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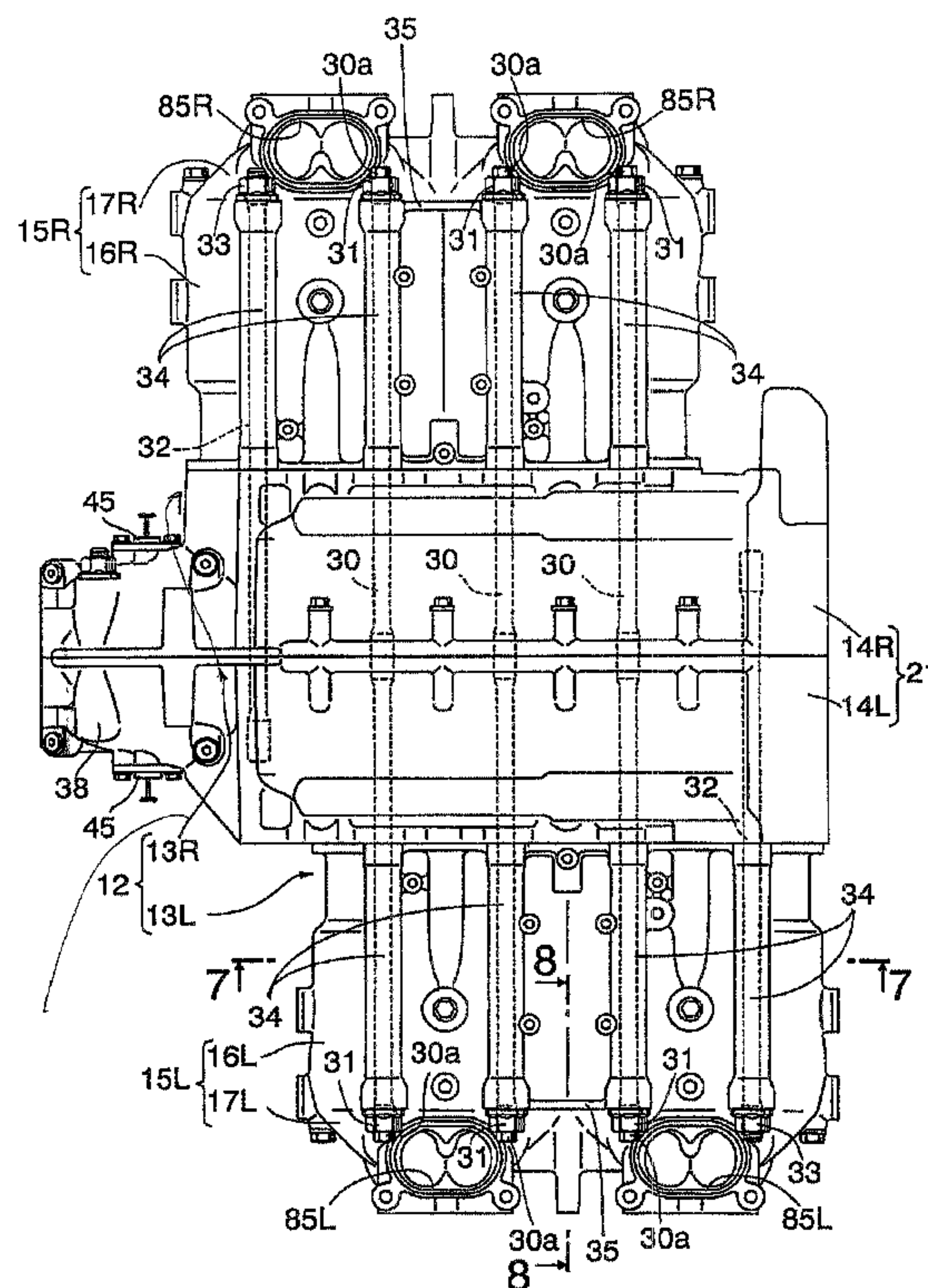
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(54) Title: LIQUID-COOLED ENGINE



(57) Abrégé/Abstract:

To simplify the connection of a cylinder barrel and a cylinder head to a crankcase and to lighten an engine in the liquid-cooled engine provided with the crankcase, the cylinder barrel having a water jacket on the cylinder side for cooling and connected to the crankcase and the cylinder head connected to the cylinder barrel. Plural mounting bosses extended from fitting planes to a crankcase of cylinder barrels to cylinder heads are integrated with cylinder blocks in which the cylinder barrels and the cylinder heads are integrated in a state in which the mounting bosses encircle cylinder bores, and the cylinder blocks are fastened to the crankcase by bolts inserted into each mounting boss.

ABSTRACT OF THE DISCLOSURE

To simplify the connection of a cylinder barrel and a cylinder head to a crankcase and to lighten an engine in the liquid-cooled engine provided with the crankcase, the cylinder barrel having a water jacket on the cylinder side for cooling and connected to the crankcase and the cylinder head connected to the cylinder barrel. Plural mounting bosses extended from fitting planes to a crankcase of cylinder barrels to cylinder heads are integrated with cylinder blocks in which the cylinder barrels and the cylinder heads are integrated in a state in which the mounting bosses encircle cylinder bores, and the cylinder blocks are fastened to the crankcase by bolts inserted into each mounting boss.

LIQUID-COOLED ENGINE

FIELD OF THE INVENTION

5 The present invention relates to a liquid-cooled engine provided with a crankcase that supports a crankshaft so that the crankshaft can be rotated, a cylinder barrel having a cylinder bore and a water jacket on the cylinder side for cooling that encircles the cylinder bore and connected to the crankcase and a cylinder head having a water jacket on the head side
10 communicating with the water jacket on the cylinder side and connected to the cylinder barrel.

BACKGROUND OF THE INVENTION

Such a liquid-cooled engine is already known in JP-A-2002-213302 and
15 others.

In the conventional type liquid-cooled engine, the cylinder barrel and the cylinder head are separately formed and work for connecting the cylinder barrel and the cylinder head to the crankcase is troublesome. Besides, to
20 maintain the sealing performance of a gasket inserted between the cylinder barrel and the cylinder head, a bolt for fastening the cylinder barrel and the cylinder head is required, the number of parts increases, and the weight of the engine increases.

25 The invention is made in view of such a situation and the object is to provide a liquid-cooled engine in which the connection of a cylinder barrel and a cylinder head to a crankcase is simplified and which can contribute to its lightening.

30 SUMMARY OF THE INVENTION

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The present invention is based upon a liquid-cooled engine provided with a crankcase that supports a crankshaft so that the crankshaft can be rotated, a cylinder barrel having a cylinder bore and a water jacket on the cylinder side for cooling encircling the cylinder bore and connected to the crankcase and a cylinder head having a water jacket on the head side that communicates with the water jacket on the cylinder side and connected to the cylinder barrel, and is characterized in that plural mounting bosses extended from a fitting plane to the crankcase of the cylinder barrel to the cylinder head are integrated with a cylinder block in which the water jacket on the cylinder side and the water jacket on the head side mutually communicate and the cylinder barrel and the cylinder head are integrated in a state in which the mounting bosses encircle the cylinder bore and the cylinder block is fastened to the crankcase by bolts inserted into each mounting boss.

An aspect of the invention is characterized in addition to the configuration according to the invention described above in that a coupling wall for coupling at least one set of mounting bosses out of mutually adjacent two sets of a pair of mounting bosses between the cylinder bores mutually adjacent in an axial direction of the crankshaft is integrated with the cylinder block having the plural cylinder bores arranged in the axial direction of the crankshaft.

A further aspect of the invention is characterized in addition to the configuration according to the invention described above in that rod guide pipes where each rod to which power from the crankshaft is transmitted and which configures a part of a valve system is inserted so that the rod can be axially moved and the coupling wall are arranged on sides of both cylinder blocks.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the invention are shown in the drawings, wherein:

Fig. 1 is a side view showing an engine equivalent to a first embodiment;

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Fig. 2 is a plan a part of which is cut off showing the engine;

Fig. 3 is an enlarged front view viewed from a direction shown by an arrow 3 in Fig. 1;

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Fig. 4 is a plan showing the body of the engine;

Fig. 5 is a bottom view showing the body of the engine;

10 Fig. 6 is a sectional view viewed along a line 6-6 in Fig. 3;

Fig. 7 is a sectional view viewed along a line 7-7 in Fig. 4;

Fig. 8 is an enlarged sectional view viewed along a line 8-8 in Fig. 4;

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Fig. 9 is a schematic drawing in which the engine is viewed from the rear side to show a circulating system of cooling water;

Fig. 10 is a sectional view viewed along a line 10-10 in Fig. 9; and

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Fig. 11 shows a second embodiment corresponding to Fig. 9.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments shown in the attached drawings of the invention will be described below.

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Figs. 1 to 10 show a first embodiment when the invention is applied to a four-cycle horizontal opposed four-cylinder engine, Fig. 1 is a side view showing an engine, Fig. 2 is a plan showing the engine a part of which is cut off, Fig. 3 is an enlarged front view viewed from a direction shown by an arrow 3 in Fig. 1, Fig. 4 is a plan showing the body of the engine, Fig. 5 is a bottom view showing the body of the engine, Fig. 6 is a sectional view viewed along a line 6-6 in Fig. 3, Fig. 7 is a sectional view viewed along a line 7-7 in Fig. 4, Fig. 8 is an enlarged sectional view viewed along a line 8-8 in Fig. 4, Fig. 9 is a schematic drawing showing a circulatory system of cooling water when the engine is viewed from the rear side, and Fig. 10 is a sectional view viewed along a line 10-10 in Fig. 9.

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First, referring to Figs. 1 to 3, the four-cycle horizontal opposed four-cylinder engine is mounted in an airplane for example, is housed inside a front cowl of an airframe of the airplane so that the axis of a crankshaft 11 is extended longitudinally, and a spinner provided with plural propellers is coaxially coupled to the crankshaft 11.

Also referring to Fig. 4, the body of the engine 12 is provided with a left engine block 13L arranged on the left side when the engine is viewed from the rear side and a right engine block 13R arranged on the right side when the engine is viewed from the rear side.

The left engine block 13L is provided with a left crankcase 14L and a left cylinder block 15L connected to the left crankcase 14L, and the right engine block 13R is provided with a right crankcase 14R connected to the left crankcase 14L and a right cylinder block 15R connected to the right crankcase 14R on the reverse side to the left crankcase 14L.

