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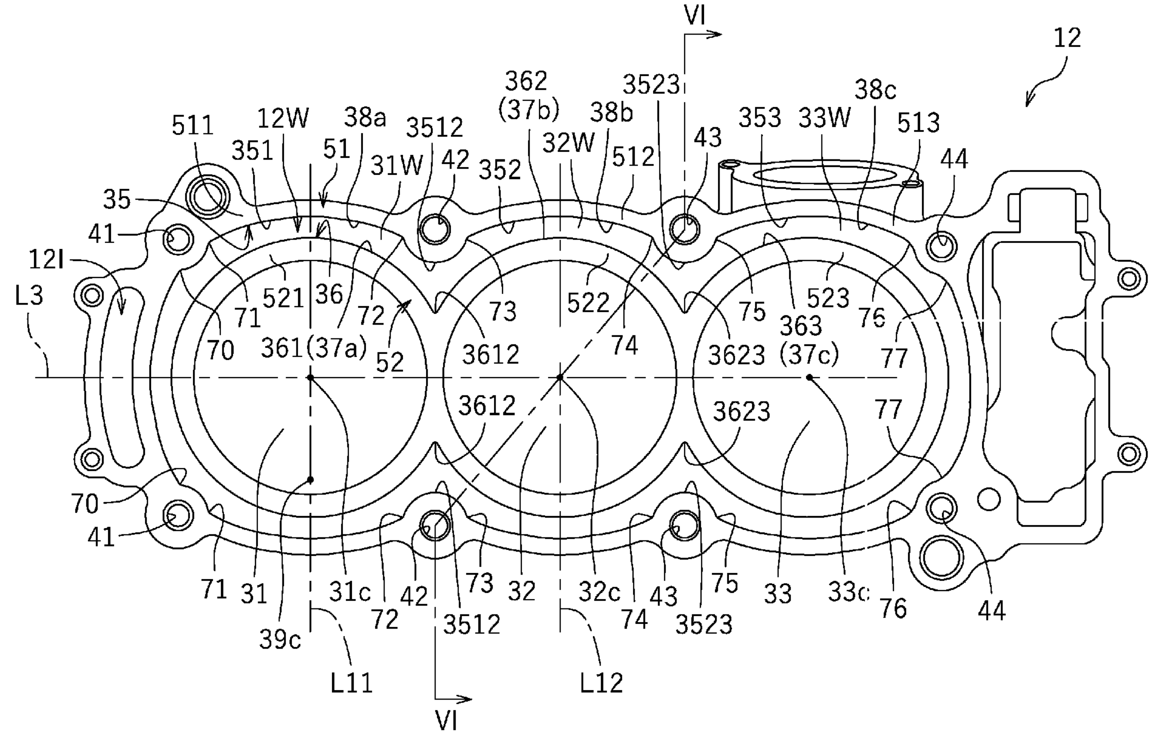
(54) **INTERNAL COMBUSTION ENGINE, STRADDLED VEHICLE, AND METHOD FOR MANUFACTURING INTERNAL COMBUSTION ENGINE**

(57) An internal combustion engine (10) comprises a cylinder body (12) comprising: a first hole (41), into which a bolt is inserted, and a water jacket (12W) formed therein; and a cylinder head that is fastened to the cylinder body (12) by the bolt. As the cylinder body (12) is seen along a cylinder axial line (31c), an outer contour (35) of the water jacket (12W) comprises a first depressed portion (71) that is located radially outward of the first hole (41) and that is depressed in a direction radially outward of a cylinder (31).

FIG.4



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Description

FIELD OF INVENTION

[0001] The present invention relates to an internal combustion engine having a water jacket through which coolant passes, a straddled vehicle, and a method for manufacturing an internal combustion engine.

BACKGROUND TO INVENTION

[0002] Internal combustion engines including a cylinder body having a cylinder, a cylinder head that defines a combustion chamber together with the cylinder, and bolts that fasten together the cylinder head and the cylinder body, have been known in the art. A water-cooled internal combustion engine includes a water jacket through which a coolant flows and which is formed in a portion of the cylinder body around the cylinder (see, for example, JP2011-167706A (Honda Motor Co Ltd)).

