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(54) Automotive internal combustion engine.

(57) The present invention relates to an internal combustion engine for automotive vehicle comprising a cylinder block (7) and a cylinder head (11), said engine being disposed transversely in an engine compartment with the crankshaft (6) extending perpendicularly to the traveling direction of the vehicle, wherein a coolant water passage (131) for connecting a delivery port (129) of the water pump (120) to an inlet (132a) of said cylinder head water (135) jacket is disposed independently of said cylinder block water jacket (134) and the cylinder head (11) is cooled by coolant water prior to circulating the coolant water through the cylinder block water jacket (134) of the cylinder block (7).

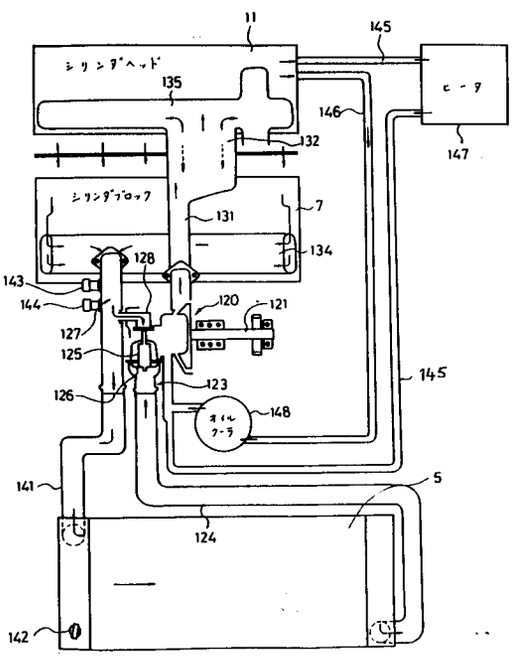

FIG. 15

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The present invention relates to an automative internal combustion engine comprising a cylinder block water jacket for circulating a flow of coolant water formed therein and a cylinder head mounted on said cylinder block provided with a cylinder head water jacket for circulating coolant water therethrough formed therein, wherein the flow of coolant water is circulated through a water pump supported through said cylinder block.

Conventionally, with an internal combustion engine for automotive vehicles which comprises a plurality of cylinders arranged in parallel to the crankshaft of the cylinder block, a water pump for circulating the coolant water is provided which is installed on an end surface of the cylinder block which substantially extends perpendicularly to the crankshaft.

Accordingly, the water pump frequently projects from the cylinder block in the crankshaft direction which undesirably tends to lengthen the overall length the engine in the crankshaft direction.

The above-mentioned positioning of the water pump is similarly undesirable when the so-called transverse engine concept has been adopted, accommodating the engine in a transverse direction in an engine compartment of the vehicle.

Moreover, normally, a radiator of the cooling system is provided in front of the engine and needs to be connected to said water pump to cool the engine by circulation coolant water through at least the cylinder block of the engine. In case of supporting the water pump at a laterally facing surface of the cylinder block of a transverse engine, a relatively space-consuming and complicated tubing is required in order to connect the water pump to the radiator.

From EP-A-196871 an automative internal comubstion engine as indicated in the preamble portion of claim 1 is known. From GB-A-2 143 584 it is known to rotatably support a water pump drive shaft for driving a water pump on a cylinder block in parallel to a crankshaft. However, said arrangements do not yet prove to be fully satisfactory to overcome the aboveinformed deficiencies.

It has already been deliberated to shorten the engine unit in the crankshaft direction by installing the water pump on a side face to the cylinder block which is parallel to its crankshaft. On the other hand, it is desirable to take care to lower preferably the temperature of the cylinder head enabling to increase the engine output by elevating the permissible combustion temperature. Of course, such a strategy requires improved and forced cooling of the cylinder head. Therefore, it has been deliberated to mount the water pump directly on the cylinder head, in particular, to install it at one side of the engine, intending to supply coolant water to the cylinder head prior to supplying cooling water to the cylinder block cooling structure. However, under said design aspects, the internal combustion engine tends to become bulky because the side face of the cylinder head in a crankshaft direction is provided with intake and exhaust pipes and any location of the water pump at the cylinder head requires to avoid interference with these pipes.

Accordingly, the present invention aims to improve the layout of an automotive internal combustion engine in order to render the engine more compact equipped with a simplified cooling arrangement for the water cooling system which, moreover, enables an improved cooling of the cylinder head structure which is subject to increased temperature load caused by the combustion process occuring in adjacent combustion chambers defined by the cylinder head structure.

According to the present invention the above objective is performed in that a coolant water passage for connecting a delivery port of the water pump to an inlet of said cylinder head water jacket is disposed independently of said cylinder block water jacket and the cylinder head is cooled by a coolant water prior to circulating the coolant water through the cylinder block water jacket of the cylinder block.

Thus, the cylinder head of the engine is cooled prior to the cylinder block and, accordingly, the cooling efficiency of the cooling system is considerably improved as the parts of maximal thermal load are cooled first whereas the other parts of the engine are cooled hereinafter.

Moreover, according to a preferred aspect of the present invention, there is a bypass structure in between the water pump and a water outlet of the cylinder block leading to the radiator in order to obtain an improved warming up capacity of the engine.

The latter can be obtained by disposing the water pump and the water outlet of the cylinder block cooling structure at the same side of the cylinders side-by-side oriented in the frontwards direction of the vehicle.

Thus, the water pump, together with the water pump drive shaft, is disposed on one side face of the cylinder block which is parallel to its cranskhaft and, preferably, the inlet of water jacket of the cylinder head is provided through a side face of the cyldiner head on the same side on which the water pump is installed at the cylinder block and the coolant water passage for connecting delivery port of the water pump to the inlet of the water jacket of the cylinder head is provided independently of the water jacket of the cylinder block.

With the vehicle engine unit structure according to this invention, when the water pump is driven, the coolant water from the radiator is sent from the delivery port of the water pump to the

coolant water inlet on one side face of the cylinder head through a coolant water passage and is supplied to the cylinder head water jacket for the cylinder head to cool the cylinder head. Then, the coolant water from the cylinder head is supplied to the cylinder block water jacket for the cylinder block to cool the cylinder block and is finally sent to the radiator.

As mentioned above, with the vehicle engine unit structure according to this invention, since its water pump is mounted on the cylinder block and the coolant water is supplied to the cylinder head water jacket for the cylinder head through a coolant water passage provided independently of the cylinder block water jacket, although the cylinder head is cooled prior to the cylinder block, the water pump can be disposed without interfering with intake pipes and exhaust pipes, and the engine unit can be made compact.

Further, since the water pump and coolant water inlet of the cylinder head water jacket are positioned on the side faces, on the same side parallel to the crankshaft, of the cylinder block and the cylinder head respectively, the water pump and the coolant water passage will not overlap with each other longitudinally of the crankshaft, which makes it possible to shorten the engine unit longitudinally of the crankshaft.

According to a preferred embodiment of the present invention, the water pump drive shaft, to which the rotation of the crankshaft is transmitted, is mounted on the front side of the transverely-disposed engine in parallel to the crankshaft enabling the water pump to be mounted within the extent of the crankshaft and, moreover, preferably the suction side of the water pump is connected to the radiator through a piping with the coolant water inlet provided on the front side of the engine being connected with the delivery port of the water pump.

With the vehicle engine unit structure according to this invention, the drive shaft is rotated in connection with the crankshaft, and the water pump installed on the front side of the engine is driven by this drive shaft. Thus, the coolant water sucked from the radiator through a piping is supplied to the coolant water inlet provided on the front (forwardly of the vehicle) side of the engine from the delivery port of the water pump and, after cooling the engine while circulating through it, is returned to the radiator.

According to an advantageous embodiment, since the water pump is mounted on the drive shaft to which is transmitted the rotation of the crankshaft in such a manner that the water pump is positioned within the engine width longitudinally of the crankshaft, the engine width longitudinally of the crankshaft can be reduced, which is advantageous for mounting the engine unit on the vehicle body.

Further, since according to another preferred embodiment of this invention the coolant water inlet provided on the side face of the engine unit forwardly of the vehicle is connected with the delivery port of the water pump while the suction side of the water pump is connected with the radiator through a piping, pipings will not project longitudinally of the crankshaft, and pipings can be simplified and shortened.

Other preferred embodiments of the present invention are laid down in the further sub-claims.

Further objectives, features and advantages of the present invention will become more apparent from the following description of an embodiment of the present invention in conjunction with the associated drawings wherein:

Figure 1 is a side view showing the assembled state of an automotive internal combustion engine according to the present invention,

Figure 2 is a plan view for Figure 1,

Figure 3 is a side view of the internal combustion engine shown in Figure 1,

Figure 4 is a front view of the internal combustion engine of Figure 3,

Figures 5 and 6 are partially broken-away side views of the internal combustion engine of Figure 1,

Figure 7 is a sectional view along the line VII-VII in Figure 6,

Figure 8 is a sectional view along the line VII-VII in Figure 5,

Figure 9 is a plan view of the cylinder block of the internal combustion engine according to Figure 1,

Figure 10 is an arrow view along the arrow mark 1 in Figure 9,

Figure 11 is a sectional view along the line XI-XI in Figure 10,

Figure 12 is a vertical sectional view of the cylinder head of the internal combustion engine of Figure 1,

Figure 13 is a sectional view along the line XIII-XIII in Figure 12,

Figure 14 is a side view of the cylinder head of the internal combustion engine according to the present invention on the side opposite to that on which a second drive chain is provided, and

Figure 15 is a system diagram of the cooling system of the internal combustion engine according to the present invention.

In Figures 1 and 2, the reference number 1 denotes the engine compartment of an automobile formed above and between the right and left front wheels 3 connected through front wheel shafts 2. Within this engine compartment 1 is mounted an engine unit 4 having a 4-stroke 6-cylinder internal combustion engine with its radiator 5 arranged in

front of this engine unit 4. The engine unit 4 is disposed with its crankshaft 6 extending laterally of the vehicle so that the passenger compartment may be spacious.

The crankshaft 6 of the engine unit is journalled between the cylinder block 7 and the bearing case 8 as shown in Figs. 5 to 7, and is connected with each piston 9 provided in the respective cylinder through the respective connecting rod 10. As shown in Figs. 3 and 7 in double-dotted chain lines, a disk 90 having projections 90a mounted on its periphery is provided on one end of the crankshaft 6 projecting out of the cylinder block 7 to detect the phase of the crankshaft rotation by sensing the passing of the projection 90a mounted on the disk 90 by a crank sensor 91 mounted on the cylinder block 7.