The left cylinder block 15L is composed of a left cylinder barrel 16L connected to the left crankcase 14L and a left cylinder head 17L integrated with the left cylinder barrel 16L on the reverse side to the left crankcase 14L, and the right cylinder block 15R is composed of a right cylinder barrel 16R connected to the right crankcase 14R and a right cylinder head 17R integrated with the right cylinder barrel 16R on the reverse side to the right crankcase 14R.

Further also referring to Figs. 5 and 6, cylinder bores 18L, 18L; 18R, 18R mutually opposite with the crankshaft 11 between both sides are arranged in an axial direction of the crankshaft 11 in the cylinder barrels 16L, 16R of both cylinder blocks 15L, 15R, each pair is provided in a mutually offset state in the axial direction, a combustion chamber 19L ---, 19R --- is formed between each cylinder bore and each cylinder head 17L, 17R in each cylinder bore 18L ---, 18R ---, and a piston 20L ---, 20R --- is fitted so that the piston can be slid.

Both engine blocks 13L, 13R are arranged opposite in a state in which each axis of the cylinder bores 18L ---, 18R --- is substantially horizontal, the left

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and right crankcases 14L, 14R are mutually fastened to form a crankcase 21 in cooperation, and the crankshaft 11 coupled to both pistons 20L ---, 20R -- - via connecting rods 22L ---, 22R --- is supported between the left and right crankcases 14L, 14R so that the crankshaft can be rotated.

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In the left crankcase 14L, a front journal supporting wall 23L, a first intermediate journal supporting wall 24L, a second intermediate journal supporting wall 25L, a third intermediate journal supporting wall 26L and a rear journal supporting wall 27L respectively supporting a left half of the crankshaft 11 on longitudinal both sides of the connecting rods 22L --- are provided at an interval longitudinally, in the right crankcase 14R, a front journal supporting wall 23R, a first intermediate journal supporting wall 24R, a second intermediate journal supporting wall 25R, a third intermediate journal supporting wall 26R and a rear journal supporting wall 27R respectively supporting a right half of the crankshaft 11 on longitudinal both sides of the connecting rods 22R --- are provided at an interval longitudinally, and the crankshaft 11 is supported by the each journal supporting wall 23L to 27L of the left crankcase 14L and each journal supporting wall 23R to 27R of the right crankcase 14R so that the crankshaft can be rotated.

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Each journal supporting wall 23L to 27L, 23R to 27R of the left and right crankcases 14L, 14R is fastening by a pair of stud bolts 28 --- and a pair of nuts 29 --- respectively vertically holding the crankshaft 11.

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The stud bolts 28 --- for fastening the front journal supporting walls 23L, 23R and the rear journal supporting walls 27L, 27R are formed so that they are longer than the stud bolts 28 --- for fastening the first, second and third intermediate journal supporting walls 24L to 26L; 24R to 26R.

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The nuts 29 --- fitted to the outside face of the right crankcase 14R are screwed on the stud bolts 28 --- planted in the front journal supporting wall 23L of the left crankcase 14L and inserted into the front journal supporting wall 23R of the right crankcase 14R, and the nuts 29 --- fitted to the outside face of the left crankcase 14L are screwed on the stud bolts 28 --- planted in the rear journal supporting wall 27R of the right crankcase 14R

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and inserted into the rear journal supporting wall 27L of the left crankcase 14L.

5 The nuts 29 --- fitted to the second and third intermediate journal supporting walls 25R, 26R are screwed on the stud bolts 28 --- planted in the second and third intermediate journal supporting walls 25L, 26L of the left crankcase 14L and inserted into the second and third intermediate journal supporting walls 25R, 26R of the right crankcase 14R, and the nuts --- fitted to the first intermediate journal supporting wall 24L are screwed
10 on the stud bolts 28 --- planted in the first intermediate journal supporting wall 24R of the right crankcase 14R and inserted into the first intermediate journal supporting wall 24L of the left crankcase 14L.

15 The left and right engine blocks 13L, 13R are mutually connected by through bolts 30 --- a pair of which is arranged in each part corresponding to the first, second and third intermediate journal supporting walls 24L to 26L, 24R to 26R of both crankcases 14L, 14R and two sets of a pair of stud bolts 32 ---.

20 Each through bolt 30 --- pierces the left and right engine blocks 13L, 13R with the stud bolts 28 arranged by a pair in the first to third intermediate journal supporting walls 24L to 26L, 24R to 26R to mutually fasten the first, second and third intermediate journal supporting walls 24L to 26L, 24R to 26R between each through bolt and the crankshaft 11, and each nut
25 31 --- is screwed on both ends of each through bolt 30 --- protruded from the cylinder heads 17L, 17R of the left and right engine blocks 13L, 13R. In addition, to prevent the through bolt 30 --- from being turned when the nut 31 --- is tightened, each hexagonal tool fitting part 30a --- for example for fitting a tool not shown is coaxially provided to both ends of each
30 through bolt 30 --- in a state in which the tool fitting part is protruded from each nut 31 ---.

One set of stud bolts 32 --- out of two sets of stud bolts 32 --- are planted in the front journal supporting wall 23L of the left crankcase 14L, pierce the
35 right engine block 13R, and each nut 33 --- is screwed on each stud bolt --- protruded from the cylinder head 17R of the right engine block 13R. Further, the other set of stud bolts 32 --- out of the two sets of stud bolts 32 -

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-- are planted in the rear journal supporting wall 27R of the right crankcase 14R, pierce the left engine block 13L, and each nut 33 --- is screwed on each stud bolt 32 --- protruded from the cylinder head 17L of the left engine block 13L.

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In addition, each stud bolt 32 --- is arranged with a pair of stud bolts 28 --- for fastening the front journal supporting walls 23L, 23R of the left and right crankcases 14L, 14R and a pair of stud bolts 28 --- for fastening the rear journal supporting walls 27L, 27R of the left and right crankcases 14L, 14R
10 between the stud bolt 32 and the crankshaft 11.

Each through bolt 30 --- and each stud bolt 32 --- are arranged in a state in which they surround the cylinder bores 18L ---, 18R --- at an interval by 90° for example as shown in Fig. 7, and plural mounting bosses 34 --- extended
15 from the fitting planes of the cylinder barrels 16L, 16R to the crankcase 21 to the cylinder heads 17L, 17R are integrated with the cylinder blocks 15L, 15R to insert the through bolts 30 --- and the stud bolts 32 --- in a state in which the mounting bosses surround the cylinder bores 18L ---, 18R ---.

20 Each coupling wall 35 --- that couples at least one set of mounting bosses 34, 34 --- out of two sets of mounting bosses 34, 34 --- arranged in a part corresponding to the cylinder bores 18L, 18L; 18R, 18R mutually adjacent in the axial direction of the crankshaft 11 and mutually adjacent in a pair, in the first embodiment, a pair of mounting bosses 34, 34 --- mutually
25 adjacent on the upper wall sides of the cylinder blocks 15L, 15R is integrated with the cylinder blocks 15L, 15R as shown in Fig. 8.

A supporting cylinder 38 formed in cooperation of the left and right crankcases 14L, 14R is formed in the front of the crankcase 21 in a forward
30 protruded state, the front of the crankshaft 11 coaxially pierces the supporting cylinder 38, is protruded from the front end of the supporting cylinder 38, a ring gear 39 is fixed to the protruded part of the crankshaft 11 from the front end of the supporting cylinder 38, and the spinner not shown is coaxially attached to the ring gear 39. In addition, a plain bearing
35 40 is inserted between the front of the supporting cylinder 38 and the crankshaft 11, an annular sealing member (not shown) is inserted between

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the supporting cylinder 38 and the crankshaft 11 in front of the plain bearing 40.

Driving force is applied to the crankshaft 11 by a starting system 41 when
5 the engine is started, the starting system 41 is a well-known system
provided with a starting motor 42 supported by a lower part of the left
crankcase 14L in the crankcase 21 and a pinion 43 protruded so that the
pinion is engaged with the ring gear 39 when the rotational speed of the
starting motor 42 is equal to or more than a predetermined value, and
10 after the engine is started, the pinion 43 is separated from the ring gear 39
and is returned to its original position.

Plural protrusions 44 --- are protruded at an equal interval in a
circumferential direction from the crankshaft 11 in the supporting
15 cylinder 38, and a pair of crank angle sensors 45, 45 for detecting a crank
angle by the protrusions 44 --- are attached to the supporting cylinder 38 in
a state in which the crank angle sensors are out of phase by 180°.

Also referring to Figs. 9 and 10, a water pump 46 rotated by the crankshaft
20 11 is attached to the crankcase 21 on the side of one end in the axial
direction of the crankshaft 11, in the first embodiment, on the side of the
rear side.

A driving gear 47 is coaxially attached to the rear end of the crankshaft 11
25 in parts protruded from the rear journal supporting walls 27L, 27R, and a
rotor 49 of a motor 48 attached to the rear of the crankcase 21 is coupled to
the driving gear 47 axially and so that the relative turning is impossible. A
cover 51 is attached to the rear end of the crankcase 21 and a stator 50 of the
motor 48 is attached to the cover 51.

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A pump housing 54 of the water pump 46 is composed of a case 52
integrated with a cylindrical shaft supporting part 52a fitted to the cover 51
fluid-tightly and a pump cover 53 with the case 52 between the pump
cover and the cover 51, and the case 52 and the pump cover 53 is jointly
35 fastened to the cover 51.

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A pump shaft 55 that pierces the shaft supporting part 52a fluid-tightly is supported by the shaft supporting part 52a so that the pump shaft can be rotated, and one end of the pump shaft 55 protruded from the shaft supporting part 52a is supported by the crankcase 21 so that the pump shaft
5 can be rotated. In a pump chamber 56 formed in the pump housing 54, a moving blade 57 is fixed to the other end of the pump shaft 55. Further, a driven gear 58 fixed to the pump shaft 55 between the shaft supporting part 52a and the crankcase 21 is engaged with an idle gear 59 supported between the crankcase 21 and the cover 51 so that the idle gear can be
10 turned, and the idle gear 59 is engaged with the driving gear 47.