[0003] FIG. 13 is a partial cross-sectional view schematically showing an example of a conventional water-cooled internal combustion engine. Designations 201, 202 and 203 denote the cylinder body, the cylinder head and the bolts, respectively. The cylinder body 201 includes a cylinder 204, and a water jacket 205 is formed in a portion of the cylinder body 201 around the cylinder 204. A piston 206 is arranged inside the cylinder 204. The cylinder head 202, the cylinder 204 and the piston 206 together define a combustion chamber 207.

[0004] Although not shown in FIG. 13, a gasket is interposed between the cylinder head 202 and the cylinder body 201. Since the cylinder head 202 and the cylinder body 201 are fastened together by the bolts 203, the cylinder body 201 is in close contact with the cylinder head 202 with the gasket therebetween. The portion of the cylinder body 201 around the cylinder 204 is under a pressure (hereinafter referred to as the surface pressure) from the cylinder head 202.

[0005] An internal combustion engine repeatedly goes through a cycle of intake, compression, combustion and exhaust. During the combustion stroke, the mixture combusts in the combustion chamber 207. This combustion creates a force on the cylinder head 202 in the direction away from the cylinder body 201 (upward in FIG. 13). In other words, the cylinder head 202 is under a force such as to lift the cylinder head 202 off the cylinder body 201. During the process, the surface pressure applied to the portion around the cylinder 204 fluctuates. In order to suppress the fluctuation of the surface pressure, there is a need to increase the fastening force of the bolts 203. However, in order to increase the fastening force of the bolts 203, the bolts 203 need to be designed to have a structure such that it is possible to endure the increased fastening force by, for example, increasing the thickness of the bolts 203, and it is necessary to ensure a sufficient thickness of the cylinder body 201 and the cylinder head 202. As a result, it may lead to an increase in cost and size of the internal combustion engine.

[0006] An object of at least one embodiment of at least one aspect of the present invention may be to obviate or at least mitigate one or more problems and/or disadvantages in the prior art.

[0007] An object of at least one embodiment of at least one aspect of the present invention may be to seek to provide an internal combustion engine including a water jacket formed in a portion of the cylinder body around the cylinder, wherein it may be possible to suppress an increase in cost and size of the internal combustion engine by suppressing the fluctuation of the surface pressure applied to the portion around the cylinder.

SUMMARY OF INVENTION

[0008] According to a first aspect of the present invention there is provided an internal combustion engine which may comprise one or more of the following features.

[0009] A cylinder body may comprise a cylinder. A water jacket may be formed around the cylinder. A first hole may be formed outward of the water jacket in a radial direction of the cylinder and/or may extend parallel to an axial line of the cylinder.

[0010] The internal combustion engine may comprise a cylinder head that may have a hole extending on a center line of the first hole and/or that may cover the cylinder.

[0011] The internal combustion engine may comprise a first bolt that may be inserted into the first hole and the hole of the cylinder head to fasten together the cylinder head and the cylinder body.

[0012] As the cylinder body may be seen along the axial line of the cylinder, the cylinder body may comprise an outer contour that may define an outer side of the water jacket in the radial direction of the cylinder, an inner contour that may define an inner side of the water jacket in the radial direction of the cylinder, a first opposing surface that may be located outward of the outer contour in the radial direction of the cylinder and/or that may oppose the cylinder head, and/or a second opposing surface that may be located inward of the inner contour in the radial direction of the cylinder and/or that may oppose the cylinder head.

[0013] As the cylinder body may be seen along the axial line of the cylinder, the outer contour may comprise a first depressed portion that may be located radially outward of the first hole and/or that may be depressed in a direction radially outward of the cylinder.

