

Description

[0001] The present invention relates to a cylinder head structure of a direct injection diesel engine, and a direct injection diesel engine.

[0002] Conventionally, as disclosed in EP 1 094 213 A2 for example, a cylinder head structure for a direct injection diesel engine in this kind has been proposed, which drives an intake valve and exhaust valve arranged in parallel with the cylinder axis via swing-arm type rocker arm (simply referred to as swing arm). In this structure, two camshafts of the intake one and exhaust one are held by a cam holder separately mounted on the upper surface of the cylinder head, thereby avoiding the problem of the interference between the cam holder and a head bolt.

[0003] That is, the combustion pressure in direct injection diesel engines is generally so high that extremely high load acts on the cylinder head, which requires the larger number of head bolts per cylinder or the use of thicker bolt than the diesel engines with auxiliary chamber or gasoline engines. As a result, spaces for head bolt holes and bosses therefor are necessarily enlarged, causing the difficulty in ensuring a space for integrally forming cam holders.

[0004] In a cylinder head of a direct injection diesel engine disclosed in EP 0 819 841 B1, a depression extending towards a cylinder head disposed thereunder is formed at the substantially central portion of a head cover (or valve cover) with respect to the width direction of the cover; openings are bored across its bottom portion in the thickness direction; the upper end of an injection nozzle for each cylinder is inserted in the opening; grooves running from the depression to the intake side are formed on the upper surface of the head cover; and fuel supply pipes for each cylinder are disposed in the grooves. That is, the depression in the upper surface of the head cover serves as spaces for disposing fuel supply pipes, thereby suppressing an increase in the height of the engine.

[0005] Additionally, in both the engines disclosed in both the EP patent publications, a peripheral wall is formed extending upward from the periphery of the cylinder head, and the head cover is attached on the peripheral wall. This configuration has been proposed in consideration for the fact that the great noise is likely to be emitted upward from the engine because the direct injection diesel engine inevitably emits great combustion noise and the noise is transmitted to the cylinder head via injection nozzle or the like. With the increased height of the peripheral wall of the cast-iron cylinder head with greater rigidity than the head cover, the surface area is correspondingly decreased for noise reduction.

[0006] In the structure disclosed in EP 1 094 213 A2, a hydraulically-actuated lash adjuster is provided at an end pivot of the swing arm. The adjuster is provided for the automatic adjustment of valve clearance by use of

hydraulic pressure. This advantageously requires no maintenance service, but disadvantageously increases the cost. In this regard, recently, the abrasion resistance in the sliding portions of the valve system has been increased by the weight reduction of the overall valve system of the engine, by the adoption of new materials in the lubricating portion, and by the advance of the lubrication technologies. This has extended the interval of the valve clearance adjustment, so that a mechanical type lash adjuster has been increasingly popular again.

[0007] However, the provision of the high wall at the upper periphery of the cylinder head as disclosed in the EP publications makes it difficult to adjust the mechanical type adjuster. That is, conventional direct injection diesel engines arrange intake and exhaust valves in parallel with the cylinder axis. Thus, when viewed along the back and forth direction of the engine as shown in FIG. 5 of EP 1 094 213 A2, the end pivot of the swing arm is disposed closely to the peripheral wall on both the right and left sides. In the case of disposing the mechanical type lash adjuster on the end pivot, the adjustment work of the adjuster is difficult due to the adjacent peripheral wall serving as an obstacle to the work.

[0008] In view of the above problem, an object of the present invention is to ease in the adjustment work of the valve clearance in a DOHC direct injection diesel engine equipped with a swing-arm type valve system while accommodating the demand for the downsizing of the engine, even with a mechanical type adjuster mechanism provided at an end pivot of a swing arm.

[0009] The object is solved according to the invention by the cylinder head structure of a direct injection diesel engine according to claim 1 and by the direct injection diesel engine according to claim 9. Preferred embodiments of the present invention are subject of the dependent claims.

[0010] Thus, according to the present invention, the adjustment work of the valve clearance is easily performed in a DOHC direct injection diesel engine equipped with a swing-arm type valve system while the demand for the downsizing of the engine is accommodated, even with a mechanical type adjuster mechanism provided at an end pivot of a swing arm.

[0011] In achieving the above object, according to the present invention, the position of a seal between a periphery of a cylinder head and a head cover, that is, the height of a peripheral wall of the cylinder head of a direct injection diesel engine is lower than a predetermined height, thereby easing in the adjustment work of a mechanical lash adjuster mechanism adjacently provided.

[0012] Particularly, according to the present invention, there is provided a cylinder head structure of a direct injection diesel engine. An injector preferably is substantially vertically arranged in the cylinder head corresponding in position to the center of each of cylinders. An intake valve and an exhaust valve are disposed preferably substantially in parallel with the injector. The intake valve and the exhaust valve are driven by a cam-

shaft via a swing-arm type rocker arm. Mechanical lash adjuster mechanisms are respectively provided at each of the end pivots of the rocker arms for the intake valve and the exhaust valve. Each of the end pivots are located on both the lateral or left and right sides of the cylinder head when viewed in the alignment direction of the cylinders. An intake camshaft and an exhaust camshaft are provided extending in the alignment direction of the cylinders, and rotatably supported by a cam holder mounted on the upper surface of the cylinder head. The cam holder comprises a main body elongated in the alignment direction of the cylinders, a cam journal integrally or unitarily formed with the main body and positioned, preferably branching off from the main body between the adjacent cylinders, and a cam cap attached on the top portion of the cam journal. A first seal is provided at a periphery of a head cover attached over the cylinder head and adapted to abut on a first sealing surface provided at a periphery of the cylinder head. An injector opening, through which the plurality of the injectors are inserted, is formed at a substantially central portion of the head cover so as to face the upper surface of the main body of the cam holder. A second seal is provided at a lower portion of a periphery of the injector opening and adapted to abut on a second sealing surface provided at the upper surface of the main body of the cam holder. The first sealing surface is located lower than a mating surface between a cam journal and the cam cap.

[0013] According to the above constitution, by the adoption of the mechanical lash adjuster mechanism for the adjustment of the valve clearance of the intake and exhaust valves, cost reduction is achieved in comparison with the adoption of a hydraulic type. In addition, the cam holder is structurally separated from the cylinder head, without the need for the consideration of the interference with head bolts on the cylinder head. This enhances the flexibility in layout thereof, thereby reducing the size of the engine.

[0014] Moreover, the height of the first sealing surface at the periphery of the cylinder head, that is, the height of the peripheral wall of the cylinder head is dimensioned so that the top portion of the peripheral wall is located lower than the mating surface between the cam journal and the cam cap of the cam holder. The lower-located peripheral wall allows the adjuster mechanism to be easily adjusted, in spite of the fact that the end pivot or the mechanical lash adjuster mechanism is located adjacent to the peripheral wall of the cylinder head due to perpendicular arrangement of the intake and exhaust valves unique to diesel engines.

[0015] To summarize, the present invention allows to downsize a direct injection diesel engine and to reduce the cost by the adoption of the mechanical lash adjuster mechanism, while avoiding the difficulty in the clearance adjustment of the intake and exhaust valves which would be caused by the adoption of the mechanical lash adjuster mechanism.

[0016] Preferably, the second seal of the head cover

may be provided at a lower edge of a peripheral extension extending downward from the periphery of the injector opening, a plurality of fasteners for fastening the head cover to the cylinder head may be disposed along the first seal of the head cover, and the fastening force to be applied to the fasteners may be predetermined so that oil tight is maintained between the second seal and the second sealing surface of the cam holder.

[0017] Accordingly, the peripheral extension extending downward from the periphery of the injector opening in the head cover increases the rigidity of the peripheral portion of the opening. By fastening the head cover to the cylinder head with the plurality of fasteners disposed at the periphery of the head cover so that the lower edge of the peripheral extension is tightly pressed against the upper surface of the main body of the cam holder, both the first and second seals ensure tight seal.

[0018] More preferably, the injector opening in the head cover may be elongated in the alignment direction of the cylinders, each of the injectors may be fixed to the main body of the cam holder by a bolt via clamps within the injector opening, and each of the clamps may be adapted to achieve the rotational positioning of the injector about its axis and fixation thereof.

[0019] Accordingly, the fixation of each of the injectors by use of the clamp achieves the rotational positioning of the injector about its axis, so that an injection bore is appropriately positioned with respect to a glow plug even with the use of a multi-hole type nozzle. This prevents human error in assembling work for ensuring the startability in cold state.

[0020] Further preferably, the clamp may be arranged so that its longitudinal direction is oriented substantially in the elongated direction of the injector opening. This allows the injector and clamp to be exposed to the outside of the head cover in in-line arrangement, thereby simplifying the cylinder head in structure.

[0021] Still further preferably, the head cover may be configured such that the portion on the intake side of the injector opening is situated lower than the portion on the exhaust side thereof, and individual fuel pipes for supplying fuel from a common rail to each of the plurality of injectors may be arranged above the portion on the intake side.

[0022] This suppresses the increase in the engine height due to the arrangement of the individual fuel pipe above the head cover.

[0023] Still further preferably, a fuel return pipe for returning excessive fuel to a fuel supply system may be disposed extending in the alignment direction of the cylinders along the injector opening in the head cover.

[0024] This eases in the layout of the fuel return pipe to be arranged over the injector for each cylinder.

[0025] Still further preferably, the bolt may be adapted to fix the clamp in such a way that a head of the bolt is exposed to the outside of the head cover within the injector opening, body of the bolt is preferably substantially vertically inserted in a through hole formed in the

cam holder, and a tip of the body is screwed in a bolt hole formed in the cylinder head.

[0026] Moreover, a washer preferably may be fitted onto the body of the bolt and located between the clamp and the main body of the cam holder, the washer being provided with a first seal ring which abuts on the main body of the cam holder and a second seal ring for sealing between an outer surface of the body of the bolt and an inner surface of the through hole in the cam holder.

[0027] According to this constitution, the head of the bolt used for fixing the clamp for the injector to the cam holder is exposed to the outside of the head cover, so that the bolt is easily fastened, thereby easing in the fixation operation of the injector. Herein, the reactive force produced by the injector injecting highly-pressurized fuel is so large that fastening the injector to the cam holder is insufficient for enduring the reactive force. To cope with this, the body of the bolt should penetrate the cam holder and be fastened to the cylinder head. However, this may cause the possible leak of engine oil out of the head cover along the body of the bolt.

[0028] To surely prevent the possible leak of engine oil, this configuration adopts a double seal structure, comprising a washer fitted onto the body of the bolt and located between the clamp and the main body of the cam holder, a first seal ring for sealing between the washer and the main body of the cam holder, and a second seal ring for sealing between an outer surface of the body of the bolt and an inner surface of the through hole in the cam holder.

[0029] In accordance with the present invention, there is further provided a direct injection diesel engine equipped with the cylinder head structure according to the present invention or the preferred embodiment thereof.

[0030] The cylinder head structure according to the present invention or the preferred embodiment thereof may be advantageously combined with a direct injection diesel engine comprising two intake valves and two exhaust valves for each cylinder.

[0031] Other features, aspects, and advantages of the present invention will become apparent from the following description of the invention which refer to the accompanying drawings.