On the cylinder block 7 is mounted a cylinder head 11 constituting the engine E, on which head 11 is provided a head cover 12, and each cylinder is provided with an ignition plug 13.

The bearing case 8 is provided with an oil pan 14 connected with an oil tank 15 which tank 15 is disposed forwardly of the vehicle from the bottom to the top of the engine through the entire height of the engine.

As shown in Figs. 5 and 6, the cylinder bank of the engine is inclined from the verticality backward of the vehicle. The power takout shaft 16 for taking out the output power of the crankshaft 6 is disposed in parallel with the crankshaft 6 and further is disposed slantly forwardly above the crankshaft 6. The oil tank 15 reserving engine oil is located slantly forwardly under the crankshaft 6 and the power output shaft 16 and is thus faced forwardly of the vehicle as shown by the arrow mark FWD in Figs. 3, 4 and 6. The power takeout shaft 16 is positioned in such a manner that the angle formed between the cylinder axis plane L1 and the plane L2 including both of the crankshaft 6 axis and the power output shaft 16 axis may be an acute angle.

The oil pan 14 has a pair of oil passages 17 formed vertically through both sides of the guide portion 14a as shown in Fig. 6, and the engine oil collected in the oil pan 14 is sucked in through the inlet port 17a at the bottom of the oil passage 17 and is sent to the oil tank 15 by discharge pumps 18 and 19 mounted on the power takeout shaft 16. The oil pan 14 and the oil tank 15 is partitioned by a wall provided with oil passages 17. The oil which has lubricated various portions of the engine is collected at the bottom of the crank chamber A formed with the cylinder block 7, bearing case 8 and oil pan 14, and the inlet port 17a is provided with a net 20 so that dust may not be sucked in. Inside the oil pan 14 is mounted a plate 21 on the guide portion 14a.

The oil reserved in the tank 15 is sucked through a strainer 25 and a pipe 26 disposed at the bottom of the tank 15 and then is fed to various lubricating points in the engine by the oil pump 24 provided on the power output shaft 16 through an oil cooler 22 and an oil filter 23, then through an oil passage 14b formed through the oil pan 14 and an oil passage 8a formed through the bearing case, and further through oil passages 7a and 11a formed through the cylinder block 7 and the cylinder head 11, respectively.

This circulation of oil is shown by arrow marks in Fig. 6.

The oil tank 15 is provided, at its top, with an oil refill mouth 15a closed by a refill cap 27, and is further provided with a breather portion 15b by forming a labyrinth with partitions (not shown) within its top portion.

As shown in Figs. 7 and 8, the crankshaft 6 has a gear 28 formed around one of its crankarms, and this gear 28 is in engagement with the gear 29 mounted on the power takout shaft 16.

Power transmission from the crankshaft 6 to the power takeout shaft 16 is not limited to through gears 28 and 29 as described above, but may be through a chain, and the gears or the chain may be arbitrarily positioned at one end of the crankshaft or midway of it.

The countershaft 31 is journalled on the cylinder head 11 on one side of the cylinder block 7, and the gear 30 provided on the power takeout shaft 16 is connected to the gear 32 on the countershaft 31 through a first chain 33, with a reduction ratio of, e.g., 0.8. Further, the gear 34 mounted on this countershaft 31 is connected to the gears 38 on the camshafts 37 for the valve operating mechanism 36 through a second chain 35 with a reduction ratio of, e.g., 0.6, so that the camshafts 37 may be rotated by the rotation of the crankshaft 6. The cams 39 formed integrally with the camshafts 37 are rotated together with the camshafts 37 and operate the intake and exhaust valves (not shown) to open/close the intake and exhaust passages 11c and 11d formed through the cylinder head 11 with predetermined timings. The camshafts 37 are rotatably journalled on the cylinder head 11 through a cam cap 102. Each intake passage 11c is provided with a fuel injector (not shown) to supply fuel with predetermined timings.

The countershaft 31 is jounalled on the cylinder head 11 above the power takeout shaft 16 and under the intake passage 11c and an intake pipe 41 leading from this intake passage 11c. The first chain 33 is extended along the cylinder axes, and further, as shown in Figs. 8 through 10, is positioned between the cylinders X1 and X2 on one side of the cylinder X1. The second chain 35 is positioned on the other side of the cylinder X1 on

one side of the engine.

The cylinder head 11 supporting the countershaft 31 has accommodation openings 112 and 113 formed for accommodating gears 32 and 34 both mounted on the countershaft 31, and covered by a cap 114 and a cover 116, respectively. The accommodation opening 112 on the side on which is connected the first chain 33 is opened slantly upward.

A drive shaft 121 for driving the water pump 120, positioned on the front side of the engine proper E, is journalled on the front side of the cylinder block 7 in parallel to the crankshaft 6 and the power output shaft 16, and the gear 122 provided on this drive shaft 121 is in engagement with the first chain 33 so that the drive shaft 122 may be rotated by and in connection with the crankshaft 6. Since the drive shaft 121 is on the same side of the cylinder axis plane L1 with respect to the power takeout shaft 16 which is an indispensable component for taking out the output power of the crankshaft 6, the engine width laterally of the crankshaft will not be particularly increased by providing this drive shaft 121.

As shown in Figs. 8 and 11, the water pump 120 is positioned within the width of the engine proper E in the crankshaft direction. On the suction side of this water pump 121 is provided a water inlet fitting 123, which is connected to the outlet of the radiator 5 through a piping 124. As shown in Figs. 6 and 15, the water inlet fitting 123 is incorporated with a regulating valve 125 provided with a thermostat 126 for allowing the coolant water to flow into the water pump 120 when the temperature of the coolant water within the engine is over a predetermined limit.

The delivery port 129 on the delivery side of the water pump 120 is connected to the coolant water inlet 130 provided on the front (with respect to the vehicle) side of the cylinder block 7, and the coolant water is supplied to the coolant water passage 132 formed within the cylinder head 11 from this coolant water inlet 130 through a coolant water passage 131 formed within the cylinder block 7 around the drive shaft 121. This coolant water inlet 131 is required only to be positioned on the side faces forwardly of the vehicle, and it may be directed either laterally of the vehicle as in this embodiment or forwardly of the vehicle.

Since the water pump 120 is mounted on the cylinder block 7 in such a manner that the coolant water inlet 130 of the cylinder block 7 is covered by the delivery port 129 of the water pump 120, no piping is required to connect the coolant water inlet 130 to the delivery port 129. Further, since the coolant water passage 131 and the coolant water inlet 130 formed through the cylinder block 7 are formed through one side face of the bearing portion 133 swelling forwardly of the cylinder block 7, they require no particular swelling to be formed on the cylinder block 7, which will prevent the engine proper E from becoming bulky.

As shown in Figs. 9 and 11, the coolant water passage 131 formed through the cylinder block 7 is opened on the top end face of the cylinder block 7, and the coolant water passage 132 of the cylinder head 11 is opened on the bottom face of the cylinder head 11. The opening 131a of the coolant water passage 131 on the cylinder block side is opened opposite to the opening 132a of the coolant water passage 132 on the cylinder head side. Therefore, the coolant water passages 131 and 132 can be communicated with each other only by mounting the cylinder head 11 on the cylinder block 7.

The coolant water passage 131 does not join the water jacket 134 for the cylinder block 7 but is communicated with the coolant water passage 132 formed within the cylinder head 11, and through this coolant water passage 132 is led the coolant water to the water jacket 135 formed within the cylinder head 11. This flow of the coolant water is shown by arrow marks in Fig. 15.

Since the coolant water inlet 132a of the head water jacket 135 for the cylinder head 11 is opened at a height lower than the intake passage 11c and the intake pipe 41, and further since the coolant water passage 132 is formed integrally with the cylinder head 11, the coolant water passage 132 will not interfere with the intake passage 11c and the intake pipe 41, which facilitates arrangement of the coolant water passage.

Thus, since the water pump 120 is mounted on the cylinder block 7 and the coolant water is supplied to the head water jacket 135 for the calinder head 11 through coolant water passages 131 and 132 provided independently of the block water jacket 134 as described above, although the cylinder head 11 is cooled prior to the cylinder block 7, the water pump 120 can be disposed without interfering with the intake pipe 41, exhaust pipe 40, etc., which makes it possible to obtain a compact engine unit.

Further, since the water pump 120 and the coolant water inlet 132a of the head water jacket 135 are positioned on the side faces, on the same side parallel to the crankshaft 6, of the cylinder block 7 and the cylinder head 11 respectively, the water pump 120 and the coolant water passage 131 will not overlap with each other longitudinally of the crankshaft 6, which makes it possible to shorten the engine unit longitudinally of the crankshaft 6.

The mounting seats 120a for the water pump 120, the coolant water inlet 132a of the head water jacket 135 and the coolant water inlet 130a of the

coolant water passage 131 are required only to be positioned on the side faces, parallel to the crankshaft 6, of the cylinder head 11 or the cylinder block 7, and they are not necessarily to be opened perpendicularly to the crankshaft 6. In this embodiment, they are opened longitudinally of the crankshaft 6 or of the cylinder axis.

The coolant water passage 131 may be formed with a hose or the like separate from the cylinder block 7. Further, the water pump 120 and the coolant water passage 131 may be provided on the exhaust side.

As shown in Figs. 12 and 13, the cylinder head 11 is fastened on the cylinder block 7 through bolts 137 inserted through boss portion 136 between cylinders, is provided with intake passages 11c and exhaust passages 11d formed on one and the other side of and above each combustion chamber, and is further provided with an ignition plug 13 fastened at the center of each combustion chamber.

The water jacket 135 for the cylinder head 11 is formed around the boss portions 136, intake passages 11c and exhaust passages 11d. Between these cylinders are provided flow regulating portions 138 in which are formed guide portions 138a to guide the coolant water so that the coolant water may flow with a prescribed speed to cool the cylinder head 11. these flow regulating portions 138 are positioned on the exhaust side effectively to cool the exhaust side whose temperature is apt to be higher than the intake side. Further, the guide portion 138a of the flow regulating portion 138 is positioned in such a manner that their tips are offset by a distance Z from ignition plugs 13 to the exhaust side to elevate the cooling effect by leading the coolant water toward the exhaust side of the ignition plugs 13. This flow of the coolant water within the cylinder head 11 is shown by arrow marks in Figs. 12 and 13.