[0014] With the internal combustion engine described above, the surface of the cylinder body that opposes the cylinder head may comprise the first opposing surface on the outer side relative to the water jacket and the second opposing surface on the inner side relative to the water jacket. Since the first bolt fastens the cylinder head to the cylinder body, the first opposing surface and the second opposing surface may be under a pressure from the cylinder head. With the internal combustion engine described above, the provision of the first depressed portion may decrease the volume of a portion of the first opposing surface in the vicinity of the first hole and accordingly may decrease the rigidity thereof, as compared with a case where the first depressed portion is absent. Therefore, in the vicinity of the first hole, the rigidity of the second opposing surface may be (relatively) higher than the rigidity of the first opposing surface. In the vicinity of the first hole, the surface pressure between the first opposing surface and the cylinder head may be lower while the surface pressure between the second opposing surface and the cylinder head may be higher. Therefore, it may be possible to suppress the fluctuation of the surface pressure applied to the portion of the cylinder body around the cylinder during the combustion of the mixture. Thus, it may be possible to suppress an increase in cost and size of the internal combustion engine.

[0015] According to one preferred embodiment, the cylinder body may comprise a second hole that may be formed outward of the water jacket in the radial direction of the cylinder and that may extend parallel to the axial line of the cylinder. The internal combustion engine may comprise a second bolt that may be inserted into the second hole to fasten together the cylinder head and the cylinder body. As the cylinder body is seen along the axial line of the cylinder, the outer contour may comprise a second depressed portion that may be located radially outward of the second hole and/or that may be depressed in a direction radially outward of the cylinder. As the cylinder body is seen along the axial line of the cylinder, the inner contour may comprise an arc that may be centered at a center of the cylinder and that may have a first curvature. As the cylinder body is seen along the axial line of the cylinder, a portion of the outer contour between the first depressed portion and the second depressed portion may comprise an arc whose center may be off the center of the cylinder, and that may have a second curvature smaller than the first curvature.

[0016] According to the embodiment described above, the width of the water jacket may be larger and/or the area of the first opposing surface may be smaller, as compared with a case where a portion of the water jacket between the first depressed portion and/or the second depressed portion of the outer contour may be an arc that may be centered at the center of the cylinder. Therefore, the rigidity of the second opposing surface may be relatively high/higher than the rigidity of the first opposing surface. The surface pressure between the first opposing surface and the cylinder head may be lower while the surface pressure between the second opposing surface and the cylinder head may be higher. This further suppresses the fluctuation of the surface pressure applied to the portion of the cylinder body around the cylinder during the combustion of the mixture. Thus, it may be possible to further suppress an increase in cost and size of the internal combustion engine.

[0017] According to one preferred embodiment, as the cylinder body is seen along the axial line of the cylinder, an entirety of a portion of the outer contour between the first depressed portion and the second depressed portion may be an arc whose center may be off the center of the cylinder, and that may have a second curvature smaller than the first curvature.

[0018] According to the embodiment described above, the area of the second opposing surface may increase and the rigidity of the second opposing surface may become relatively higher. Therefore, the surface pressure between the second opposing surface and the cylinder head may further increase. This may further suppress the fluctuation of the surface pressure applied to the portion of the cylinder body around the cylinder during the combustion of the mixture. Thus, it may be possible to further suppress an increase in cost and size of the internal combustion engine.

[0019] According to one preferred embodiment, as the cylinder body is seen along the axial line of the cylinder, an angle between a first straight line, which may connect between the center of the cylinder and the center of the first hole, and a second straight line that may connect between the center of the cylinder and a point along the first depressed portion that may be farthest away from the center of the cylinder may be 5° to 15°.

[0020] According to the embodiment described above, the first depressed portion may be provided in the vicinity of the first hole into which the first bolt may be inserted. The advantageous effects described above may be pronounced as compared with a case where the first depressed portion may be provided far away from the first hole.

[0021] According to one preferred embodiment, as the cylinder body is seen along the axial line of the cylinder, a length, between the cylinder and the water jacket, of a first straight line that connects between the center of the cylinder and the center of the first hole may be longer than a length, between the first hole and the water jacket, of the first straight line.

[0022] According to the embodiment described above, the area of the second opposing surface may be large in the vicinity of the first hole. In the vicinity of the first hole, the rigidity of the second opposing surface may be high, thereby increasing the surface pressure between the second opposing surface and the cylinder head. This may further suppress the fluctuation of the surface pressure applied to the portion of the cylinder body around the cylinder during the combustion of the mixture. Thus, it may be possible to further suppress an increase in cost and size of the internal combustion engine.