FIG. 1 is a top plan view of a direct injection diesel engine in accordance with an embodiment of the present invention;

FIG. 2 is a cross sectional view showing a construction of a cylinder head, centering on an injector, when viewed from the front of the engine;

FIG. 3 is a cross sectional view showing a construction of the cylinder head, centering on a valve driving system, when viewed from the front of the engine;

FIG. 4 is a top plan view of the cylinder head, with a head cover being removed and swing arm and other components being omitted;

FIG. 5 is a top plan view of a cam holder;

FIG. 6 is a top plan view corresponding to FIG. 4 showing a construction of a middle deck of the cylinder head, with a camshaft and the cam holder being removed;

FIG. 7 is an illustration showing the assembled condition of the cylinder head and the head cover at the frontal edge of the engine;

FIG. 8 is a top plan view of the head cover;

FIG. 9 is an enlarged cross sectional view showing a supporting structure of the injector to the cylinder head;

FIG. 10 (a) is an elevational view; FIG. 10 is (b) a bottom plan view of a washer to be fitted onto a bolt; FIG. 11 is a cross sectional view of a main body of a cam holder taken along its longitudinal direction, with an injector being mounted by use of a clamp and a bolt;

FIG. 12 is a horizontal cross sectional view schematically showing the structure of a water jacket in the cylinder head; and

FIG. 13 is a vertical cross sectional view of the cylinder head showing a rib provided in the water jacket between cylinders when view from the front of the engine.

[0032] A preferred embodiment of the present invention will now be described with reference to the drawings.

[0033] FIG. 1 is a plan view of a direct injection diesel engine 1 in accordance with the embodiment of the present invention, when viewed from above. The engine 1 preferably is an in-line four-cylinder engine. Four cylinders of a first, second, third, and fourth one are arranged in series from the frontal side (left side of the drawing) to the rear side (right side of the drawing) substantially along the back and forth direction of the engine 1 or preferably the longitudinal direction of a main body of the engine 1. The engine 1 preferably is longitudinally mounted in an engine compartment not shown such that the engine 1 longitudinally extends in the back and forth direction of a vehicle. On a first (right) side (upper side of the drawing) thereof, an intake system of the engine 1 is provided. On a second (left) opposite side thereof, an exhaust system of the engine 1 is provided. In this specification, the back and forth direction of the engine 1 is simply referred to as the back and forth direction in general.

[0034] Particularly, on the intake side of the engine 1, there are disposed an intake manifold 3 and a common rail 5. The intake manifold 3 is provided for supplying intake air to a combustion chamber of each cylinder 2. The common rail 5 is provided for distributing highly-pressured fuel to injectors 4, 4, ... corresponding to each of the cylinders 2. The intake manifold 3, disposed preferably substantially extending in the back and forth direction of the engine 1, comprises a surge tank 3a and an upstream intake passage 3b. The surge tank 3a com-

municates with each of the cylinders 2 via individual intake passages not shown. The upstream intake passage 3b preferably has a substantially cylindrical shape and extends slightly diagonally and outwardly towards the front from the frontal edge of the surge tank 3b. The intake passage 3b has an intake throttle valve 6 disposed at its end. The intake throttle valve 6 is driven preferably by an electric actuator. The surge tank 3a has an exhaust gas recirculation (EGR) valve 8 disposed at its rear end. The EGR valve 8 preferably is electromagnetically driven to adjust the airflow amount of exhaust gas (EGR gas) returning through an EGR pipe 7.

[0035] The injectors 4, 4, ... preferably are electromagnetically actuated. As will be described in detail, the injectors 4 are disposed substantially along the center axis z of each of the cylinder 2 (refer to FIG. 2) and supported at an angle different from 0° or 180°, preferably substantially perpendicularly to a cylinder head 10. Its distal end is formed with an injection bore fronting into the cylinder 2. On the other hand, its proximal end, containing an electromagnetic solenoid not shown, extends upward through a common opening 12 formed at the substantially central portion of a cylinder head cover 11 with respect to the width direction of the cover 11.

[0036] The common rail 5 is disposed extending substantially in the back and forth direction of the engine 1 above the surge tank 3a of the intake manifold 3. The common rail 5 is supplied with highly-pressured fuel from a high-pressure supply pump (not shown) and feeds the fuel to the injectors 4, 4, ... via individual fuel pipes 13, 13, ... provided correspondingly to each of the cylinder 2. A fuel return pipe 14 is disposed over the respective proximal ends of the four injectors 4, 4, ... and along the opening 12 of the head cover 11 elongated in the back and forth direction of the engine 1. This fuel return pipe 14 returns excessive fuel to a fuel supply system upstream of the high-pressure supply pump.

[0037] On the exhaust side of the engine 1, there are disposed an exhaust manifold 15 and a turbocharger 16. The exhaust manifold 15 is provided for exhausting combusted gas out of the combustion chamber of the cylinder 2. The turbocharger 16 is driven by the exhaust gas flowing from the exhaust manifold 15. The exhaust manifold 15 is disposed extending substantially in the back and forth direction of the engine 1 in the proximity of a side wall on the exhaust side of the cylinder head 10. At its proximal end, a turbine 16a of the turbocharger 16 is attached outside the engine 1. The turbocharger 16 compresses intake air by use of a compressor 16b provided coaxially with the turbine 16a and press-feeds the intake air to the intake manifold 3 through an intake air duct not shown.

[0038] In FIG. 1, identified by the reference numeral 17 is a relief valve for restricting the increase in the boost pressure of the turbocharger 15. Identified by the reference numeral 18 is an EGR cooler for cooling the exhaust gas (EGR gas) returning through the EGR pipe 7 to the intake system. Identified by the reference numeral

19 is an alternator driven by a crankshaft of the engine 1 via a belt, chain or the like (not shown).

[0039] FIG. 2, FIG. 3 and FIG. 4 show a valve system installed on the cylinder head 10. That is, as shown in only FIG. 3, the cylinder head 10 is formed with preferably two intake ports 21 and preferably two exhaust ports 22 for each cylinder (only a pair of them is shown in the drawing). The ports 21, 22, ... communicate with the combustion chamber via openings, which are opened and closed by an intake valve and an exhaust valve 23, 23. The intake valve and exhaust valve 23, 23 are disposed substantially in parallel with the cylinder axis z, as well as preferably substantially in parallel with the injector 4. The valves 23 are biased upward (in such a direction as to close the opening) by coil springs 24 as preferred biasing members. When the valves 23 are actuated by camshafts 26, 26 via a swing arm type rocker arms 25 (simply referred to as swing arm), the valves 23, 23 are displaced downward against biasing force of the springs 24.

[0040] Each of the swing arms 25 are disposed substantially extending in the left and right direction (the width direction of the cylinder head 10) when viewed in the back and forth direction of the engine 1, as shown in the drawing. Of both the longitudinal ends, the end close to the center of the cylinder 2 (the right end for the intake side depicted on the left in the drawing; the left end for the opposite exhaust side) is connected with a shaft end of the exhaust valve 23, 23. On the other hand, the opposite ends thereof are located on left and right sides of the cylinder head 10 and pivotally supported to end pivots 27.

[0041] More particularly, the end pivot 27 comprises a receiving portion 27a and a pivoting portion 27b. The receiving portion 27a is fixed to the cylinder head 10 and includes a rounded (substantially hemisphere) depression at its upper portion. The pivoting portion 27b comprises a complementary rounded (substantially hemisphere) projection at its lower end being slidably held in the depression of the receiving portion 27a. The pivoting portion 27b is screwed in a vertical through hole formed at the end of the swing arm 25 and fastened thereto by a lock nut 28. Accordingly, the height of the swing arm 25 can be adjusted by loosening the lock nut 28 and rotating the pivoting portion 27b about its pivotal axis, thereby enabling the adjustment of the valve clearance of the intake and exhaust valves 23, 23. That is, the end pivot 27 is provided with a mechanical lash adjuster mechanism for adjusting the valve clearance of the intake and exhaust valves 23, 23.

[0042] As shown in only FIG. 3, at the longitudinally central portion of each of the swing arms 25, a roller bearing 29 is disposed substantially in sliding contact with each cam nose of the camshaft 26, thereby reducing the sliding friction of the valve system. In FIG. 2, identified by the reference numeral 30 and depicted in phantom lines is a glow plug disposed so that its end projects into the combustion chamber of the cylinder 2.

In FIG. 2 and FIG. 3, identified by the alphabetic character w is a water jacket formed inside the cylinder head 10.

[0043] The intake and exhaust camshafts 26, 26, as shown in FIG. 4, extend substantially in the back and forth direction of the engine 1 and are rotatably supported by a cam holder 31 mounted preferably on a middle deck of the cylinder head 10 (The drawing shows camshafts 26, 26 and cam holder 31, omitting the intake and exhaust valve 23 and the swing arm 25). The cam holder 31 comprises a main body 32, a plurality of (e.g. ten) cam journals 33, 33, ... in total, and cam caps 34, 34, ... The main body 32 is formed extending substantially in the back and forth direction of the engine 1. The cam journal 33, 33, ... branch off at intermediate portions of the main body 32 towards both the lateral (left and right) sides (intake side and exhaust side). The cam caps 34, 34, ... are attached at the top of each cam journal 33.

[0044] The main body 32 and the cam journal 33, 33, ... of the cam holder 31 are integrally or unitarily formed as separately shown in FIG. 5, taking a fishbone shape as a whole. However, the main body 32 and the cam journal 33, 33, ... are not limited to this formation but may be in any other arrangement in which they are integrally or unitarily formed so that the cam journal 33, 33, ... are to be positioned between adjacent cylinders 2. The main body 32 of the cam holder 31 is formed with a groove 32a which opens upward over the substantially overall longitudinal length. Vertically passing through the bottom portion of the groove 32a, four circular holes 35, 35, ... (referred to as injector insertion hole) are formed in which an injector 4 is at least partly inserted, respectively. At a portion of the engine 1 rearward of the injector hole 35, as will be described in detail, a through hole 36 is bored in which a bolt 58 is inserted. The bolt 58 is used for fixedly securing a clamp 57 to the cylinder head 10 (refer to FIG. 9).

[0045] An upper peripheral surface of the main body 32 of the cam holder 31 except the groove 32a, as shown in FIG. 2 and FIG. 3, comprises a sealing surface 32b (as a preferred second sealing surface) which abuts on a seal 37 (as a preferred second sealing portion) disposed on the head cover 1. That is, the periphery of the injector opening 12 formed in the head cover 11 is gradually slanted down towards the inside of the opening 12. Extending downward from its lower edge, a peripheral extension 38 is formed substantially over the circumference of the opening 12. In the lower surface of the extension 38, a thin groove is formed being depressed upward for receiving the seal 37 therein. In other words, at the bottom of the periphery of the opening 12, the seal 37 is provided in abutment with the sealing surface 32b of the main body 32 of the cam holder 31.

[0046] Having been mounted on the cylinder head 10 as shown in FIG. 4, the plurality of the cam journals 33, 33, ... make a pair of a journal on the intake side and a journal on the exhaust side, with a plurality of (e.g. five) journals on the intake side and a plurality of (e.g. five)

journals on the exhaust side respectively arranged such that two cam noses for each cylinder are located between the adjacent journals substantially in the back and forth direction of the engine 1. These respective journals 33 are formed with a lower half of a journal bearing which receives a journal surface of the camshaft 26 substantially in sliding contact. The cam cap 34 to be fixed thereon is formed with an upper half of the journal bearing.