Water jackets 60L, 60R on the cylinder side for cooling are provided to each cylinder barrel 16L, 16R, water jackets 61L, 61R on the head side communicating with the water jackets 60L, 60R on the cylinder side are
15 provided to each cylinder head 17L, 17R integrated with each cylinder barrel 16L, 16R, the water pump 46 circulates cooling water between the water jackets 60L, 60R; 61L, 61R on the cylinder side and on the head side, and cooling water supply passages 62L, 62R that lead cooling water from the water pump 46 and cooling water return passages 63L, 63R that lead
20 cooling water led from the water jackets 60L, 60R on the cylinder side are provided to the crankcase 21 in parallel with the axis of the crankshaft 11 with the axis of the cylinder bores 18L ---, 18R --- between them.

In addition, the water jackets 60L, 60R; 61L, 61R on the cylinder side and
25 on the head side are formed so that cooling water supplied from the cooling water supply passages 62L, 62R is returned from the water jackets 60L, 60R on the cylinder side to the water jackets 60L, 60R on the cylinder side via the water jackets 61L, 61R on the head side. The water jackets 60L, 60R on the cylinder side are partitioned into each jacket part 64 --- on the
30 supply side communicating with the cooling water supply passages 62L, 62R and communicating with the water jackets 61L, 61R on the head side and each jacket part 65 --- on the return side communicating with the cooling water return passages 63L, 63R and communicating with the water jackets 61L, 61R on the head side in a position apart from each jacket part
35 64 --- on the supply side, and are formed in the cylinder barrels 16L, 16R.

A passage 66 that leads cooling water discharged from the pump chamber 56 of the water pump 46 to the cooling water supply passages 62L, 62R is provided to the cover 51 connected to the crankcase 21.

- 5 Each jacket part 64 --- on the supply side and each jacket part 65 --- on the return side are formed in the cylinder barrels 16L, 16R as parts enclosing a substantial half of each cylinder bore 18L ---, 18R ---, and plural branch passages 67L, 67L; 68R, 68R on the supply side and on the return side for connecting parts corresponding to each cylinder bore 18L ---, 18R --- of the
- 10 jacket part 64 --- on the supply side and the jacket part 65 --- on the return side to the cooling water supply passages 62L, 62R and the cooling water return passages 63L, 63R are provided to the crankcase 21 and the cylinder barrels 16L, 16R.
- 15 In addition, the inside diameters on the sides of the cylinder bores 18L, 18R the distance from the water pump 46 of which is far of the cooling water supply passages 62L, 62R are made smaller than the inside diameters on the sides of the cylinder bores 18L, 18R the distance from the water pump 46 of which is near, and as the distance from the water pump 46 is farther,
- 20 the inside diameters are made gradually smaller.

The water jackets 60L, 60R on the cylinder side are formed in the cylinder barrels 16L, 16R as a ring cavity encircling each cylinder bore 18L ---, 18R --- when the cylinder blocks 15L, 15R are cast, rod members 69 --- partitioning

25 the cavity by a half round and forming the jacket parts 64 ---, 65 --- on the supply side and on the return side are arranged on a straight line connecting the axis of each cylinder bore 18L ---, 18R ---, and are fitted into the cylinder barrels 16L, 16R from the sides of the cylinder heads 17L, 17R.

- 30 In addition, an intermediate part of each rod member 69 --- is formed so that the diameter is smaller to form an annular passage 70 for degasing from the jacket part 64 --- on the supply side to the jacket part 65 --- on the return side between the cylinder barrels 16L, 16R.

- 35 Plug members 105 ---, 106 --- for preventing the rod members 69 --- from being detached from the cylinder heads 17L, 17R are fitted to the cylinder

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heads 17L, 17R in a state in which the plug members are touched to the rod members 69 ---.

Particularly referring to Fig. 9, the cooling water return passages 63L, 63R mutually communicate via a coupling pipe 71, and a first return side conduit 72 communicating with the cooling water return passage 63L is connected to the crankcase 21 to lead cooling water to the radiator not shown. Water returned from the radiator is led into a second return side conduit 74, however, a thermostat 73 for leading cooling water in the first return side conduit 72 into the second return side conduit 74 without passing the radiator when the temperature of the cooling water is low is provided between the first and second return side conduits 72 and 74, and the second return side conduit 74 is connected to a connecting pipe 75 on the return side provided to the pump cover 53 of the water pump 46.

In the meantime, a steam conduit 76 for leading steam evaporated by heating to an expansion tank 77 is connected to an upper part of the first return side conduit 72, and a third return side conduit 78 for leading cooling water condensed in the expansion tank 77 is connected to a connecting pipe 79 on the return side provided to the pump cover 53 of the water pump 46. Further, an oil filter 81 is arranged on the side of an oil pan 80 attached to a lower part of the crankcase 21, cooling water from the water pump 46 is supplied to an oil cooler built in the oil filter 81 via a conduit 82 on the supply side, and the cooling water from the oil cooler is returned to the water pump 46 via a conduit 83 on the return side.

Intake ports 85L ---, 85R --- individually corresponding to each combustion chamber 19L ---, 19R --- are provided to upper parts of the left and right cylinder heads 17L, 17R, each intake port 85L ---, 85R --- is branched in two and ranges to each combustion chamber 19L ---, 19R ---.

Each intake pipe 86L ---, 86R --- curved in a circular arc is connected to each intake port 85L ---, 85R ---, electromagnetic fuel injection valves 87L ---, 87R --- for injecting fuel toward the intake ports 85L ---, 85R --- are attached to intermediate parts of the intake pipes 86L ---, 86R ---. The electromagnetic fuel injection valve 87L --- on the side of the left engine block 13L is connected to a common fuel rail 88L and the electromagnetic

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fuel injection valve 87R --- on the side of the right engine block 13R is connected to a common fuel rail 88R.

5 An intake chamber 89 is arranged in an upper part of the crankcase 21 in the body of the engine 12 in a state in which the intake chamber is supported by the body of the engine 12. In addition, the upstream end of each intake pipe 86L ---, 86R --- is connected to the downstream end of each connecting pipe 90L ---, 90R ---, the upstream end of each connecting pipe 90L ---, 90R --- is inserted into the intake chamber 89 from both sides of the
10 intake chamber 89, is extended like a trumpet in the intake chamber 89, and is open to the rear side.

The downstream ends of a pair of left and right throttle bodies 92, 92 in which each throttle valve 91 is supported by a shaft are connected to the
15 rear of the intake chamber 89 in parallel, and air cleaners 93, 93 are connected to the upstream ends of both throttle bodies 92, 92. In addition, the air cleaners 93, 93 are supported by supporting stays 94, 94 attached to the intake chamber 89 and extended backward.

20 Exhaust ports 95L ---, 95R --- individually corresponding to each combustion chamber 19L ---, 19R --- are provided to lower parts of the left and right cylinder heads 17L, 17R, and exhaust pipes 96L ---, 96R --- passing the downside of the body of the engine 12 and extended backward are connected to each exhaust port 95L ---, 95R ---.

25 Substantially H-type head covers 97L, 97R are connected to the left and right cylinder heads 17L, 17R, a valve system (not shown) for driving an intake valve for controlling intake air to each combustion chamber 19L ---, 19R --- and an exhaust valve for controlling exhaust from each
30 combustion chamber 19L ---, 19R --- is housed between these head covers 97L, 97R and the cylinder heads 17L, 17R, covers 98L, 98R that cover a part on the side of the intake valve in the valve system are fastened to the upside of each head cover 97L ---, and covers 99L, 99R that cover a part on the side of the exhaust valve in the valve system are fastened to the
35 downside of each head cover 97L ---.

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The part on the side of the intake valve in the valve system housed between the head covers 97L, 97R and the cylinder heads 17L, 17R acquires valve opening driving force from a push rod pushed up at an intake stroke by power transmitted from the driving gear 47 of the crankshaft 11, the push rod every combustion chamber 19L ---, 19R --- is arranged in lower parts of the cylinder blocks 15L, 15R on both left and right sides of the crankcase 21, and is inserted into rod guide pipes 100L, 110R connecting the centers in a longitudinal direction in lower parts of the left and right crankcases 14L, 14R and the head covers 97L, 97R so that the push rod can be axially moved.

The part on the side of the exhaust valve in the valve system housed between the head covers 97L, 97R and the cylinder heads 17L, 17R acquires valve opening driving force from a pull rod pulled down at an exhaust stroke by power transmitted from the driving gear 47 of the crankshaft 11, and the pull rod every combustion chamber 19L ---, 19R --- is inserted into rod guide pipe 101L ---, 101R --- connecting the centers in a longitudinal direction in lower parts of the left and right crankcases 14L, 14R bellow the rod guide pipes 100L, 100R and the head covers 97L, 97R so that the pull rod can be axially moved.

As described above, the rod guide pipes 100L, 100R, 101L ---, 101R --- are arranged in a state in which each connects the centers in the longitudinal direction in the lower parts of the left and right crankcases 14L, 14R and the head covers 97L, 97R, a pair of mounting bosses 34, 34 --- mutually adjacent on the upper wall sides of the cylinder blocks 15L, 15R are coupled by each coupling wall 35 --- integrated with the cylinder blocks 15L, 15R, and the rod guide pipes 100L, 100R, 101L --, 101R ---and the coupling wall 35 are arranged on both upper and lower sides of the cylinder blocks 15L, 15R.

A pair of ignition plugs 102L, 102L ---, 102R, 102R --- are attached to each cylinder head 17L, 17R every each combustion chamber 19L ---, 19R ---. Besides, ignition coils 103L ---, 103R --- which are electrical units are attached to upper sides of the cylinder heads 17L, 17R between both intake pipes 86L, 86L; 86R, 86R so that a pair is arranged on both sides of the intake chamber 89, and high-tension cords 104 --- each pair of which range

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to each ignition coil 103L ---, 103R --- are connected to the ignition plugs 102L, 102L ---, 102R, 102R ---.

5 In addition, to securely enable ignition in each combustion chamber 19L ---, 19R --- even when one of a pair of ignition coils 103L ---, 103R --- is out of order, a pair of high-tension cords 104, 104 which range to the same ignition coils 103L ---, 103R --- are connected to the ignition plugs 102L ---, 102R --- of different combustion chambers 19L ---, 19R ---.

10 An electronic control unit 105 is attached to the outside face of the front side wall of the intake chamber 89 to control the operation of the engine, and an intake pressure sensor 106 and an intake temperature sensor 107 for detecting intake pressure and intake temperature in the intake chamber 89 pierce the front side wall of the intake chamber 89 from the
15 electronic control unit 105 and are inserted into the intake chamber 89.