[0023] According to one preferred embodiment, on a cross-section of the cylinder body that comprises the center line of the cylinder and the center line of the first hole, a contour of a bottom portion of the water jacket may comprise an outer curve portion that may be located on a side of the first hole and an inner curve portion that may be located on a side of the cylinder. A curvature of the outer curve portion may be smaller than a curvature of the inner curve portion.

[0024] Since the first bolt may be inserted into the first hole, a portion of the cylinder body close to the first hole may be bound by the first bolt. During the combustion of the mixture, a large local stress may occur on the portion close to the first hole. According to the embodiment described above, however, the curve (outer curve portion) of a portion of the bottom portion of the water jacket that may be close to the first hole may be more gentle than the curve (inner curve portion) of a portion thereof that may be close to the cylinder. Therefore, it may be possible to reduce the stress on the portion of the bottom portion of the water jacket that may be close to the first hole. Thus, it may be possible to improve the durability of the cylinder body.

[0025] According to one preferred embodiment, the cylinder body may comprise another cylinder that may extend parallel to the cylinder, and a third hole that may extend parallel to the axial line of the cylinder. The internal combustion engine may comprise a third bolt that may be inserted into the third hole to fasten together the cylinder head and the cylinder body. As the cylinder body is seen along the axial line of the cylinder, a straight line may pass through between the first hole and the second hole, wherein the straight line may pass through the center of the cylinder and/or may be perpendicular to a straight line that may pass through the center of the cylinder and/or a center of the other cylinder. As the cylinder body is seen along the axial line of the cylinder, a straight line may pass through between the second hole and the third hole, wherein the straight line may pass through the center of the other cylinder and/or may be perpendicular to the straight line that connects between the center of the cylinder and the center of the other cylinder. The water jacket may be formed around the cylinder and/or the other cylinder. As the cylinder body is seen along the axial line of the cylinder, the outer contour may comprise a third depressed portion that may be located radially outward of the third hole and/or may be depressed in a direction radially outward of the other cylinder.

[0026] According to the embodiment described above, the advantageous effect(s) described above can be realized for a multi-cylinder internal combustion engine.

[0027] Acording to a second aspect of the present invention there is provided a straddled vehicle comprising an internal combustion engine according to the first aspect of the present invention. The straddled vehicle may comprise a driving wheel that may be linked to the internal combustion engine with a power transmitting member therebetween and/or that may be driven by the internal combustion engine.

[0028] With the straddled vehicle described above, the advantageous effect(s) described above can be realized for an internal combustion engine for driving the driving wheel.

[0029] According to a third aspect of the present invention there is provided a method for manufacturing an internal combustion engine according to the first aspect of the present invention. The method may comprise: preparing a mold that may comprise a water jacket molding portion that may have the same shape as the water jacket and/or that may comprise a cooling passage formed therein; injecting a metal material into the mold; and/or supplying a coolant to flow through the cooling passage, thereby cooling the mold.

[0030] With the manufacturing method described above, a coolant may be supplied to flow through the cooling passage during the molding process, thereby desirably cooling the mold. Therefore, it may be possible to reliably prevent the mold from being burnt, and/or it may be possible to realize a high-quality cylinder body.

[0031] According to one preferred embodiment, the first depressed portion of the cylinder body may be formed next to the cooling passage of the water jacket molding portion.

[0032] According to the embodiment described above, it may be possible to increase the width of the water jacket molding portion for the presence of the first depressed portion. Thus, it may be possible to ensure a sufficient space for the cooling passage. The cooling passage can be formed in the water jacket molding portion without imposing design restrictions.

[0033] According to a fourth embodiment of the present invention there is provided a method for manufacturing an internal combustion engine described above. The method may comprise: preparing a mold that may comprise a water jacket molding portion that may have the same shape as the water jacket and/or that may comprise a first cooling passage and a second cooling passage formed therein; injecting a metal material into the mold; and/or supplying a coolant to flow through the first cooling passage and the second cooling passage, thereby cooling the mold. The first depressed portion of the cylinder body may be formed next to the first cooling passage of the water jacket molding portion, and/or a connecting portion between the cylinder and the other cylinder may be formed next to the second cooling passage of the water jacket molding portion.

