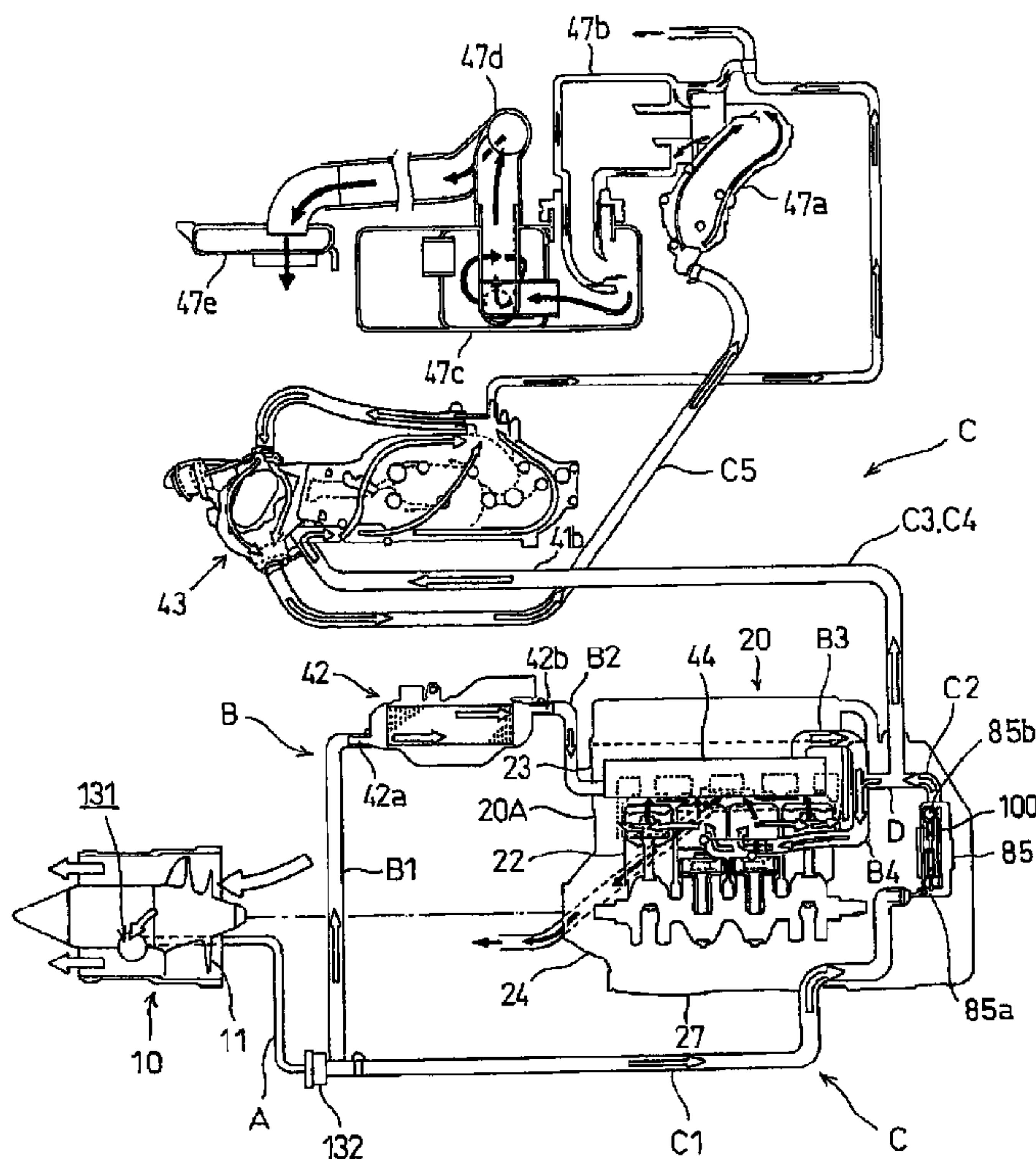




(22) Date de dépôt/Filing Date: 2007/05/01  
(41) Mise à la disp. pub./Open to Public Insp.: 2007/11/19  
(30) Priorité/Priority: 2006/05/19 (JP2006-140108)

(51) Cl.Int./Int.Cl. *F01P 7/14* (2006.01),  
*B63H 11/04* (2006.01), *B63H 11/08* (2006.01),  
*B63H 21/14* (2006.01), *F01P 3/00* (2006.01),  
*B63B 35/73* (2006.01)  
(71) Demandeur/Applicant:  
HONDA MOTOR CO., LTD., JP  
(72) Inventeurs/Inventors:  
HOI, YOSUKE, JP;  
KUSUDA, ATSUSHI, JP  
(74) Agent: DENNISON ASSOCIATES

(54) Titre : MOTEUR A COMBUSTION INTERNE POUR FAIBLE DEJAUAGEAGE  
(54) Title: INTERNAL COMBUSTION ENGINE FOR SMALL PLANING BOAT



(57) **Abrégé/Abstract:**

To provide an internal combustion engine for a small planing boat that makes it possible to prevent supercooling of the internal combustion engine before warm-up while enabling efficient cooling of the internal combustion engine after warm-up. An internal combustion engine for a small planing boat includes: a first cooling water path B through which cooling water introduced from a jet propulsion pump flows toward an internal combustion engine main body via an exhaust manifold; a second cooling water path C through which cooling water introduced from the jet propulsion pump flows toward an exhaust pipe via an oil cooler; and a bypass cooling water path D for branching a part of cooling water in the second cooling water path C which flows out from the oil cooler, so as to merge into cooling water in the first Cooling water path B which flows into the internal combustion engine main body.

### ABSTRACT OF THE DISCLOSURE

To provide an internal combustion engine for a small planing boat that makes it possible to prevent supercooling of the internal combustion engine before warm-up while enabling efficient cooling of the internal combustion engine after warm-up. An internal combustion engine for a small planing boat includes: a first cooling water path B through which cooling water introduced from a jet propulsion pump flows toward an internal combustion engine main body via an exhaust manifold; a second cooling water path C through which cooling water introduced from the jet propulsion pump flows toward an exhaust pipe via an oil cooler; and a bypass cooling water path D for branching a part of cooling water in the second cooling water path C which flows out from the oil cooler, so as to merge into cooling water in the first cooling water path B which flows into the internal combustion engine main body.

## INTERNAL COMBUSTION ENGINE FOR SMALL PLANING BOAT

### FIELD OF THE INVENTION

- 5 The present invention relates to an internal combustion engine mounted in a small planing boat that planes across the water.

### BACKGROUND OF THE INVENTION

- 10 In an internal combustion engine mounted in a small planing boat, cooling of the internal combustion engine is effected by using the water on which the small planing boat is floated as cooling water. Water is introduced from the downstream positive-pressure side of a jet propulsion pump driven by the internal combustion engine, and is supplied to desired portions of the internal combustion engine.

15

- While cooling water is made to circulate in the cooling system of an internal combustion engine mounted in a vehicle that travels on the ground, in the cooling system of an internal combustion engine mounted in a small planing boat, new cooling water is constantly supplied to cool the internal combustion engine. Accordingly, during cold running, supercooling may occur before the warm-up of the internal combustion engine.
- 20

When supercooling of the internal combustion engine occurs, the amount of blowby gas that blows through the gap between the piston and the cylinder

increases, and so-called dilution, whereby fuel dissolves into lubricating oil to dilute the lubricating oil, proceeds to accelerate degradation of oil.

5 In view of this, in an internal combustion engine mounted in a small planing boat, cooling water passes through the exhaust system before being supplied to the internal combustion engine main body (see. for example, JP-A No. 2003-49645).

10 In the cooling system for the internal combustion engine of the water jet propulsion boat (small planing boat) disclosed in JP-A No. 2003-49645, the cooling water introduced from the water suction port of the jet propulsion unit is branched to form two cooling water paths.

15 One of the cooling water paths is a path leading to the cylinder and then to the cylinder head of the internal combustion engine main body via the upstream-side exhaust pipe and the exhaust manifold. The cooling water that has been raised in temperature in the upstream-side exhaust pipe and the exhaust manifold is supplied to the water jackets of the cylinder and cylinder head, thereby preventing supercooling of the internal combustion engine before warm-up to  
20 alleviate dilution of lubrication oil.

The other cooling water path is a path leading to the downstream-side exhaust pipe and then to the muffler via the oil tank. The cooling water that has cooled the oil in the oil tank is supplied to the downstream-side exhaust pipe and the  
25 muffler to thereby cool the downstream side of the exhaust pipe and the muffler.

30 However, once the internal combustion engine has been warmed up, in the former cooling water path for cooling the internal combustion engine main body, the temperature of the cooling water that has passed through the upstream-side exhaust pipe and the exhaust manifold is too high. Since such high-temperature cooling water is supplied to the water jackets of the cylinder and cylinder head, the internal combustion engine cannot be cooled efficiently.

The present invention has been made in view of the above-mentioned problems. Accordingly, it is an object of the present invention to provide an internal combustion engine for a small planing boat that makes it possible to prevent supercooling of the internal combustion engine before warm-up while enabling efficient cooling of the internal combustion engine after warm-up.

### **SUMMARY OF THE INVENTION**

According to an aspect of the invention, there is provided an internal combustion engine for a small planing boat, in which cooling water supplied from a jet propulsion pump driven by an internal combustion engine is introduced to the internal combustion engine to effect cooling, including: a first cooling water path through which cooling water introduced from the jet propulsion pump flows toward a main body of the internal combustion engine via an exhaust manifold; a second cooling water path through which cooling water introduced from the jet propulsion pump flows toward an exhaust pipe via an oil cooler; and a bypass cooling water path for branching a part of cooling water in the second cooling water path which flows out from the oil cooler, so as to merge with cooling water in the first cooling water path which flows into the main body of the internal combustion engine.

According to a second aspect of the invention, there is provided an internal combustion engine for a small planing boat with a supercharger, in which cooling water supplied from a jet propulsion pump driven by an internal combustion engine is introduced to the internal combustion engine to effect cooling, including: a first cooling water path through which cooling water introduced from the jet propulsion pump flows toward a main body of the internal combustion engine via an exhaust manifold after cooling an oil cooler that cools intake air pressurized by the supercharger; a second cooling water path through which cooling water introduced from the jet propulsion pump flows toward an exhaust pipe via the supercharger after cooling the oil cooler; and a bypass cooling water path for branching a part of cooling water in the second cooling water path which flows out from the oil cooler, so as to merge with cooling water in the first cooling water path which flows into the main body of the internal combustion engine.

According to the first aspect of the internal combustion engine for a small planing boat, in the first cooling water path, the cooling water that has been raised in temperature after passing through the exhaust manifold that warms up quickly is supplied to the cylinder block and cylinder head of the internal combustion engine main body, thereby making it possible to prevent supercooling of the internal combustion engine before warm-up and hence alleviate dilution of lubricating oil. Once the internal combustion engine has been warmed up, the temperature of the cooling water that has passed through the exhaust manifold and been raised in temperature is too high. Accordingly, a part of the cooling water from the oil cooler is merged with this cooling water via the bypass cooling water path, thereby allowing the cooling water to be lowered in temperature before being supplied to the internal combustion engine main body. The internal combustion engine can be thus cooled efficiently.

15

According to the second aspect of the internal combustion engine for a small planing boat, in an internal combustion engine for a small planing boat which includes a supercharger and an intercooler, by interposing the intercooler on the upstream side of the exhaust manifold in the first cooling water path, the cooling water introduced from the jet propulsion pump can cool the intake air at the intercooler, and the cooling water that has cooled the intercooler flows into the exhaust manifold and is raised in temperature. Since this cooling water that has been raised in temperature is supplied to the cylinder block and cylinder head of the internal combustion engine main body, it is possible to prevent supercooling of the internal combustion engine before warm-up and hence alleviate dilution of lubricating oil.

20  
25

Once the internal combustion engine has been warmed up, the temperature of the cooling water that has passed through the exhaust manifold and been raised in temperature is too high. Accordingly, a part of the cooling water from the oil cooler upstream of the supercharger is merged with this cooling water via the bypass cooling water path, thereby allowing the cooling water to be lowered in temperature before being supplied to the internal combustion engine main body. The internal combustion engine can be thus cooled efficiently.

30

**BRIEF DESCRIPTION OF THE DRAWINGS**

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

5

Fig. 1 is a side view of a small planing boat incorporating an internal combustion engine according to an embodiment of the present invention.

Fig. 2 is a plan view of the same.

10

Fig. 3 is a sectional view taken along the line III-III of Fig. 1.

[Fig. 4 is a front view, partially in section and partially omitted, of the boat body and internal combustion engine.

15

Fig. 5 is a top view of the internal combustion engine.

Fig. 6 is a left-side view of the internal combustion engine.

20

Fig. 7 is a rear view of the internal combustion engine.

Fig. 8 is a front view, partially in section and partially omitted, of the internal combustion engine.

25

Fig. 9 is a side sectional view of the internal combustion engine.

Fig. 10 is a right-side view, partially cut away and partially omitted, of the internal combustion engine.

30

Fig. 11 is a sectional view of a crankshaft as seen from the bottom of a cylinder block.

Fig. 12 is a rear view showing the interior of a cam chain chamber.

Fig. 13 is a bottom view of a crankcase.

Fig. 14 is a bottom view of an oil pan.

5 Fig. 15 is a top view of the oil pan.

Fig. 16 is a side view of an oil strainer.

Fig. 17 is an enlarged main-portion sectional view of an oil vertical passage.

10

Fig. 18 is a perspective view of a filter.

Fig. 19 is a view showing the circulation path of lubricating oil.

15 Fig. 20 is a view showing the circulation path of cooling water.

#### **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

An embodiment of the present invention will now be described below with reference to Figs. 1 to 20.

20

Fig. 1 is a side view of a small planing boat 1 incorporating an internal combustion engine for small planing boat 20 according to this embodiment, Fig. 2 is a plan view of the same, and Fig. 3 is a sectional view of the same.

25 In the small planing boat 1, a boat body 2 constituting a floating body structure is constructed by forming a space inside the boat by a hull 3 on the lower side forming the bottom of the boat, and a deck 4 on the upper side. An internal combustion engine 20 is accommodated in the space inside the boat body 2. One to three occupants sit in a saddle-riding manner on a seat 5 at the center of the  
30 deck 4 on the boat body 2. Steering is performed by operating a handlebar 6 located in front of the seat 5.

A jet propulsion pump 10 driven by the internal combustion engine 20 constitutes the propulsion means of the small planing boat 1. The jet propulsion pump 10 is arranged in a rear portion of the hull 3.

5 The jet propulsion pump 10 is an axial flow pump and of a structure in which an impeller 11 is interposed in the flow passage extending from a water intake port 12 formed at the bottom of the boat to a nozzle 13 provided in a jet port formed at the rear end of the boat body (see Fig. 20). A shaft 15 of the impeller 11 is coupled to a crankshaft 21 of the internal combustion engine 20 via a joint 56.