Further, as shown in Fig. 6, the coolant water in the head water jacket 135 for the cylinder head 11 is supplied from the communicating passages 139 through the lower portion of the cylinder head 11 to the block water jacket 134 through communicating passages 139 formed through the cylinder block 7 to cool the cylinder block 7. Accordingly, the coolant water is first led to the cylinder head 11 to cool it whose temperature is apt to become higher due to engine operation, and then cools the cylinder block 7, so that the engine can be cooled effectively.

The coolant water outlet 14C communicated with the water jacket 134 formed within the cylinder block 7 is formed on the front side of the cylinder block 7 in the vicinity of the water pump 120. On this coolant water outlet 140 is fastened a water outlet fitting 127 which is communicated with the inlet side of the radiator 5 through a piping 141. The radiator 5 is provided with a fan switch 142. The inlet and the outlet of the radiator 5 are positioned symmetrically to each other to make the coolant flow across the radiator 5.

Accordingly, the coolant water flows as shown by arrow marks in Fig. 13. That is, while the engine is running and the coolant water temperature has reached a prescribed limit, the thermostat 126 in the regulating valve 125 works to intercept the bypass passage 128 while communicating the water inlet fitting 123 with the water pump 120 to send the coolant water from the radiator 5 to the cylinder head 11 and the cylinder block 7 by the water pump 120 through the water inlet fitting 123 to cool them. The coolant water after cooling the cylinder block 7 is returned to the radiator 5 through the water outlet fitting 127.

As shown in Fig. 15, this water outlet fitting 127 is provided with a water temperature sender 143 and a water temperature sensor 144. This water outlet fitting 127 provided on the water outlet 140 is communicated with the water inlet fitting 123 through a bypass passage 128 on the front side of the cylinder block 7, and, by mounting this water outlet fitting 127, water inlet fitting 123 and water pump 120 in parallel and close to one another, the bypass passage 128 and water pump 120 in parallel and close to one another, the bypass passage 128 can be shortened and piping can be facilitated while heat loss can be reduced.

Hereupon, the water outlet fitting 127 and the water pump 120 may be mounted on the contrary positions so that the coolant water may be supplied to the cylinder block prior to the cylinder head.

As shown in Fig. 15, two coolant water pipings 145 and 146 are connected to the upper portion of the cylinder head 11, the formeer 145 being connected to the water pump 120 through a heater 147 and the latter 146 being joined to the piping 145 through an oil cooler 148 to be connected to the water pump 120.

The oil cooler 148 is cooled by this coolant water while engine operation, and the heater 147 supplies warm air into the passenger compartment when necessary while engine operation. Since the coolant water temperature is low just after engine start, the regulating valve 125 in the water inlet fitting 123 intercepts the cooling water supply from the radiator 5 making the bypass passage 128 communicative through the action of the thermostat 126, and the coolant water from the cylinder head 11 is circulated by the water pump 120 from the water outlet fitting 127 and the bypass passage 128 through the water pump 120 to the cylinder head 811 and the cylinder block 7.

After the engine is started and the coolant water temperature has reached a prescribed limit, the thermostat 126 of the regulating valve 125

works to communicate the water inlet fitting 123 with the water pump while intercepting the bypass passage 128, and the coolant water is sent to the radiator 5 through the water outlet fitting 127 to be cooled through heat-exchange there, then cools the cylinder head 11 and the cylinder block 7 through circulation by the water pump 120.

Since the coolant water is continually circulated from the coolant water piping 146 connected to the cylinder head 11 through the oil cooler 148 while the engine is running, air is prevented from being collected within the water jacket 135 for the cylinder head 11 even when the coolant water is circulated for cooling from the cylinder head 11 to the cylinder block 7.

The position of the coolant water piping 146 is not limited to one shown in Fig. 5, but may be on th end face of the cylinder head 11 opposite to that on which the second chain 35 is provided as shown in Fig. 14. In this case shown in Fig. 14, since the coolant water piping 146 is connected to the highest position of the water jacket 135, the water jacket 135 can be securely bleeded of air.

The cylinder head 11 has exhaust pipes 40 and intake pipes 41 connected to each cylinder. Each intake pipe 41 is connected to a surge tank 42 which is extended laterally of the vehicle and supported on the cylinder block 7 through stays 43. This surge tank 42 is provided with a throttle valve 44 at its air inlet end.

As shown in Fig. 1, on one end of the power takeout shaft 16 is provided a flywheel 45 and a clutch mechanism (not shown), so that the power may be transmitted to the front wheel shafts 2 for front wheels 3 through a transmission 47. The primary side of the transmission 47 is disposed on the power takeout shaft 16, and the secondary side is disposed on a countershaft 48 to rotate the front wheel shaft 2 through a gear 49 provided on the wheel shaft 2.

On the other end of the power takeout shaft 16 is provided an auxiliary drive pulley 50 with its periphery accommodated within a concave 51 provided at an end of the cylinder block 7 laterally opposite to a bearing 60 for the crankshaft 6 as shown in Fig. 7, and a belt 55 is wrapped around this auxiliary drive pulley 50 and the auxiliary pulleys for auxiliaries such as alternator 52, power steering pump 53, air compressor 54, etc., so that these auxiliaries are simultaneously driven by the power takeout shaft 16. The tension of this belt 55 can be adjusted through an idler pulley 92.

Although a drive shaft 121, which is rotated through the first chain 33 originally for transmitting the rotation of the powere takeout shaft 16 to the countershaft 31, is employed in this embodiment as the drive shaft to which is to be transmitted the rotation of the crankshaft 6, the water pump 120 may be provided instead on the power takeout shaft 16 or on the countershaft 31.

Claims

1. An automotive internal combustion engine comprising a cylinder block water jacket for circulating a flow of coolant water formed therein and a cylinder head mounted on said cylinder block provided with a cylinder head water jacket for circulating coolant water therethrough, formed therein, wherein the flow of coolant water is circulated through a water pump supported through said cylinder block, **charcterized in that,** a coolant water passage (131) for connecting a delivery port (129) of the water pump (120) to an inlet (132a) of said cylinder head water jacket (135) is disposed independently of said cylinder block water jacket (134) and the cylinder head (11) is cooled by coolant water prior to circulating the coolant water through the cylinder block water jacket (134) of the cylinder block (7).

2. An automotive internal combustion engine as claimed in Claim 1, **characterized in that,** the water pump (120) for supplying coolant water from the radiator (5) to the cylinder head water jacket (135) and the cylinder block water jacket (134) is disposed on the forwardly facing front side of the cylinder block (7) which extends in parallel to the crankshaft (6).

3. An automotive internal combustion engine as claimed in claims 1 or 2 **characterized in that,** the coolant water inlet (132a) of the cylinder head water jacket (135) is disposed at the same front side of the engine at which the water pump (120) is installed at the cylinder block (7).

4. An automotive internal combustion engine as claimed in at least one of the preceding Claims 1 to 3 **characterized in that,** the coolant water inlet (132a) of the water jacket (135) of the cylinder head (11) opens at a height lower than an intake passage (11c) and an air intake pipe (41) of the internal combustion engine.

5. An automotive internal combustion engine as claimed in at least one of the preceding Claims 1 to 4 **characterized in that,** a coolant water passage (132) of the cylinder head (11) communicating with the cylinder head water jacket (135) is formed integrally with the cylinder head (11) and/or the coolant water passage (131) of the cylinder block (7) is formed integrally with said cylinder block (7).

6. An automotive internal combustion engine as claimed in at least one of the preceding Clams 1 to 5 **characterized in that,** the coolant water passage (132) formed within the cylinder head (11) is connected to the coolant water inlet (130) of the cylinder block (7) through a coolant water passage (131) formed within the cylinder block (7) around a water pump drive shaft (121).

7. An automotive internal combustion engine as claimed in Claim 6, **characterized in that,** the coolant water passage (131) formed through the cylinder block (7) terminates at the top end face of the cylinder block (7) whereas the coolant water passage (132) of the cylinder head (11) terminates at a bottom face of the cylinder head (11) in a manner that an opening (131a) of the coolant water passage (131) of the cylinder block is disposed opposite to an opening (132a) of the coolant water passage (132) of the cylinder head to communicate to each other after the assembly of the cylinder head (11) on the cylinder block (7).

8. An automotive internal combustion engine as claimed in any of the preceding Claims 1 to 7 **characterized in that,** both the cylinder head (11) and the cylinder block (7) obtain communicating passages (139) which are aligned to each other in a manner to supply the coolant water from the cylinder head water jacket (135) through said co-operating communicating passages (139) formed through the lower portion of the cylinder head (11) and the upper portion of the cylinder block (7) to the cylinder block water jacket (134) to cool said cylinder block (7).

9. An automotive internal combustion engine as claimed in any of the preceding Claims 1 to 8 **characterized in that,** a coolant water outlet (140) communicated with the cylinder block water jacket (134) is disposed on the forwardly facing front side of the cylinder block (7) in the vicinity of the water pump (120), moreover, a bypass passage (128) is provided in between the water pump (120) and a water outlet fitting (127) of the cylinder block coolant water outlet (140) bypassing said cylinder block (140).

10. An automative internal combustion engine as claimed in claim 8, **characterised in that**, the coolant water outlet (140) of the cylinder block (7) is disposed side by side to the water pump (120), both facing to the radiator (5).