[0047] The journals 33, 33 on the intake side and the exhaust side located at the foremost portion of the engine 1 undergo larger load than other journals. To cope with this, the areas of the lower bearings of the journals are specially enlarged, and the cam cap 34 to be attached thereto is in integral or unitary construction of those on the intake and exhaust sides.

[0048] In a top plan view of an upper surface of the middle deck of the cylinder head 10 with the camshaft 26 and cam holder being removed, as shown in FIG. 6, the middle deck is formed with injector holes 41, 41, ... vertically penetrating the middle deck correspondingly in position to the central portions of the first through fourth cylinders 2. Surrounding the holes 41, 41, ..., four through holes 42, 42, ... are formed for each of the cylinders 2. In the through holes 42, 42, ..., valve shafts of the intake and exhaust valves 23, 23 are inserted. At the back of each injector hole 41, a bolt hole 43 is bored in which a bolt body of a bolt 58 is screwed. The bolt 58 fastens a clamp 57 (refer to FIG. 9) of the injector 4.

[0049] Surrounding each of first through fourth cylinders 2, through holes 45, 45, ... are formed, through which cylinder head bolts 44, 44, ... (refer to FIG. 2 and FIG. 3) are inserted for fastening the cylinder head to a cylinder block (not shown). A plurality of (e.g. six) head bolts 44, 44, ... are arranged at substantially regular intervals in the circumferential direction around each of the first through fourth cylinders 2. Of the six bolts, e.g. two head bolts 44, 44 located between adjacent cylinders are used in common for the cylinders.

[0050] In a top plan view of the engine 1 as shown in the drawing, the head bolt 44, 44 used in common for the adjacent two cylinders 2, 2 at least partly overlap with fastening bosses 46, 46, ... to which the cam journals 33, 33 of the cam holder 31 are fastened. The two head bolts 44, 44 located at the rear end of the engine 1 also overlap with the fastening bosses 46, 46, ... That is, in this embodiment, head bolt through holes 45, 45, ... between the cylinders 2 on the middle deck of the cylinder head 10 interfere with the fastening bosses 46, 46, ... of the cam holder 31, showing the difficulty in integrally forming the cam holder 31 on the middle deck.

[0051] In other words, the cylinder head 10 according to this embodiment uses a relatively large number of head bolts 44, 44 to accommodate high combustion pressure inevitably produced by direct injection diesel engines, which provides relatively large spaces for the head bolt through hole 34 and corresponding bosses. In spite of this, however, by providing the cam holder 31 separately from the cylinder head 10 in structure, in-

creased flexibility is attained in the layout of the fastening boss 46 of the cam holder 31 and the head bolt through hole 45 on the middle deck, allowing them to be appropriately arranged on the cylinder head 10 being compact in size.

[0052] The middle deck of the cylinder head 10 mounted with the valve system of the engine 1 as described above is covered with the head cover 11 from above and shielded from the outside, as shown in FIGS. 2 and 3. That is, as also shown in FIG. 4 and FIG. 6, the cylinder head 10 is integrally or unitarily formed with a wall 47 extending upward over the periphery of the cylinder head 10. An upper surface of the wall 47 is joined in an oil tight manner with a lower surface of a peripheral wall 50 extending downward from a periphery of the head cover 11. Particularly, the upper surface of the peripheral wall 47 is formed with a sealing surface 47a (as a preferred first sealing surface) to be joined with a lower edge of the peripheral wall 50. In the sealing surface 47a, a plurality of bolt holes 48, 48, ... are bored at substantially regular intervals in the circumferential direction along the peripheral wall 47.

[0053] The peripheral wall 50 of the head cover 11, on the intake side, extends so as to bend downward towards its outside portion. On the exhaust side and rear side of the engine 1, the peripheral wall 50 bends down substantially perpendicularly at the outer periphery of the head cover 11 and extends downward. Additionally, the peripheral wall 50 on the frontal side of the engine 1, as shown in FIG. 7, is cut way or recessed correspondingly to a contour of the cam cap 34 provided at the frontal edge of the cam holder 31. Along the cutaway, the lower edge of the peripheral wall 50 is joined with the upper surface of the cam cap 34. Accordingly, sealing surfaces, similar to the sealing surface 47a of the cylinder head 10, are formed in the upper surface of the cam cap 34 and side surface continuing from both left and right ends of thereof.

[0054] As shown in FIGS. 2 and 3, in the lower surface of the peripheral wall 50 of the head cover 11, a thin groove is formed being depressed downward substantially over its periphery. In the groove, a seal 51 (as a preferred first sealing portion) is attached in abutment with the sealing surface 47a at the upper edge of the peripheral wall 47 of the cylinder head 10. That is, at the lower edge of the peripheral wall 50 formed at the periphery of the head cover 11, the seal 51 is provided in abutment with the sealing surface 47a of the cylinder head 10. In addition, as shown in FIG. 8, at the periphery of the head cover 11, a plurality of flanges 52, 52, ... are formed substantially correspondingly in position to the bolt holes 48, 48, ... in the peripheral wall 47 of the cylinder head 10. A circular hole 53 is formed vertically penetrating each flange 52.

[0055] Then, as shown in FIGS. 1 through 3, when the head cover 11 is mounted on the cylinder head 10 with the peripheral wall 50 mating with the peripheral wall 47, the lower surface of the peripheral wall 50 of the head

cover 11 is joined with the upper surface (the first sealing surface) of the peripheral wall 47 of the cylinder head 10, and the circular holes 53, formed in each of the plurality of the flanges 52, 52, ... at the periphery of the head cover 11, come into communication with each of the bolt holes 48 at the periphery of the cylinder head 10. Similarly, the lower surface of the peripheral extension 38 extending downward from the periphery of the injector opening 12 in the head cover 11 is joined with the sealing surface 32b (the second sealing surface) of the main body 32 of the cam holder 31. In this state, by inserting bolts 54, 54, ... from above into the circular holes 53, 53, ... in each of the flange 52, 52, ... at the periphery of the head cover 11 and screwing the bolt body of the bolt 54 into the bolt hole 48, the head cover 11 is fastened to the cylinder head 10.

[0056] In other words, the cylinder head 10 according to this embodiment arranges the bolts 54, 54, ... (as preferred fasteners) for fastening the head cover 11 along the first seal at the periphery of the head cover 11, with no bolts arranged in the second seal along the injector opening 12. However, by fastening the plurality of bolts 54, 54, ... at the periphery of the head cover 11 to the predetermined greater torque, the seal 37 maintains oil tight of the sealing portion between the periphery of the injector opening 12 and the sealing surface 32b of the main body 32 of the cam holder 31 on the cylinder head 10, even with no or relatively smaller number of the fasteners in the second seal as described above,

[0057] This configuration ensures that the peripheral wall 50 of the head cover 11 and the peripheral wall 47 of the cylinder head 10 are joined with each other by the plurality of fastening bolts 54, 54, ... arranged in the joint portion (first seal), thereby enabling the seal 51 to maintain oil tight therebetween. Additionally, this configuration ensures that the lower edge of the peripheral extension 38 extending downward from the periphery of the injector opening 12 of the head cover is sufficiently tightly pressed against the upper surface of the main body 32 of the cam holder 31 arranged on the cylinder head 10, thereby enabling the seal 37 provided at the joint portion (second seal) to maintain oil tight therebetween. The fastening bolts 54 preferably are also provided at the frontal portion of the peripheral wall 50 of the head cover 11, so that the seal 51 maintains oil tight between the frontal portion of the peripheral wall 50 and the frontal edge of the cam cap 34.

[0058] The cylinder head 10 according to this embodiment features that: as shown in FIG. 2 and FIG. 3, the height of the first seal joining the cylinder head 10 and the head cover 11 with each other at the periphery thereof, that is, the height of the peripheral wall 47 of the cylinder head 10, is smaller than a predetermined height so as not to adversely interfere with the adjustment work of the mechanical lash adjuster mechanism of the end pivot 27 disposed adjacently to the peripheral wall 47. That is, in this embodiment, the level of the sealing surface 47a of the peripheral wall 47 is lower than a mating

surface between the cam journals 33, 33, ... of the cam holder 31 and the cam caps 34, 34, ...

[0059] More particularly, as shown only in FIG. 3, the peripheral wall 47 has the substantially same height on the intake side and on the exhaust side, and both are lower than the lock nut 28 screwed onto the pivoting portion 27b of the end pivot 27 of the adjacent swing arm 25. With this construction, when the head cover 11 has been removed from the cylinder head 10, the upper end of the pivoting portions 27b and the lock nuts 28 of each of the end pivots 27 on the intake side and on the exhaust side project upward beyond the level of the upper surface of the peripheral wall 47 of the cylinder head 10. This eases in the adjustment work of the height of the swing arms 25 by loosening the lock nuts 28 and rotating the pivoting portions 27b. That is, the adjustment work of the valve clearance is easily performed by use of the mechanical lash adjuster mechanism of the end pivots 27.

[0060] In the head cover 11, as shown in FIGS. 2, 3, and 8, a first bulging portion 11 a and a second bulging portion 11 b are formed on the exhaust side of the injector opening 12, with an oil separator chamber not shown being defined therein. The first bulging portion 11a is stepped upward over the portion lying from the center (the central portion between the first cylinder and the second cylinder in the drawings) to the rear in the back and forth direction of the engine 1. The second bulging portion 11 b is further stepped upward from the first bulging portion 11 a on the rear side of the engine 1.

[0061] In other words, the head cover 11 is configured such that the portion on the intake side of the injector opening 12 is situated lower than the portion on the exhaust side thereof, with the individual fuel pipe 13, running from the common rail 5 to each of the injectors 4, being arranged above the portion on the intake side as indicated by phantom lines in FIG. 2. That is, the individual fuel pipe 13 is arranged above the relatively lower portion of the head cover 11, thereby suppressing the increase in the engine height due to the arrangement of the individual fuel pipe 13.

(Supporting structure of injectors)

[0062] Next, a supporting structure of injectors 4, 4, ... in the cylinder head 10 will now be described with reference to FIGS. 2, 9, 10, and 11. As described above, the injector 4 for each cylinder 2 is at least partly inserted from above into the injector insertion hole 35 formed in the main body 32 of the cam holder 31 and the injector hole 41 communicating with the insertion hole 35 thereunder, and is disposed preferably substantially along the cylinder axis z. With the above-described condition being maintained, the injectors 4, 4, ... are or can be fixed by the clamp 57 with respect to the main body 32 of the cam holder 31. The clamp 57 is substantially contained in the groove 32a of the main body 32 of the cam holder 31 so as to extend substantially in its longitudinal direc-

tion, and fastened on the middle deck of the cylinder head 10 by bolts 58 vertically passing therethrough with the main body 32 of the cam holder 31 interposed.

[0063] The injector opening 12 formed in the head cover 11, as shown in FIG. 8, is elongated in the head longitudinal direction corresponding to the main body 32 of the cam holder 31, taking a slit-like shape. Thus, as best shown in FIG. 11, the clamp 57 is arranged so that its longitudinal direction is oriented substantially in the longitudinal direction of the slit. The injector 4, clamp 57 and the bolt 58 are exposed to the outside of the head cover 11 through the injector opening 12.

[0064] The longitudinal end of the clamp 57 branches into two claws 57a, 57a. The claws 57a, 57a hold the injector 4 and force it downward, so as to fixedly hold the injector 4. That is, the injector 4 has a substantially cylindrical shape as a whole, and is formed with a narrow neck 4a with a polygonal or rectangular cross section at the longitudinally central portion. The narrow neck 4a is held by the claws 57a, 57a of the clamp 57.