10

Accordingly, when the impeller 11 is rotationally driven by the internal combustion engine 20 via the shaft 15, this causes the water sucked up from the water intake port 12 at the bottom of the boat to jet out from the jet port via the nozzle 13. The reaction at this time propels the boat body 2, allowing the small  
15 planing boat 1 to plane across the water.

15

The propulsion force by the jet propulsion pump 10 is controlled through operation of a throttle lever 7 attached to the handlebar 6. The nozzle 13 is rotated via an operating wire through steering of the handlebar 6. The  
20 advancing direction is changed by changing the direction of the outlet of the nozzle 13.

20

The internal combustion engine 20 is arranged at substantially the center inside the boat body 2 and below the seat 5. The boat body 2 has an accommodating  
25 chamber 8 provided at the front portion thereof. A fuel tank 9 is provided between the accommodating chamber 8 and the internal combustion engine 20.

25

The internal combustion engine 20 is an inline 4-cylinder internal combustion engine of a DOHC 4-stroke cycle, and is vertically placed inside the boat body 2  
30 with the crankshaft 21 oriented in the longitudinal direction of the boat body 2.

30

An internal combustion engine main body 20A is formed as follows. Referring to Fig. 8, a cylinder block 22 and a crankcase 23 that are split into upper and lower parts are joined together such that the crankshaft 21 is rotatably journalled on a

parting surface 24. A cylinder head 25 is overlapped onto the cylinder block 22, and a cylinder head cover 26 is further placed over the cylinder block 22. Further, an oil pan 27 is attached under the crankcase 23.

- 5 It should be noted that in this specification, the left and right directions are determined with reference to the advancing direction of the boat body.

Mount brackets 22a, 22a are provided at the front and rear of the lower end of the right-side surface of the cylinder block 22 so as to project diagonally upward  
10 (see Figs. 8, 11). On the other hand, a pair of front and rear mount brackets 23a, 23a are provided to the crankcase 23 so as to project from the left-side surface in parallel to the parting surface 24 (see Figs. 8, 13).

Accordingly, the mount brackets 22a and the mount brackets 23a that are  
15 provided so as to project on the left and right sides of the internal combustion engine main body 20A project at an obtuse angle relative to each other. As shown in Fig. 4, the mount brackets 22a and 23a are mounted at the same horizontal height via rubber isolator members 29, 29 to mountings 28L, 28R provided on the left and right sides of the hull 3 inside the boat body 2, whereby  
20 the internal combustion engine 20 is supported in a suspended manner.

Accordingly, the parting surface 24 between the cylinder block 22 and the crankcase 23 is parallel to the projecting direction of the left-side mount bracket 23a, and is hence inclined so as to be angled upward to the left with respect to the  
25 horizontal line H (see Figs. 4, 8).

In the internal combustion engine main body 20A, a cylinder 22b of the cylinder block 22 is formed so as to extend perpendicularly to the parting surface 24, and the cylinder head 25 and the cylinder head cover 26 are provided in the  
30 extending direction of the cylinder 22b, with the oil pan 27 being also attached to the crankcase 23 in the direction perpendicular to the parting surface 24. Accordingly, as shown in Fig. 4 (and Fig. 8), the internal combustion engine main body 20A is mounted to the boat body 2 so as to be generally tilted to the right side.

As shown in Fig. 8, a piston 30 reciprocates inside the cylinder 22b that is tilted to the right, and the crankshaft 21 is rotated via a connecting rod 31.

5 The cylinder head 25 overlapped on the cylinder 22b has a combustion chamber 32 formed so as to be opposed to the top surface of the piston 30. An intake port 33I and an exhaust port 33E are formed so as to extend to the left and right from openings formed in the combustion chamber 32.

10 Cam shafts 35I and 35E for respectively sliding an intake valve 34I for opening/closing the opening of the intake port 33I, and an exhaust valve 34E for opening/closing the opening of the exhaust port 33E, are provided at the position of the joining surface between the cylinder head 25 and the cylinder head cover 26.

15

On the left side of the internal combustion engine main body 20A, an intake manifold 40 that communicates with the intake port 33I is connected and arranged so as to project. An exhaust manifold 44 that communicates with the exhaust port 33E is connected on the right side of the internal combustion engine 20 (see Figs. 4, 5).

20

A turbo-charger 43 and an intercooler 42 for cooling the intake air pressurized by the turbo-charger 43 are disposed in rear of the internal combustion engine main body 20A (see Figs. 5, 6, 7).

25

It should be noted that the turbo-charger 43 may be a supercharger.

As shown in Fig. 6, the intercooler 42 is positioned at the height of the joining surface between the cylinder head 25 and the cylinder head cover 26, and the turbo-charger 43 is positioned at the height of the joining surface between the cylinder head 25 and the crankcase 23. The turbo-charger 43 is disposed directly below and in close proximity to the intercooler 42.

30

The intake manifold 40 is provided to the left-side surface of the internal combustion engine main body 20A so as to project at substantially the same height as the intercooler 42. The intake manifold 40 and the intercooler 42 that is disposed in rear of the internal combustion engine main body 20A are coupled to  
5 each other by a throttle body 41.

As shown in Fig. 5, the intake manifold 40 consisting of a collection of intake pipes leading to respective cylinders is bent rearward along the left-side surface of the internal combustion engine main body 20A and is connected to the throttle  
10 body 41 that is common to the respective cylinders. The throttle body 41 is connected to the intercooler 42 while being oriented diagonally so as to wrap around to the rear of the internal combustion engine main body 20A.

Since the throttle body 41 is disposed so as to wrap around to the rear of the  
15 internal combustion engine main body 20A and thus approaches the intercooler 42 located in rear of the internal combustion engine main body 20A, the throttle body 41 is directly connected to the intercooler 42 without the use of additional piping.

As shown in Fig. 5, the intake manifold 40 is curved such that its port-side outer edge comes closer to the center of the internal combustion engine main body 20A as it extends toward the rear-end side. The intake path extending from the intercooler 42 to the intake manifold 40 via the throttle body 41 is thus curved  
20 gently along the portion of the internal combustion engine main body 20A from the rear surface to the left-side surface.  
25

The intercooler 42, the throttle body 41, and the intake manifold 40 are disposed in a concentrated fashion along the portion of the internal combustion engine main body 20A from the rear surface to the left-side surface. Further, the throttle  
30 body 41 is disposed so as to wrap around to the rear of the internal combustion engine main body 20A, thereby reducing the lateral width of the portion in rear of the internal combustion engine main body 20A.

Further, since the throttle body 41 is disposed so as to wrap around to the rear of the internal combustion engine main body 20A and hence comes closer to the intercooler 42 located in rear of the internal combustion engine main body 20A, the throttle body 41 can be directly connected to the intercooler 42 to thereby  
5 reduce piping and the like.

A turbine portion 43T of the turbo-charger 43 arranged directly below the intercooler 42 is connected to an exhaust lead-out passage 44a of the exhaust manifold 44, and a compressor portion 43C thereof is connected to the intercooler  
10 42 above the turbo-charger 43.

That is, since the turbo-charger 43 is arranged directly below the intercooler 42, as shown in Fig. 7, a connecting pipe 42i extending downward from the intercooler 42 is directly connected to a connecting pipe 43o extending upward  
15 from the compressor portion 43C.

Accordingly, no special piping for connection is required.

In this way, the intake path leading to the intake manifold 40 from the turbo-charger 43 via the intercooler 42 is curved gently and formed in an efficient  
20 manner so that the distance of the intake path becomes the shortest, and hence the intake resistance becomes the smallest to achieve an improvement in intake efficiency.

On the other hand, the exhaust path of the internal combustion engine 20 leads to the turbine portion 43T of the turbo-charger 43 from the exhaust manifold 44 via the exhaust lead-out passage 44a. As shown in Figs. 1 and 2, and also with  
25 reference to Fig. 20, the exhaust that has rotated a turbine wheel in the turbine portion 43T sequentially passes through an exhaust pipe 47a, a backflow prevention chamber 47b (chamber for preventing backflow of water so that water  
30 does not enter the turbo-charger or the like in the event the boat capsizes), a water muffler 47c, and a piping 47d to reach a water chamber 47e leading into the water to be discharged into the water.

As described above, the crankshaft 21 is rotatably journalled to respective bearings of the parting surface 24 between the cylinder block 22 and the crankcase 23. Two balancer shafts 36L, 36R for canceling secondary vibration are rotatably journalled to the bearings on the left and right sides of the crankshaft  
5 21.

A total of five crank journals 21j, including three crank journals 21j between four crank web 21w pairs corresponding to the four cylinders of the crankshaft 21, and two crank journals 21j at the front and at the rear, are rotatably journalled by  
10 being held between semi-arcuate bearings, which are formed in five ribs 22r, 23r respectively formed on both upper and lower sides of the cylinder block 22 and crankcase 23 and constituting vertical walls in the longitudinal direction, via metal bearings.

As shown in the bottom view of the cylinder block 22 in Fig. 9, of the five ribs 22r on which the crankshaft 21 is journalled by means of their bearings, four ribs 22r excluding a rib 22rc at the center are flat without being bent all the way to the left and right ends thereof. On the other hand, the left and right end portions of the rib 22rc at the center are bent so as to be offset forward (leftward as seen in Fig. 9)  
15 with respect to the bearing portion to which the crankshaft 21 is journalled.  
20

Rear-side bearing portions of the balancer shafts 36L, 36R are provided in the left and right portions of the central rib 22rc which are thus offset forward, and front-side bearing portions of the balancer shafts 36L, 36R are provided in the left and  
25 right portions of the rib 22r that forms the outer wall on the foremost side.

That is, the balancer shafts 36L, 36R are arranged side by side in parallel on the left and right sides of the crankshaft 21, and have their front and rear portions rotatably journalled to the bearing of the rib 22r on the foremost side and the  
30 bearing of the rib 22rc at the center, respectively, via metal bearings. The balancer shafts 36L, 36R are thus disposed so as to be offset toward the front side of the cylinder block 22.

Further, the balancer shafts 36L, 36R have their balance weights divided by the central rib 22rc. The balancer shafts 36L, 36R have balance weights 36Lw, 36Rw located between the center rib 22rc and a rib 25r adjacent to and in front of the center rib 22rc, and include balance weights 36Lw, 36Rw that project rearward in a cantilevered fashion from the center rib 22rc.

The lateral width of the cylinder block 22 is large on the front side where the balancer shafts 36L, 36R are disposed, and is small on the rear side where no balancer shafts 36L, 36R are disposed.

As shown in Figs. 9 and 11, a drive gear 21g is formed in the outer periphery of the crank web 21w of the crankshaft 21 which rotates along each of the inner surfaces of the ribs 22r, 23r constituting the foremost outer walls of the cylinder block 22 and crankcase 23.

On the other hand, the balancer shafts 36L, 36R also have driven gears 36Lg, 36Rg formed along the inner surfaces of the ribs 22r, 23r constituting the foremost outer walls.

Further, the driven gear 36Lg of the left-side balancer shaft 36L and the drive gear 21g in the outer periphery of the crank web 21w of the crankshaft 21 directly mesh with each other.

On the other hand, as shown in Fig. 8, at a position diagonally upward to the left from the driven gear 36Rg of the right-side balancer shaft 36R, an intermediate shaft 37 is supported on the rib 22r of the cylinder block 22, and an intermediate gear 37g rotatably journaled to the intermediate shaft 37 meshes with the driven gear 36Rg of the right-side balancer shaft 36R and, at the same time, also meshes with the drive gear 21g in the outer periphery of the crank web 21w of the crankshaft 21.

Accordingly, as the crankshaft 21 rotates, the left and right balancer shafts 36L, 36R rotate in opposite directions, and act to cancel secondary vibrations by rotating at twice the rotational speed of the crankshaft 21.

The gear mechanisms formed by the drive gear 21g, the intermediate gear 37g, and the driven gears 36Lg, 36Rg for transmitting the rotation of the crankshaft 21 to the left and right balancer shafts 36L, 36R are disposed inside the cylinder  
5 block 22 and the crankcase 23 along the inner surfaces of the ribs 22r, 23r constituting the foremost outer walls, and are located at positions that are the same as and overlapping those of the mount brackets 22a, 23a of the cylinder block 22 and crankcase 23 with respect to the longitudinal direction as seen in side view.

10

Accordingly, a sufficiently high rigidity can be secured for portions in the periphery of the gear mechanisms for transmitting rotary power and for the bearing portions of the balancer shafts 36L, 36R in the cylinder block 22 and the crankcase 23, without the provision of an additional special structure.

15

As shown in Fig. 11, at the portion of the crankshaft 21 projecting outward from the ribs 22r, 23r constituting the outer walls of the cylinder block 22 and crankcase 23, a starter driven gear 51 is provided along each of the outer surfaces of the ribs 22r, 23r via a one-way clutch 50, and further, an outer rotor 54r of an  
20 AC generator 54 is attached in front of the starter driven gear 51 (see Fig. 9).

As indicated by the two-dot chain line in Fig. 8, a small-diameter gear 52s rotatably supported on a reduction gear shaft 52 meshes with the starter driven gear 51, and a large-diameter gear 52b that is integral with the small-diameter  
25 gear 52a meshes with a drive gear 53a fitted onto the drive shaft of a starter motor 53 located above the left-side balancer shaft 36L.

On the other hand, as shown in Fig. 9, the rear portion of the crankshaft 21 projects rearward while being journalled via bearings 55 to the bearing portion in  
30 the rear wall of each of the cylinder block 22 and crankcase 23. This rear end portion is coupled via the joint 56 to the shaft 15 connected to the impeller 11 of the above-mentioned jet propulsion pump 10.

Referring to Fig. 9, a cam chain chamber 57 is formed between the rear walls of the cylinder block 22 and crankcase 23 and the ribs 22r, 23r on the rearmost side. In the cam chain chamber 57, a drive sprocket 58 is fitted onto the crankshaft 21, and as shown in Fig. 12, a cam chain 60 is suspended between the drive sprocket 58 and driven sprockets 59I, 59E fitted onto the rear end portions of the above-mentioned cam shafts 35I, 35E that are located above.

In the cam chain chamber 57, left and right cam chain guides 65, 66 are provided along the cam chain 60 from the cylinder head 25 to the cylinder block 22.

10

The upper end of the cam chain guide 66 on the starboard side is rockably journalled to a support shaft 67 provided so as to project from the cylinder head 25, and a lower part of the cam chain guide 66 is urged by a cam chain tensioner 68 attached to the cylinder block 22 so as to hold down the cam chain 60 and impart an appropriate tension (see Fig. 12).

15

To attach the cam chain guide 66, the cam chain guide 66 is inserted from the upper end opening of the cam chain chamber 57 in the cylinder head 25, and the journalling portion at the upper end of the cam chain guide 66 is journalled to the support shaft 67. However, since the support shaft 67 is located at some depth from the upper end opening of the cam chain chamber 57, the operation of journalling the journalling portion at the upper end of the cam chain guide 66 to the support shaft 67 is not easy.