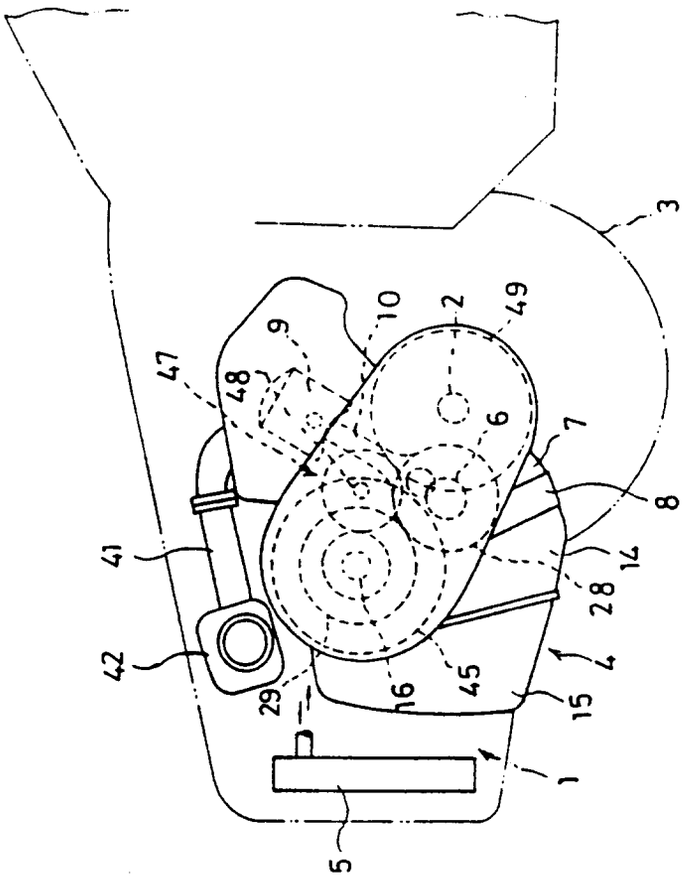

FIG. 1

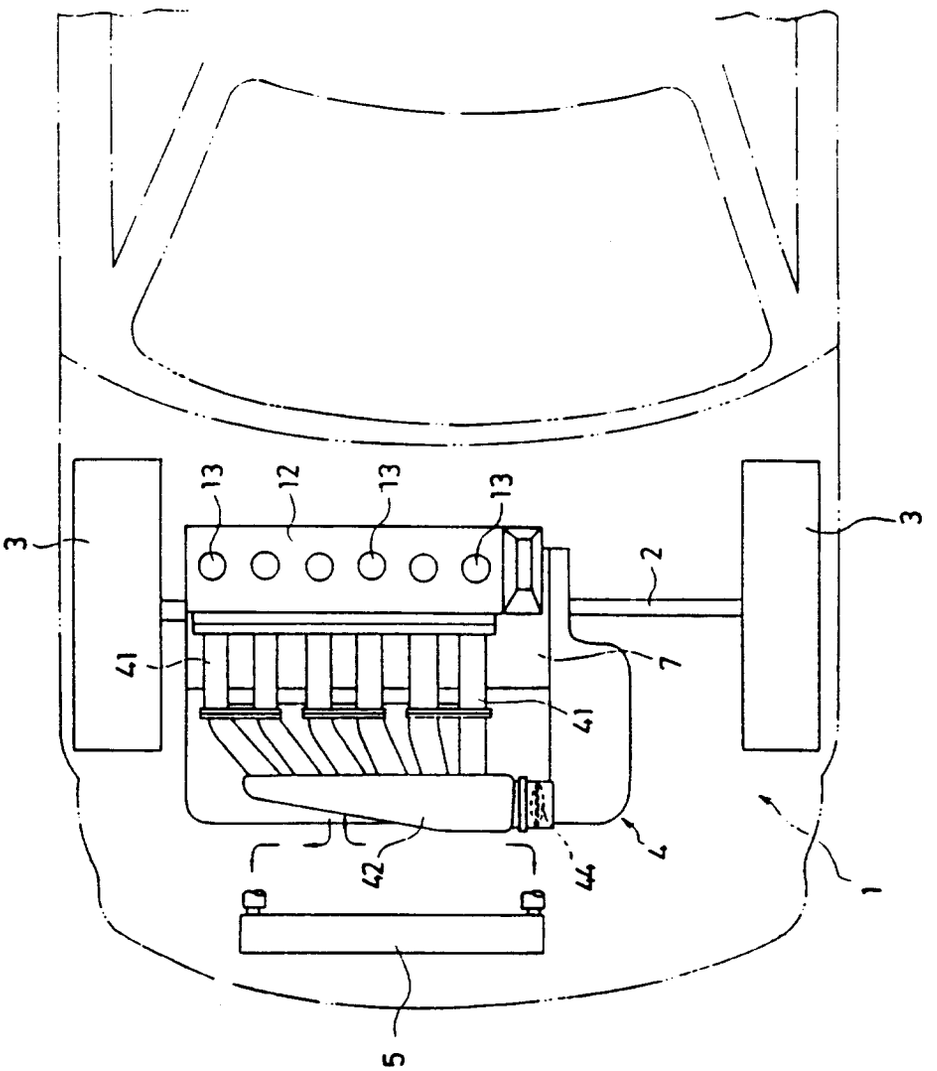

FIG. 2

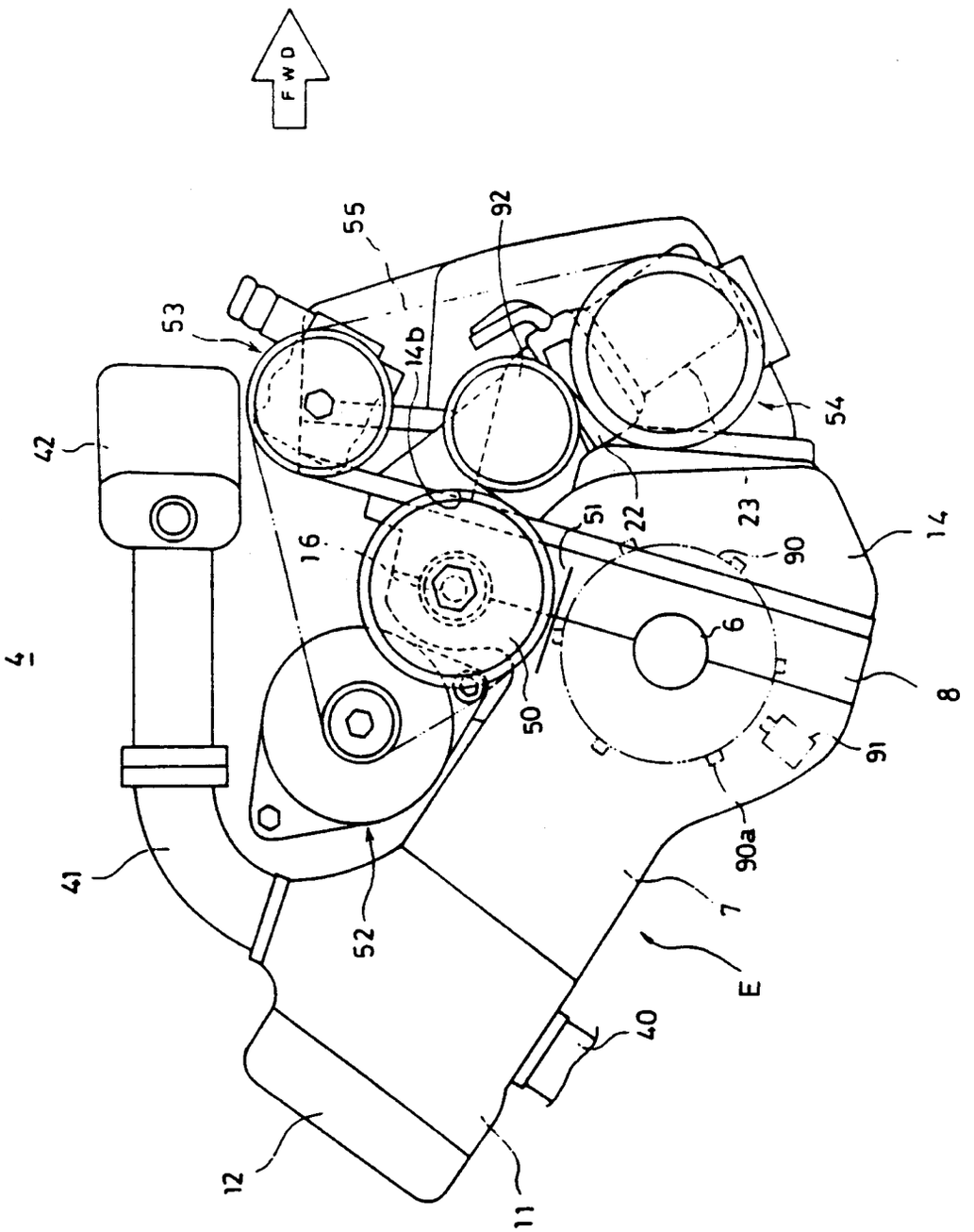
FWD
4
41
42
53
55
92
14b
54
22
23
51
16
90
14
6
8
50
91
90a
7
52
E
40
12
11