[0065] In this manner, the narrow neck 4a of the injector 4 is held by the claws 57a, 57a of the clamp 57, thereby preventing the rotational displacement of the injector 4 about its axis. Accordingly, the rotational positioning of the injector 4 about its axis is completed when the injector 4 has been fitted to the cylinder head 10 from above the main body 32 of the cam holder 31 and fixed by the clamp 57.

[0066] The engine 1 according to this embodiment preferably uses the injector 4 of well-known multi-hole type having a plurality of injection bores formed in a nozzle at its tip. Some of the injection bores should be opened at appropriate positions with respect to the glow plug 30. That is, in general, a diesel engine which causes mixture to self-ignite uses a glow plug for ensuring the startability in a cold environment. A part of fuel spray is brought into direct contact with the tip of the glow plug projecting into the combustion chamber of the cylinder 2, so that the ensured self-ignition is attained even in the cold environment.

[0067] For this reason, in the case with a multi-hole type injector 4 as in this embodiment, the injector 4 should be positioned appropriately about its axis so that fuel spray from any one of the injection bores contacts with the tip (refer to FIG. 2) of the glow plug 30. In this regard, the clamp 57 as described above is advantageously used. That is, this embodiment uses the clamps 57 to position and fix the respective injectors 4 for each of the cylinders 2, thereby preventing the occurrence of human error in an assembling operation to ensure the favorable cold start of the engine 1.

[0068] As shown in FIG. 9, a head of the bolt 58 for fixing the clamp 57 is located within the injector opening in the head cover 11 and is exposed to the outside of the head cover 11. The body of the bolt 58 is inserted from above into a circular hole 57b passing vertically through the substantially longitudinally central portion of the clamp 57, penetrates the bolt through hole 36

formed in a main body 32 of the cam holder 31 and communicating the circular hole 57b, and is located inside the head cover 11. The tip of the body of the bolt 58 is screwed into the bolt hole 43 opening on the middle deck of the cylinder head 10.

[0069] As described above, the head of the bolt 58 is exposed to the outside of the head cover 11, so that the fastening work of the bolt 58 is facilitated, thereby easing in the mounting work of the injector 4. Meanwhile, the body of the bolt 58 passes through the main body 32 of the cam holder 31 and is fastened to the cylinder head 10, so that the injector 4 is reliably held even if the injector 4 produces a considerably great reactive force during the high-pressure fuel injection.

[0070] In the above-described arrangement of the bolt 58, however, engine oil may adversely leak out of the inside of the head cover 11 along the body of the bolt 58. To cope with this, this embodiment uses a washer 59 fitted onto a predetermined position of the body of the bolt 58, and disposes two seal rings 60, 61 by use of the washer 59, so as to prevent the oil leak.

[0071] That is, the washer 59, as shown in FIG. 10 of an enlarged view thereof, comprises a cylinder portion 59a and a collar 59b. The cylinder portion 59a is loosely fitted onto the body of the bolt 58. The collar 59b is extended outward from an end of the cylinder portion 59a. The collar 59b is integrally or unitarily provided with a first seal ring 60, made from a resilient material such as rubber, by vulcanized adhesion. The other end of the cylinder portion 59a is provided with a second seal ring 61 in the similar manner. Thus, as shown in FIG. 9, the washer 59 is or can be fitted onto the body of the bolt 58 and located between the lower surface of the clamp 57 and the bottom surface of the groove 32a of the main body 32 of the cam holder 31. With this arrangement, the first seal ring 60 maintains oil tight between the bottom surface of the groove 32a and the lower surface of the collar 59b of the washer 59 (vertical clearance in the drawing), and the second seal ring 61 maintains oil tight between the inner surface of the bolt through hole 36 formed in the main body 32 of the cam holder 31 and the outer surface of the body of the bolt 58 (horizontal clearance in the drawing).

[0072] As described above, a double seal structure is attained with the first seal ring 60 sealing the clearance in the axial direction of the bolt 58 and the second seal ring 61 sealing the clearance in the radial direction of the bolt 58, thereby reliably preventing the oil leak out of the head cover 11 even with the degradation in sealing performance of any one of the seal rings due to the tolerance in components or the assembling error.

[0073] Therefore, according to the cylinder head structure of the direct injection diesel engine 1 in accordance with this embodiment, there is provided the double overhead camshaft (DOHC) direct injection diesel engine 1, comprising the intake and exhaust camshafts 26, 26 separately provided, and the intake and exhaust valves 23, 23 driven by each of the camshafts 26, 26 via

the swing arm 25, wherein the cam holder 31 is provided separately from the cylinder head 10 in structure. Accordingly, the interference with the head bolt 44 and other components is eliminated, thereby reducing the size of the cylinder head 10 and thus the engine 1.

[0074] In addition, the mechanical positioning mechanism (mechanical lash adjuster mechanism) for adjusting the valve clearance is provided at each of the end pivots 27 of the swing arms 25 which drive the intake and exhaust valves 23, 23. Accordingly, cost reduction is achieved in comparison with adopting the hydraulic lash adjuster.

[0075] Moreover, because of the preferred substantially vertical arrangement of the intake and exhaust valves 23, 23 unique to the direct injection diesel engine 1, the end pivot 27 of each swing arm 25 is located closely to the peripheral wall 47 of the cylinder head 10. In consideration for this, the peripheral wall 47 is reduced in height, thereby easing in the adjustment work of the valve clearance by use of the mechanical lash adjuster mechanism.

[0076] That is, according to the preferred embodiment of the present invention, the downsizing of the direct injection diesel engine is attained with reduced cost by the adoption of the mechanical lash adjuster mechanism. Additionally, even with the adoption of the mechanism, difficulty is avoided in the adjustment work of the clearance of the intake and exhaust valves.

[0077] It should be appreciated that this embodiment applies the cylinder head structure to the in-line four-cylinder diesel engine longitudinally mounted in the engine compartment of the vehicle, but may not be limited to this application. For example, the present invention may apply to a direct injection diesel engine transversely mounted in the engine compartment, an in-line three or five or more cylinder direct injection diesel engine, or a V-type direct injection diesel engine with three or more cylinder arranged in each bank.

[0078] In the cylinder head of the direct injection diesel engine 1 according to the embodiment, the flow of the coolant in the water jacket w is directed downward towards the ceiling of each cylinder 2 for reducing thermal load. That is, as shown in FIG. 12 of a horizontal cross sectional view of the cylinder head 10, and as shown in FIG. 13 of vertical cross sectional view of the cylinder head 10 between the third and fourth cylinders 2, 2, a reinforcing beam 62 is formed connecting the middle deck and a lower deck of the cylinder head 10 at the inside of the water jacket w between the adjacent cylinders 2, 2, and a pair of ribs 63, 63 are formed extending downward from the middle deck and in the right and left direction, on both the right and left sides of the reinforcing beam 62.

[0079] The provision of the ribs 63, 63 between the adjacent cylinders 2, 2 causes the coolant, flowing from the rear edge to the frontal edge of the engine 1 in the water jacket w (indicated by bold arrows in FIG. 12), to be directed downward between the cylinder 2, 2 towards

the ceiling of each cylinder 2. This enhances cooling efficiency in the ceiling of each cylinder 2 which undergoes especially high thermal load.

[0080] With the above-described construction, however, the coolant flow is blocked by the rib 63 at the upper portion of the water jacket w, possibly causing bubbles in the coolant to gather in the vicinity of the rib 63, which may locally degrade the cooling efficiency thereof. In this regard, the cylinder head 10 of the engine 1 according to the embodiment is formed with a bypass passage 64 communicating the upstream portion with the downstream portion of the rib 63 as shown in the drawing. The passage 64 conveys the bubbles in the coolant from the upstream portion to the downstream portion of the rib 63, thereby preventing the bubble from gathering in the water jacket w.

Claims

1. A cylinder head structure of a direct injection diesel engine (1), comprising:

a cylinder head (10),
 an injector (4) which preferably is substantially vertically arranged in the cylinder head (10) corresponding in position to the center of each of cylinders (2),
 an intake valve (23) and an exhaust valve (23), which preferably are disposed substantially in parallel with the injector (4), the intake valve (23) and the exhaust valve (23) being driven by a camshaft (26) via a swing-arm type rocker arm (25),
 mechanical lash adjuster mechanisms (27, 28) respectively provided at each of the end pivots (27) of the rocker arms (25) for the intake valve (23) and the exhaust valve (23), each of the end pivots (27) being located on both the lateral sides of the cylinder head (10) when viewed in the alignment direction of the cylinders (2),
 an intake camshaft (26) and an exhaust camshaft (26) provided extending in the alignment direction of the cylinders (2), and rotatably supported by a cam holder (31) mounted on the upper surface of the cylinder head (10),
 the cam holder (31) comprising a main body (32) elongated in the alignment direction of the cylinders (2), a cam journal (33) integrally or unitarily formed with the main body (32) and positioned between the adjacent cylinders (2), and a cam cap (34) attached on the top portion of the cam journal (33),
 a first seal (51) provided at a periphery (50) of a head cover (11) attached over the cylinder head (10) and adapted to abut on a first sealing surface (47a) provided at a periphery (47) of the cylinder head (10),

an injector opening (12), through which the plurality of the injectors (4) are inserted, being formed at a substantially central portion of the head cover (11) so as to face the upper surface of the main body (32) of the cam holder (31), and

a second seal (37) provided at a lower portion of a periphery of the injector opening and adapted to abut on a second sealing surface (32b) provided at the upper surface of the main body (32) of the cam holder (31),

wherein the first sealing surface (47a) is located lower than a mating surface between a cam journal (33) and the cam cap (34).

2. The cylinder head structure of a direct injection diesel engine (1) as defined in Claim 1,

wherein the second seal (37) of the head cover (11) is provided at a lower edge of a peripheral extension (38) extending downward from the periphery of the injector opening (12),

a plurality of fasteners (54) for fastening the head cover (11) to the cylinder head (10) is disposed along the first seal (51) of the head cover (11), and

the fastening force to be applied to the fasteners (54) is predetermined so that oil tight is maintained between the second seal (37) and the second sealing surface (32b) of the cam holder (31).

3. The cylinder head structure of a direct injection diesel engine (1) as defined in any one of Claims 1 and 2,

wherein the injector opening (12) in the head cover (11) is elongated in the alignment direction of the cylinders (2),

each of the injectors (4) are fixed to the main body (32) of the cam holder (31) by a bolt (58) via clamps (57) within the injector opening (12), and

each of the clamps (57) are adapted to achieve the rotational positioning of the injector (4) about its axis and fixation thereof.

4. The cylinder head structure of a direct injection diesel engine (1) as defined in Claim 3,

wherein the clamp (57) is arranged so that its longitudinal direction is oriented substantially in the elongated direction of the injector opening (12).

5. The cylinder head structure of a direct injection diesel engine (1) as defined in any one of Claims 3 and 4,

wherein the head cover (11) is configured such that the portion on the intake side of the injector opening (12) is situated lower than the portion on the exhaust side thereof, and

individual fuel pipes (13) for supplying fuel from a common rail (5) to each of the plurality of

injectors (4) is arranged above the portion on the intake side.