20

In view of this, the cam chain guide 66 has a knob portion 66a that extends upward from the upper end and is bent. The knob portion 66a is pinched, thereby facilitating the operation of journalling the journaling portion at the upper end of the cam chain guide 66 to the support shaft 67.

25

It should be noted that the detachment of the cam chain guide 66 is also facilitated due to the provision of the knob portion 66a to the cam chain guide 66.

30

As shown in Fig. 13, an elongated rectangular opening is provided in the longitudinal direction in the lower surface of the crankcase 23, and a mating

surface 23b is formed in the edge of that opening. The oil pan 27 is attached from below in conformity with the mating surface 23b.

5 Screw holes 23p are formed in the rectangular mating surface 23b. As shown in Figs. 14 and 15, bolts 61 are inserted through mounting holes 27p, which are formed in a rectangular edge mating surface 27b of the oil pan 27, and threaded into the screw holes 23p, thereby attaching the oil pan 27 to the crankcase 23.

10 Referring to Fig. 13, a main oil passage 23C extends through the crankcase 23 in the longitudinal direction along the lower surface of the crankcase 23 and opens in the front wall of the crankcase 23. Bolt holes 23d are formed on the left and right of the five ribs 23r across the oil passage 23C. Fastening bolts 38 penetrating the bolt holes 23d are threaded into the cylinder block 22, thereby fastening and coupling the crankcase 23 and the cylinder block 22 together (see 15 Fig. 8).

It should be noted that left- and right-balancer oil passages 23L, 23R for supplying oil to the bearings of the left and right balancer shafts 36L, 36R are provided on the left and right of the main oil passage 23C so as to be parallel to 20 the main oil passage 23C. The left- and right-balancer oil passages 23L, 23R both open in the front wall of the crankcase 23 (see Fig. 8).

Further, within the rectangular mating surface 23b of the crankcase 23, a frame wall 70 in the shape of an elongated rectangle is formed in the longitudinal 25 direction in the rear half portion. The frame wall 70 is formed by a total of four sides consisting of the three sides including the front, left, and right side, and the rear side constituted by the wall of the mating surface 23b. The portion inside the frame wall 70 has a raised bottom surface 71 and is downwardly open (see Fig. 13).

30 The lower end face of the frame wall 70 is flush with the mating surface 23b of the oil pan 27.

On the other hand, as shown in Figs. 14 and 15, inside the oil pan 27, a frame wall 72, which forms an oil passage in correspondence with side walls excluding the rear portions of the left and right sides of the frame wall 70 of the crankcase 23, is erected from the bottom surface.

5

An oil recovery passage 73 is provided so as to extend straight forward with a circular opening formed in the front-side wall of the frame wall 72. The oil recovery passage 73 opens in the front wall of the oil pan 27 (see Fig. 8), and communicates with an oil pump 90 that will be described later.

10

Referring to Fig. 15, the rear portion of each of the left-side wall and right-side wall of the frame wall 72 that is a vertical wall is cut away in a U shape to form a communication opening. Grooves 72L, 72R are each formed in the respective inner edge portions of the three sides of the communication opening.

15

It should be noted that while the communication opening of the left-side wall is perpendicular to the lateral direction, as for the communication opening of the right-side wall, the rear portion of the right-side wall is bent toward the center so as to be closer to the center side as it extends rearward.

20

Accordingly, as seen in the top view of Fig. 15, the groove 72L of the communication opening of the left-side wall and the groove 72R of the communication opening of the right-side wall are formed in a substantially V shape such that they approach each other as they extend rearward.

25

Horizontally elongated, rectangular oil strainers 74L, 74R are fitted in the grooves 72L, 72R in a substantially vertical position. Hence, the oil strainers 74L, 74R are also arranged in a substantially V shape.

30 The side view of the oil strainer 74L is shown in Fig. 16.

A rubber member 74Lb is provided around the frame in the edge portion of a rectangular oil screen 74La corresponding to the communication opening in the left-side wall of the frame wall 72.

Although the other oil strainer 74R is of the same structure in which a rubber member 74Rb is provided around the frame in the edge portion of a rectangular oil screen 74Ra corresponding to the communication opening in the right-side wall of the frame wall 72 (see Fig. 9), the oil strainer 74R is longer since its rear portion is inclined toward the center, and the oil screen 74Ra has a larger surface area.

When the oil pan 27 is attached to the crankcase 23 in the state where the oil strainers 74L, 74R are respectively fitted in the grooves 72L, 72R of the respective communication openings of the frame wall 72, the end face of the frame wall 70 on the crankcase 23 side and the end face of the frame wall 72 on the oil pan 27 side are brought to face each other, and the rubber members 74Lb, 74Rb at the upper ends of the oil strainers 74L, 74R abut on the left-side wall and right-side wall of the frame wall 70, so the space inside the oil pan 27 is partitioned off by the frame walls 70, 72, the raised bottom surface 71, the oil pan bottom surface, and the oil strainers 74L, 74R, and a cavity 79 constituting an oil passage of a rectangular parallelepiped shape is formed.

The cavity 79 communicates with the oil recovery passage 73 from the opening in the front-side wall of the frame wall 72.

Accordingly, oil that has accumulated in the oil pan 27 passes through the oil screens 74La, 74Ra of the oil strainers 74L, 74R and flows into the cavity 79 before entering the oil recovery passage 73.

Since the oil strainers 74L, 74R are placed vertically in the oil pan 27, as compared with the case of horizontal placement, the lateral width of the oil pan 27 can be reduced, thereby facilitating conformity to the configuration of the hull 3 at the center of the bottom of the small planing boat sloping laterally upward. Further, a sufficient space can be provided on the left and right of the oil strainer even when the vertical width of the oil pan is made small, thereby making it possible to make the vertical width of the oil pan itself small, and hence lower the total height of the internal combustion engine.

Further, since the oil strainers 74L, 74R are arranged in a substantially V shape in the rear portion of the oil pan 27, oil that has gathered in the rear portion of the oil pan 27 at the time of acceleration can be readily filtered, and the oil strainers  
5 74L, 74R themselves can be reduced in size.

Further, the flow of oil that lubricates respective portions of the cylinder head 25 and drops through the can chain chamber 57 is not hindered and can be returned to the oil pan 27.  
10

The cavity 79 partitioned off by the oil strainers 74L, 74R is defined by the frame wall 70 formed in the crankcase 23 and the raised bottom surface 71 and by the frame wall 72 formed in the oil pan 27 and the oil pan bottom surface. Accordingly, no special dedicated part is required, thereby making it possible to  
15 achieve a reduction in the number of parts.

Further, the structure in which the oil strainers 74L, 74R are held between the crankcase 23 and the oil pan 27 contributes to the ease of assembly.

20 Coplanar mating surfaces 22f, 23f, 27f are formed in the front surfaces of the cylinder block 22, crankcase 23, and oil pan 27 described above (see Fig. 8). A tank body 81 of an oil tank 80 is joined to the mating surfaces 22f, 23f, 27f.

It should be noted that the oil tank 80 is formed by the tank body 81 and a tank  
25 cover 88 covered over the front surface of the tank body 81.

As shown in Figs. 4 and 9, the tank body 81 has parallel mating surfaces, that is, a mating surface 81r, which is joined to the mating surfaces 22f, 23f, 27f in the front surfaces of the cylinder block 22, crankcase 23, and oil pan 27, and a mating  
30 surface 81f with the tank cover 88. An ACG cover portion 82 that covers the AC generator 54 and the reduction gears 52a, 52b is formed so as to bulge forward from the mating surface 81r. A generally vertically elongated oil accommodating portion 83 is formed in the space from above the ACG cover portion 82 to the left and right sides thereof. Further, a water-cooling type oil-cooler accommodating

portion 85 is formed on the right side of the oil accommodating portion 83 and at a position higher than the crankshaft 21 so as to partially jut out.

5 It should be noted that Fig. 4 is a front view showing a state in which the tank body 81 is attached to the front surfaces of the cylinder block 22, crankcase 23, and oil pan 27.

A breather chamber 84 is provided in the space above the oil accommodating portion 83.

10

As shown in Fig. 9, the outer rotor 54r of the above-mentioned AV generator 54 is secured to the distal end portion of the crankshaft 21 by means of a bolt 63 together with a coupling 62a.

15 The coupling 62a is coupled to a coupling 62b at the rear end of a pump shaft 95 of the oil pump 90 that will be described later.

20 A coupling cover portion 82a that covers the couplings 62a, 62b is formed at the center of the ACG cover portion 82 so as to project rearward. An inner stator 54s of the AC generator 54 is supported in position while being fixed to the coupling cover portion 82a.

The oil pump 90 is provided in front of the ACG cover portion 82 that covers the AC generator 54 from the front.

25

The oil pump 90 has a first case 92 that is joined to the above-mentioned tank body 81 from the front, and a second case 93 that is joined from the front to be attached to the tank body 81 together with the first case 92 by means of a bolt 94. The pump shaft 95 that extends through these front and rear cases, that is, the first and second cases 92, 93, coaxially with the crankshaft 21 extends through the ACG cover portion 82. The above-mentioned coupling 62b is secured from the rear to the rear end of the pump shaft 95 by means of a bolt 95a.

30

[0076]

A scavenging pump 90S is provided by fitting an inner rotor onto a shank of the pump shaft 92 in the first case 95, and a feed pump 90F is provided by fitting an inner rotor onto a shank of the pump shaft 95 in the second case 93.

- 5 Accordingly, the rotation of the crankshaft 21 is transmitted via the couplings 62a, 62b to the rotation of the pump shaft 95 so that the scavenging pump 90S and the feed pump 90F are driven.

- 10 Referring to Figs. 4 and 9, an oil recovery passage 86 connected to the oil recovery passage 73 of the oil pan 27 is formed in a lower portion of the tank body 81. A part of the oil recovery passage 86 is formed in the rear surface of the first case 92, and the oil recovery passage 86 extends upward to reach the scavenging pump 90S.

- 15 Accordingly, as the scavenging pump 90S is driven, lubricating oil that has accumulated in the oil pan 27 passes through the oil strainers 74L, 74R to be sucked in forward through the oil recovery passage 73, and passes through the oil recovery passage 86 to reach the scavenging pump 90S located above.

- 20 Referring to Fig. 9, a common recovered-oil discharge passage 87 is formed above the scavenging pump 90S by the rear surface of the first case 92 and the front surface of the tank body 81. The upper end of the recovered-oil discharge passage 87 opens in the oil accommodating portion 83 of the oil tank 80. Recovered-oil discharged by driving of the scavenging pump 90S is recovered  
25 into the oil accommodating portion 83 of the oil tank 80 passing through the recovered-oil discharge passage 87.

- 30 Further, as shown in Fig. 9, a supply-oil intake passage 96 is formed below the feed pump 90F by the front surface of the first case 92 and the rear surface of the second case 93, and also a supply-oil discharge passage 98 is formed above the feed pump 90F.

The lower end of the supply-oil intake passage 96 is open at a height close to the bottom surface of the oil accommodating portion 83, and the upper end of the

supply-oil intake passage 96 communicates with the suction port of the feed pump 90F. A screen oil filter 97 is interposed in the supply-oil intake passage 96.

5 After extending upward from the discharge port of the feed pump 90F, the supply-oil discharge passage 98 is bent rearward and connected to a horizontal hole 98a formed in the tank body 81.

10 The horizontal hole 98a communicates with a vertical hole 98b also formed in the tank body 81 and is directed upward. The upper end of the vertical hole 98b opens in an annular shape in the mounting surface of an oil filter 110 that will be described later, and communicates with an oil inlet 111 of the oil filter 110 (see Fig. 10).

15 Accordingly, when the feed pump 90F is driven, lubricating oil is sucked upward from a lower portion of the oil accommodating portion 83 of the oil tank 80 by way of the supply-oil intake passage 96 to be discharged to the supply-oil discharge passage 98. The lubricating oil is then pressure-fed upward through the horizontal hole 98a and the vertical hole 98b formed in the tank body 81 to reach the oil filter 110.

20 It should be noted that a relief valve 99 is interposed in the supply-oil discharge passage 98 between the supply-oil discharge passage 98 and the oil accommodating portion 83. When the discharge pressure of the oil being supplied is too high, the relief valve 99 causes excess oil to be returned to the oil  
25 accommodating portion 83.

30 As shown in Figs. 4 and 10, a water-cooling type oil cooler 100 is provided so as to project from the vertically elongated oil-cooler accommodating portion 85 defined in the front surface of the tank body 81.

The oil cooler 100 includes a plurality of heat-exchange plates 100a through which oil passes, an upstream-side pipe 100b whose upper portion communicates with the inner portions of the plates 100a, and a downstream-side pipe 100c whose lower portion communicates with the inner portions of the

plates 100a. The upstream-side pipe 100b and the downstream-side pipe 100c are respectively connected to upper and lower holes formed on the tank body 81 side, thereby attaching the oil cooler 100 to the tank body 81.

5 As shown in Fig. 10, the oil cooler 100 is covered from the front by a part of the tank cover 88. Cooling water flows into/out of the oil-cooler accommodating portion 85 inside the oil cooler 100, thereby cooling the oil in the oil cooler 100.

10 As shown in Fig. 10, at a position in rear of the upstream-side pipe 100b, the upper hole of the tank body 81 to which the upstream-side pipe 100b of the oil cooler 100 is connected communicates with one outlet of an oil thermostat 105 including a switching valve 105a, and the lower hole to which the downstream-side pipe 100c of the oil cooler 100 is connected communicates with an oil vertical passage 107, which is an oil passage on the downstream side of the oil cooler 100  
15 and extends downward.

The other outlet of the oil thermostat 105 detours around the oil cooler 100 and communicates with a bypass oil passage 106 that connects to the oil vertical passage 107.  
20

Further, as shown in Fig. 10, the inlet of the oil thermostat 105 communicates via an upstream-side oil passage 113 of the oil cooler 100 with an oil outlet 112 of the oil filter 110 that is attached above the oil thermostat 105.

25 As mentioned above, in the oil filter 110, the oil that has been pressure-fed by the feed pump 90F flows in from the oil inlet 111, and the filtered oil flows out from the oil outlet 112.

30 In the oil thermostat 105, due to the movement of the switching valve 105a, the oil cooler 100 side is opened and the bypass oil passage 106 side is closed when the temperature of lubricating oil is equal to or higher than a predetermined temperature, and the bypass oil passage 106 side is opened and the oil cooler 100 side is closed when the temperature of lubricating oil is lower than the predetermined temperature.

In the bypass oil passage 106, a low-pressure oil switch 115 is attached to detect an abnormal decrease in oil pressure. Further, in the oil vertical passage 107 located downstream from the oil cooler 100 and the bypass oil passage 106, a high-pressure oil switch 116 is attached to detect an abnormal increase in oil pressure.

As shown in Fig. 10, while the low-pressure oil switch 115 is attached to the bypass oil passage 106 so as to project to the right side, the high-pressure oil switch 116 is attached to the oil vertical passage 107, which extends vertically, so as to project forward by utilizing the space below the oil cooler 100.