FIG. 3

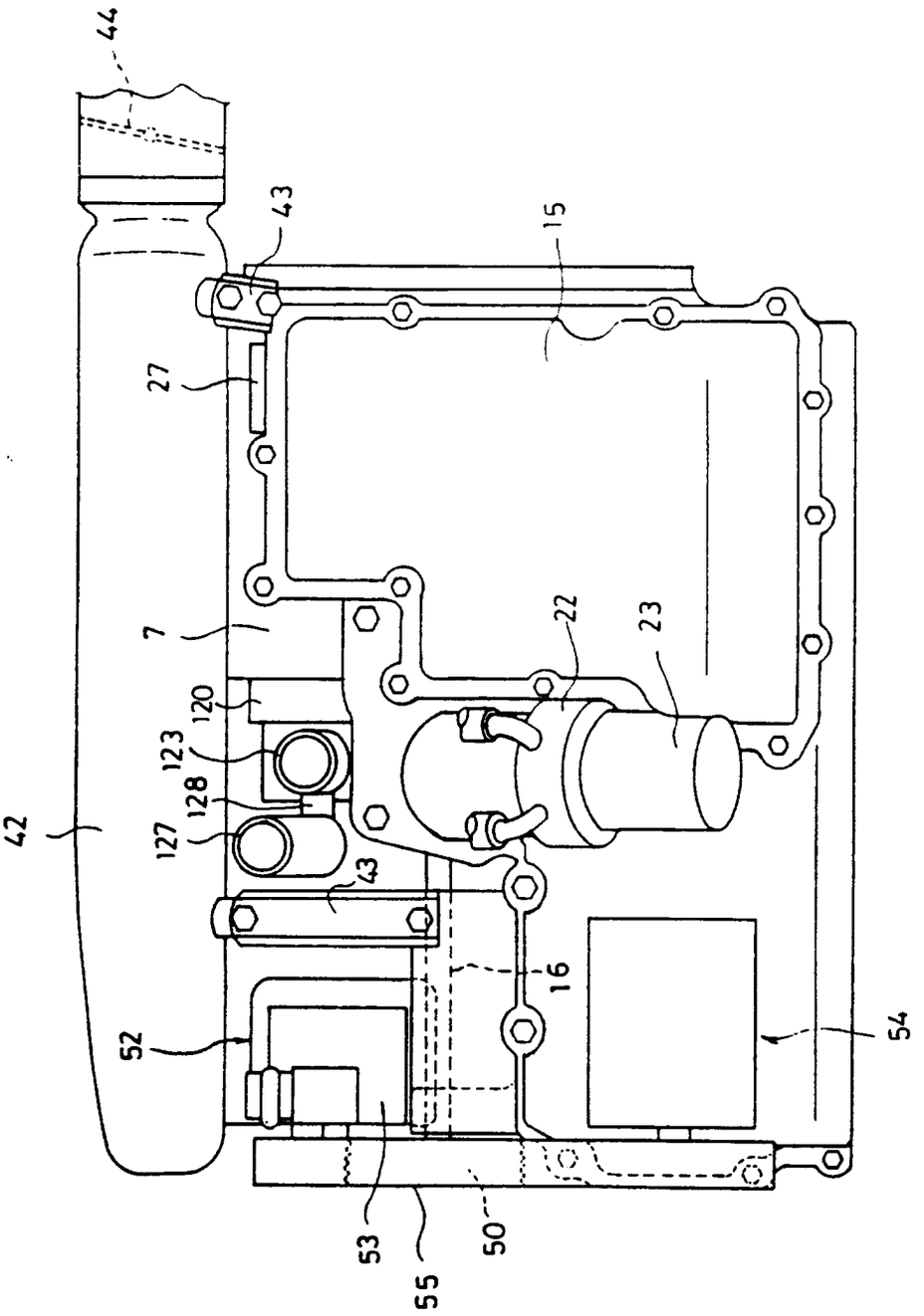

FIG. 4

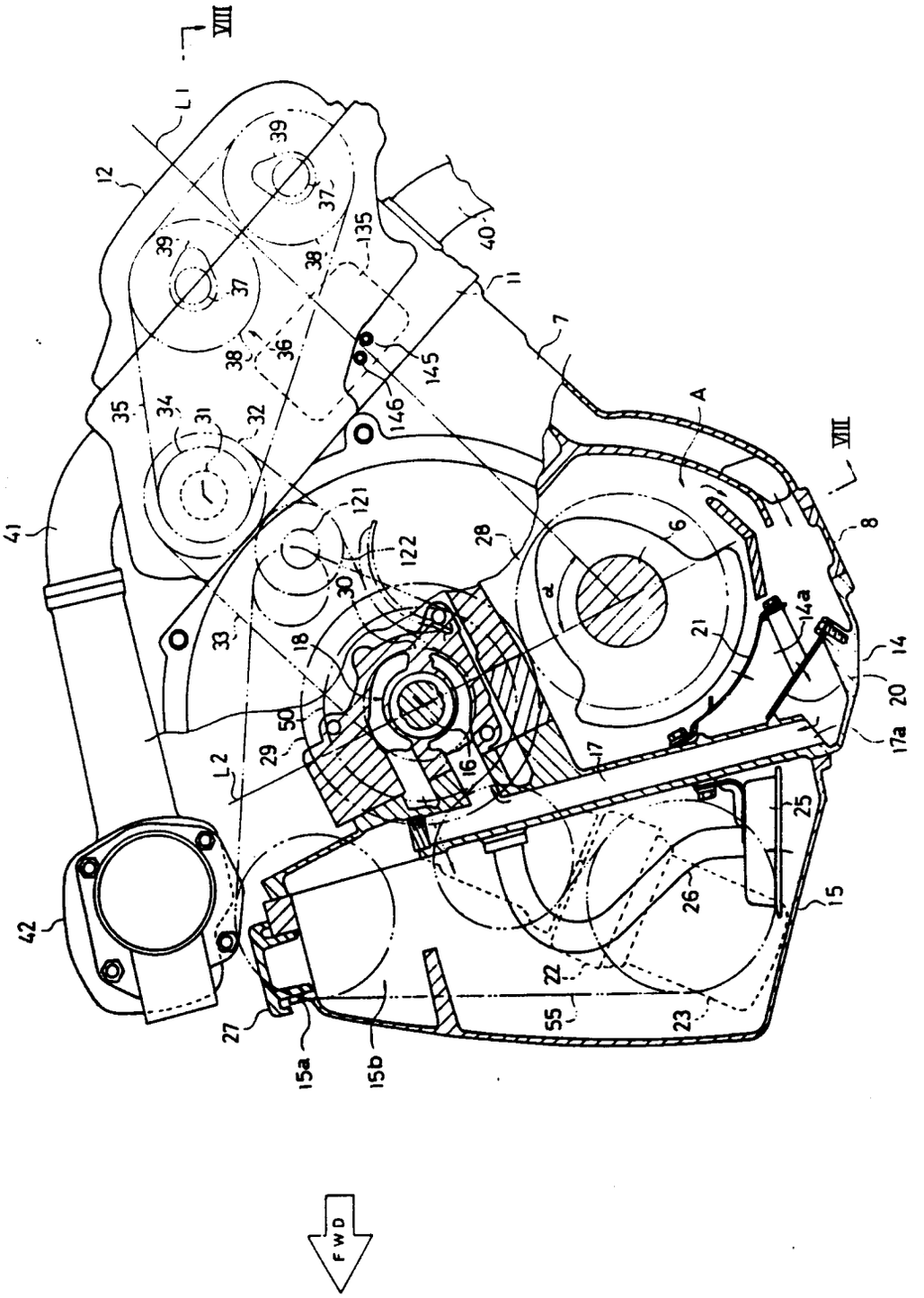
4
VIII
L1
12
39
37
135
40
11
7
38
36
145
146
35
34
31
32
A
41
121
122
28
6
8
33
18
30
d
21
14a
14
20
50
29
L2
16
17
17a
25
42
26
15
22
55
23
27
15a
15b
FWD

FIG. 5

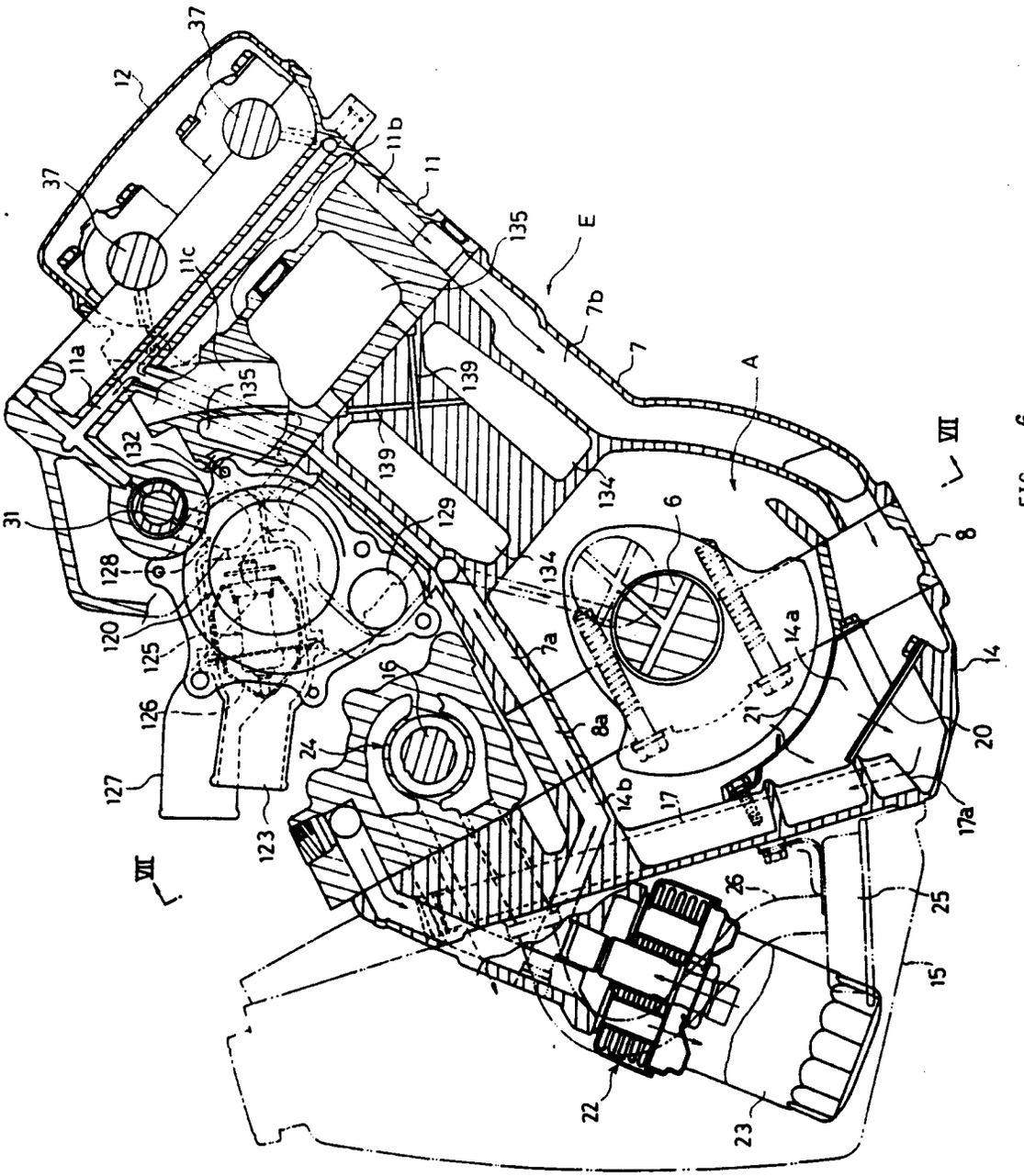
37
12
11b
11
37
11c
135
E
7b
7
11a
135
A
139
139
132
VIII
31
129
134
6
8
128
134
120
7a
14a
14
125
16
21
126
8a
20
24
14b
17
17a
127
123
VII
26
25
15
22
23