The electromagnetic fuel injection valves 87L ---, 87R ---, the ignition coils 103L ---, 103R --- and the electronic control unit 105 are arranged around the intake chamber 89, however, the electromagnetic fuel injection valves
20 87L ---, 87R ---, the ignition coils 103L ---, 103R --- and the electronic control unit 105 are covered with a shield cover 108 covering at least a part of the intake chamber 89 and attached to the body of the engine 12.

25 The shield cover 108 is formed by a steel plate for example in a state in which it covers most except the rear of the intake chamber 89 in the first embodiment and an upper part of the body of the engine 12, and the edge of an opening of the shield cover 108 is formed so that the edge is touched to the body of the engine 12. A part of the high-tension cord 104 extended from the ignition coils 103L --- 103R --- is also covered with the shield
30 cover 108.

The number of parts is reduced by covering the electromagnetic fuel injection valves 87L ---, 87R ---, the ignition coils 103L ---, 103R --- and the electronic control unit 105 with one shield cover 108 to shield them as
35 described above, compared with a case that each electrical unit is individually shielded, and the electrical units can be shielded, making the whole engine compact. In addition, as the high-tension cord 104 --- itself is

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not required to be individually shielded in a part covered with the shield cover 108 by also covering a part of the high-tension cord 104 --- with the shield cover 108, the secondary voltage drop of the high-tension cords 104 -- can be enhanced by not requiring an individual shield.

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As the electronic control unit 105 is attached to the outside face of the front side wall of the intake chamber 89, the intake pressure sensor 106 and the intake temperature sensor 107 for detecting intake pressure and intake temperature in the intake chamber 89 pierce the front side wall of the intake chamber 89 from the electronic control unit 105 and are inserted into the intake chamber 89, the electronic control unit 105 can be shielded, in addition, the intake pressure sensor 106 and the intake temperature sensor 107 are directly connected to the electronic control unit 105, and labor for connecting a conductor can be saved.

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Next, to explain the action of the first embodiment, the water pump 46 is attached to the crankcase 21 on the side of one end along the axis of the crankshaft 11, in the crankcase 21, the cooling water supply passages 62L, 62R for leading cooling water from the water pump 46 and the cooling water return passages 63L, 63R for leading cooling water led out from the water jackets 60L, 60R on the cylinder side with which the cylinder barrels 16L, 16R are provided are provided in parallel with the axis of the crankshaft 11 with each axis of the cylinder bores 18L ---, 18R --- between them, and the water jackets 60L, 60R on the cylinder side and the water jackets 61L, 61R on the head side are formed so that cooling water supplied from the cooling water supply passages 62L, 62R is returned to the water jackets 60L, 60R on the cylinder side via the water jackets 61L, 61R on the head side from the water jackets 60L, 60R on the cylinder side.

Therefore, piping outside the engine for leading cooling water from the water pump 46 to the cylinder barrels 16L, 16R is not required, and besides as piping outside the engine for leading cooling water from the cylinder heads 17L, 17R is not required, cooling water piping around the engine can be simplified.

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In addition, as the water jackets 60L, 60R on the cylinder side are partitioned into each jacket part 64 --- on the supply side communicating

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with the cooling water supply passages 62L, 62R and communicating with the water jackets 61L, 61R on the head side and each jacket part 65 --- on the return side communicating with the cooling water return passages 63L, 63R and communicating with the water jackets 61L, 61R on the head side in a position apart from the jacket part 64 --- on the supply side and are formed in the cylinder barrels 16L, 16R, the cooling water supply passages 62L, 62R and the cooling water return passages 63L, 63R can be cast or bored from the same direction along the axis of the crankshaft 11 and workability for the formation of passages can be enhanced.

10

Besides, as each jacket part 64 --- on the supply side and each jacket part 65 --- on the return side are formed in the cylinder barrels 16L, 16R provided with plural cylinder bores 18L ---, 18R --- arranged in the axial direction of the crankshaft 11 as parts encircling a substantial half of each cylinder bore 18L ---, 18R --- and plural branched passages 67L ---, 67R ---; 68L ---, 68R --- on the supply side and on the return side for connecting parts corresponding to each cylinder bore 18L ---, 18R --- of the jacket part 64 --- on the supply side and the jacket part 65 --- on the return side to the cooling water supply passages 62L, 62R and the cooling water return passages 63L, 63R are provided between the crankcase 21 and each cylinder barrel 16L, 16R, passage structure for uniformly cooling the part corresponding to each cylinder bore 18L ---, 18R --- in the multi-cylinder engine can be easily configured.

25 In addition, the quantity of cooling water that flows in the water jacket 60L, 60R on the cylinder side and the water jacket 61L, 61R on the head side respectively corresponding to each cylinder bore 18L ---, 18R --- can be more uniformed by gradually changing each diameter of the linear cooling water supply passages 62L, 62R and the linear cooling water return passages 63L, 63R as in this embodiment.

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As the cylinder barrels 16L, 16R and the cylinder heads 17L, 17R are mutually integrated with the water jackets 60L, 60R on the cylinder side and the water jackets 61L, 61R on the head side, the productivity of the cylinder barrels 16L, 16R and the cylinder heads 17L, 17R can be enhanced by integrally forming a sand core in a form that the water jackets 60L, 60R; 61L, 61R on the cylinder side and on the head side mutually range.

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Further, as the rod member 69 --- for partitioning the ring cavity which encircles the cylinder bores 18L ---, 18R --- and which is formed in the cylinder barrels 16L, 16R in casting in a half and forming the jacket parts 64 ---, 65 --- on the supply side and on the return side is inserted into the cylinder barrels 16L, 16R from the sides of the cylinder heads 17L, 17R, the water jackets 60L, 60R on the cylinder side can be easily partitioned into the jacket part 64 --- on the supply side and the jacket part 65 --- on the return side after the productivity and castability are enhanced by forming each part corresponding to the cylinder bores 18L ---, 18R --- of the water jackets 60L, 60R on the cylinder side out of the sand core in the form of a ring and enhancing the performance of sand stripping.

As in a state in which the mounting bosses encircle the cylinder bores 18L ---, 18R --- with which the cylinder barrels 16L, 16R are provided, the plural mounting bosses 34 --- extended to the cylinder heads 17L, 17R from the fitting planes to the crankcase 21 of the cylinder barrels 16L, 16R are integrated with the cylinder blocks 15L, 15R in which the water jackets 60L, 60R on the cylinder side and the water jackets 61L, 61R on the head side mutually communicate and the cylinder barrels 16L, 16R and the cylinder heads 17L, 17R are integrated and the cylinder blocks 15L, 15R are fastened to the crankcase 21 by the through bolts 30 --- and the stud bolts 32 --- respectively inserted into each mounting boss 34 ---, the connection of the cylinder barrels 16L, 16R and the cylinder heads 17L, 17R to the crankcase 21 can be simplified, as no gasket is required between the cylinder barrels 16L, 16R and the cylinder heads 17L, 17R, no bolt for maintaining the sealing performance of a gasket is required, the number of parts is required, and the engine can be lightened. In addition, the circumferences of the cylinder bores 18L ---, 18R --- can be sufficiently reinforced by the plural mounting bosses 34 --- encircling the cylinder bores 18L ---, 18R --- so that a fastening load of the through bolts 30 --- and the stud bolts 32 respectively inserted into the mounting bosses 34 --- can be born.

In addition, as the coupling wall 35 --- for coupling at least one set of mounting bosses 34, 34 --- out of mutually adjacent two sets of a pair of mounting bosses 34, 34 --- between the cylinder bores 18L, 18L; 18R, 18R mutually adjacent in the axial direction of the crankshaft 11, in this

embodiment, a pair of mounting bosses 34, 34 --- mutually adjacent on the sides of the upper side walls of the cylinder blocks 15L, 15R is integrated with the cylinder blocks 15L, 15R, no bolt is required to be arranged between each cylinder bore 18L ---, 18R ---, the strength of each cylinder barrel 16L, 16R between the cylinder bores 18L ---, 18R --- can be increased by the coupling wall 35 ---, distance between cylinder bores 18L ---, 18R --- in the axial direction of the crankshaft 11 can be reduced, and the engine can be miniaturized.

As the rod guide pipes 100L, 100R, 101L ---, 101 R --- where the push rod and the pull rod to which power from the crankshaft 11 is transmitted and which configure a part of the valve system are inserted so that they can be axially moved and the coupling wall 35 are arranged on vertical both sides of the cylinder blocks 15L, 15R, balance in rigidity between the cylinder blocks 15L, 15R is enhanced and the occurrence of distortion in each inside diameter of the cylinder bores 18L ---, 18R --- of the cylinder blocks 15L, 15R can be inhibited.

Fig. 11 shows a second embodiment of the invention and the same reference number is allocated to a part corresponding to the part in the first embodiment.

A pair of water pumps 46 rotated by a crankshaft 11 are attached to a crankcase 21 on the side of one end of the crankshaft 11, in the second embodiment, on the side of the rear end.

A cooling water supply passage 62L for leading cooling water from one water pump 46 to a jacket part 64 on the supply side in a water jacket 60L on the cylinder side of a left cylinder barrel 16L, a cooling water supply passage 62R for leading cooling water from the other water pump 46 to a jacket part 64 on the supply side in a water jacket 60R on the cylinder side of a right cylinder barrel 16R, a cooling water return passage 63L for leading cooling water led out from a jacket part 65 on the return side in the water jacket 60L on the cylinder side of the left cylinder barrel 16L and a cooling water return passage 63R for leading cooling water led out from the jacket part 65 on the return side in the water jacket 60R on the cylinder in the right cylinder barrel 16R are provided to the crankcase 21 in parallel

with the axis of the crankshaft 11 with the cylinder bores 18L, 18R between both sides on a projection drawing of planes perpendicular to the axes of the cylinder bores 18L, 18R.

- 5 Return side conduits 110L, 110R are individually connected to the cooling water return passages 63L, 63R and the return side conduits 110L, 110R are connected to a first return side conduit 72 in common. Water returned from a radiator not shown is led to a second return side conduit 74 connected to both water pumps 46, 46 in common, however, a thermostat
- 10 73 for leading cooling water in the first return side conduit 72 to the second return side conduit 74 without passing the radiator when the temperature of the cooling water is low is provided between the first and second return side conduits 72, 74.
- 15 In the meantime, a steam conduit 76 for leading steam evaporated by heating to an expansion tank 77 is connected to an upper part of the cylinder block 15L in a state in which the steam conduit communicates with the cooling water return passage 63L, and a third return side conduit
- 20 78 for leading cooling water condensed in the expansion tank 77 is connected to the second return side conduit 74. Further, cooling water from both water pumps 46, 46 is supplied to an oil cooler built in an oil filter 81 via a conduit on the supply side 82 and the cooling water from the oil cooler is returned to the thermostat 73 via a conduit 111 on the return side.
- 25 The similar effect to that in the first embodiment can be also produced by the second embodiment.