[0034] According to the embodiment described above, it may be possible to increase the width of the water jacket molding portion for the presence of the first depressed portion. Thus, it may be possible to ensure a space for the first cooling passage. The first cooling passage can be formed in the water jacket molding portion without imposing design restrictions. With a multi-cylinder internal combustion engine, the connecting portion between cylinders is not easily cooled and is likely to be hot during the molding process. According to the embodiment described above, however, since the second cooling passage is formed next to the connecting portion between cylinders in the water jacket molding portion, it is possible to effectively cool the connecting portion. Therefore, it may be possible to reliably prevent the mold from being burnt, and/or it may be possible to realize a high-quality cylinder body.

[0035] According to the present invention it may be possible to provide an internal combustion engine comprising a water jacket formed in a portion of the cylinder body around the cylinder, wherein it may be possible to suppress an increase in cost and size of the internal combustion engine by suppressing the fluctuation of the surface pressure applied to the portion around the cylinder.

BRIEF DESCRIPTION OF DRAWINGS

[0036] An embodiment of the present invention will now be described, by way of example only, and with reference to the accompanying drawings, which are:

- **FIG. 1** a side view of a motorcycle according to an embodiment of the present invention;
- **FIG. 2** a cross-sectional view of a portion of an internal combustion engine;
- **FIG. 3** a cross-sectional view of a portion of a cylinder body and a cylinder head;
- **FIG. 4** a plan view of the cylinder body;
- **FIG. 5** a plan view of the cylinder body;
- **FIG. 6** a cross-sectional view of the cylinder body and the cylinder head taken along line VI-VI of FIG. 4;
- **FIG. 7** an enlarged cross-sectional view of a portion of the cylinder body;
- **FIG. 8** a plan view of a gasket;
- **FIG. 9** a perspective view of a mold used for manufacturing the cylinder body;
- **FIG. 10** a perspective view drawn so that cooling passages formed inside the mold are visible;
- **FIG. 11** a plan view of the cylinder body with cooling passages drawn;
- **FIG. 12** a plan view of a cylinder body according to a reference example; and
- **FIG. 13** a partial cross-sectional view schematically showing an example of a conventional internal combustion engine.

DESCRIPTION OF DRAWINGS

[0037] An embodiment of the present invention will now be described with reference to the accompanying drawings. FIG. 1 is a side view of a motorcycle 1, which is an example of a straddled vehicle. The motorcycle 1 includes a front wheel 2, a rear wheel 3, an internal combustion engine (hereinafter referred to as "the engine") 10, a handle 4, a fuel tank 5, and a seat 6. The engine 10 is linked to the rear wheel 3 by a power transmitting member such as a chain 7. The rear wheel 3 is a driving wheel that is driven by the engine 10.

[0038] As shown in FIG. 2, the engine 10 ha a crankcase 11, a cylinder body 12 connected to the crankcase 11, a cylinder head 13 connected to the cylinder body 12, and a cylinder head cover 14 connected to the cylinder head 13. The engine 10 is a multi-cylinder engine. In the present embodiment, the engine 10 is a three-cylinder engine having a first cylinder 31, a second cylinder 32 and a third cylinder 33.

[0039] The cylinder head 13 is provided with an ignitor 16, an intake valve (not shown) and an exhaust valve 18. The first to third cylinders 31 to 33 are provided inside the cylinder body 12. A piston 19 is accommodated inside each of the cylinders 31 to 33. The cylinder head 13, the cylinders 31 to 33 and the pistons 19 together define a combustion chamber 58. The piston 19 is linked to a crankshaft 21 by a connecting rod 20. The crankshaft 21 is arranged inside the crankcase 11. The crankshaft 21 extends in a vehicle width direction. A generator 22 is attached to a left end portion of the crankshaft 21. A sprocket 23 is attached to a right end portion of the crankshaft 21. A cam chain 24 is wound around the sprocket 23. The cam chain 24 is also wound around a sprocket 26 attached to a camshaft 25.

[0040] The engine 10 is a water-cooled engine. As shown in FIG. 3, the cylinder body 12 has water jackets 121 and 12W through which coolant passes. The cylinder head 13 also has a water jacket 13W through which the coolant passes. A gasket 28 is interposed between the cylinder body 12 and the cylinder head 13. As will be described later, the gasket 28 has a plurality of holes 28a and 28b (see FIG. 8). The water jacket 12W of the cylinder body 12 and the water jacket 13W of the cylinder head 13 communicate with each other through the holes 28a and 28b of the gasket 28.