FIG. 6

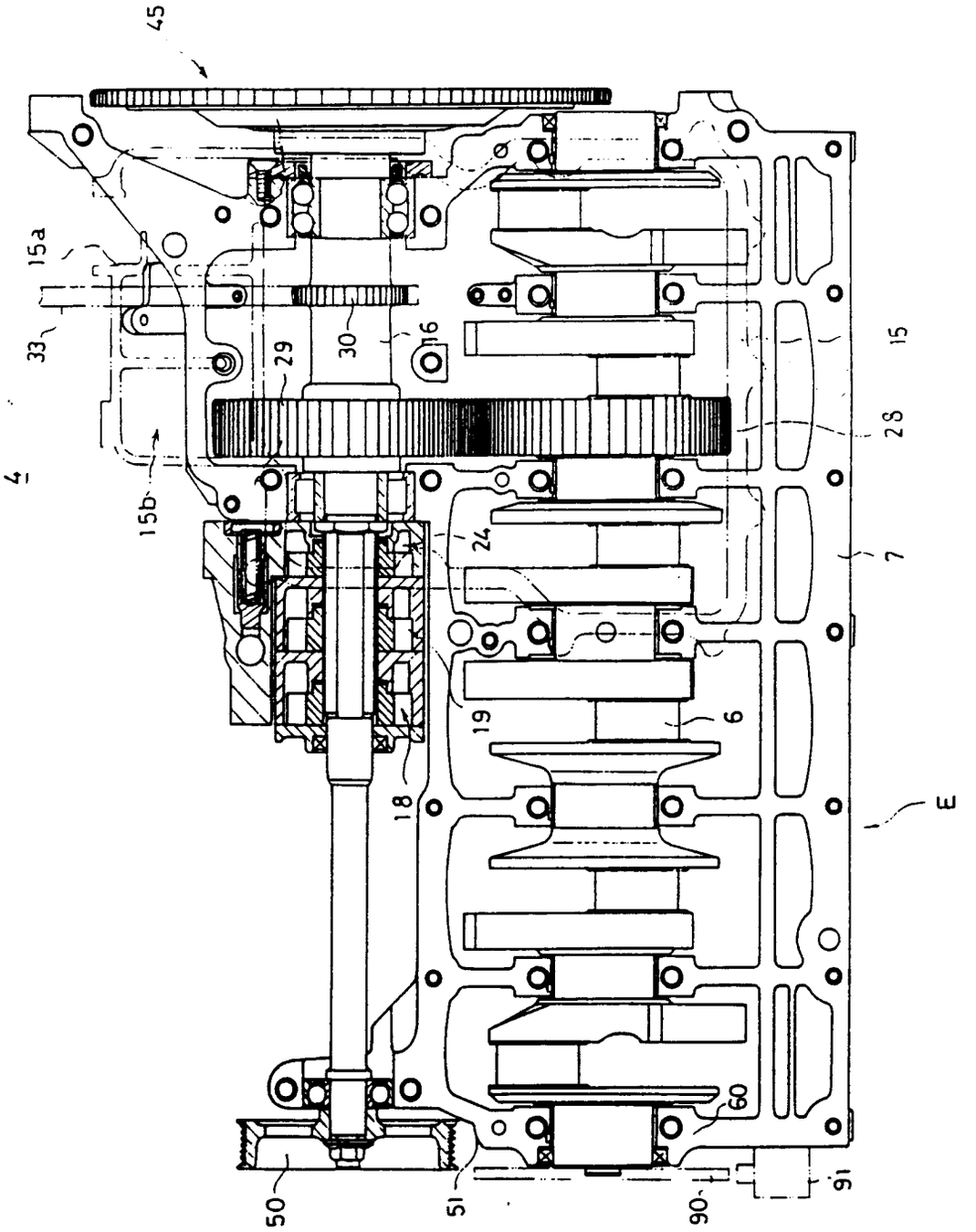

FIG. 7

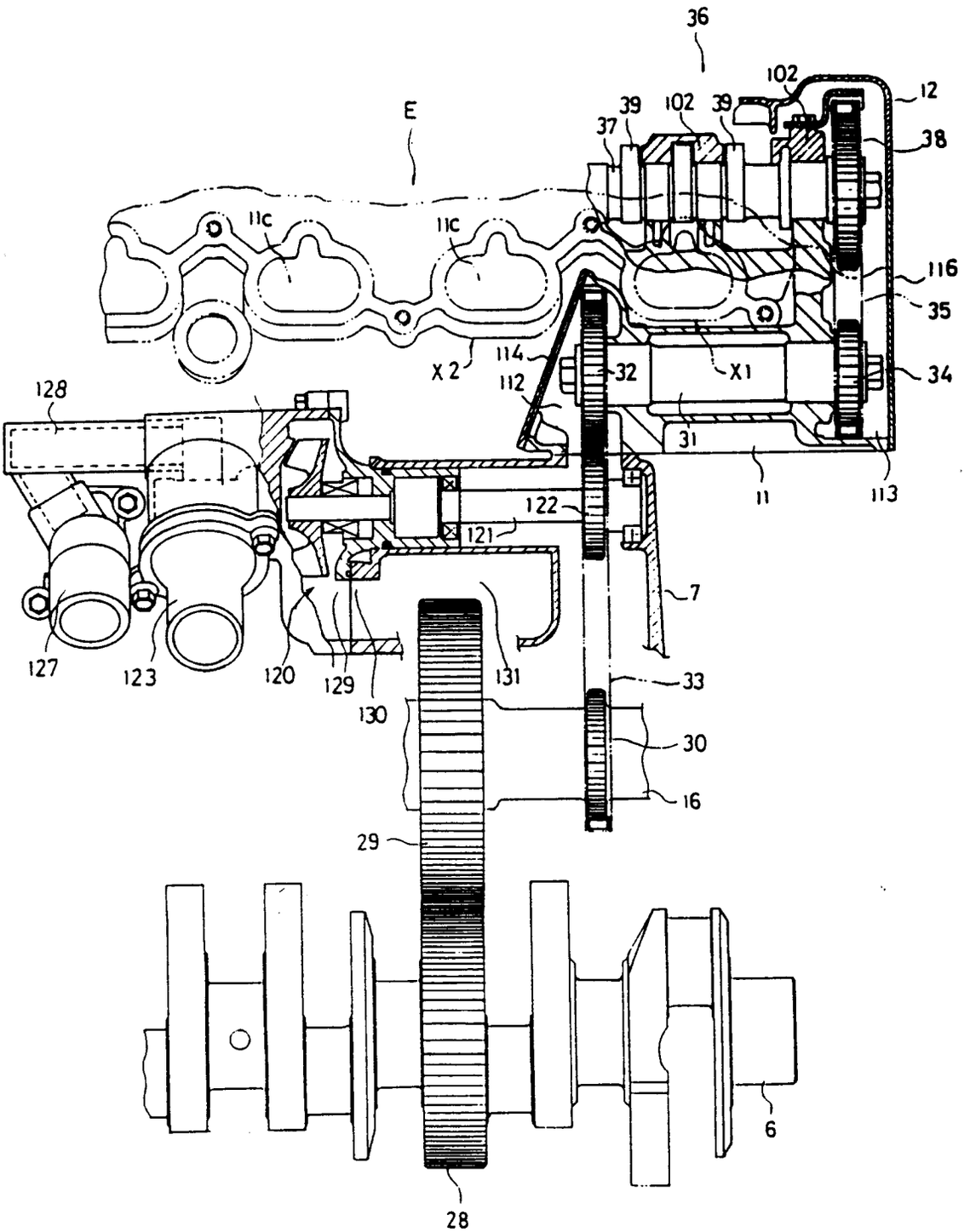
36
102
12
E
39
102
39
37
38
11c
11c
116
35
X2
114
32
X1
34
128
112
31
11
113
122
121
7
127
123
120
129
130
131
33
30
16
29
6
28