6. The cylinder head structure of a direct injection diesel engine (1) as defined in any one of Claims 3 to 5,
 wherein a fuel return pipe (14) for returning
 excessive fuel to a fuel supply system is disposed
 extending in the alignment direction of the cylinders
 (2) along the injector opening (12) in the head cover
 (11). 5
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7. The cylinder head structure of a direct injection diesel engine (1) as defined in any one of Claims 3 to 6,
 wherein the bolt (58) is adapted to fix the
 clamp (57) in such a way that a head of the bolt (58)
 is exposed to the outside of the head cover (11)
 within the injector opening (12), body of the bolt (58)
 is preferably substantially vertically inserted in a
 through hole (36) formed in the cam holder (31), and
 a tip of the body is screwed in a bolt hole (43) formed
 in the cylinder head (10). 15
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8. The cylinder head structure of a direct injection diesel engine (1) as defined in any one of Claims 3 to 7,
 a washer (59) is fitted onto the body of the bolt (58)
 and is located between the clamp (57) and the main
 body (32) of the cam holder (31), the washer (59)
 being provided with a first seal ring (60) which abuts
 on the main body (32) of the cam holder (31) and a
 second seal ring (61) for sealing between an outer
 surface of the body of the bolt (58) and an inner surface
 of the through hole (36) in the cam holder (31). 25
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9. A direct injection diesel engine (1) equipped with the
 cylinder head structure as defined in any one of
 Claims 1 to 8. 35

10. The direct injection diesel engine (1) as defined in
 Claim 9,
 wherein the engine (1) comprises two intake
 valves (23) and two exhaust valves (23) for each
 cylinder (2). 40

