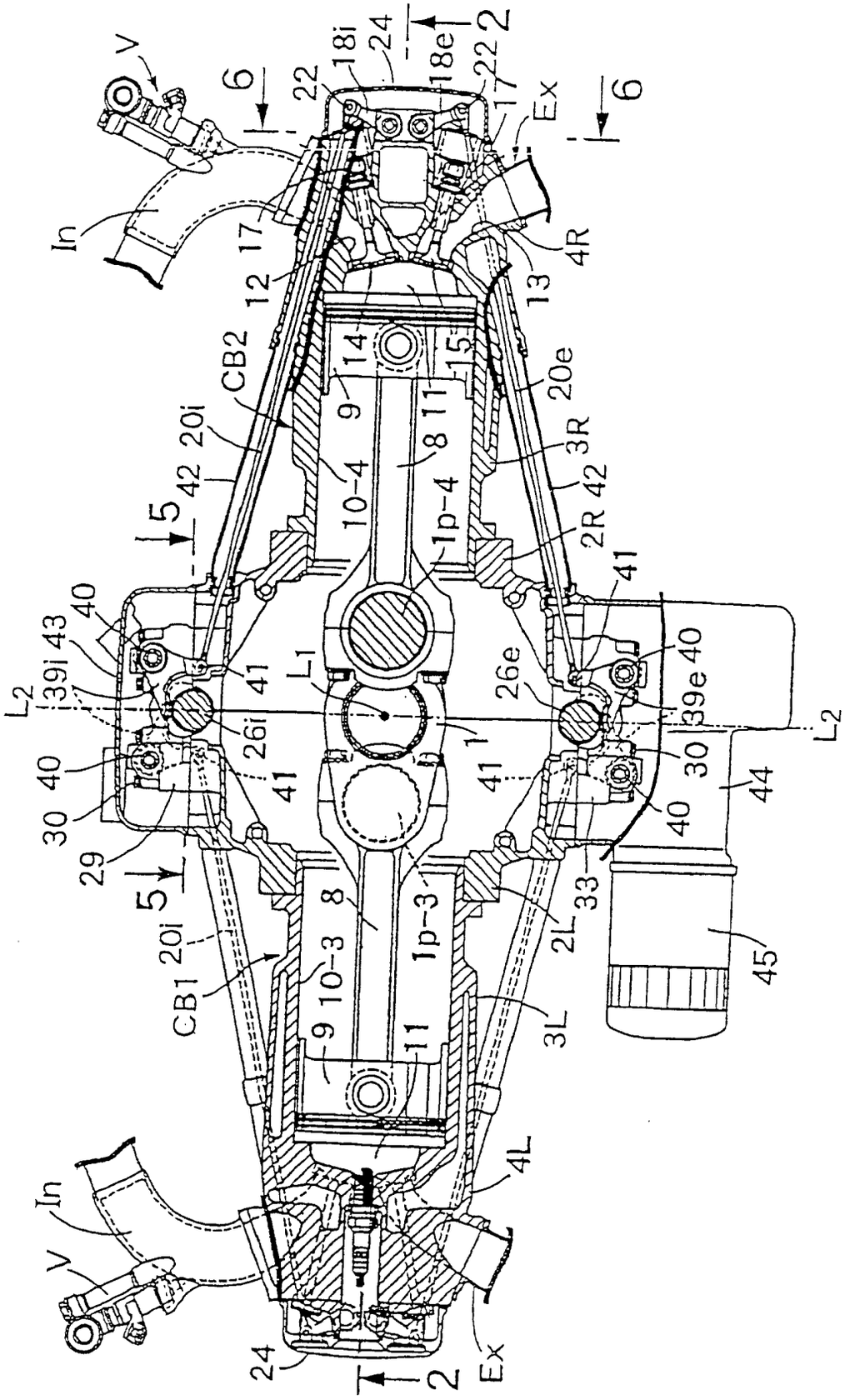
Claims

1. A valve system for an OHV-type four-cylinder internal combustion engine comprising a pair of cylinder banks (CB1, CB2) disposed symmetrically on opposite sides of an imaginary line (L2-L2) orthogonal to the axis line (L1-L1) of a crankshaft (1), wherein each of said cylinder banks (CB1, CB2) comprises integrally a crankcase portion (2L, 2R) for rotatably supporting said crankshaft (1), a cylinder block portion (3L, 3R) on the outside of said crankcase portion (2L, 2R), and a cylinder head portion (4L, 4R) on the outside of said cylinder block portion (3L, 3R), valve camshafts (26i, 26e; 26) operating in connection with said crankshaft (1) are rotatably supported at said crankcase portions (2L, 2R), while valve-operating members (18i, 18e) for operating intake and exhaust valves (14, 15) for opening and closing intake and exhaust ports (12, 13) of combustion chambers (11) are provided at said cylinder head portions (4L, 4R), and oscillating arms (39i, 39e) operating in connection with said valve camshafts (26i, 26e; 26) are connected with said valve-operating members (18i, 18e) through pull rods (20i, 20e) disposed on lateral sides of said cylinder banks (CB1, CB2).