- According to the present invention, as the cylinder block is composed of the cylinder barrel and the cylinder head which are integrated and the cylinder block is fastened to the crankcase, the connection of the cylinder barrel and the cylinder head to the crankcase can be simplified, as no gasket between the cylinder barrel and the cylinder head is required, no bolt for maintaining the sealing performance of a gasket is required, the
- 30 number of parts is reduced, and the engine can be lightened. In addition, the circumferences of the cylinder bore can be sufficiently reinforced by the
- 35

plural mounting bosses encircling the cylinder bore so that a fastening load of the bolts inserted into the mounting bosses can be born.

- 5 According to an embodiment of the invention, no bolt is required to be arranged between each cylinder bore, the strength of the cylinder barrel between the cylinder bores can be increased by the coupling wall, distance between the cylinder bores in the axial direction of the crankshaft can be reduced, and the engine can be miniaturized.
- 10 Further, according to another embodiment of the invention, balance in rigidity between the cylinder blocks is enhanced and the occurrence of distortion in the inside diameter of the cylinder bore with which the cylinder block is provided can be inhibited.
- 15 The embodiments of the invention have been described, however, the invention is not limited to the embodiments and various design changes without deviating from the invention described in Claims are possible.

- 20 For example, in the first and second embodiments, the case that the invention is applied to the horizontal opposed multi-cylinder engine has been described, however, the invention can be also applied to a V-type multi-cylinder engine and a single-cylinder engine.

**THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE
PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:**

1. A liquid-cooled engine provided with a crankcase that
5 supports a crankshaft so that the crankshaft can be rotated, a cylinder barrel
having a cylinder bore and a water jacket on the cylinder side for cooling
encircling the cylinder bore and connected to the crankcase and a cylinder
head having a water jacket on the head side that communicates with the
water jacket on the cylinder side and connected to the cylinder barrel
10 wherein: plural mounting bosses extended from a fitting plane to the
crankcase of the cylinder barrel to the cylinder head are integrated with a
cylinder block in which the water jacket on the cylinder side and the water
jacket on the head side mutually communicate and the cylinder barrel and
the cylinder head are integrated in a state in which the mounting bosses
15 encircle the cylinder bore; and the cylinder block is fastened to the
crankcase by bolts inserted into each mounting boss.
2. A liquid-cooled engine according to Claim 1, wherein: a
coupling wall for coupling at least one set of mounting bosses out of
20 mutually adjacent two sets of a pair of mounting bosses between the
cylinder bores mutually adjacent in an axial direction of the crankshaft is
integrated with the cylinder block having the plural cylinder bores
arranged in the axial direction of the crankshaft.
- 25 3. A liquid-cooled engine according to Claim 2, wherein: rod
guide pipes where each rod to which power from the crankshaft is
transmitted and which configures a part of a valve system is inserted so
that the rod can be axially moved and the coupling wall are arranged on
sides of both cylinder blocks.