[0041] FIG. 4 and FIG. 5 are plan views of the cylinder body 12. Specifically, these figures show the cylinder body 12 as seen along the axial line (hereinafter referred to as the "cylinder axial line") 31c of the first cylinder 31. In the following description, "as shown in FIG. 4" and "as shown in FIG. 5" mean that the cylinder body 12 is seen along the first cylinder axial line 31c. Note that since the first to third cylinders 31 to 33 are arranged parallel to each other, the axial line of the second cylinder 32 and the axial line of the third cylinder 33 are parallel to the cylinder axial line 31c of the first cylinder 31.

[0042] As shown in FIG. 4, the water jacket 12W is formed around the first cylinder 31, the second cylinder 32 and the third cylinder 33. The water jacket 12W has a first water jacket portion 31W around the first cylinder 31, a second water jacket portion 32W around the second cylinder 32, and a third water jacket portion 33W around the third cylinder 33. The first water jacket portion 31W is connected to the second water jacket portion 32W, and the second water jacket portion 32W is connected to the third water jacket portion 33W.

[0043] The water jacket 12W is defined by an outer contour 35 and an inner contour 36. The outer contour 35 has a first outer contour 351 that defines the outer side of the first water jacket portion 31W in the radial direction of the first cylinder 31, a second outer contour 352 that defines the outer side of the second water jacket portion 32W in the radial direction of the second cylinder 32, and a third outer contour 353 that defines the outer side of the third water jacket portion 33W in the radial direction of the third cylinder 33. The inner contour 36 has a first inner contour 361 that defines the inner side of the first water jacket portion 31W in the radial direction of the first cylinder 31, a second inner contour 362 that defines the inner side of the second water jacket portion 32W in the radial direction of the second cylinder 32, and a third inner contour 363 that defines the inner side of the third water jacket portion 33W in the radial direction of the third cylinder 33. Note that designation 3512 denotes a boundary between the first outer contour 351 and the second outer contour 352. Designation 3523 denotes a boundary between the second outer contour 352 and the third outer contour 353. Designation 3612 denotes a boundary between the first inner contour 361 and the second inner contour 362. Designation 3623 denotes a boundary between the second inner contour 362 and the third inner contour 363.

[0044] The cylinder body 12 has first to fourth holes 41 to 44 into which bolts 29 (see FIG. 6) for fastening together the cylinder head 13 and the cylinder body 12 are inserted. The first to fourth holes 41 to 44 extend parallel to the cylinder axial line 31c. As shown in FIG. 6, the cylinder head 13 has a second hole 42A that corresponds to the second hole 42 of the cylinder body 12, and a third hole 43A that corresponds to the third hole 43 of the cylinder body 12. A bolt 29 is inserted into the second hole 42 of the cylinder body 12 and the second hole 42A of the cylinder head 13. Similarly, a bolt 29 is inserted into the third hole 43 of the cylinder body 12 and the third hole 43A of the cylinder head 13. Although not shown in the figure, the cylinder head 13 has a first hole that corresponds to the first hole 41 of the cylinder body 12, and a fourth hole that corresponds to the fourth hole 44 of the cylinder body 12. A bolt 29 is inserted into the first hole 41 of the cylinder body 12 and the first hole of the cylinder head 13. A bolt 29 is inserted into the fourth hole 44 of the cylinder body 12 and the fourth hole of the cylinder head 13. The cylinder head 13 and the cylinder body 12 are fastened together by these bolts 29. Note that the piston 19 is not shown in FIG. 6.

[0045] As shown in FIG. 4, a straight line that passes through centers 31c to 33c of the first to third cylinders 31 to 33 is denoted as L3. A straight line that passes through the center 31c of the first cylinder 31 and is perpendicular to the straight line L3 is denoted as L11. A straight line that passes through the center 32c of the second cylinder 32 and is perpendicular to the straight line L3 is denoted as L12. Then, the straight line L11 passes through between the first hole 41 and the second hole 42. The straight line L12 passes through between the second hole 42 and the third hole 43.