2. A valve system for OHV-type four-cylinder internal combustion engine as set forth in claim 1, wherein said intake and exhaust valve camshafts (26i, 26e) are disposed respectively on both sides of said crankcase portions (2L, 2R) with said crankshaft (1) therebetween, and said oscillating arms (39i, 39e) operating in connection with said valve camshafts

(26i, 26e) and said valve-operating members (18i, 18e) for operating said intake and exhaust valves (14, 15) are respectively connected to each other through said pull rods (20i, 20e) disposed on both sides of said cylinder banks (CB1, CB2).

FIG. 1


V
In
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22
18i
24
2
18e
17
Ex
4R
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13
CB2
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20e
20i
9
8
11
3R
42
10-4
1p-4
2R
5
41
40
43
39i
L1
26e
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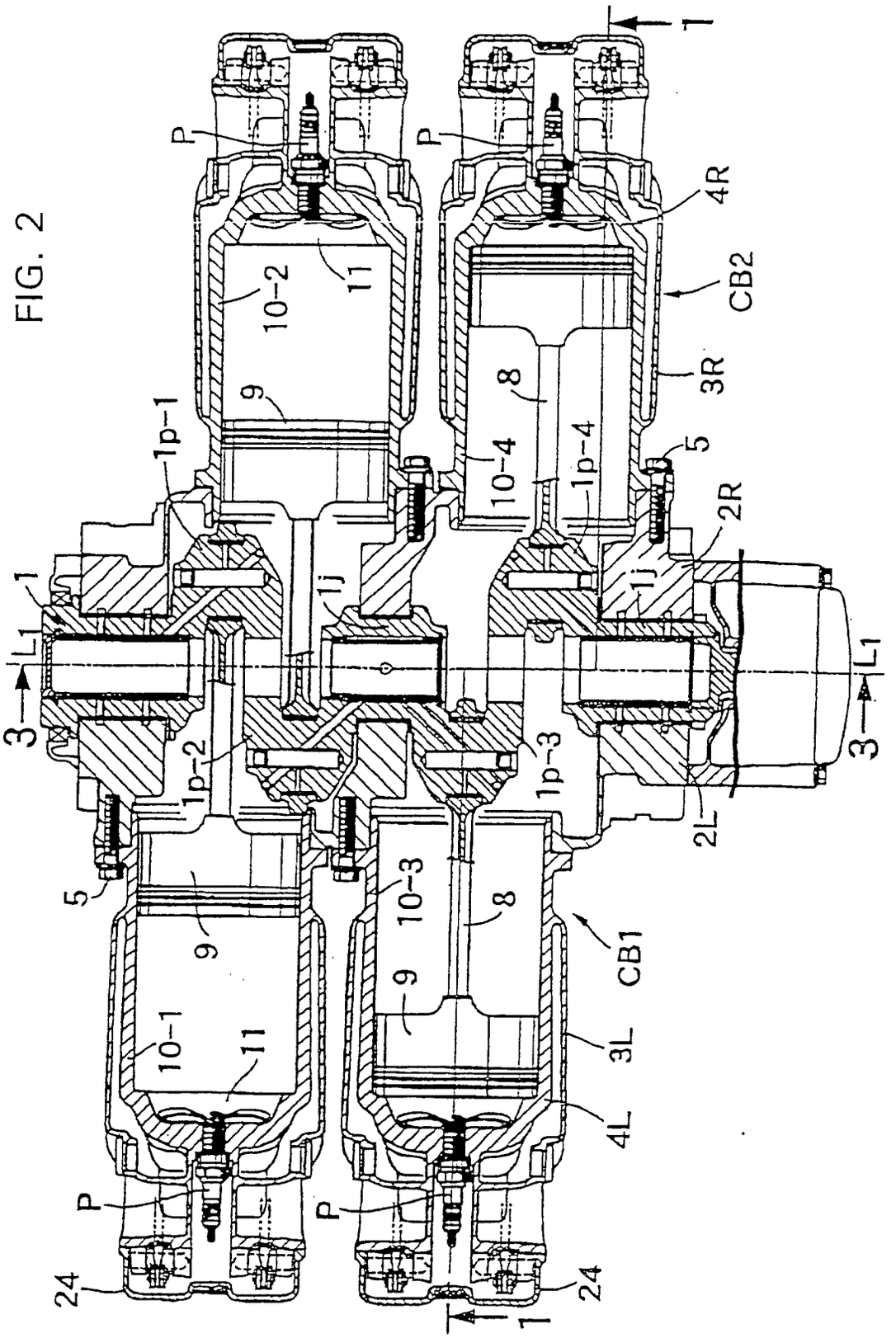