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FIG. 1

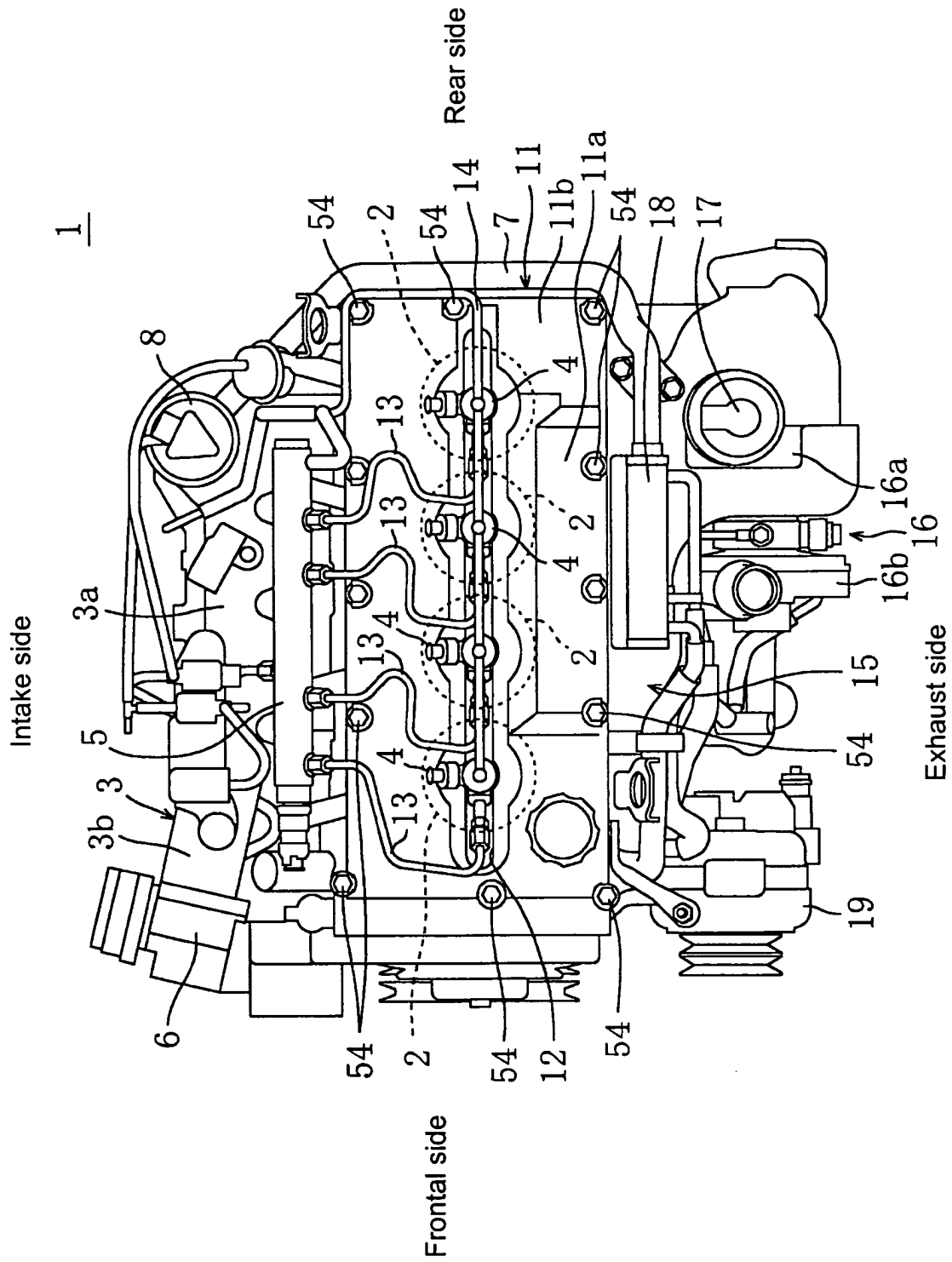


FIG. 2

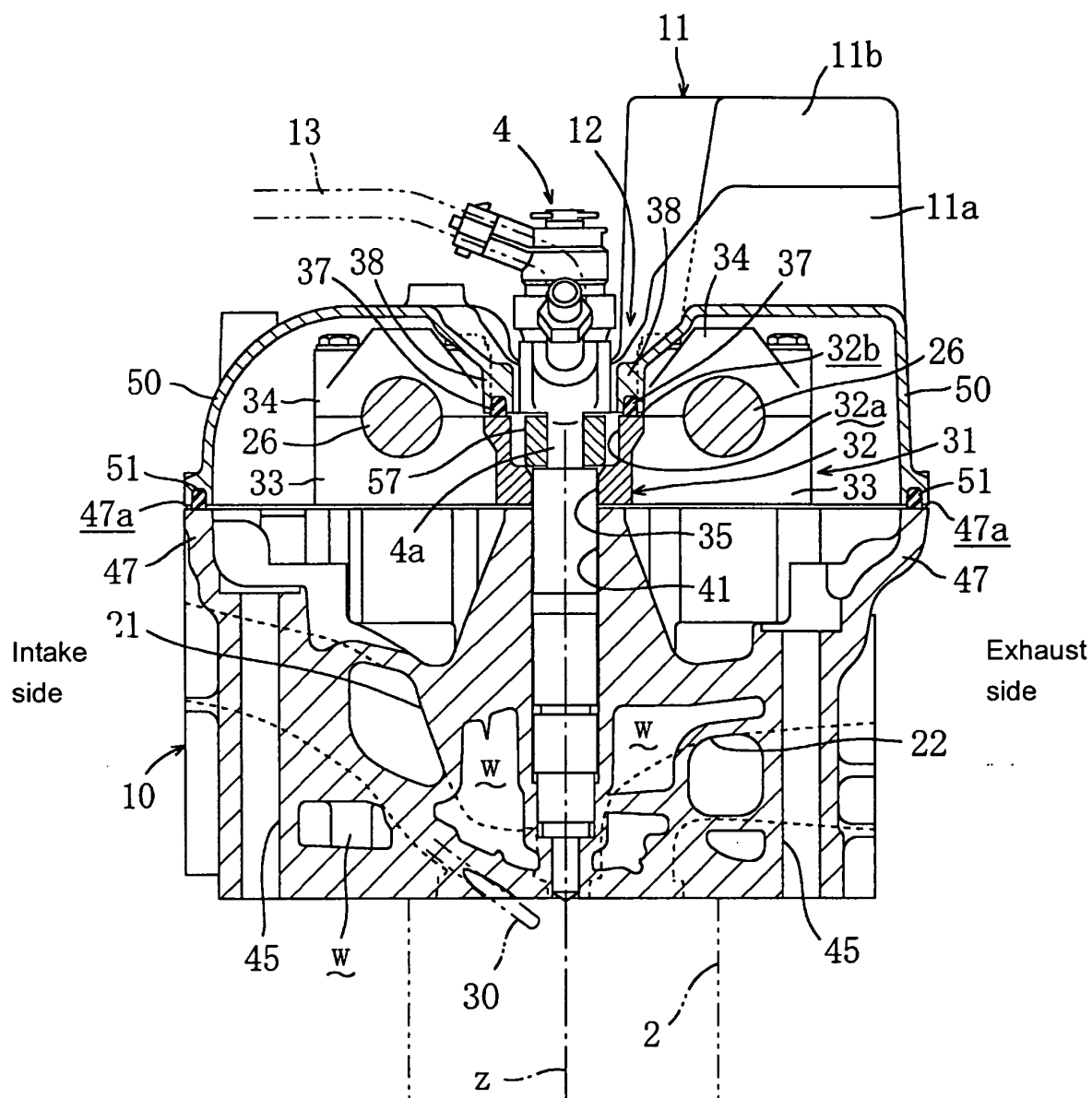


FIG. 3

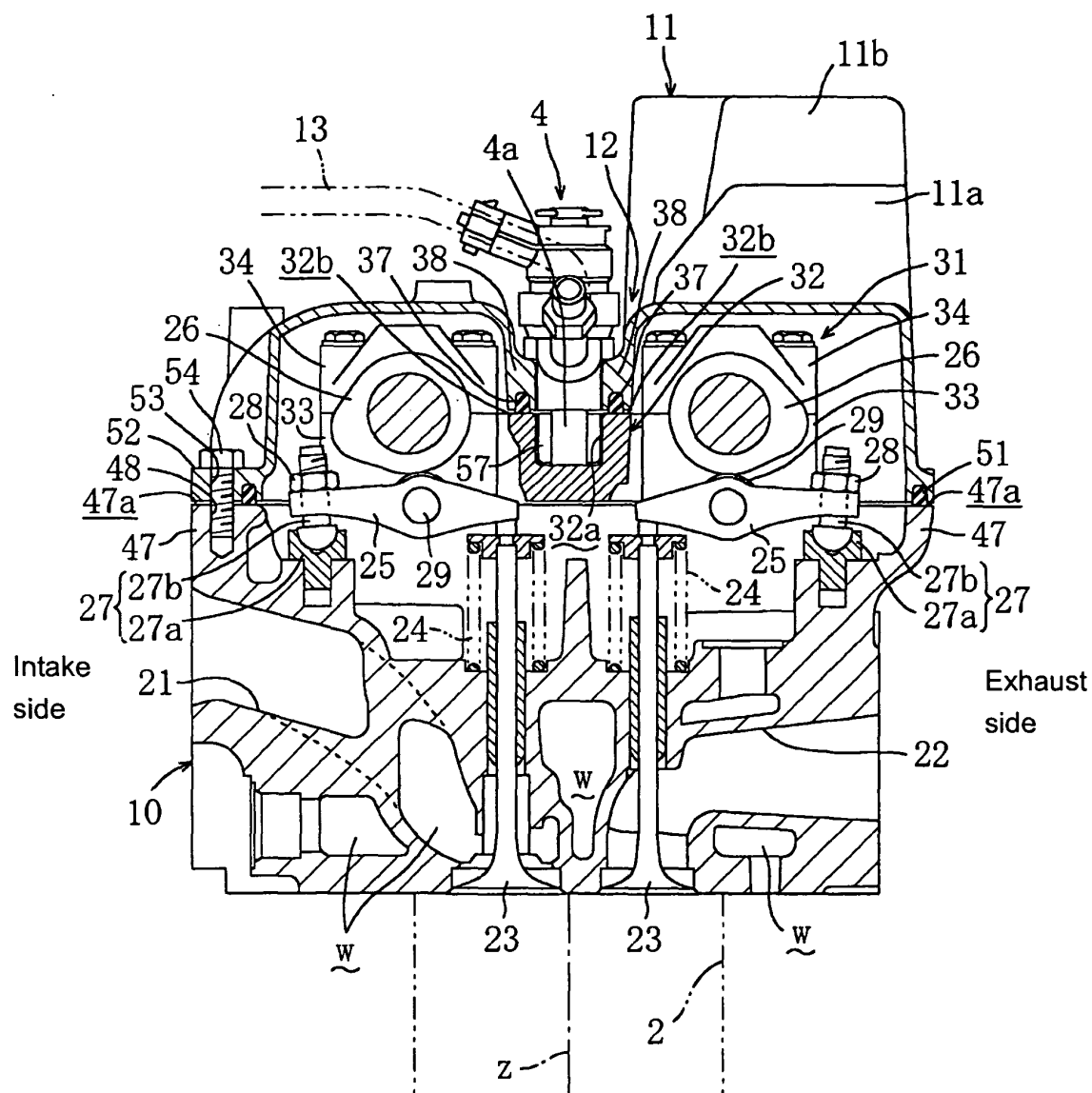


FIG. 4