As indicated by the broken line in Fig. 4, the oil vertical passage 107 is bent leftward in a lower portion of the tank body 81 to communicate with an oil horizontal passage 108. The oil horizontal passage 108 has three branching paths extending rearward. A main-gallery supply passage 109c for supplying oil to the main gallery of the internal combustion engine 20 is provided at the center, and a left-balancer supply passage 109l, and a right-balancer supply passage 109r for supplying oil to the bearing portions of the left and right balancer shafts 36L, 36R are formed at the left and right ends, respectively (see Fig. 13).

As shown in Fig. 9, the main galley supply passage 109c is connected to the main oil passage 23C of the above-mentioned crankcase 23. Oil is supplied from the main oil passage 23C to the respective bearing portions of the crankshaft 21 while being distributed through the passages in the ribs 23r.

The left-balancer supply passage 109l and the right-balancer supply passage 109r are respectively connected to the left-balancer oil passage 23L and the right-balancer oil passage 23R mentioned above (see Fig. 13). Oil vertical passages 23La, 23Ra extending upward from the left-balancer oil passage 23L and the right-balancer oil passage 23R communicate with the bearings of the left and right balancer shafts 36L, 36R, respectively. Oil is thus supplied to the respective bearings (see Fig. 8).

Further, the oil vertical passage 23Ra on the right side reaches the parting surface 24 between the crankcase 23 and the cylinder block 22, and further communicates with the oil vertical passage 22Ra formed in the cylinder block 22 to reach the bearing of the intermediate shaft 37. Oil is thus supplied to the bearing of the  
5 intermediate shaft 37.

Referring to Fig. 17 showing the connecting portion between the oil vertical passage 23Ra on the crankcase 23 side and the oil vertical passage 22Ra on the cylinder block 22 side, in the lower portion of the oil vertical passage 22Ra, there  
10 are sequentially formed an intermediate-diameter circular hole portion with an enlarged inner diameter, and a large-diameter circular hole portion that is further enlarged in diameter than the intermediate-diameter circular hole portion. The large-diameter circular hole portion opens in the parting surface 24, thereby establishing communication with the oil vertical passage 23Ra on the crankcase  
15 23 side.

Further, an orifice member 118, which is in the form of a flanged bottomed cylinder and has a small hole 118a at the bottom portion, is mounted with its cylinder portion fitted into the intermediate-diameter circular hole portion of the  
20 oil vertical passage 22Ra, and with its flange portion brought into fitting engagement with the large-diameter circular hole portion. Further, a hollow disc-shaped filter 119 is brought into fitting engagement with the large-diameter circular hole portion in a manner overlapping the flange portion.

The filter 119 has the same outer diameter as the large-diameter circular hole portion, and a hollow circular hole 119a thereof has substantially the same inner diameter as the oil vertical passage 22Ra. As shown in Fig. 18, V groove 119b is formed in the shape of a cross in the surface of the filter 119 which becomes the lower side upon fitting engagement with the large-diameter circular hole portion  
30 of the oil vertical passage 22Ra.

When the flange portion of the orifice member 118 and the filter 119 are brought into fitting engagement with the large-diameter circular hole portion of the oil vertical passage 22Ra, the lower surface of the filter 119 becomes flush with the

parting surface 24 of the cylinder block 22, and upon overlapping the cylinder block 22 and the crankcase 23 each other, the opening end face of the oil vertical passage 23Ra holds down the outer edge portion of the filter 119. The filter 119 is thus supported in place together with the orifice member 118.

5

Accordingly, the flow of oil passing through the oil vertical passage 23Ra and the oil vertical passage 22Ra to be supplied to the bearing of the intermediate shaft 37 is constricted at the location of the parting surface 24 by the orifice member 118. In this case, the filter 119 is arranged immediately before this location, so that even when such foreign matter as will clog the small hole 118a of the orifice member 118 flows in, this is blocked by the lower surface of the filter 119, and oil is made to flow via the V groove 119b formed in the shape of a cross, thereby securing the supply of oil to the bearing of the intermediate shaft 37 at all times.

10 In addition, oil is supplied from the main oil passage 23C to the bearings of the cam shafts 35I, 35E located above, and oil is also supplied to the turbo-charger 43, thereby forming a circulation path that returns to the oil pan 27.

15 The overview of the above-described circulation path of lubricating oil, as shown in Fig. 19, will be described.

20 The lubricating oil that has accumulated in the oil pan 27 is sucked up by the drive of the scavenging pump 90S, is filtered via the oil strainers 74L, 74R, and passes through the oil recovery passages 73, 86 to be sucked into the scavenging pump 90S. The lubricating oil discharged from the scavenging pump 90S is recovered into the oil tank 80.

25 The lubricating oil that has been recovered into the oil tank 80 is sucked up by the drive of the feed pump 90F, and sucked into the filter pump 90F via the screen oil filter 97. The lubricating oil discharged from the feed pump 90F passes through the horizontal hole 98a and the vertical hole 98b and flows into the oil filter 110 via the relief valve 99. The lubricating oil is then filtered before reaching the oil thermostat 105.

30

In the oil thermostat 105, when the temperature of lubricating oil is equal to or higher than a predetermined temperature, the switching valve 105a opens the oil cooler side 100 so that lubricating oil flows through the oil cooler 100 and is cooled. On the other hand, when the temperature of lubricating oil is lower than the predetermined temperature, the switching valve 95a opens the bypass oil passage 106 side so that lubricating oil flows through the bypass oil passage 106 and then flows into the oil vertical passage 107 located on the downstream side without being cooled.

10 It should be noted that the low-pressure oil switch 115 is attached to the bypass oil passage 106, and the high-pressure oil switch 116 is attached to the oil vertical passage 107.

The lubricating oil flowing downward through the oil vertical passage 107 is branched at the location of the oil horizontal passage 108 at the lower end to three branching paths and flows rearward in a lower portion of the crankcase 23. The lubricating oils branched to the left and right balancer supply passages 109l, 109r pass through the left- and right-balancer oil passages 23L, 23R to be supplied to the bearings of the left and right balancer shafts 36L, 36R, respectively.

20 It should be noted that as mentioned above, the lubricating oil supplied to the left balancer shaft 36R is further supplied to the intermediate shaft 37 as well.

The lubricating oil branched to the main-gallery supply passage 109c at the center passes through the main oil passage 23C while being further branched to be supplied to the respective bearing portions of the crankshaft 21.

30 It should be noted that the lubricating oil supplied to the respective bearing portions of the crankshaft 21 passes through an oil passage formed in the crankshaft 21 to be supplied to the connecting portion with the large-end portion of the connecting rod 31.

Further, a cam-shaft oil supply channel 120 is formed so as to extend upward from the main oil passage 23C. The lubricating oil that has ascended through the

cam-shaft oil supply channel 120 flows to an oil passage in each of the left and right cam shafts 35I, 35E to be supplied to each bearing and each cam surface from the oil passage in the shaft.

- 5 The lubricating oil that has lubricated the crankshaft 21, the left and right balancer shafts 36L, 36R, the left and right cam shafts 35I, 35E, and the like finally returns to the oil pan 27.

10 Further, a turbo oil-supply pipe 122 extends from the main oil passage 23C to the turbo-charger 43 via an oil filter 121. A part of the lubricating oil that has flown to the main oil passage 23C is supplied to the turbo-charger 43 through the turbo oil-supply pipe 122.

15 The lubricating oil supplied to the turbo-charger 43 separates into two flows, one for lubricating the bearings and the other for blocking heat on the turbine side to effect cooling. The two flows are returned to the oil pan 27 by means of two oil discharge pipes 123, 124.

20 On the other hand, the cooling system of the internal combustion engine 20 mounted in the small planing boat 1 utilizes water on which the small planing boat 1 is floated. Fig. 20 shows the circulation path of cooling water.

25 Cooling water is introduced via a cooling-water introduction hose A from a cooling water inlet port 131 on the downstream positive-pressure side of the impeller 11 of the jet propulsion pump 10. The cooling-water introduction hose A is branched on the downstream side of a one-way valve 132 to a cooling water hose B1 and to a cooling water hose C1 to form a first cooling water path B and a second cooling water path C.

30 The first cooling water path B is a path leading to the internal combustion engine main body 20A via the intercooler 42 and the exhaust manifold 44. The cooling water hose B1 is connected to an inflow connecting pipe 42a on the left side of the intercooler 42, and a cooling water hose B2 that extends to the other side from an outflow connecting pipe 42b on the right side of the intercooler 42 is connected to

an inflow joint member 44b attached to the rear portion of the water jacket of the exhaust manifold 44 (see Figs. 5, 6, 7).

5 As shown in Figs. 5 and 6, a cooling water hose B3 is connected to an outflow joint member 44c attached to the upper portion of the exhaust manifold 44. A cooling water hose B4 is connected to the cooling water hose B3 via a branching connecting pipe D. The cooling water hose B4 is connected to a lead-in joint member 22a of the cylinder block 22.

10 The water jacket of the cylinder block 22 communicates with the water jacket of the cylinder head 23.

Accordingly, in the first cooling-water path B, the cooling water that has passed through the cooling water hose B1 flows into the intercooler 42 to cool the intake  
15 air, and then passes through the cooling water hose B2 and flows into the water jacket formed in the exhaust manifold 44 to cool the exhaust manifold 44. The cooling water then passes through the cooling water hoses B3, B4 and flows into the water jacket of the cylinder block 22 of the internal combustion engine 20, and circulates in the water jacket of the cylinder block 22 and the water jacket of  
20 the cylinder head 23 to cool the internal combustion engine main body 20A before being discharged to the outside of the boat.

On the other hand, the second cooling-water path C is a path leading to the exhaust pipe 47a via the oil cooler 100. The cooling water hose C1 is connected to  
25 an inflow connecting pipe 85a in a lower portion of the oil-cooler accommodating portion 85 in the oil cooler 100. A cooling water hose C2 extending from a cooling-water outflow portion 85b in an upper portion of the oil-cooler accommodating portion 85 is connected to a cooling water hose C3 via the branching connecting pipe D. The cooling water hose C3 is connected to a  
30 cooling water hose C4 via a connecting pipe 135 installed in an upper portion of the exhaust manifold 44. The cooling water hose C4 extends rearward along the right-side surface of the cylinder head cover 26 to be connected to an inflow connecting pipe 43a of the turbo-charger 43 (see Figs. 5, 6).

As shown in Fig. 20, the cooling water that has flown into the turbo-charger 43 reaches the water jacket formed in the exhaust pipe 47a, and after the exhaust pipe 47a, sequentially passes through the backflow prevention chamber 47b, the water muffler 47c, and the piping 47d before reaching the water chamber 47e.

5

Accordingly, in the second cooling-water path C, the cooling water that has passed through the cooling water hose C1 flows into the oil-cooler accommodating portion 85 of the oil cooler 100 to cool lubricating oil, and then passes through the cooling water hoses C2, C3, C4 and flows into the water jacket of the turbo-charger 43 to cool the turbo-charger 43. Thereafter, the cooling water reaches the water jacket of the exhaust pipe 47a, takes in the exhaust air while cooling the exhaust pipe 47a, and sequentially passes through the backflow prevention chamber 47b, the water muffler 47c, and the piping 47d before reaching the water chamber 47e leading into the water to be discharged into the water.

10  
15

The branching connecting pipe D, which is commonly used for the first cooling-water path B and the second cooling-water path C described above, also forms a bypass passage communicating between the cooling water hose C2 located downstream of the oil-cooler accommodating portion 85 of the oil cooler 100, and the cooling water hose B4 located upstream of the water jacket of the cylinder block 22.

20

Accordingly, a part of the cooling water that has passed through the oil cooler 100 is mixed, via the bypass flow passage of the branching connecting pipe D, into the cooling water that has flown out from the water jacket of the exhaust manifold 44, and flows into the water jacket of the cylinder block 22.

25

The cooling system of the internal combustion engine 20 according to this embodiment is configured as described above.

30

When the cooling water introduced from the cooling water inlet port 131 of the jet propulsion pump 10 is made to directly flow to the water jackets of the cylinder block 22 and cylinder head 23 of the internal combustion engine 20,

supercooling may occur before the internal combustion engine 20 is warmed up, resulting in so-called dilution whereby fuel passes through the gap between the piston and the cylinder and dissolves into lubricating oil to dilute the lubricating oil.

5

In view of this, in the cooling system according to this embodiment, in the first cooling-water path B mentioned above, the cooling water that has been raised in temperature through the exhaust manifold 44 that warms up quickly is made to flow into the water jacket of the cylinder block 22 via the cooling water hoses B3, B4 to prevent supercooling of the internal combustion engine 20, thereby alleviating dilution and suppressing oil degradation.

Once the internal combustion engine 20 has been warmed up, the temperature of the cooling water that has passed through the exhaust manifold 44 is too high. In view of this, the cooling system according to this embodiment includes the branching connecting pipe D that also serves as a bypass passage communicating between the cooling water hose C2, which is located downstream of the oil-cooler accommodating portion 85 in the second cooling water path C, and the cooling water hose B4 in the first cooling water path B. A part of the cooling water that has passed through the oil cooler 100 on the upstream side of the turbo-charger 43 and whose temperature is not so high is made to pass through the branching connecting pipe D to be mixed into the cooling water that has passed through the exhaust manifold 44. The cooling water that is made to flow into the water jacket of the cylinder block 22 is thus maintained at an appropriate temperature, thereby enabling efficient cooling of the internal combustion engine 20.

A part of the cooling water that has passed through the oil cooler 100 is diverted into the bypass passage of the branching connecting pipe D, and all the remainder of the cooling water flows through the second cooling water path C as it is into the water jacket of the turbo-charger 43 to cool the turbo-charger 43, and then cools the exhaust pipe 47a and the like.

Further, in the lubricating system mentioned above, when the temperature of lubricating oil is equal to or higher than a predetermined temperature, the oil thermostat 105 opens the oil cooler 100 side to cool the lubricating oil, thus promoting the cooling of the internal combustion engine 20.

5

On the other hand, when the temperature of lubricating oil is lower than the predetermined temperature, the oil thermostat 105 opens the bypass oil passage 106 side so that the lubricating oil is bypassed without passing through the oil cooler 100. Accordingly, the lubricating oil is not cooled, thereby promoting warm-up and preventing supercooling from occurring during cold running.

10

Although various preferred embodiments of the present invention have been described herein in detail, it will be appreciated by those skilled in the art, that variations may be made thereto without departing from the spirit of the invention or the scope of the appended claims.

15

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

1. An internal combustion engine for a small planing boat, in which  
5 cooling water supplied from a jet propulsion pump driven by an internal  
combustion engine is introduced to the internal combustion engine to effect  
cooling, comprising: a first cooling water path through which cooling water  
introduced from the jet propulsion pump flows toward a main body of the  
internal combustion engine via an exhaust manifold; a second cooling water path  
10 through which cooling water introduced from the jet propulsion pump flows  
toward an exhaust pipe via an oil cooler; and a bypass cooling water path for  
branching a part of cooling water in the second cooling water path which flows  
out from the oil cooler, so as to merge with cooling water in the first cooling  
water path which flows into the main body of the internal combustion engine.