FIG. 2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1p-3
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FIG. 3

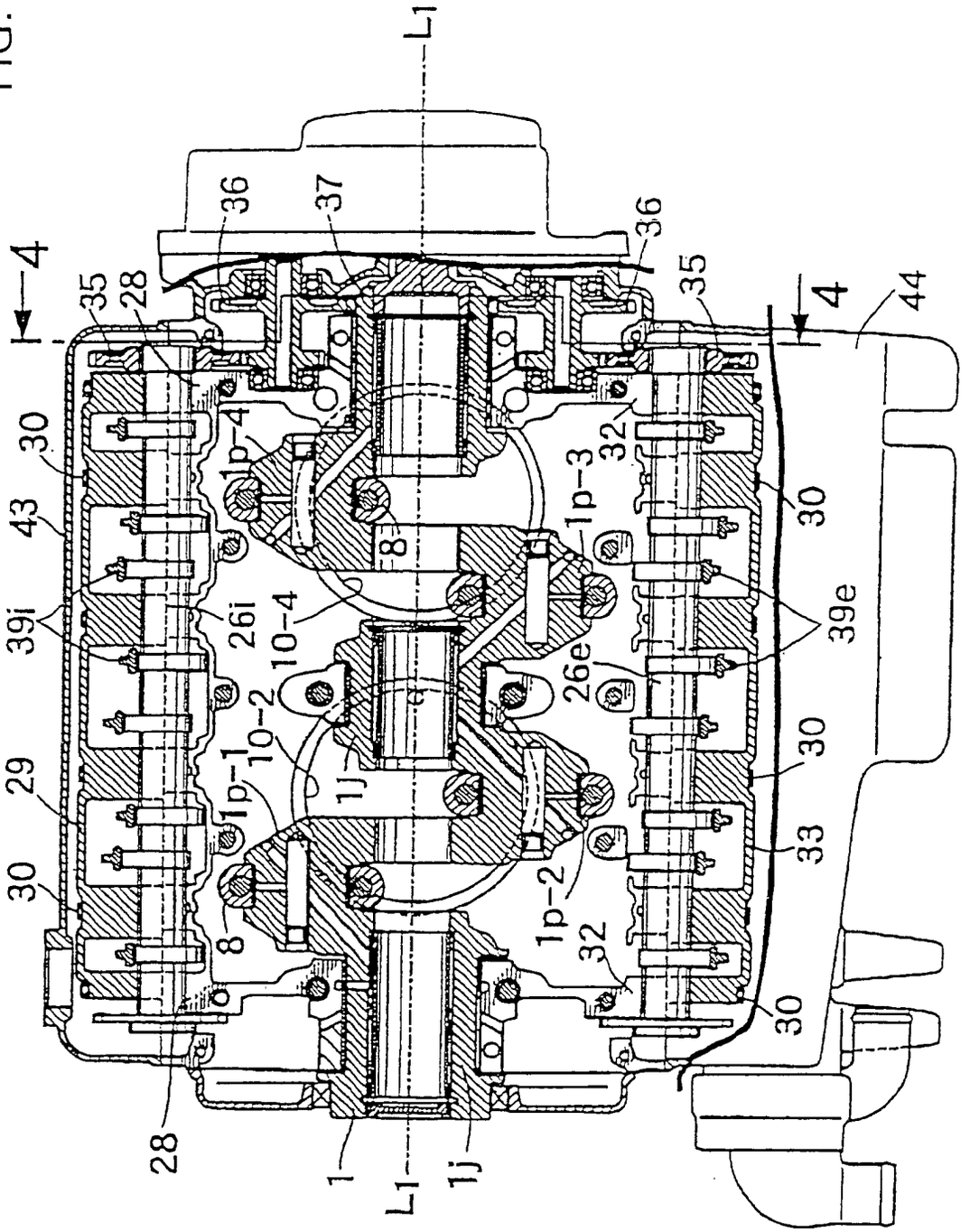
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FIG. 4

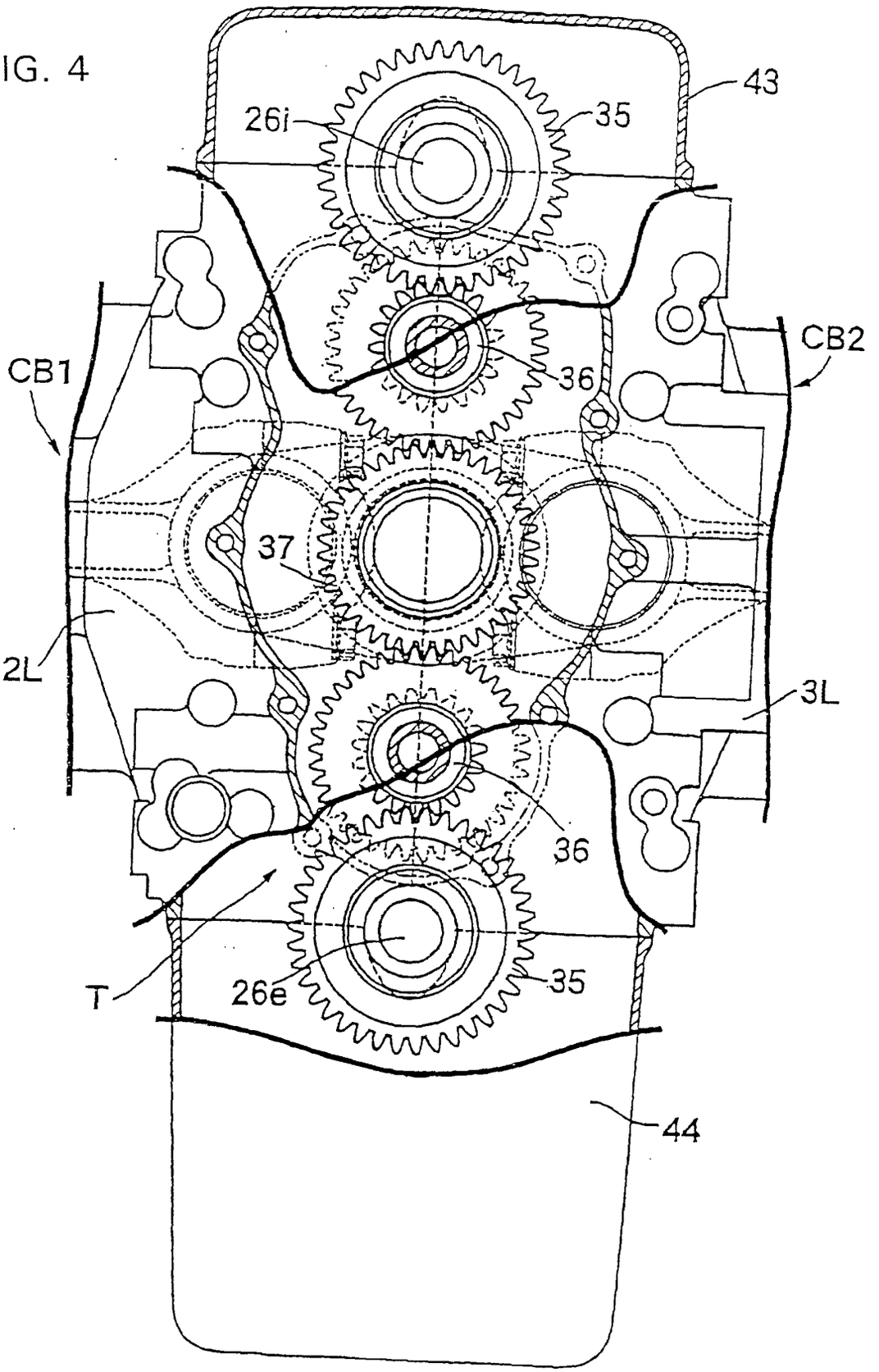

FIG. 5