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Fig. 1

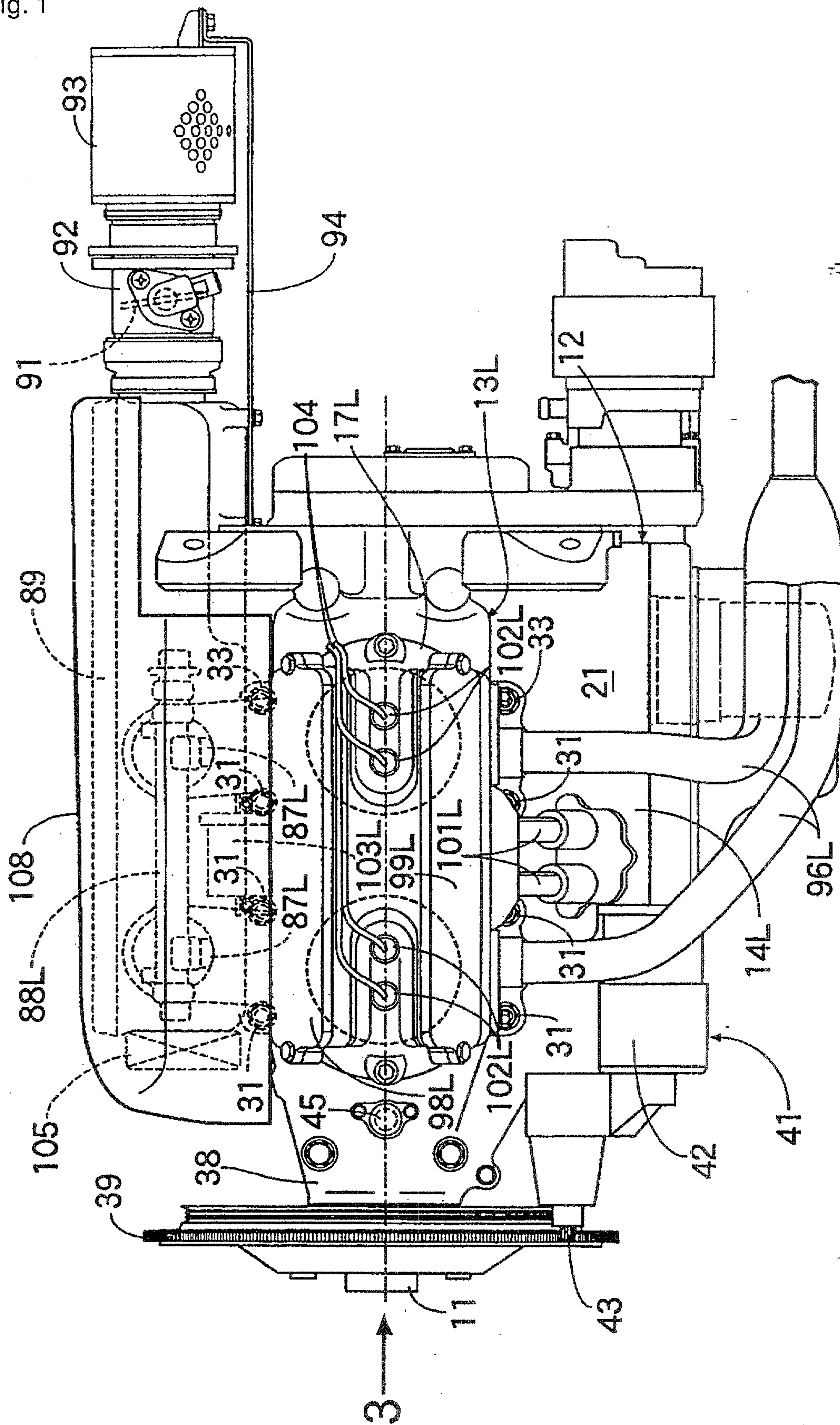


Fig. 2

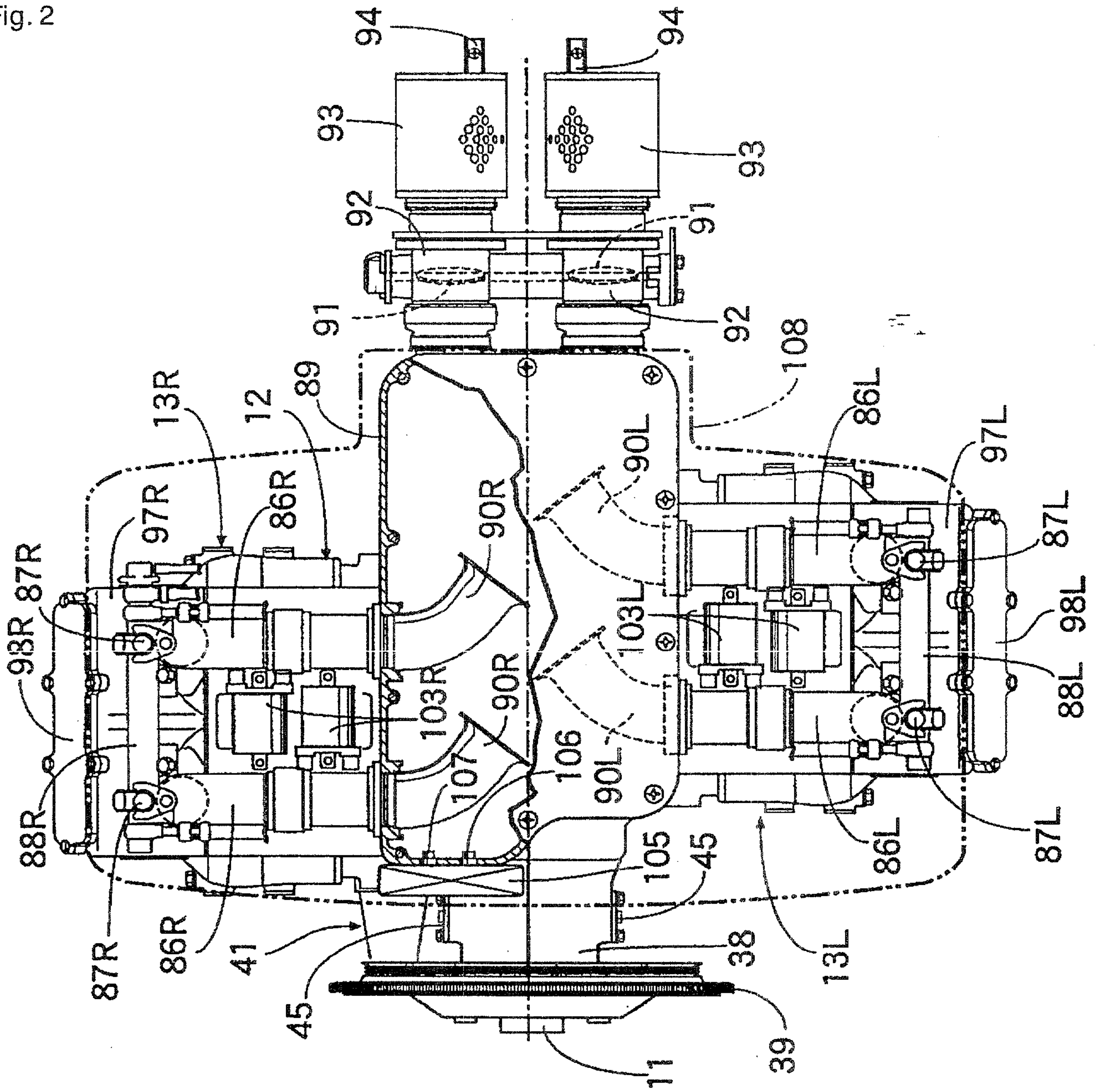


Fig. 3

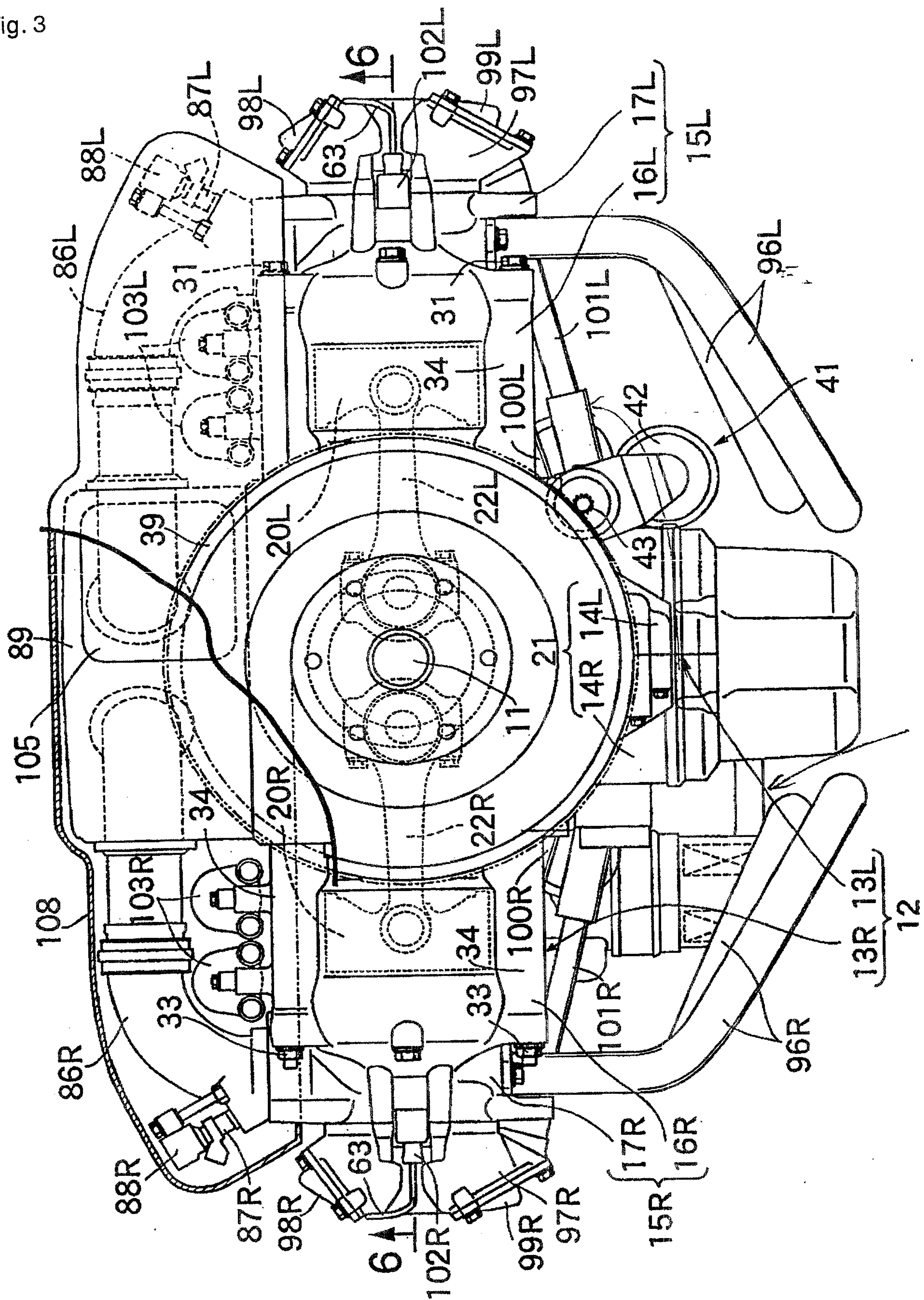