15

2. An internal combustion engine for a small planing boat with a  
supercharger, in which cooling water supplied from a jet propulsion pump  
driven by an internal combustion engine is introduced to the internal combustion  
engine to effect cooling, comprising: a first cooling water path through which  
20 cooling water introduced from the jet propulsion pump flows toward a main  
body of the internal combustion engine via an exhaust manifold after cooling an  
oil cooler that cools intake air pressurized by the supercharger; a second cooling  
water path through which cooling water introduced from the jet propulsion  
pump flows toward an exhaust pipe via the supercharger after cooling the oil  
25 cooler; and a bypass cooling water path for branching a part of cooling water in  
the second cooling water path which flows out from the oil cooler, so as to merge  
with cooling water in the first cooling water path which flows into the main body  
of the internal combustion engine.

FIG. 1

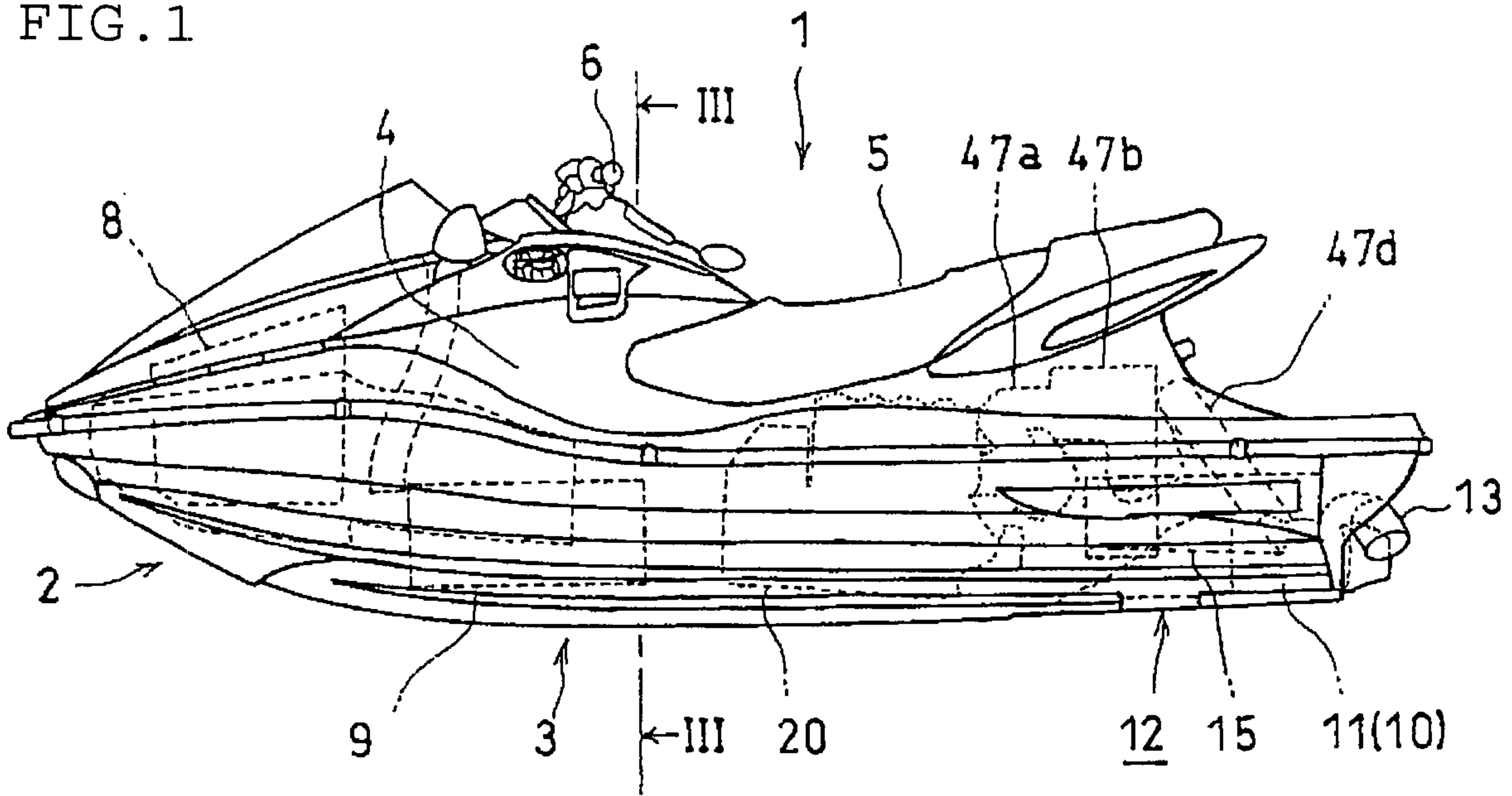


FIG. 2

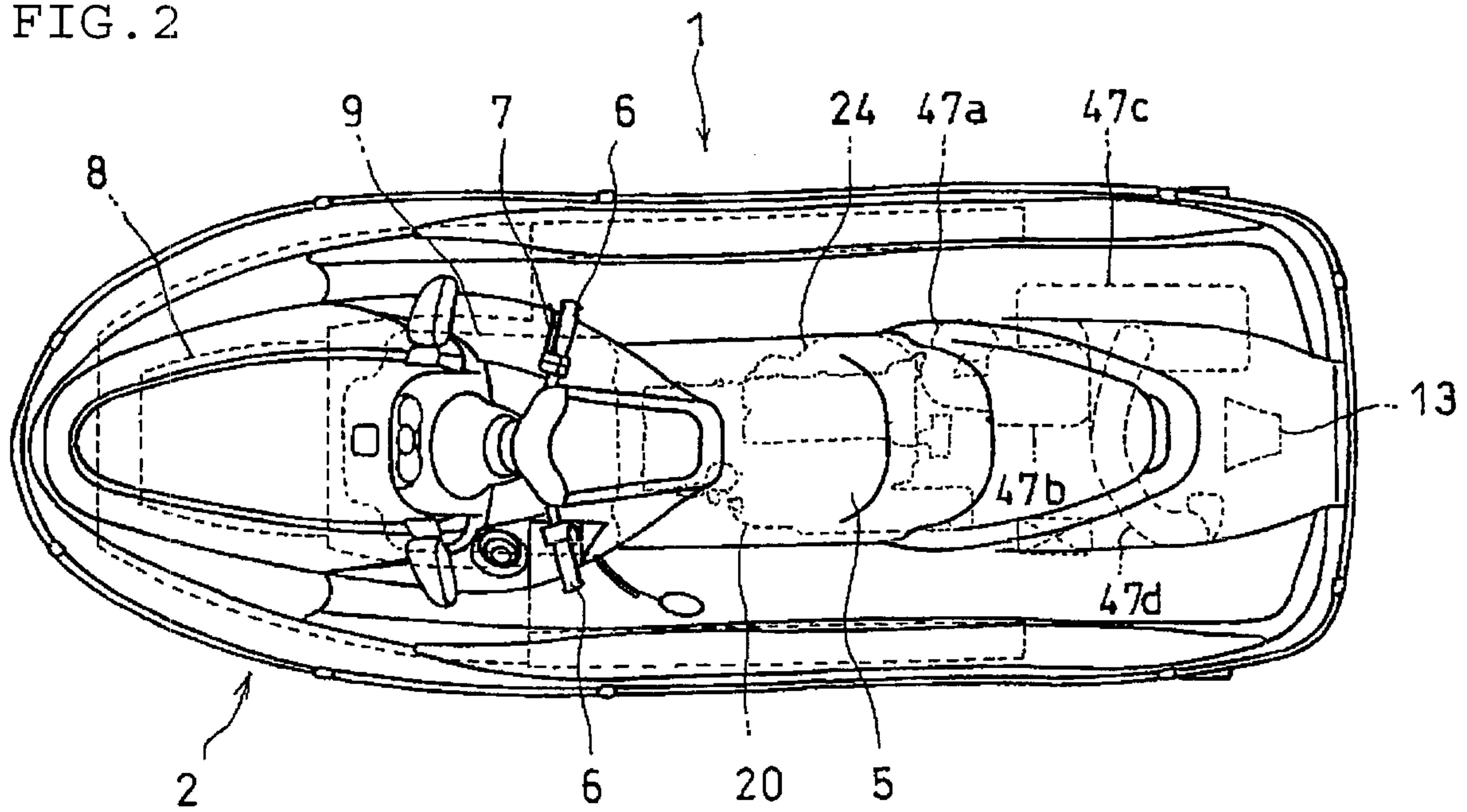




FIG. 5

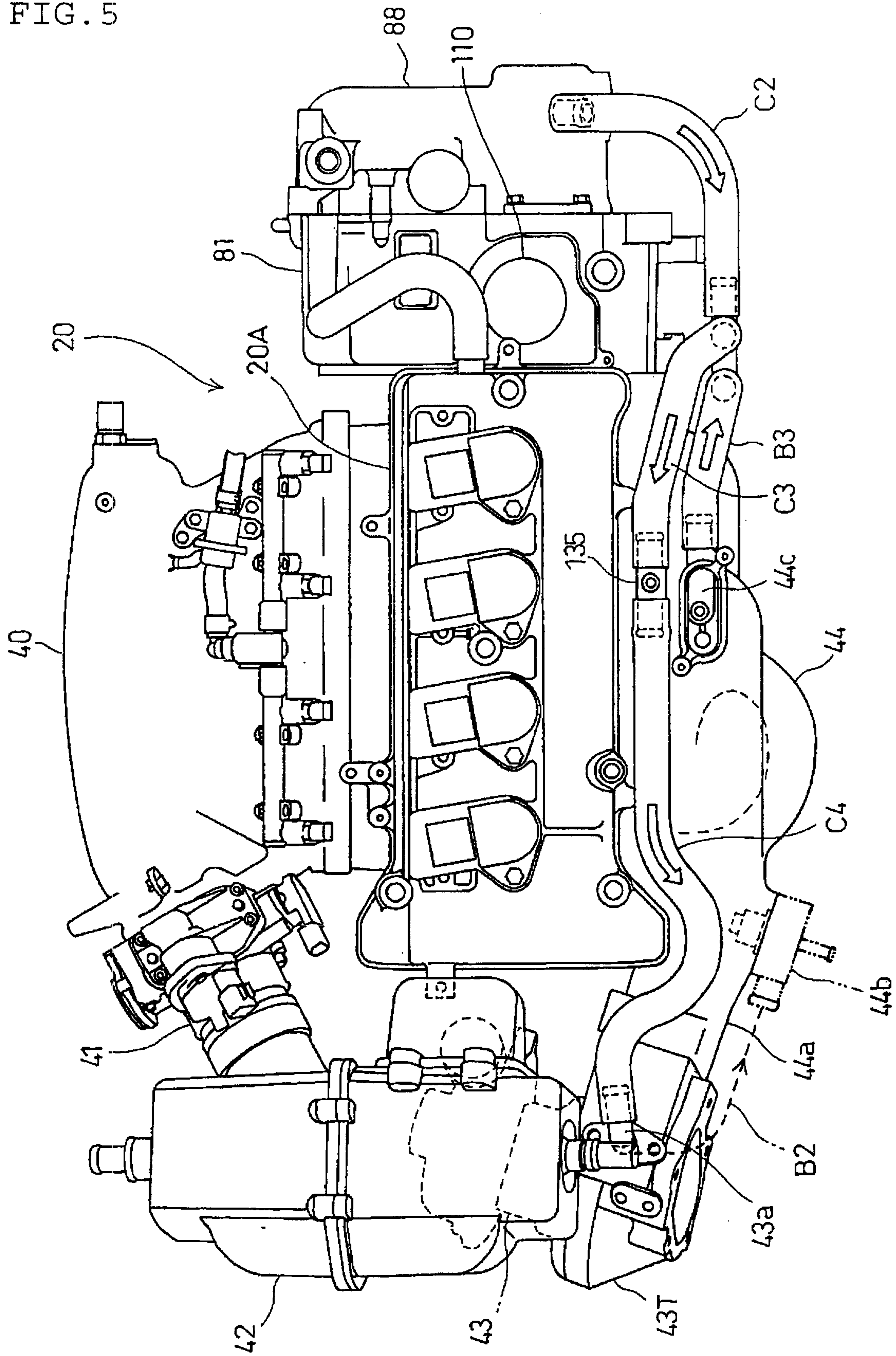




FIG. 7

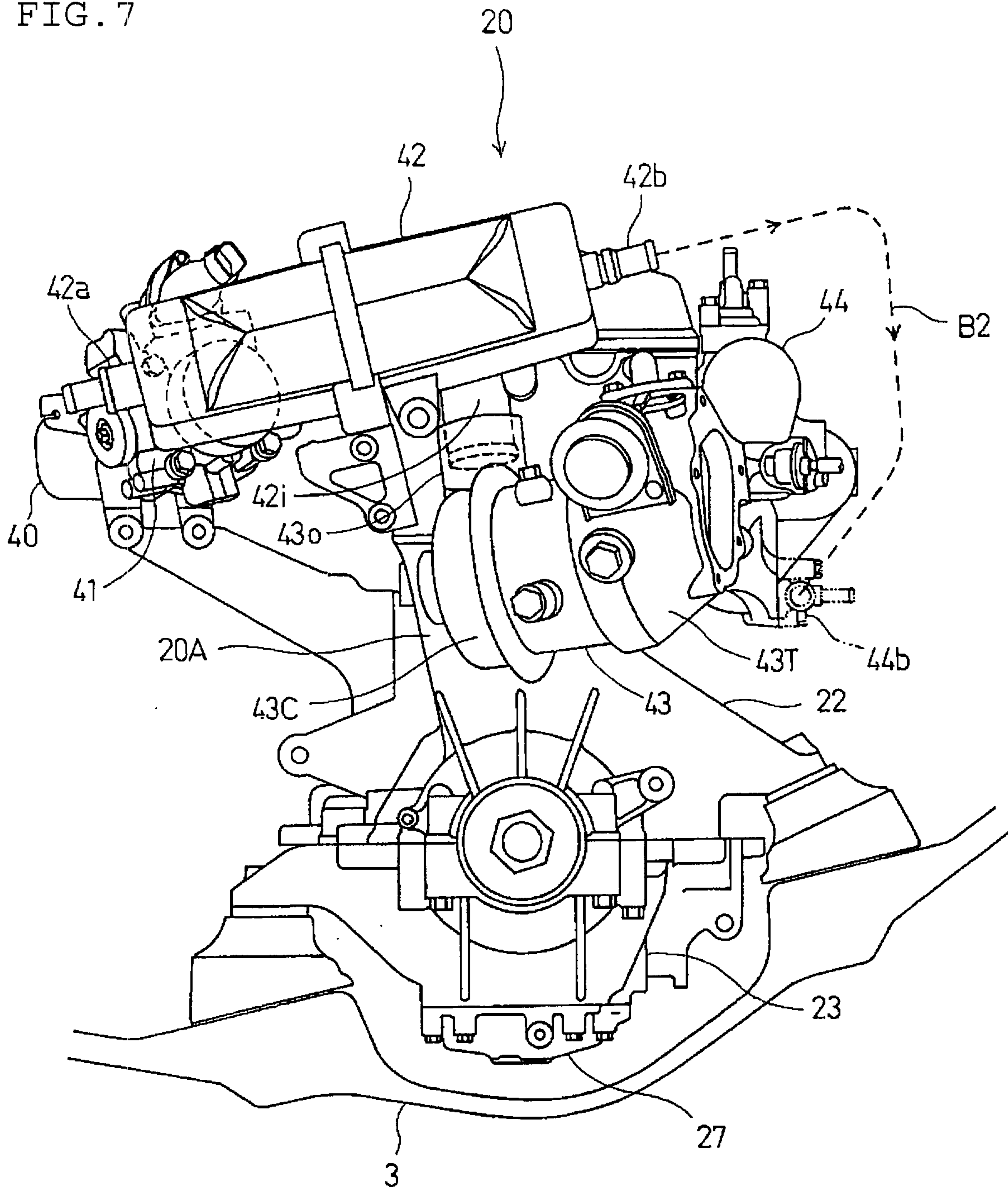


FIG. 8

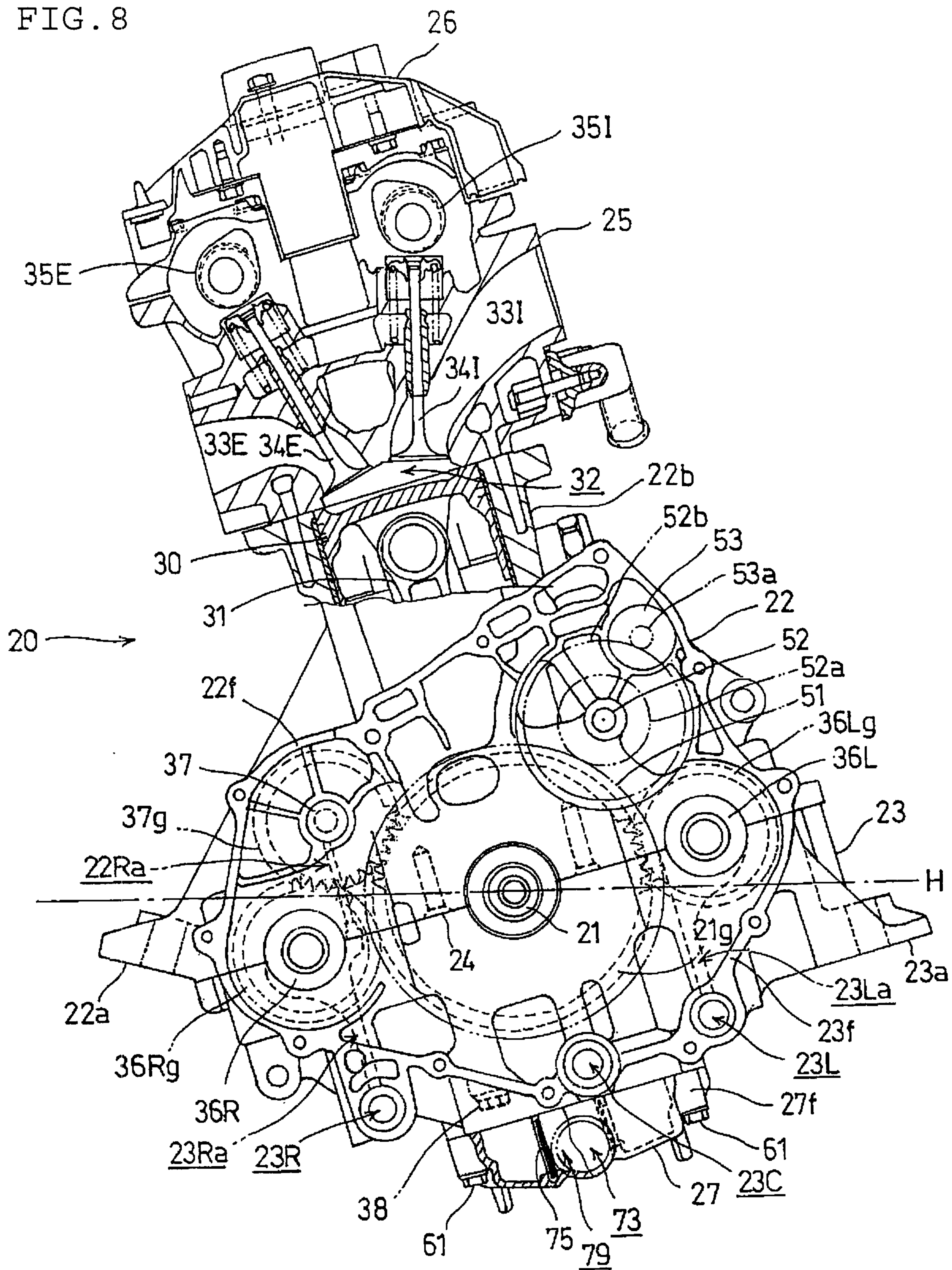


FIG. 9

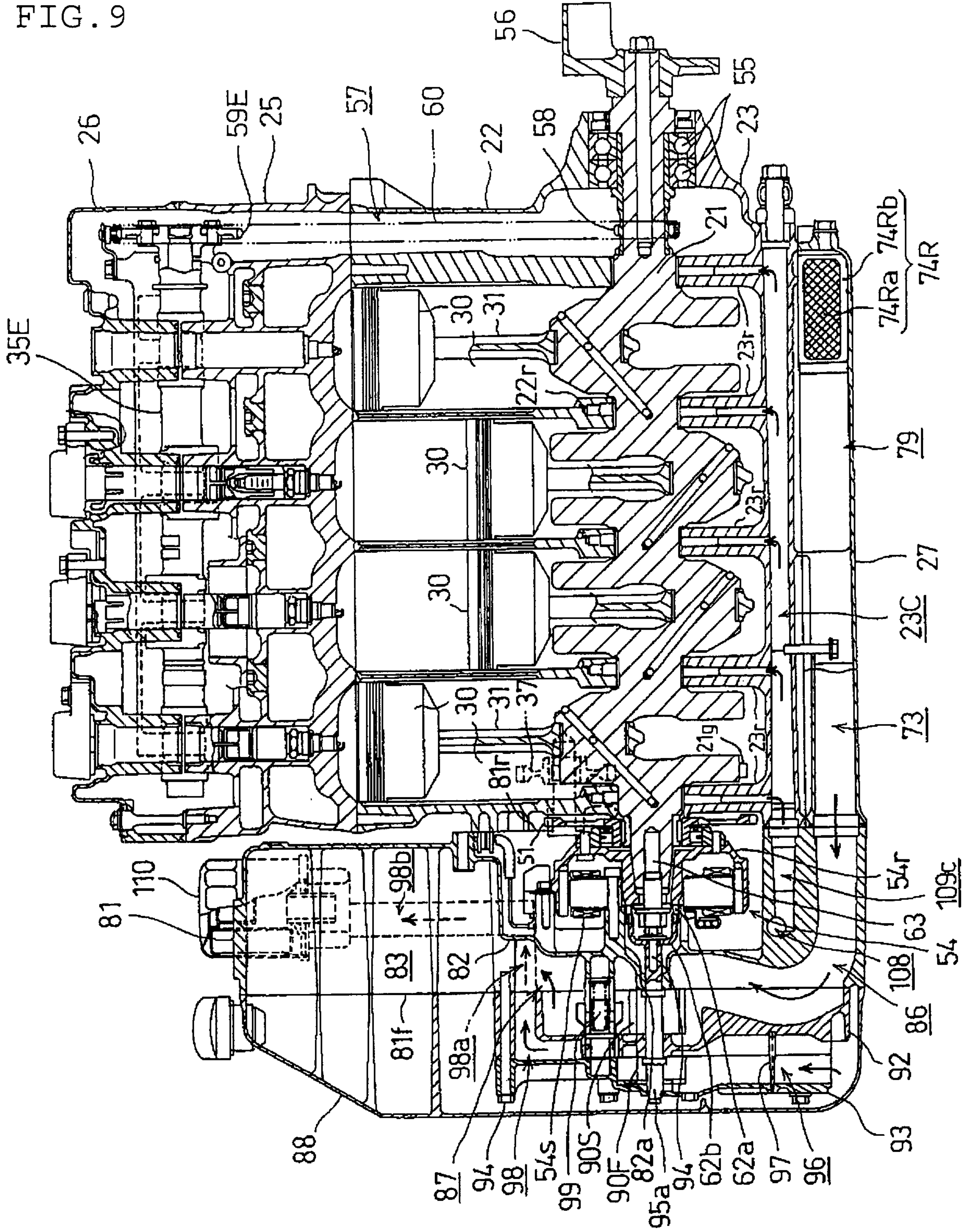


FIG. 10

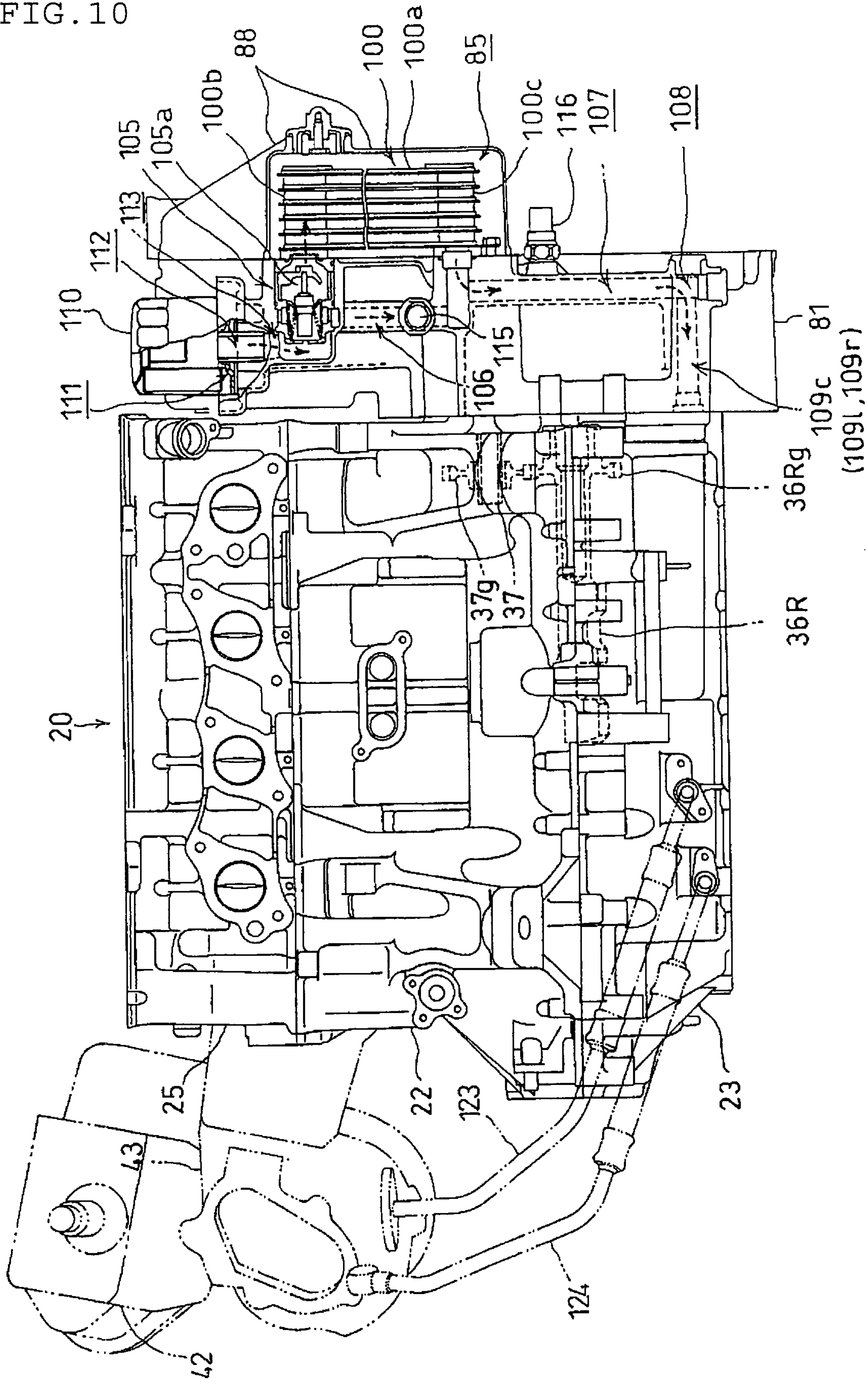


FIG. 11