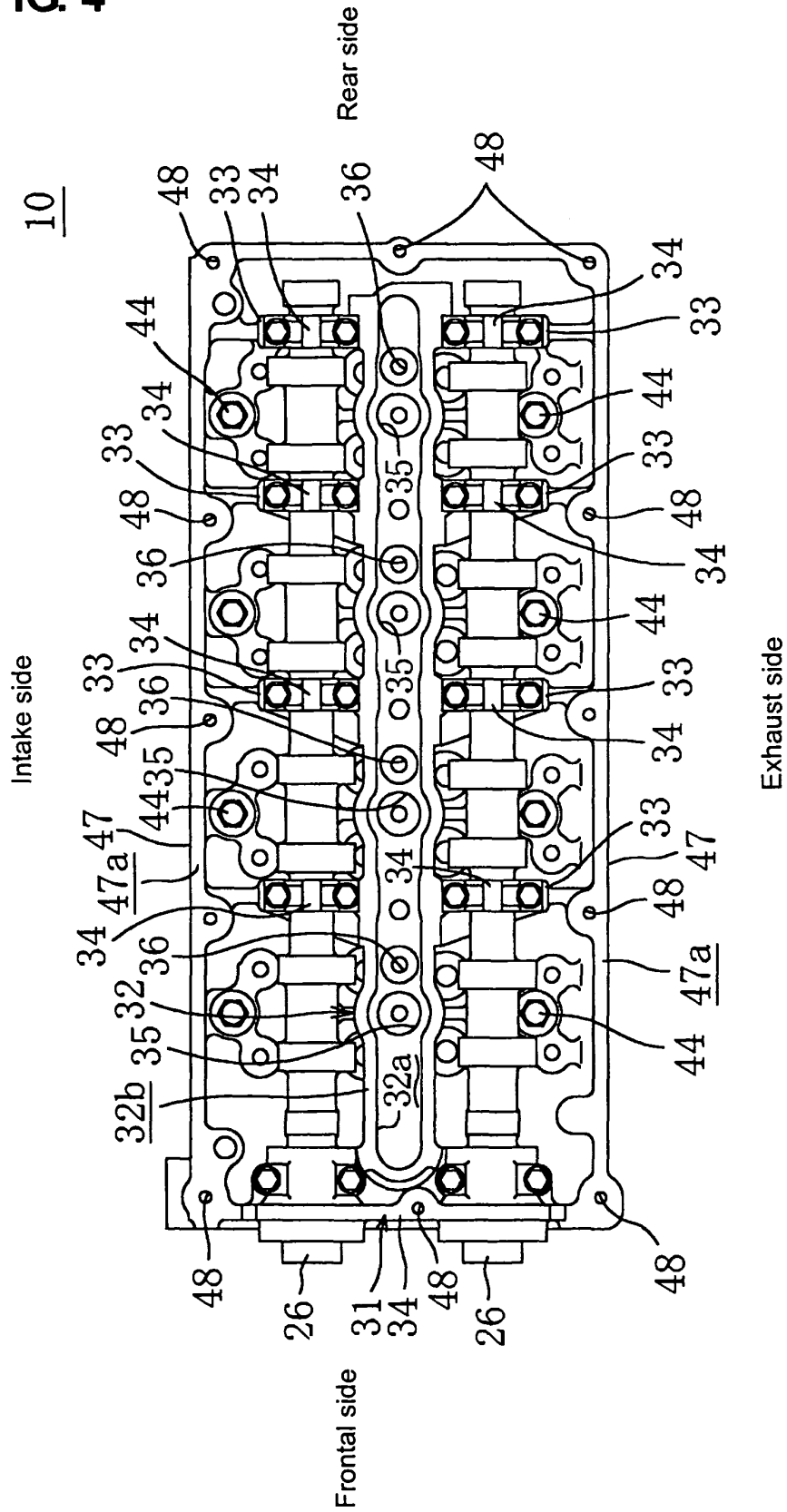


FIG. 5

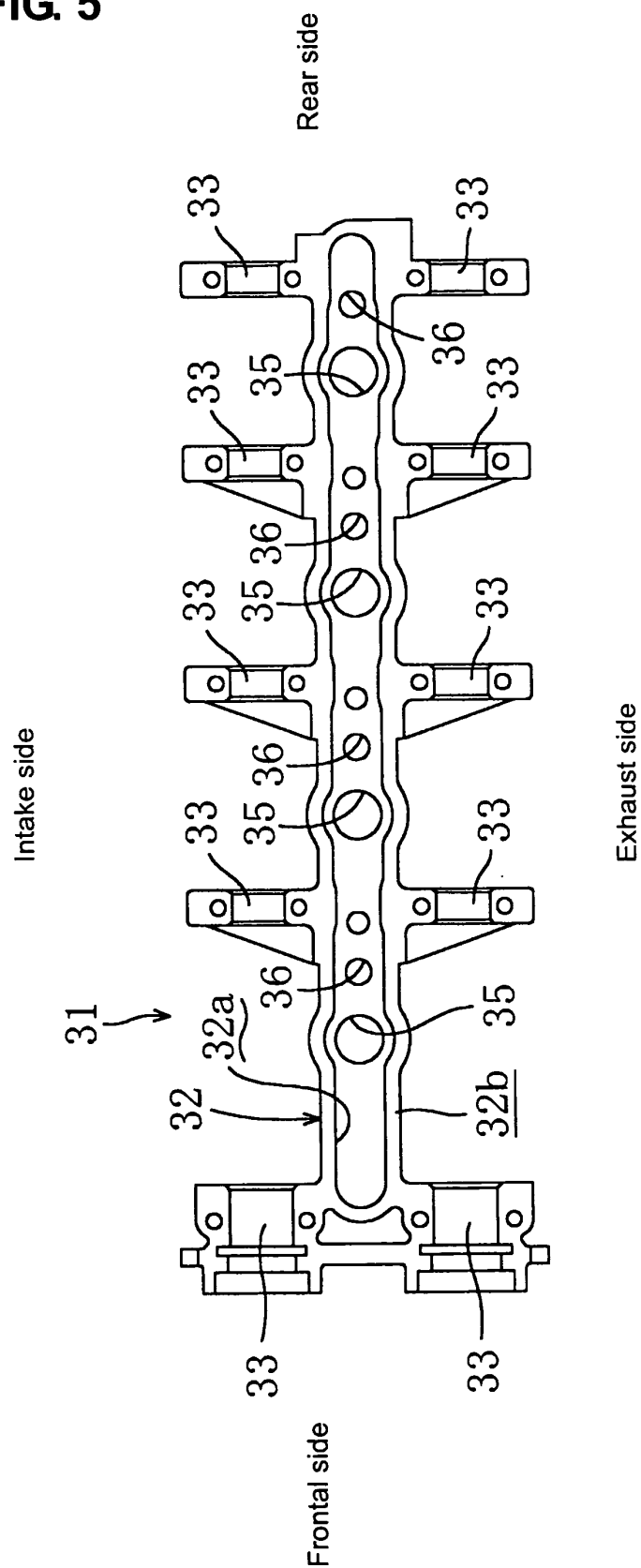


FIG. 6

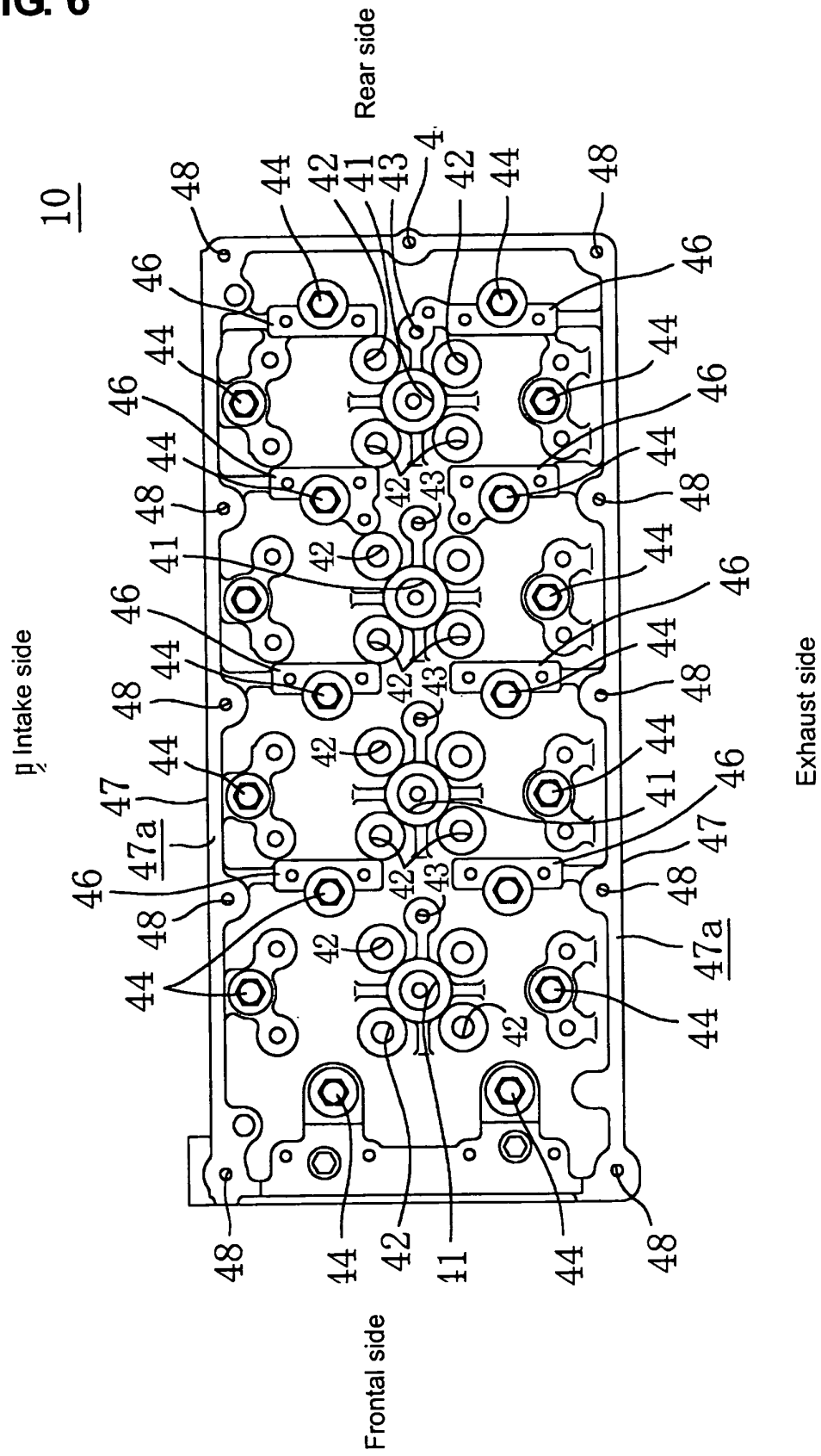


FIG. 7

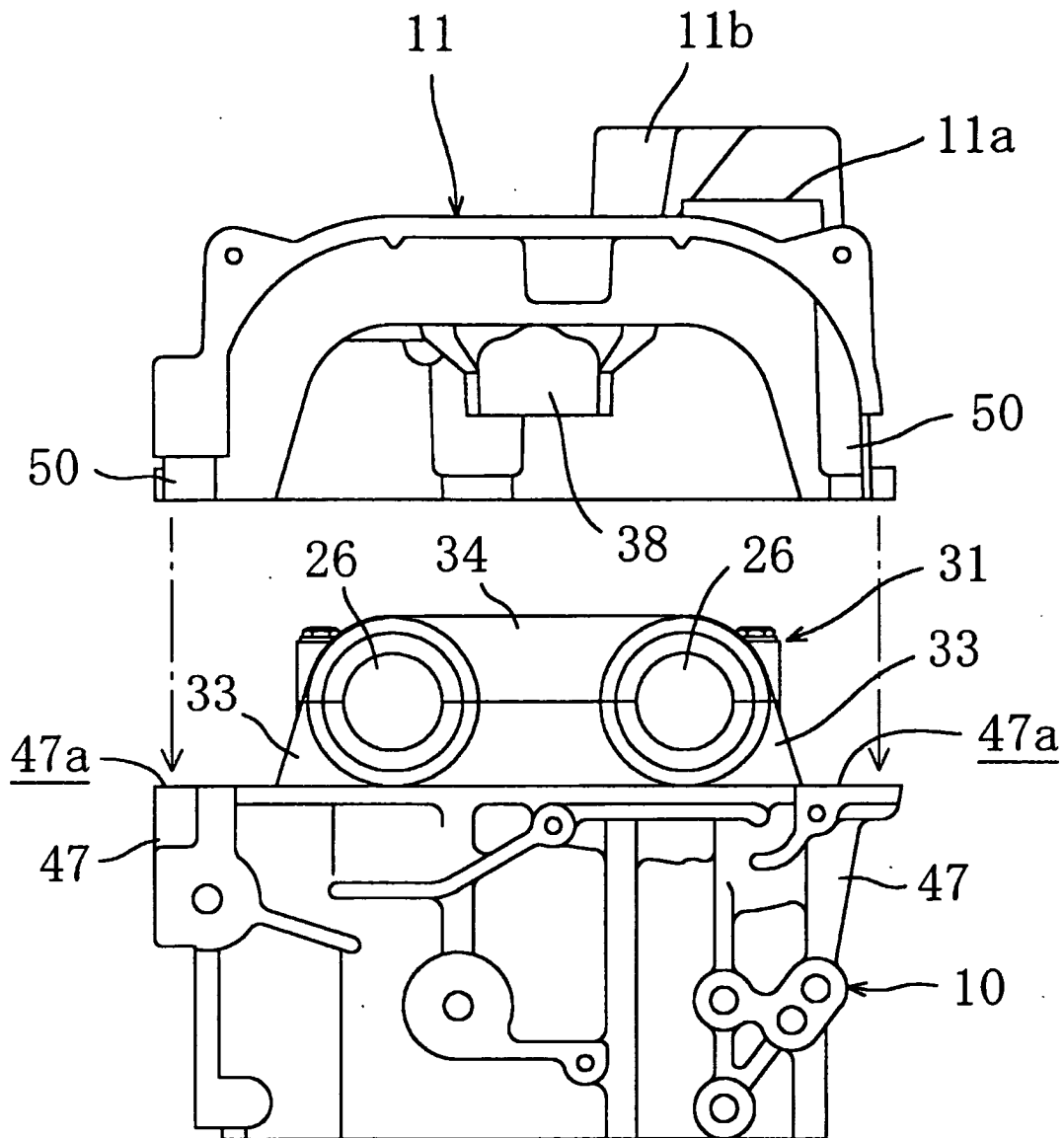


FIG. 8

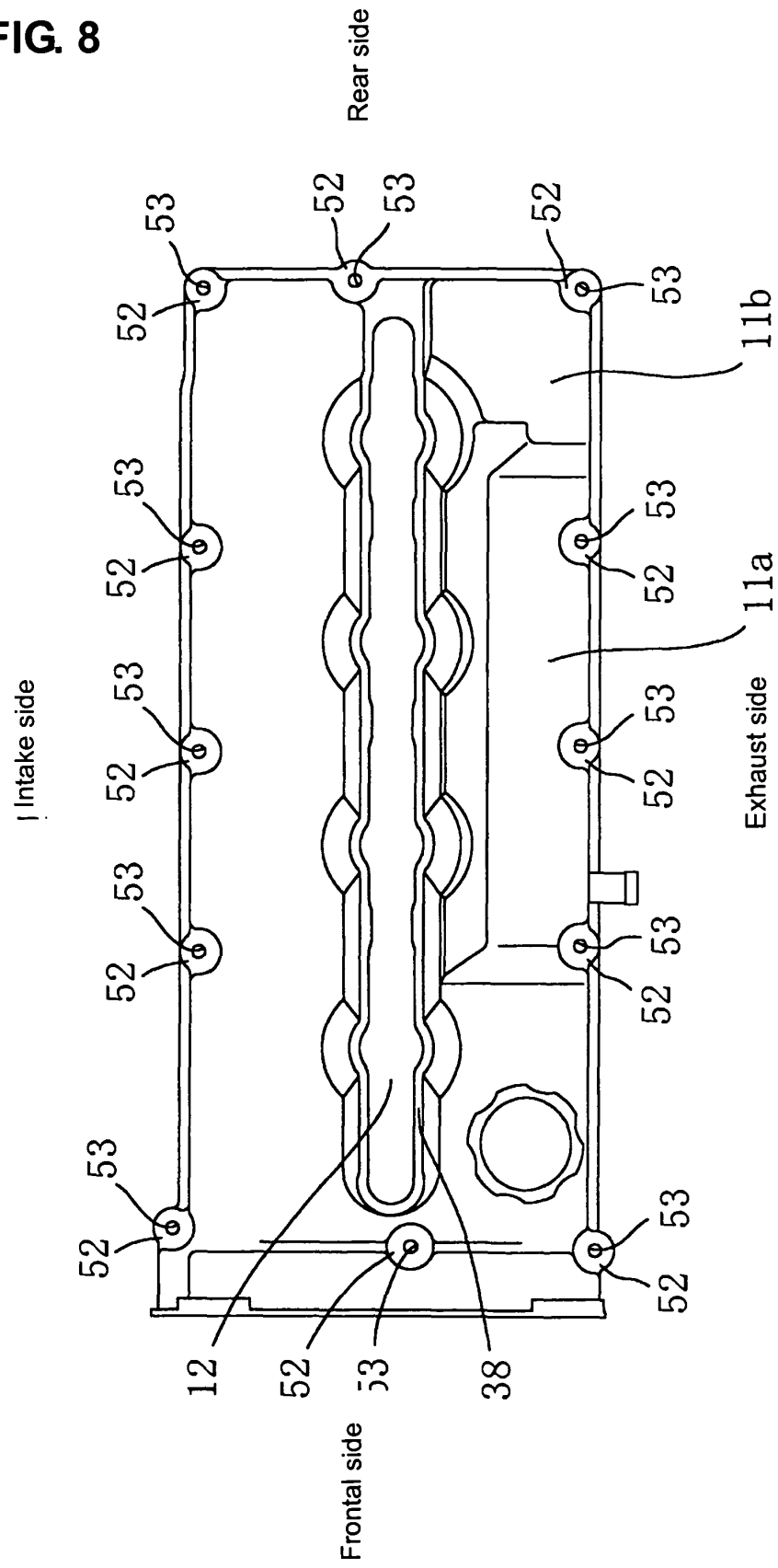