Fig. 4

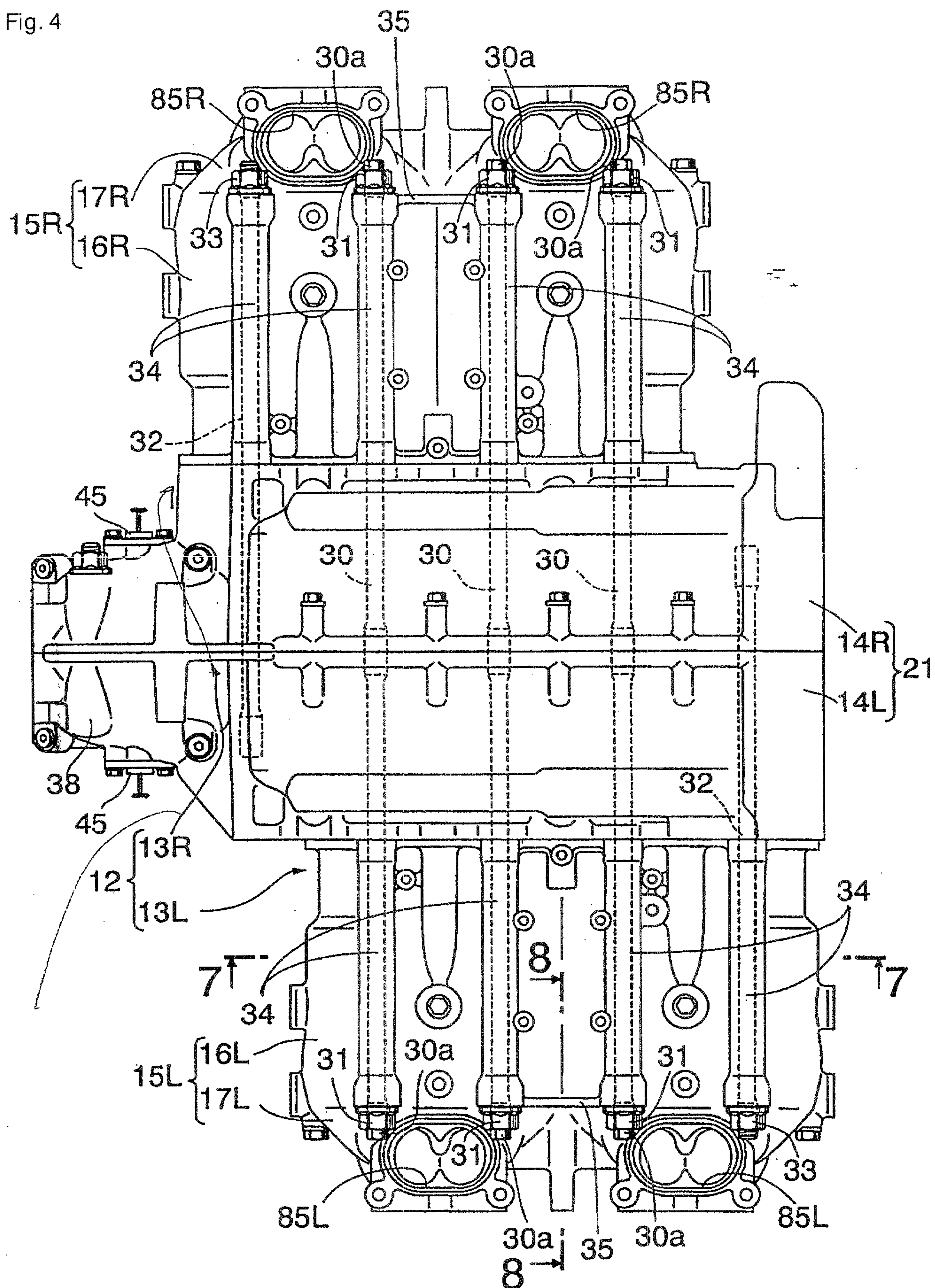


Fig. 5

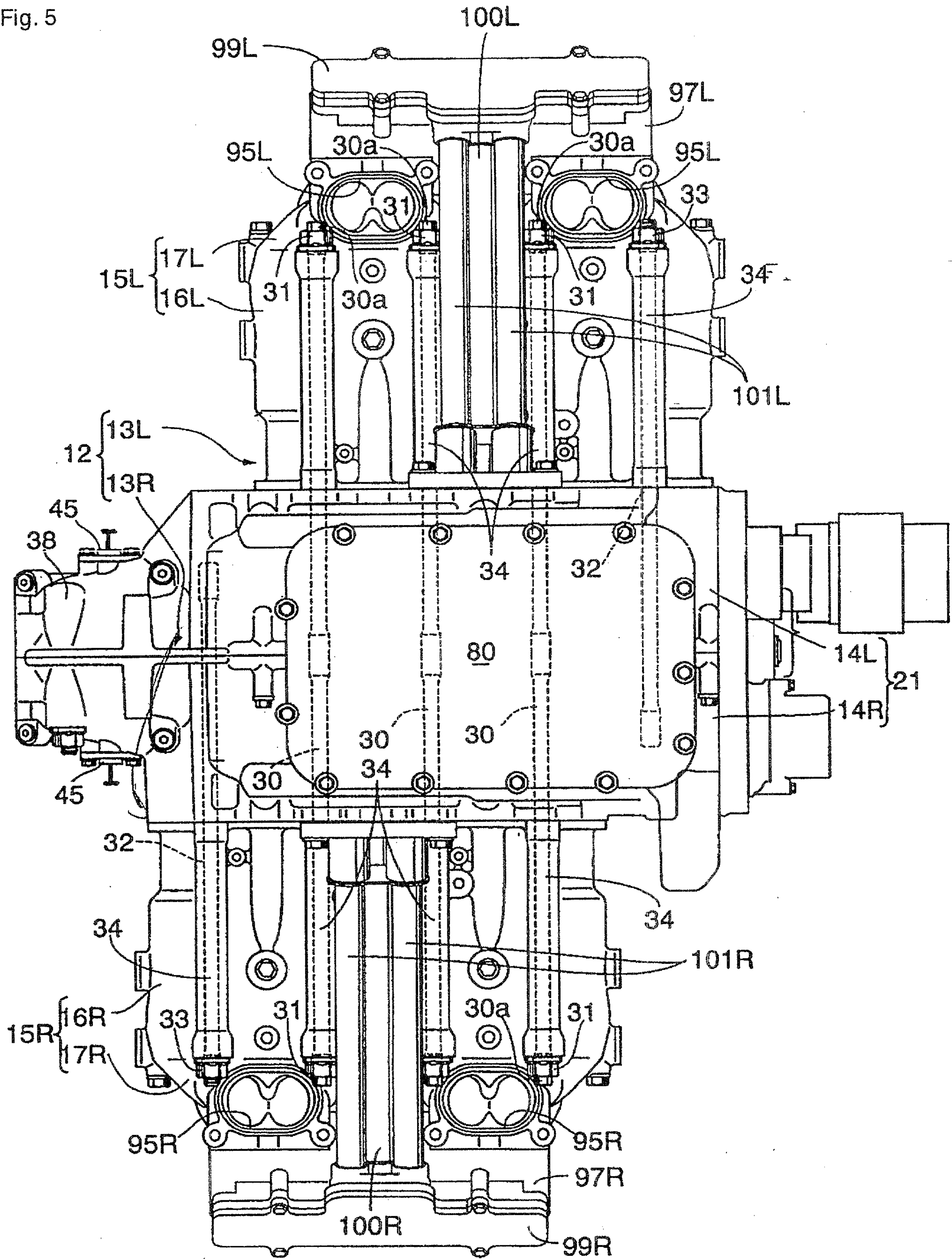


Fig. 6

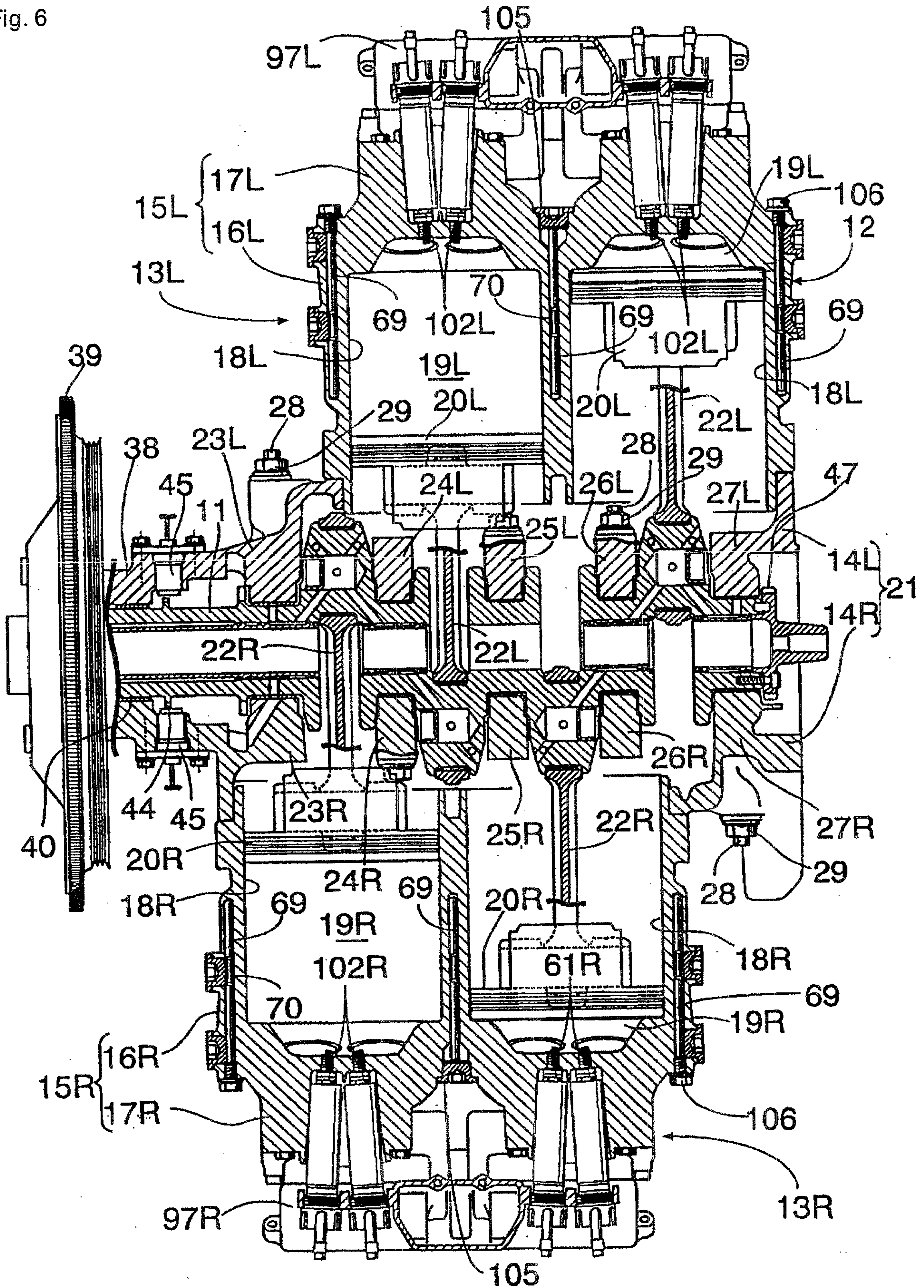


Fig. 7