FIG. 8

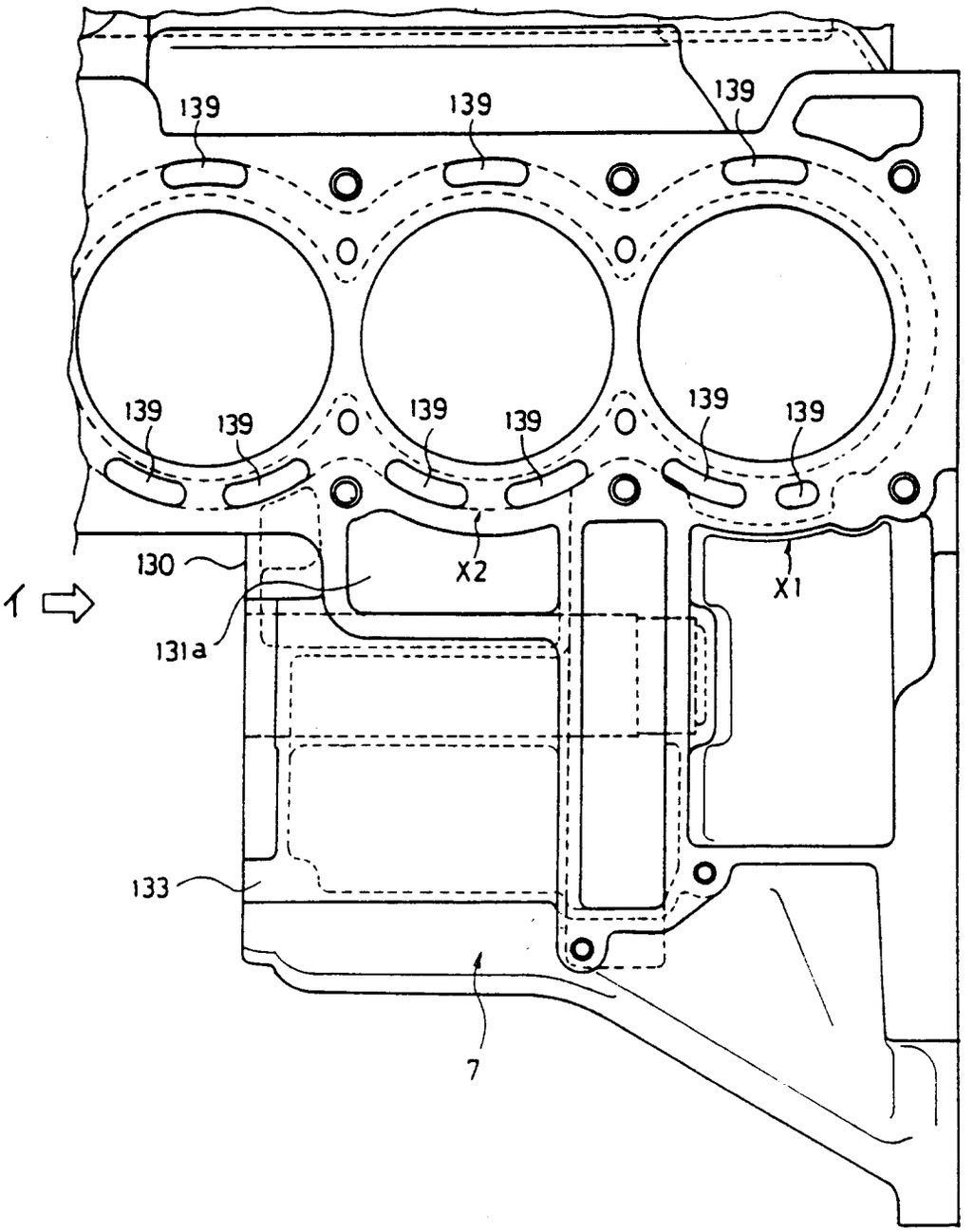

FIG. 9

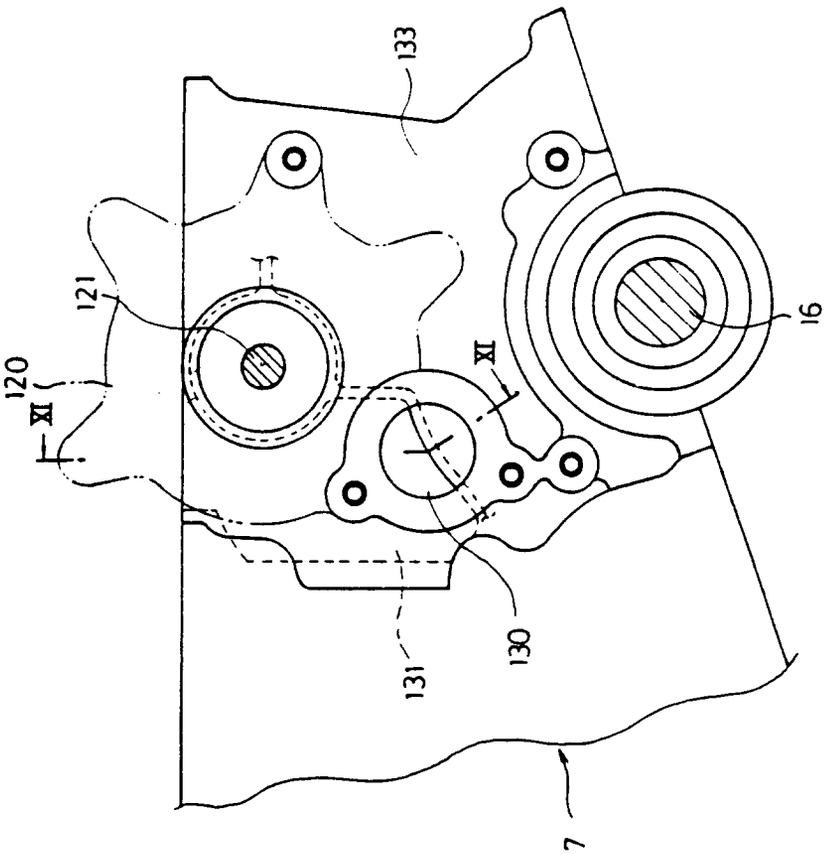

FIG. 10

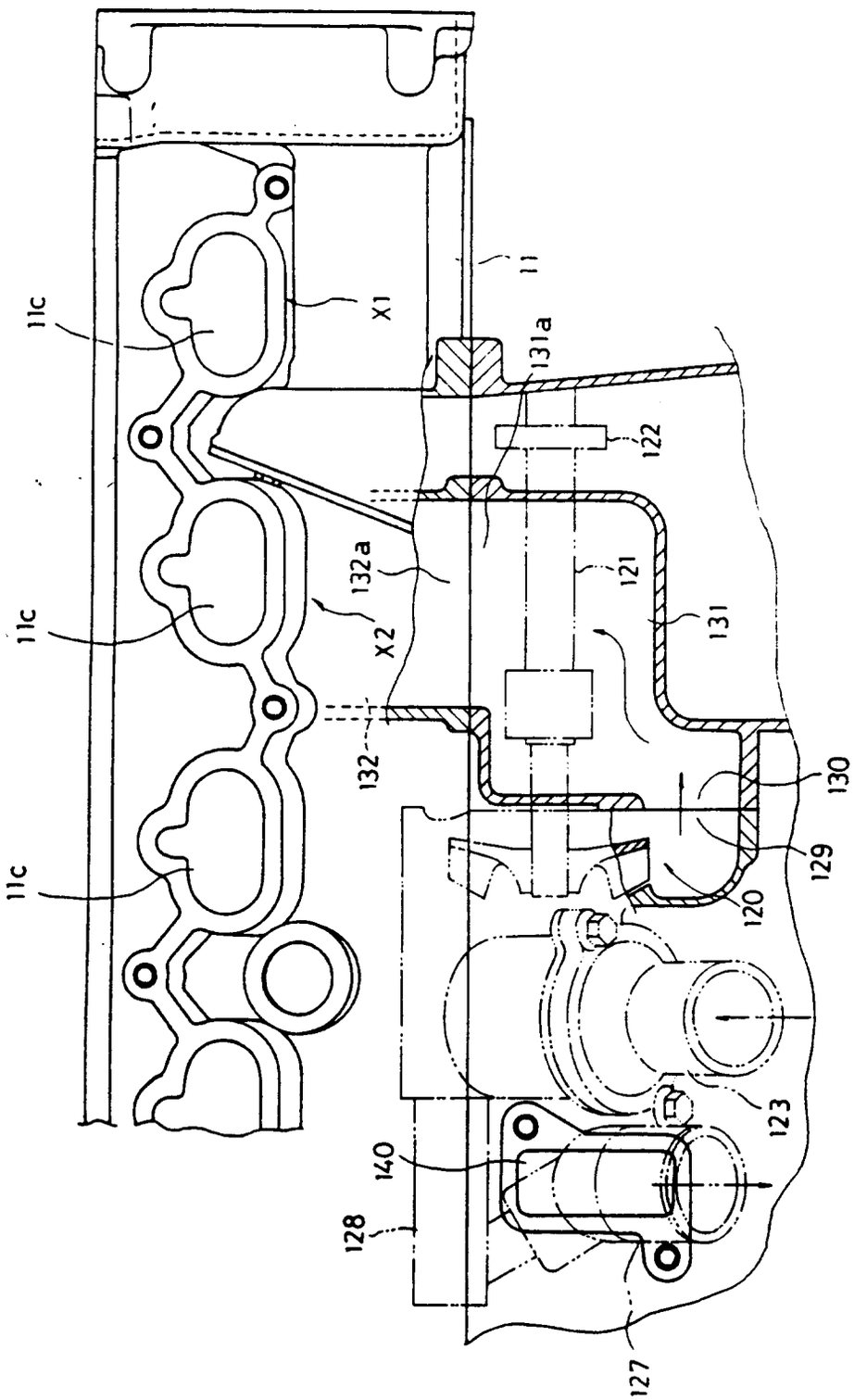
11c
11c
11c
X1
11
131a
122
132a
X2
121
131
132
130
129
120
123
140
128
127