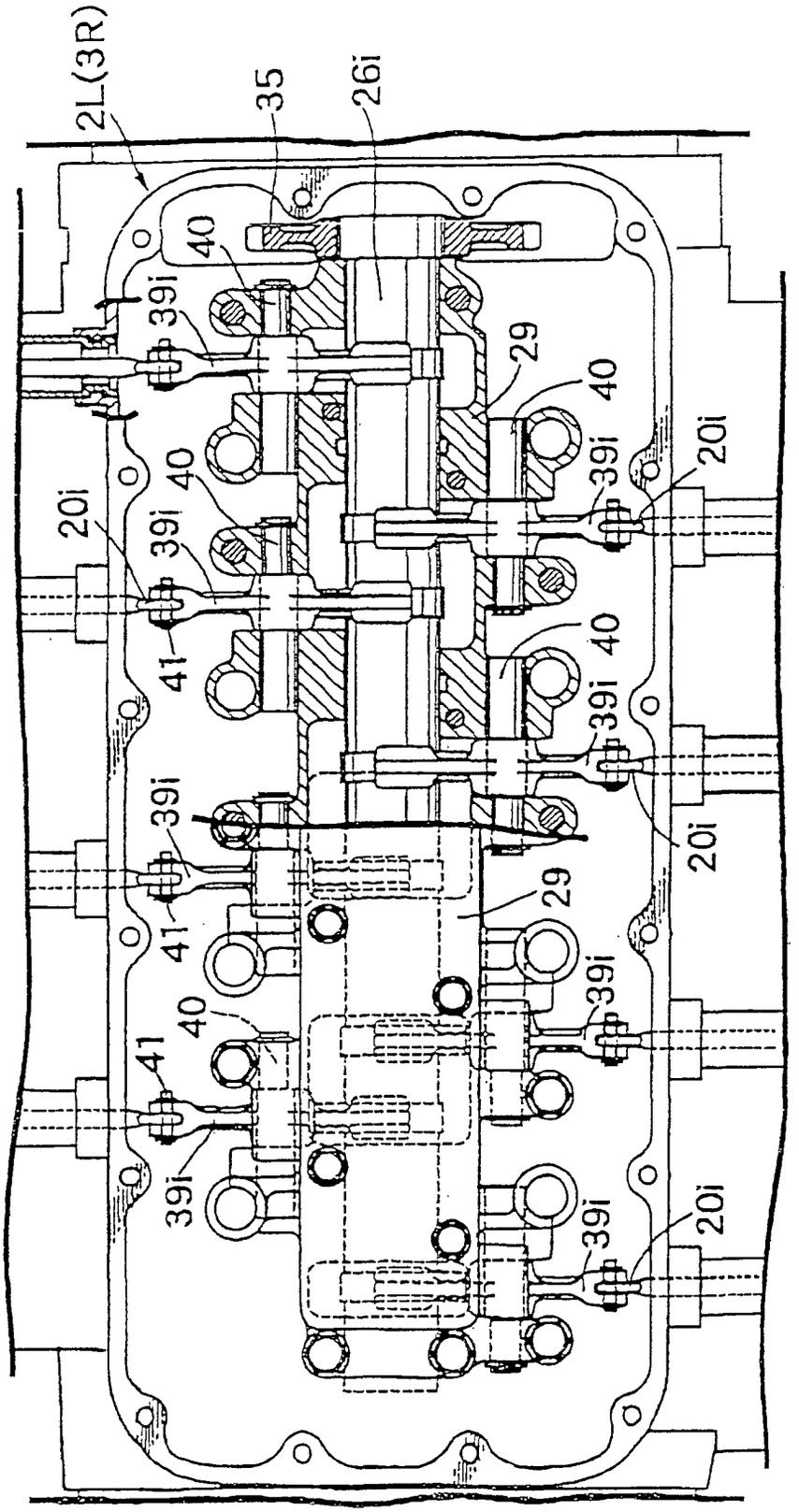

FIG. 6

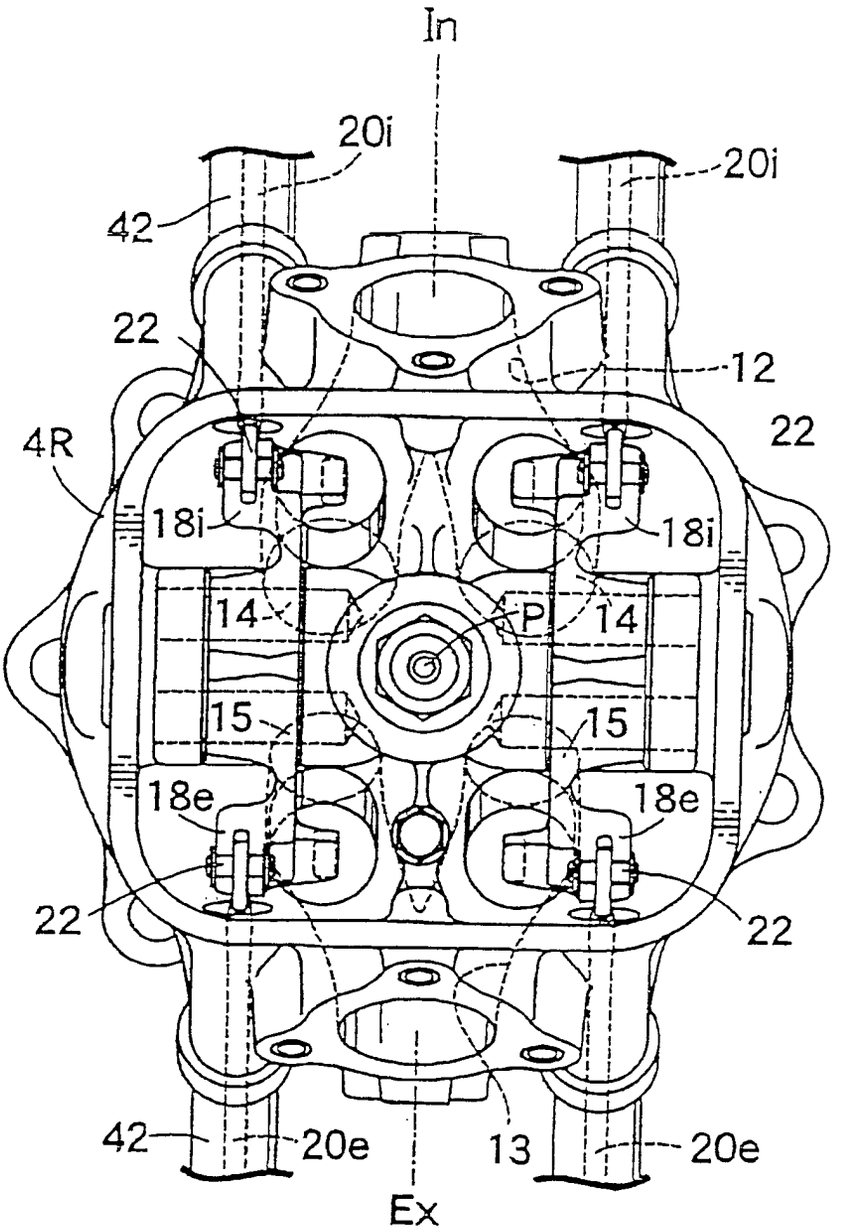
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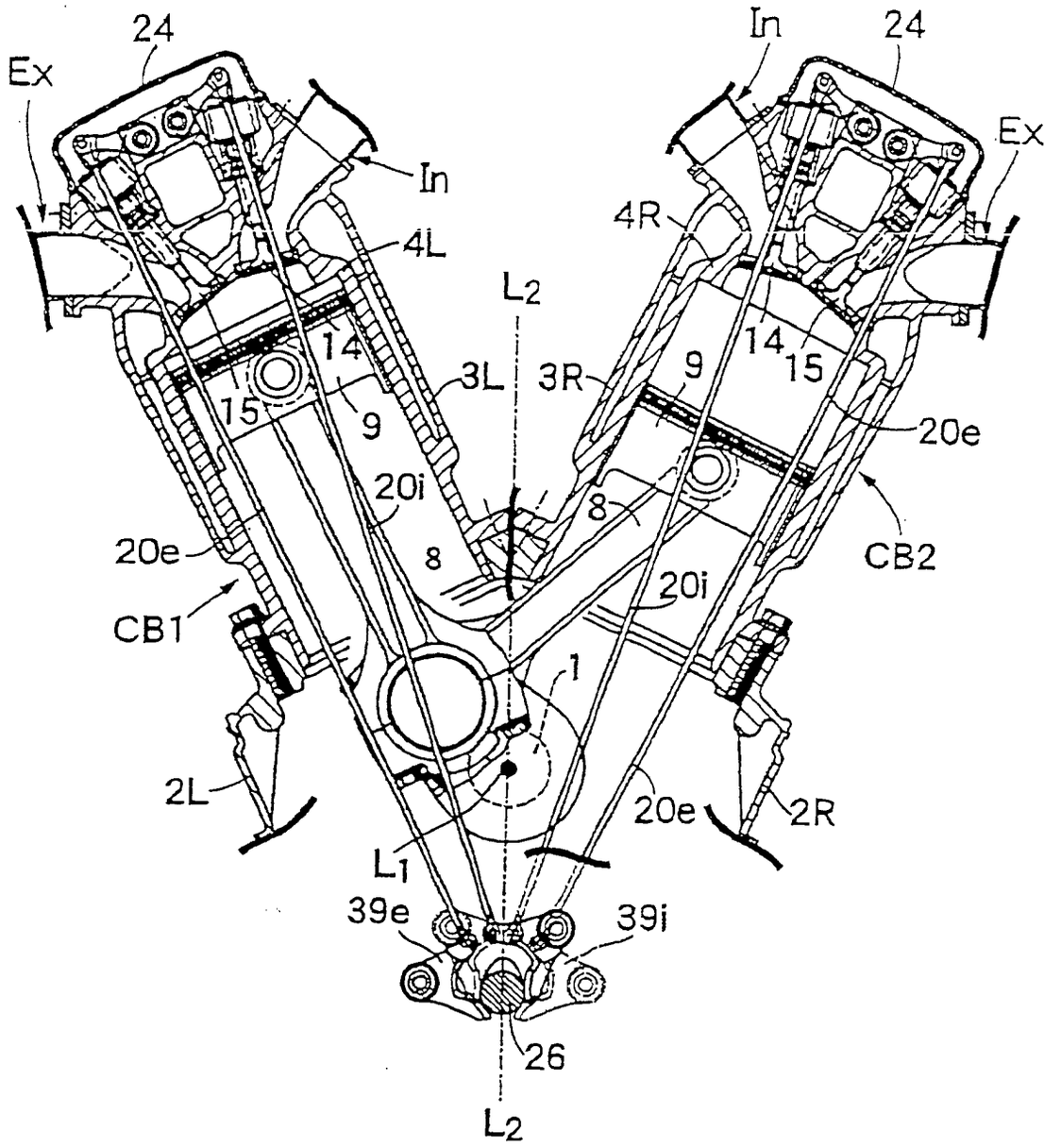
FIG. 7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