FIG. 9

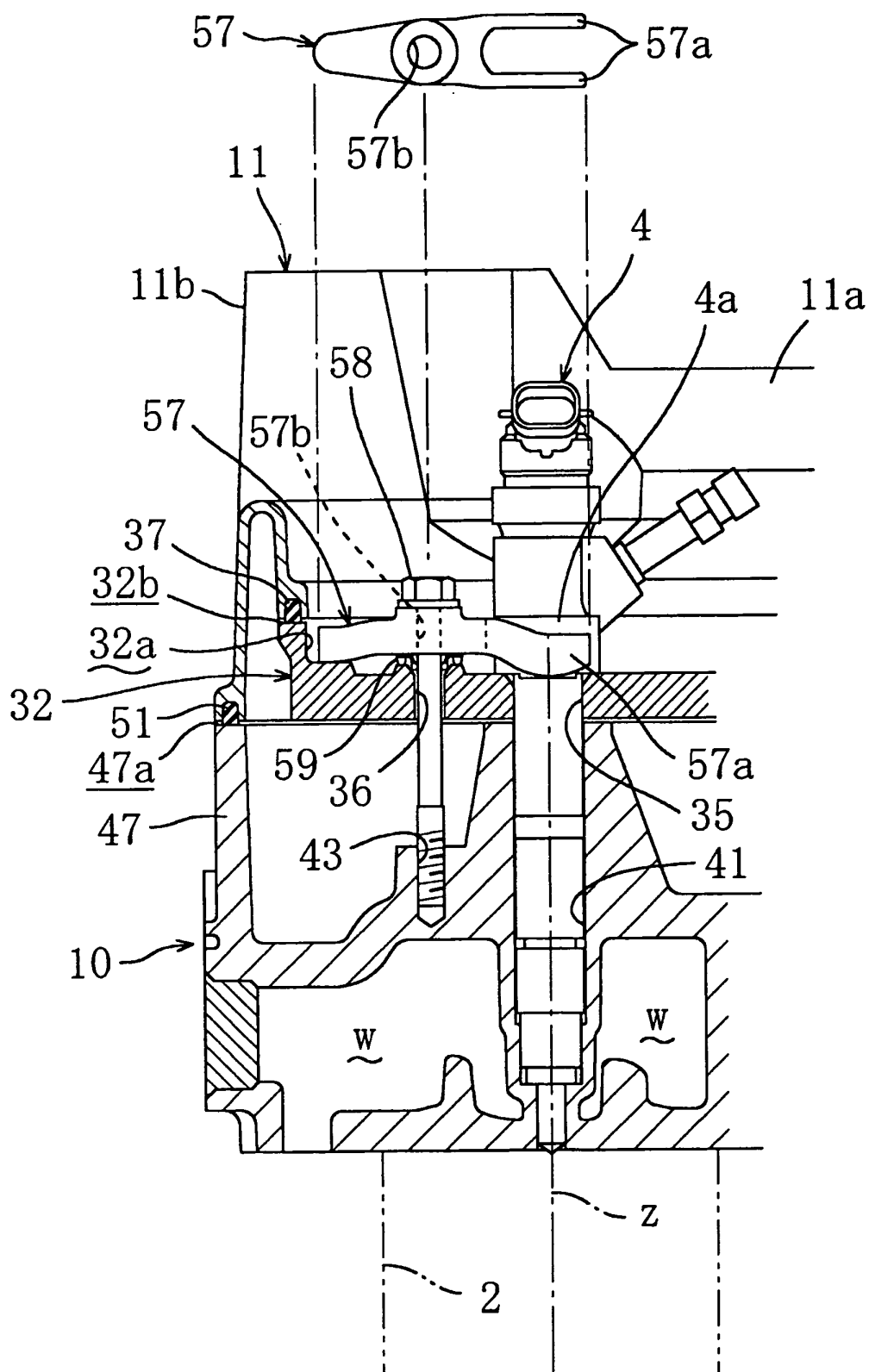


FIG. 10

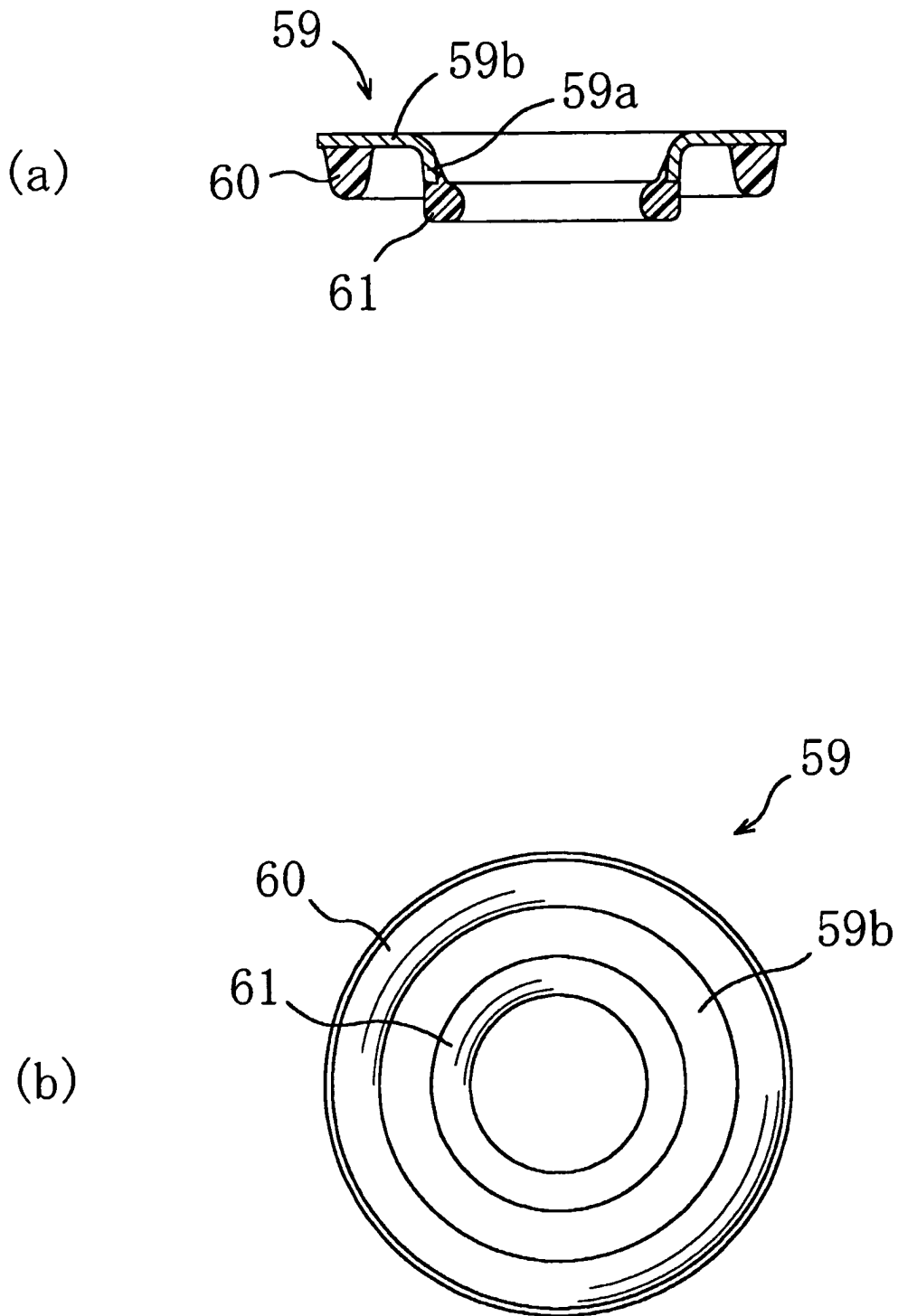


FIG. 11

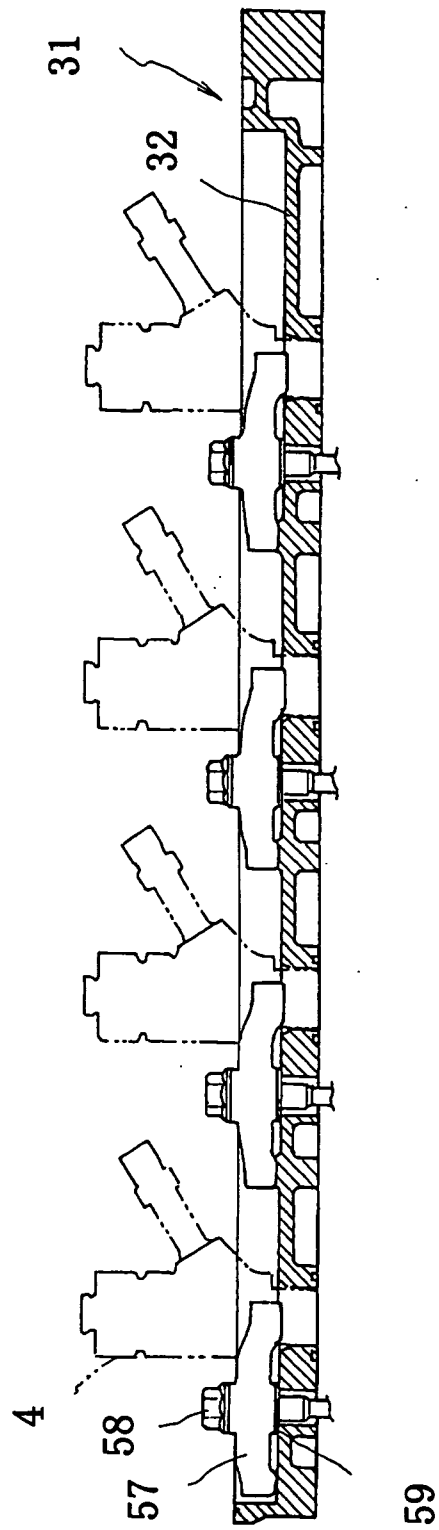


FIG. 12

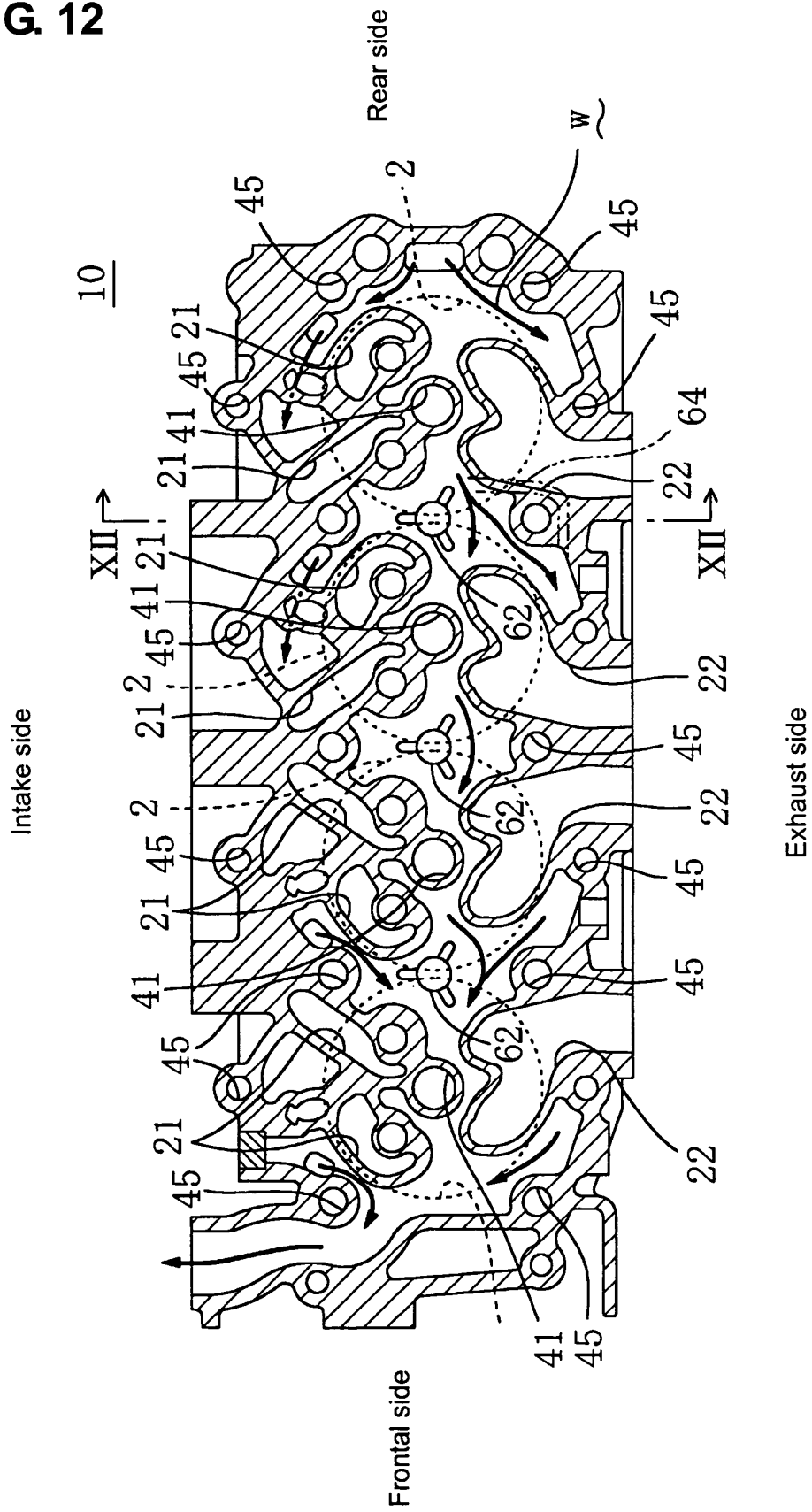


FIG. 13