FIG. 11

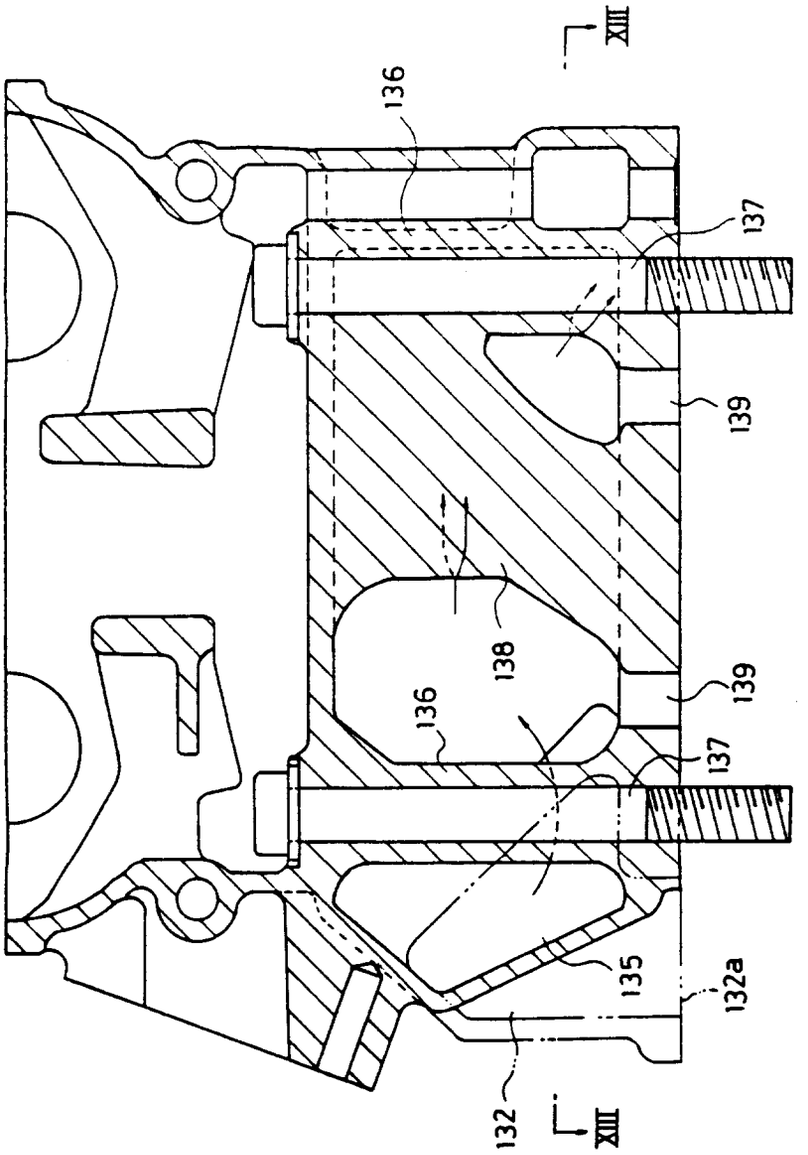

FIG. 12

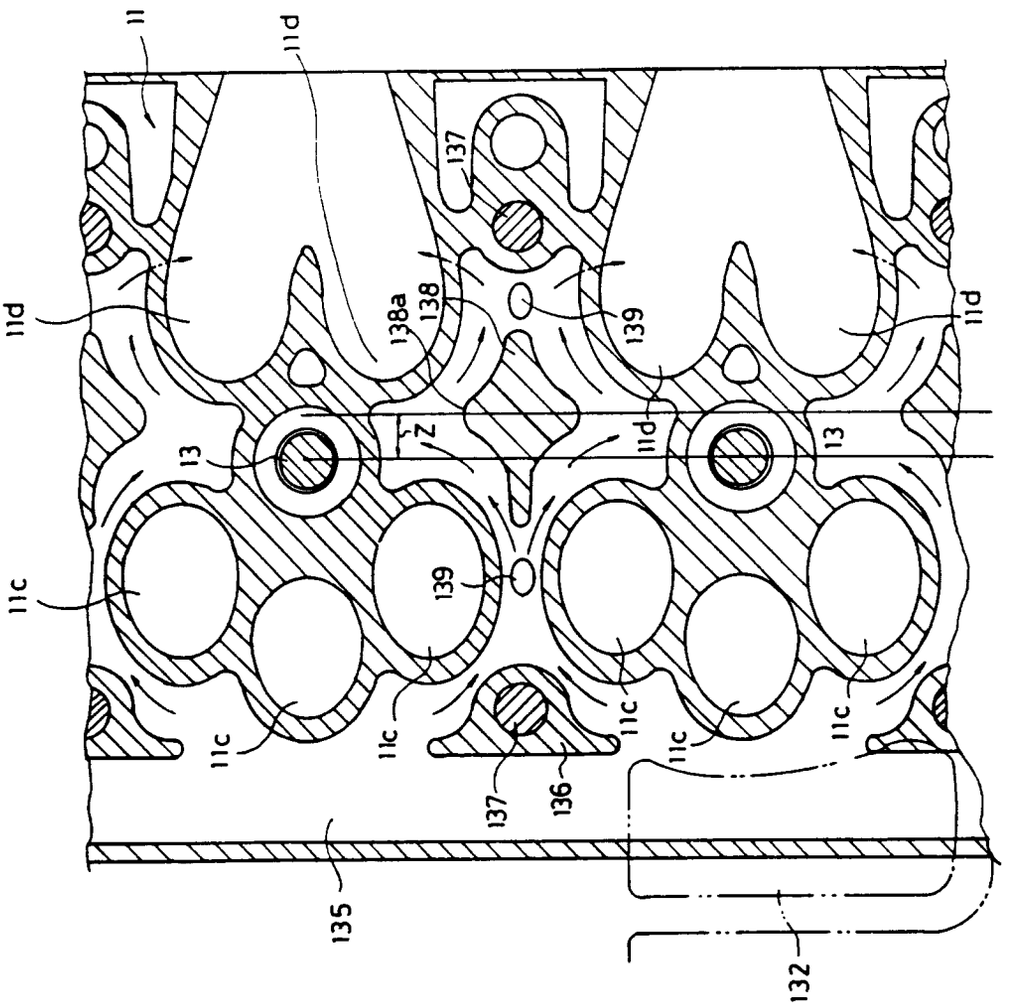
11
11d
137
138a
138
139
11d
11d
13
Z
11d
13
11c
139
11c
11c
11c
11c
11c
137
136
135
132

FIG. 13

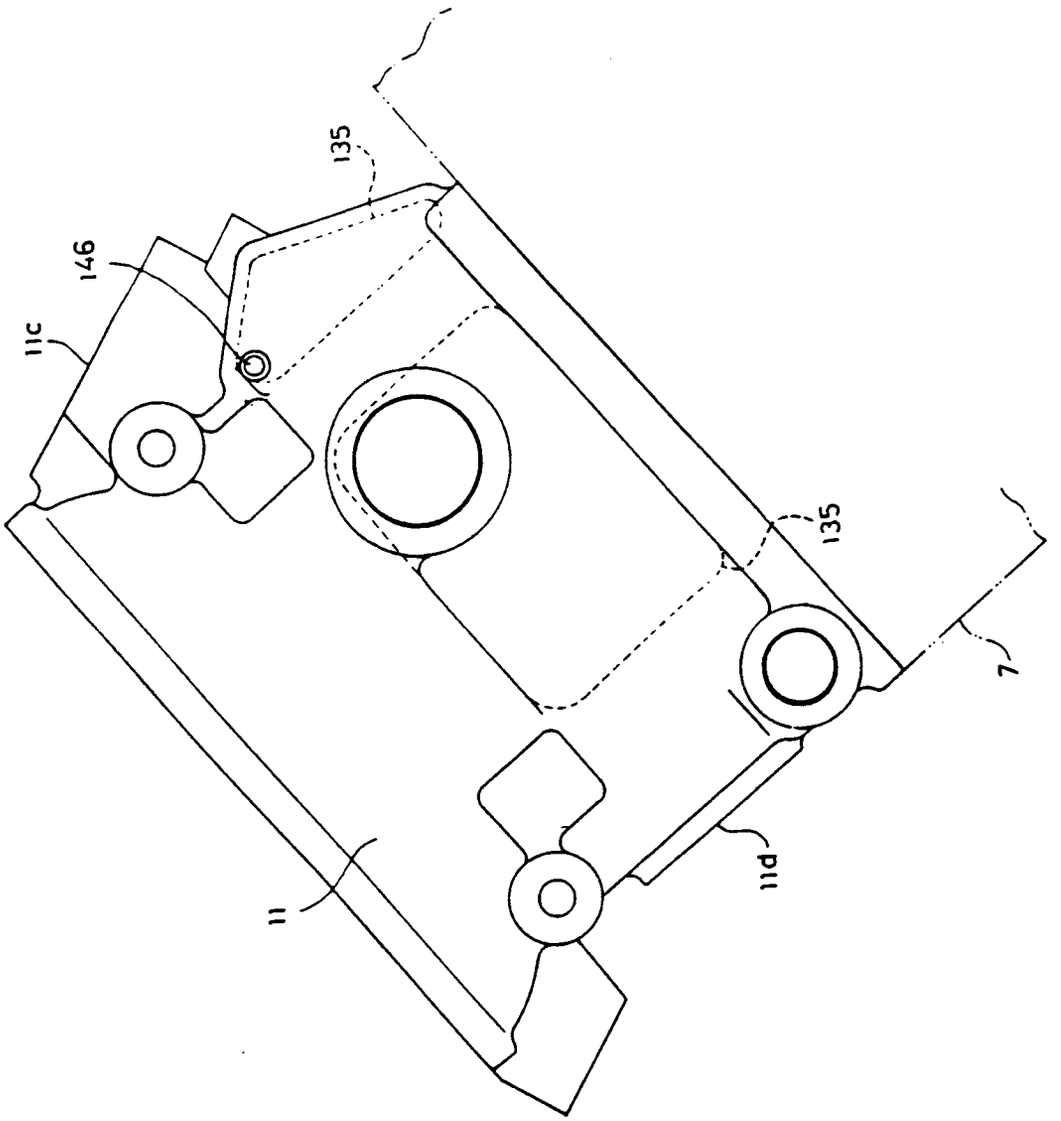

FIG. 14

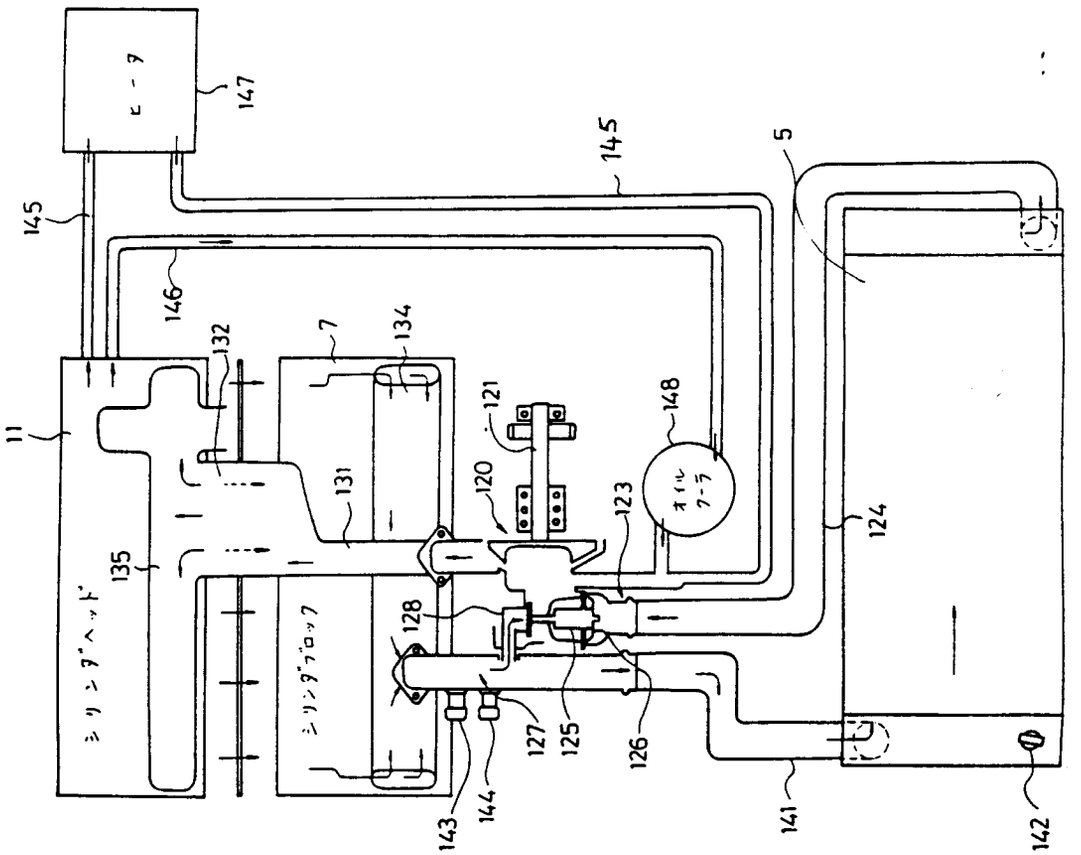
ヒータ
147
145
146
145
5
11
132
7
134
121
148
131
120
123
124
135
128
127
125
126
143
144
141
142

FIG. 15

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 93 10 5961

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	DE-C-803 449 (BÜSSING-NUTZKRAFTWAGEN GMBH) * the whole document * ---	1,5,7,8	F01P5/10 F01P3/02
Y	GB-A-2 060 772 (BMW) * the whole document * ---	1,5,7,8	
A	GB-A-2 134 594 (AUSTIN ROWER GROUP) * the whole document * -----	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)
F01P

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	08 JUNE 1993	MOUTON J.M.M.P.

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