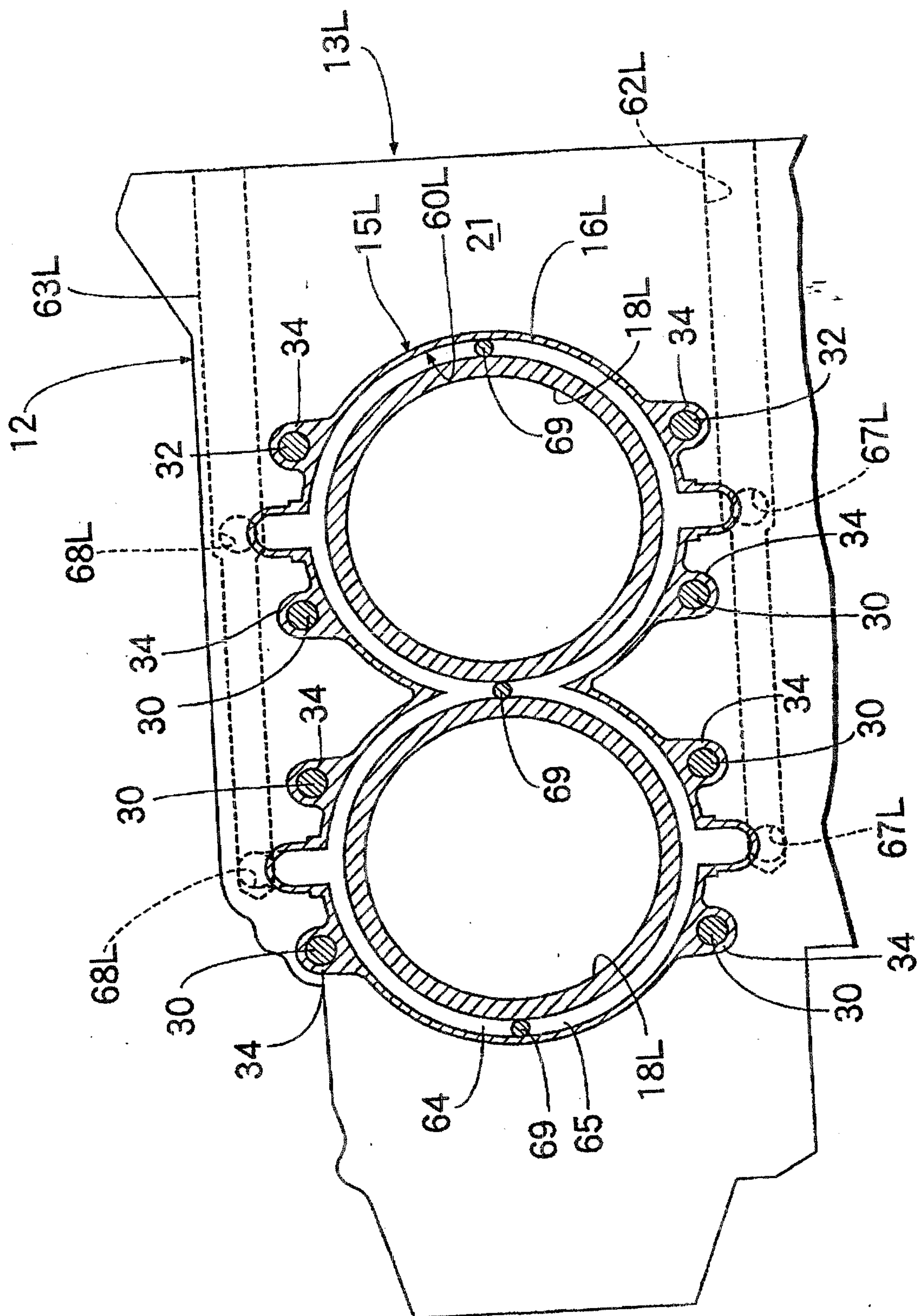


Fig. 8

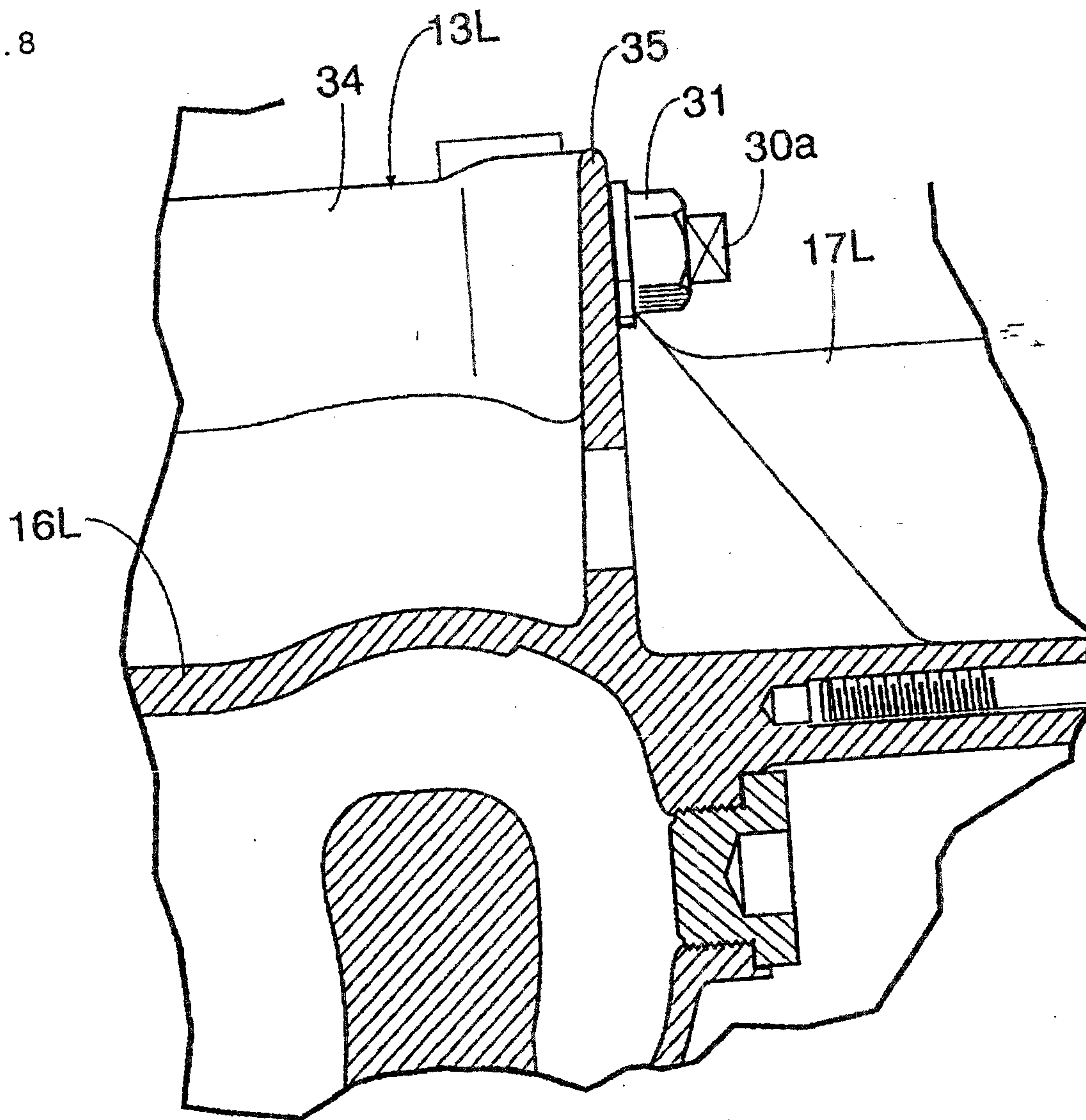


Fig. 9

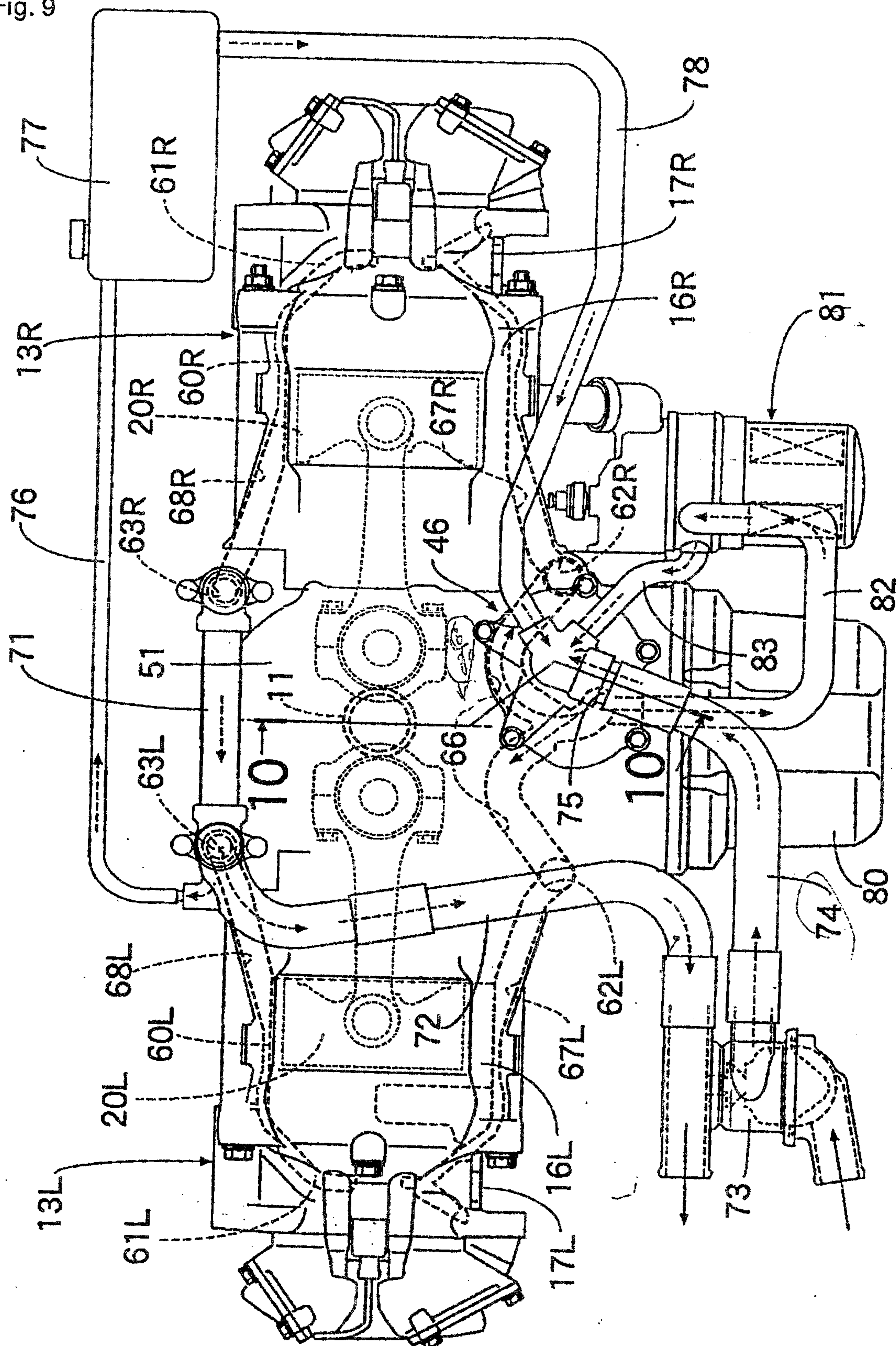


Fig. 10

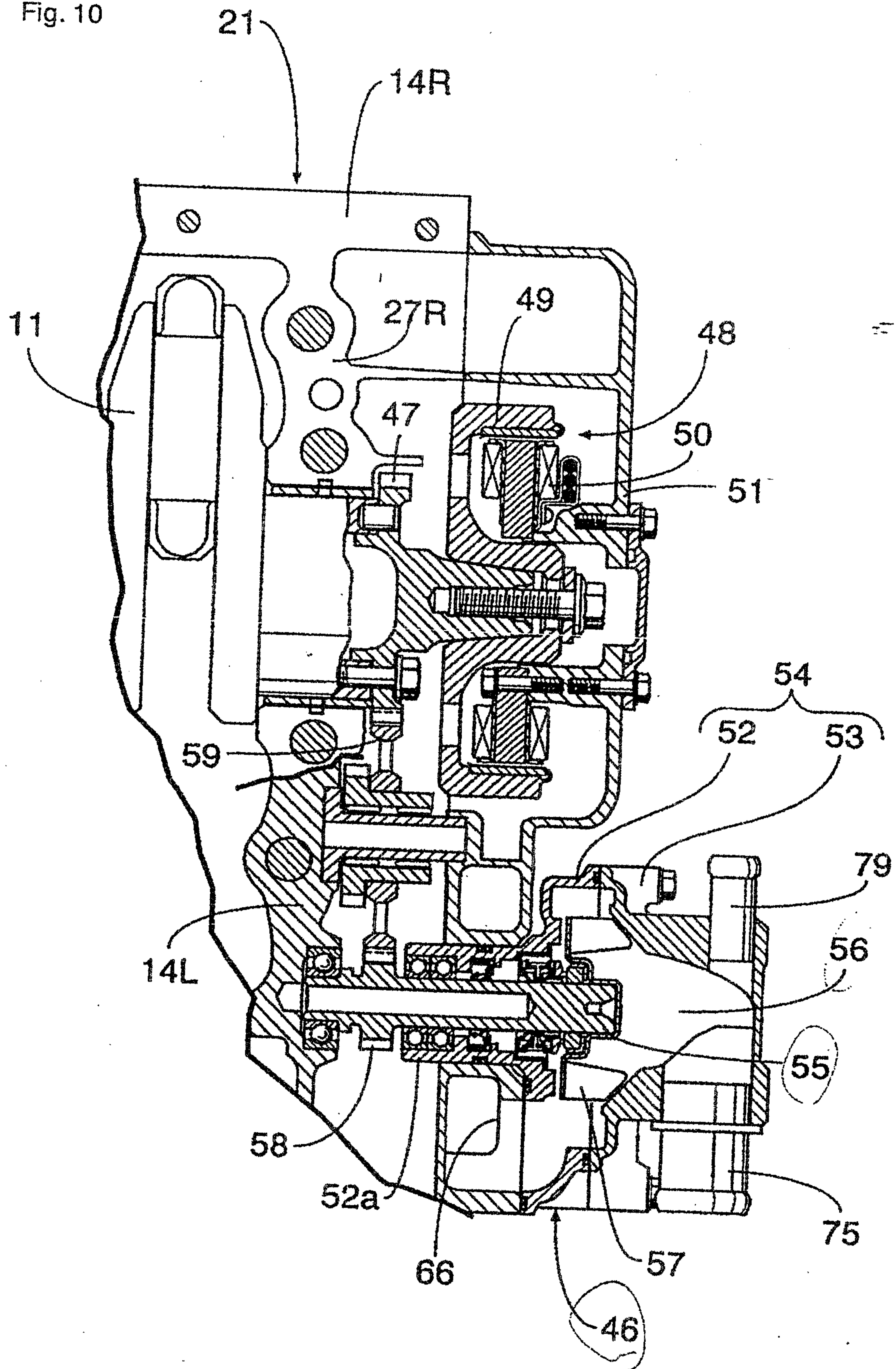


Fig. 11