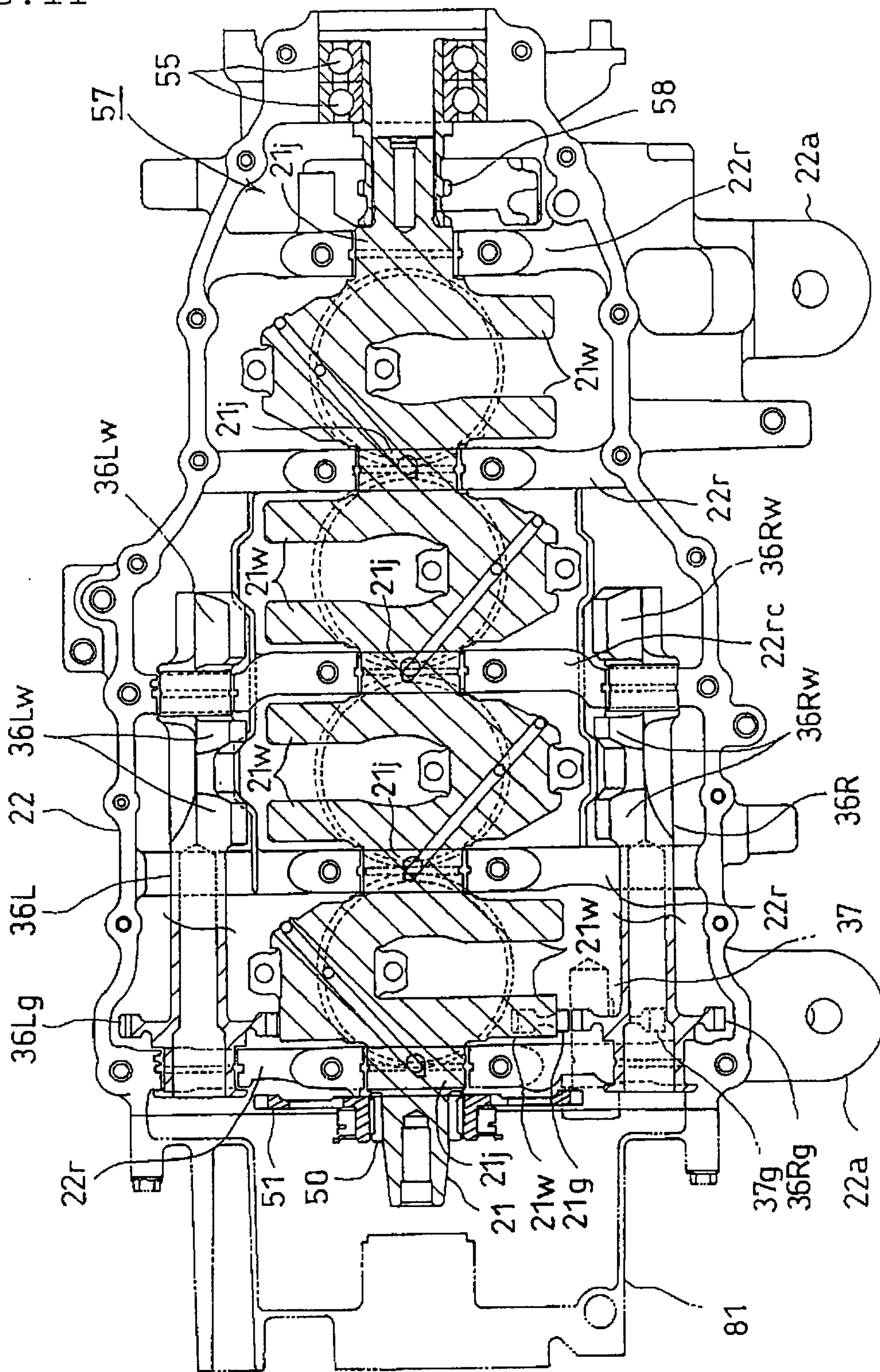


FIG. 12

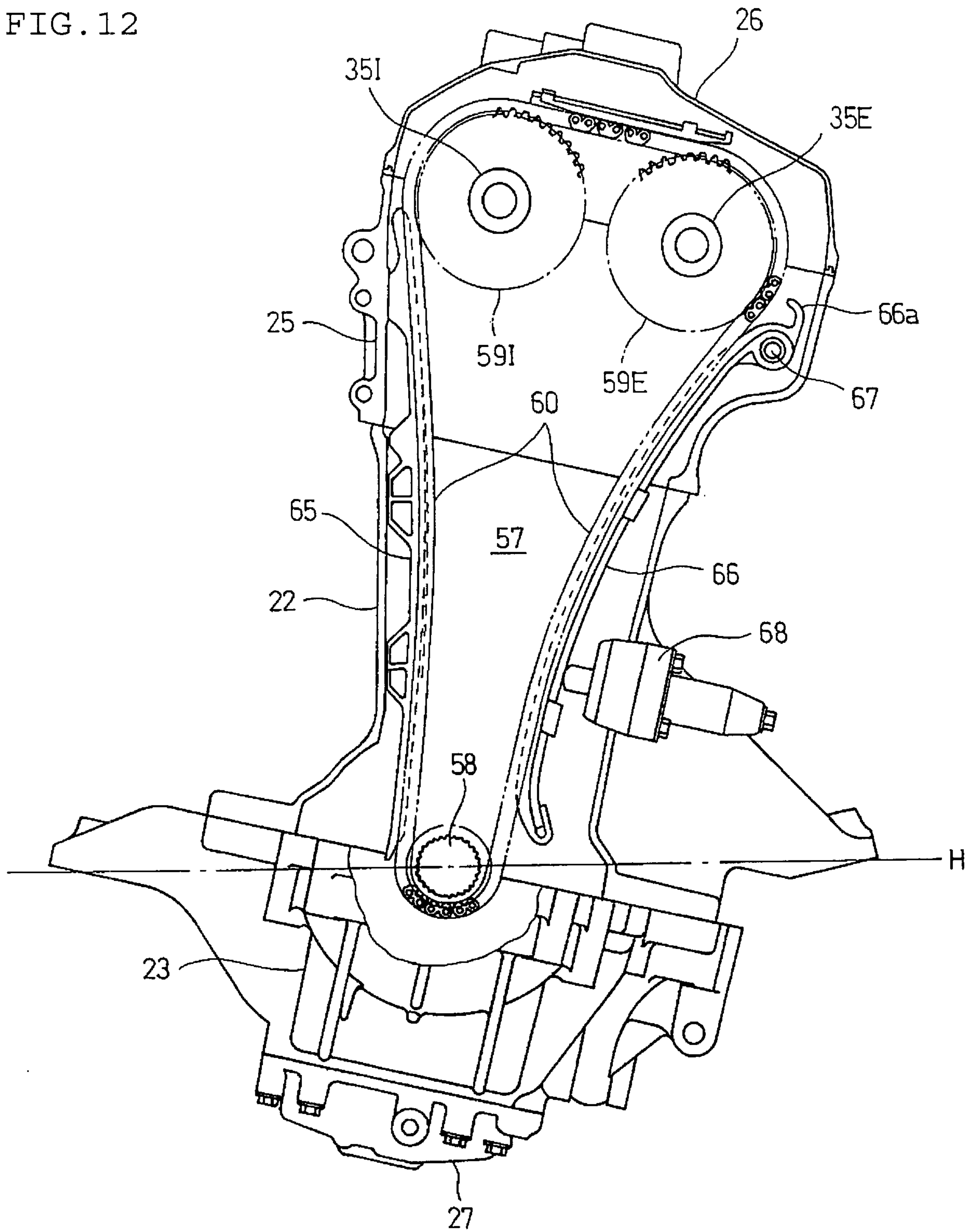


FIG. 13

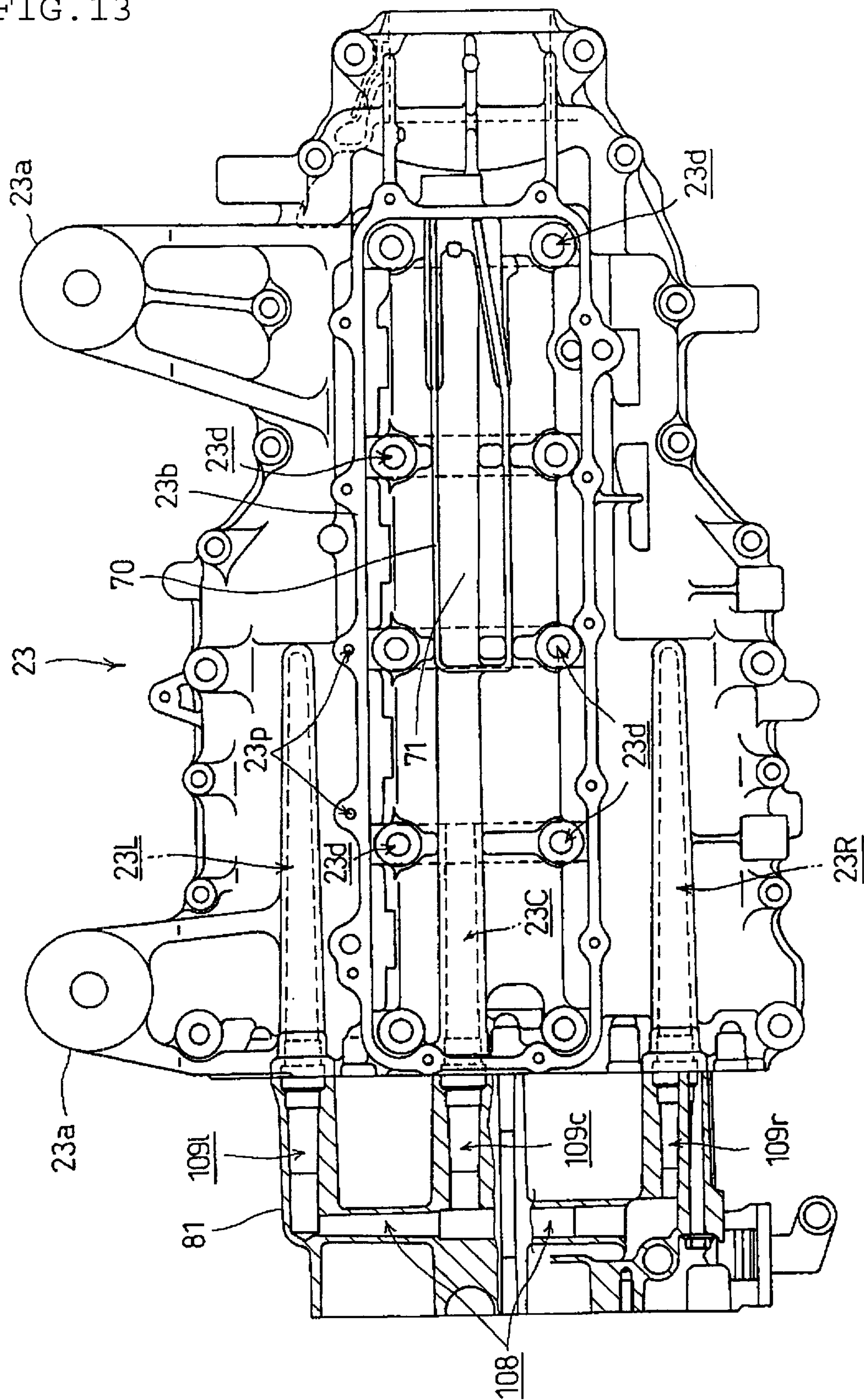


FIG. 14

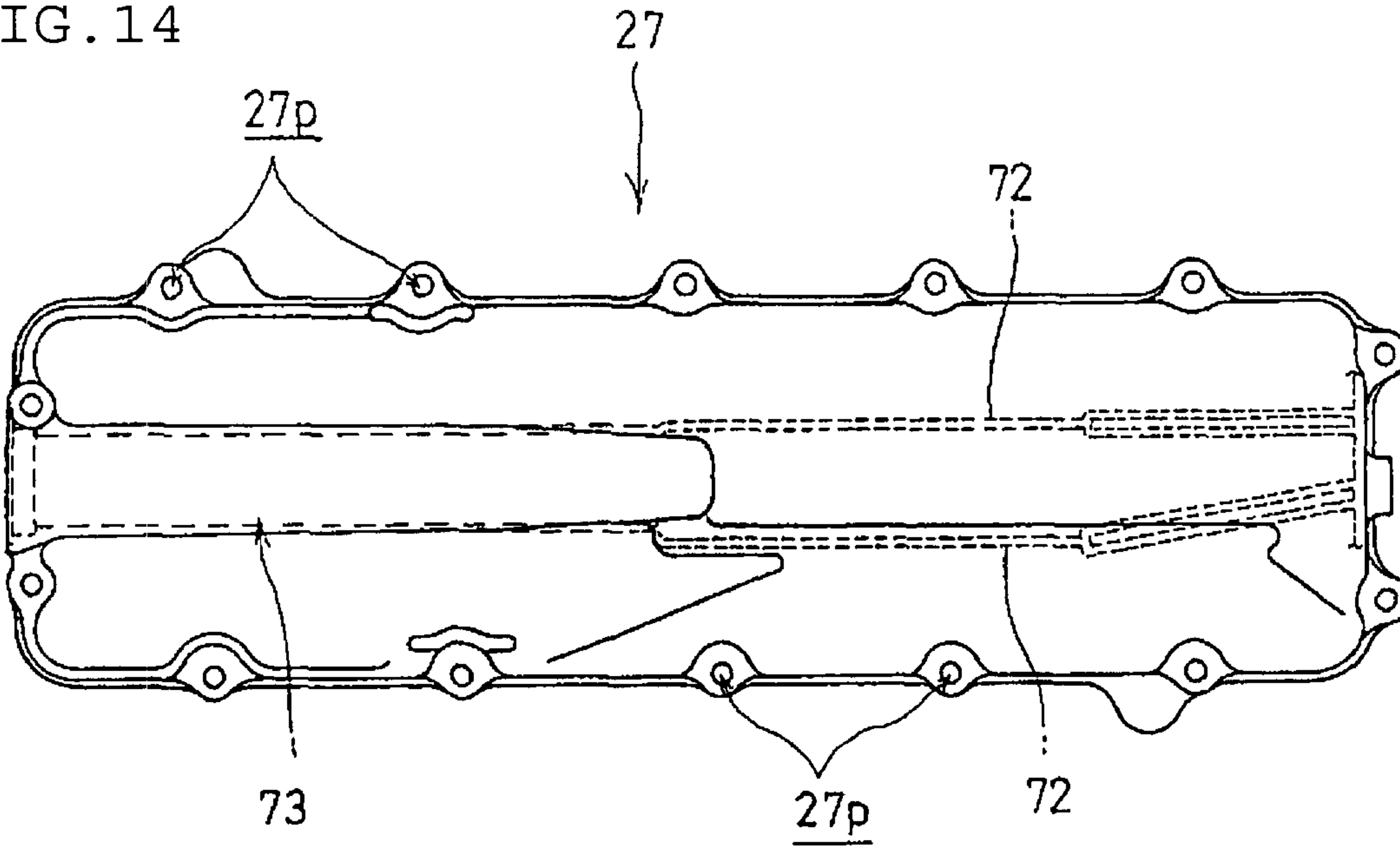


FIG. 15

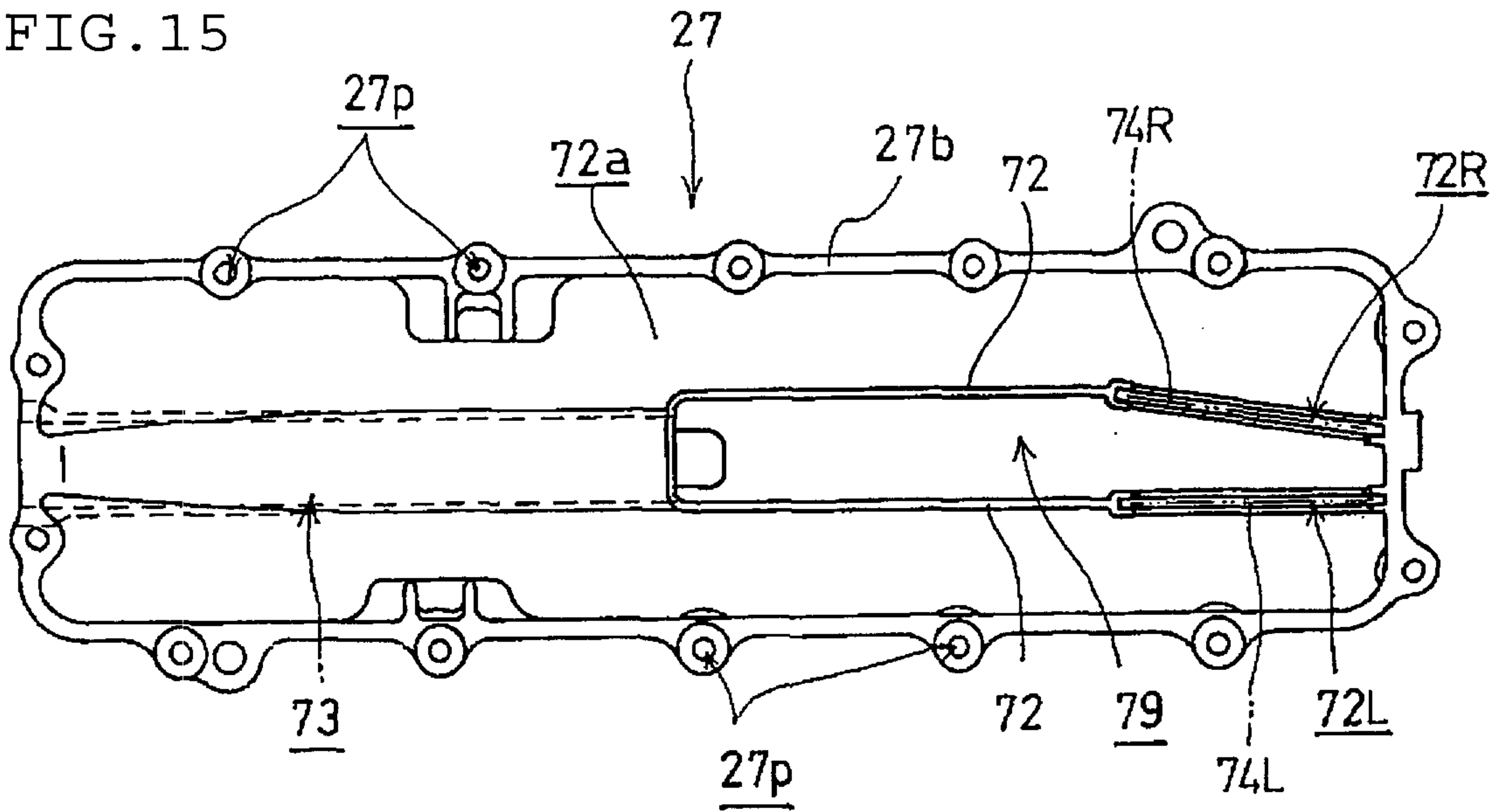


FIG. 16

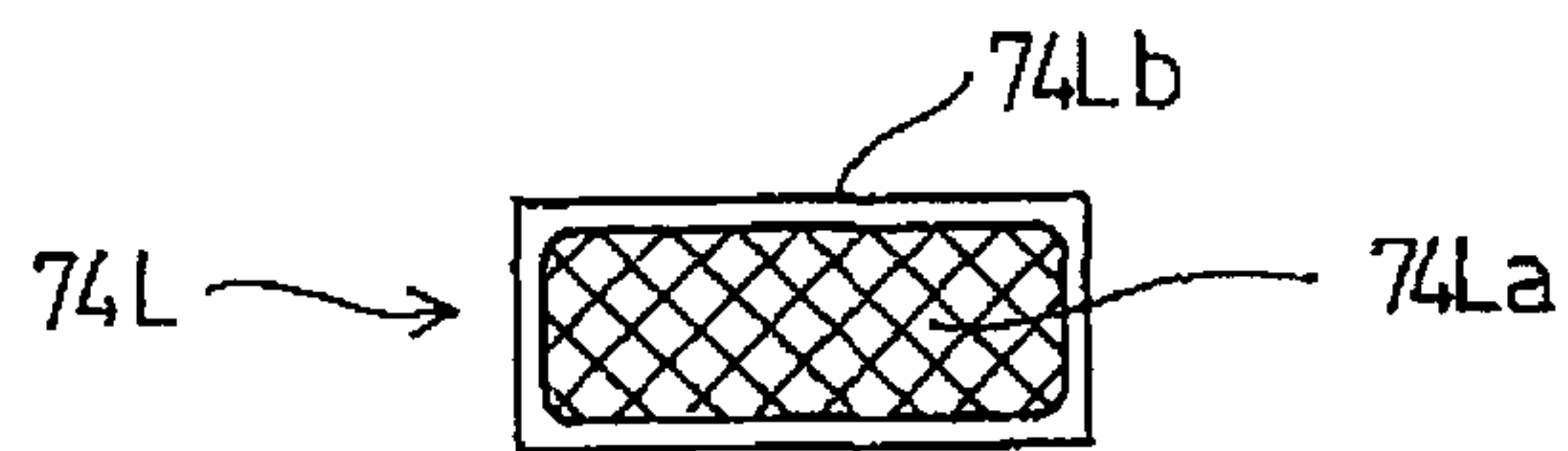


FIG. 17

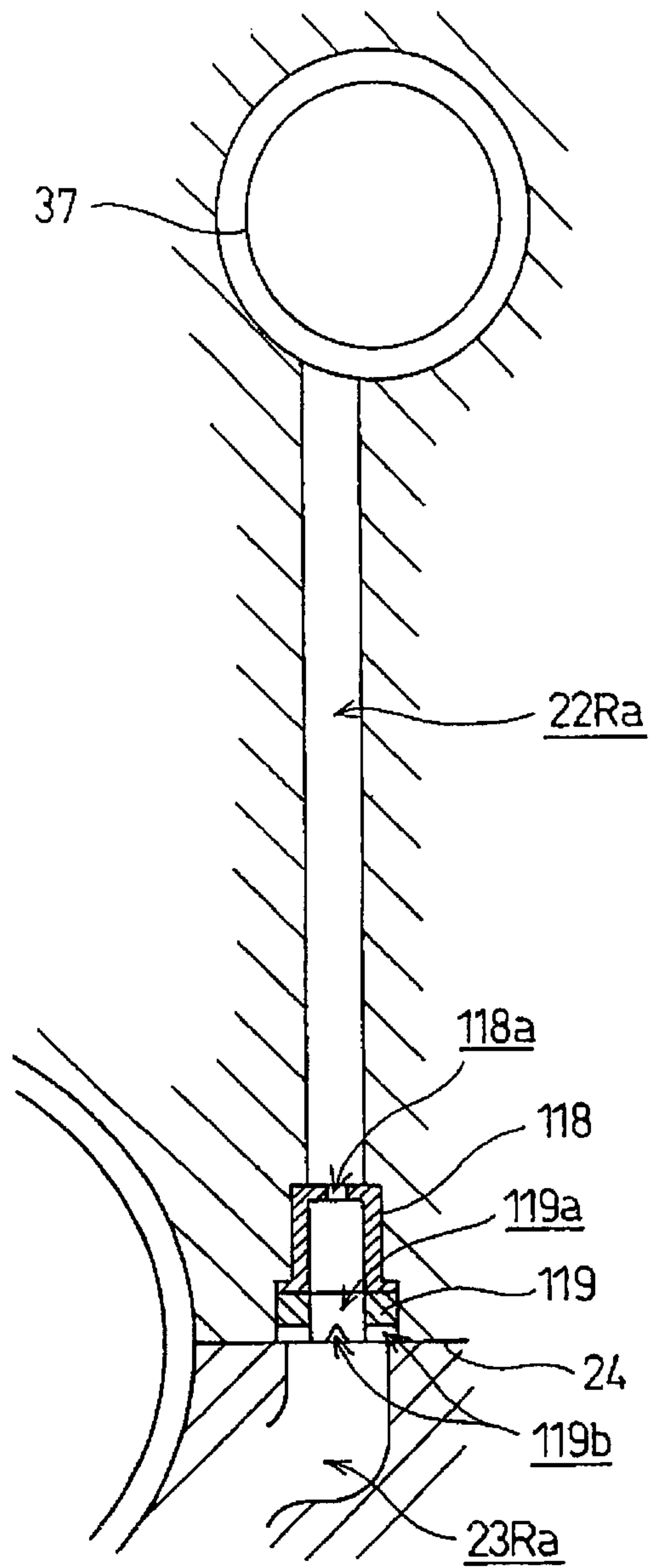


FIG. 18

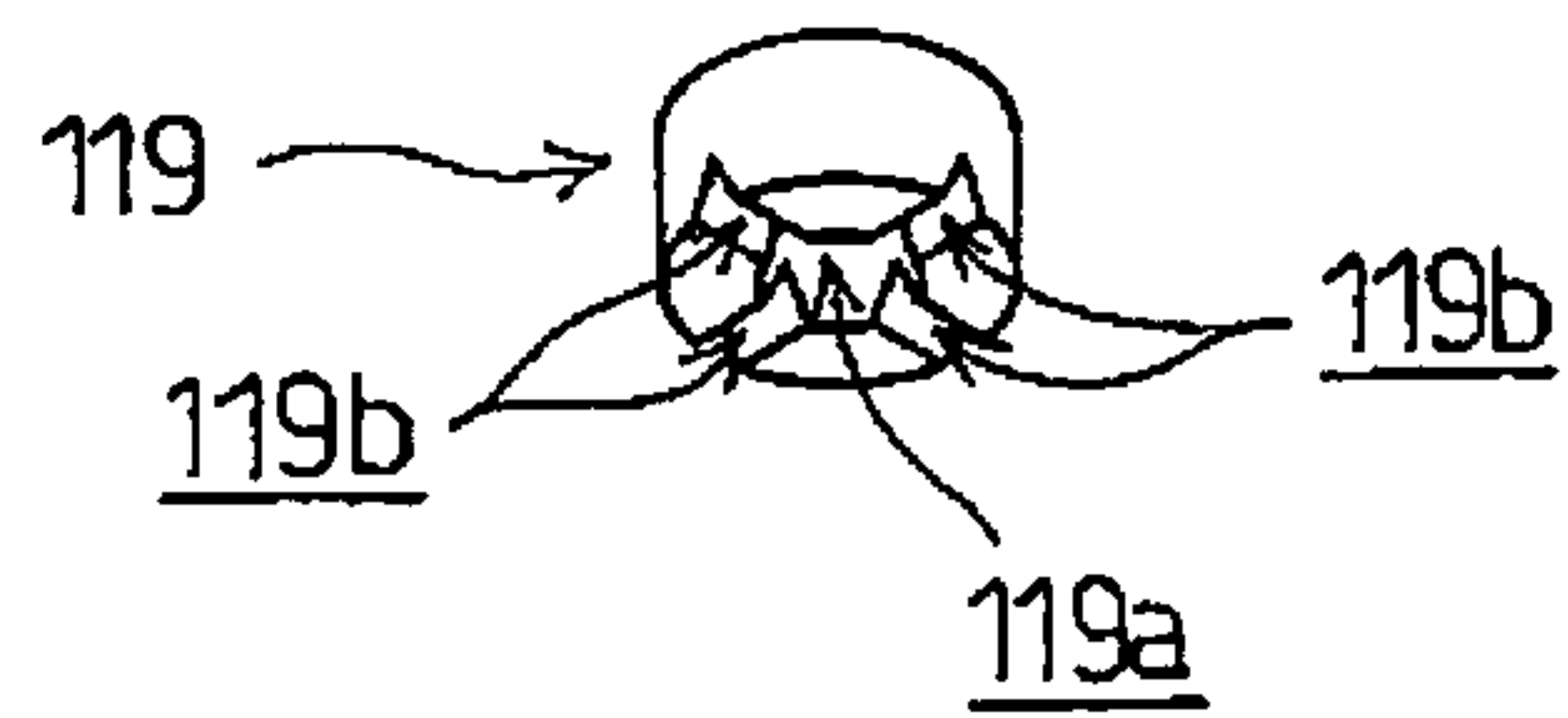


FIG. 19

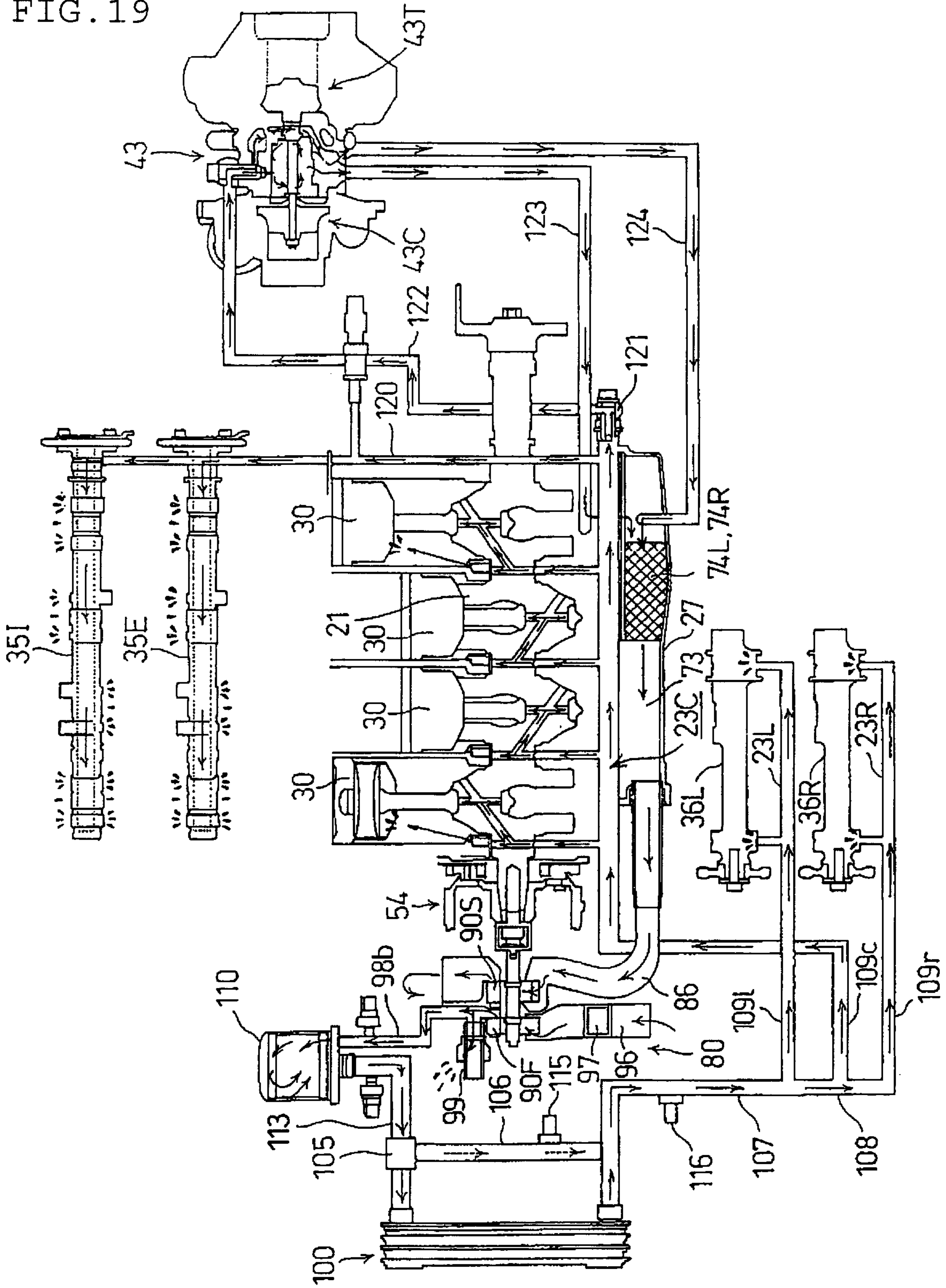


FIG. 20