[0046] As shown in FIG. 4, the cylinder body 12 has a first opposing surface 51 that is located outward of the outer contour 35 in the radial direction of the first cylinder 31, and a second opposing surface 52 that is located inward of the inner contour 36 in the radial direction of the first cylinder 31. The first opposing surface 51 has an opposing surface 511 that is located outward of the first outer contour 351 in the radial direction of the first cylinder 31, an opposing surface 512 that is located outward of the second outer contour 352 in the radial direction of the second cylinder 32, and an opposing surface 513 that is located outward of the third outer contour 353 in the radial direction of the third cylinder 33. The second opposing surface 52 has an opposing surface 521 that is located inward of the first inner contour 361 in the radial direction of the first cylinder 31, an opposing surface 522 that is located inward of the second inner contour 362 in the radial direction of the second cylinder 32, and an opposing surface 523 that is located inward of the third inner contour 363 in the radial direction of the third cylinder 33. As shown in FIG. 6, the first opposing surface 51 and the second opposing surface 52 oppose the cylinder head 13. Herein, the gasket 28 is interposed between the cylinder head 13 and the cylinder body 12. The first opposing surface 51 and the second opposing surface 52 oppose the cylinder head 13 with the gasket 28 therebetween. As used herein, "opposing the cylinder head" means both directly opposing the cylinder head and indirectly opposing the cylinder head with a gasket, or the like, therebetween.

[0047] Next, the shapes of the outer contour 35 and the inner contour 36 of the water jacket 12W will be described in detail.

[0048] As shown in FIG. 4, the outer contour 35 has depressed portions 70, 71 and 72 that are located around the first cylinder 31. The depressed portion 71 is located radially outward of the first hole 41 and is depressed in the direction radially outward of the first cylinder 31. The depressed portion 72 is located radially outward of the second hole 42 and is depressed in the direction radially outward of the first cylinder 31. The outer contour 35 has depressed portions 73 and 74 that are located around the second cylinder 32, and depressed portions 75, 76 and 77 that are located around the third cylinder 33. The depressed portion 73 is located radially outward of the second hole 42 and is depressed in the direction radially outward of the second cylinder 32. The depressed portion 74 is located radially outward of the third hole 43 and is depressed in the direction radially outward of the second cylinder 32. The depressed portion 75 is located radially outward of the third hole 43 and is depressed in the direction radially outward of the third cylinder 33. The depressed portions 76 and 77 are located radially outward of the fourth hole 44 and are depressed in the direction radially outward of the third cylinder 33. Note that in the following description, the depressed portions 71, 72 and 74 may be referred to as the first depressed portion, the second depressed portion and the third depressed portion, respectively.

[0049] As the cylinder body 12 is seen along the cylinder axial line 31c, the center of the cylinder 31 coincides with the cylinder axial line 31c. Therefore, in the following description, the same designation 31c as the cylinder axial line will be used for the center of the cylinder 31. As shown in FIG. 5, a straight line that connects between the center 31c of the cylinder 31 and a center 41c of the first hole 41 is denoted as a first straight line L1. A straight line that connects between the center 31c of the cylinder 31 and a point along the first depressed portion 71 that is farthest away from the center 31c of the cylinder 31 is denoted as a second straight line L2. In the present embodiment, the angle θ between the first straight line L1 and the second straight line L2 is 5° to 15°. The first depressed portion 71 is provided in the vicinity of the first hole 41. Note, however, that the value of the angle θ above is merely an example, and there is no particular limitation thereto.

[0050] As shown in FIG. 4, the first inner contour 361 is an arc 37a that is centered at the center 31c of the cylinder 31 and that has a first curvature. While the arc 37a may be only a portion of the first inner contour 361, the arc 37a is herein the entirety of the first inner contour 361.

[0051] A portion of the first outer contour 351 between the first depressed portion 71 and the second depressed portion 72 is an arc 38a whose center 39c is off the center 31c of the cylinder 31, and that has a second curvature smaller than the first curvature. For example, in the upper half of FIG. 4, the arc 38a of the first outer contour 351 is located upward of the arc 37a of the first inner contour 361, and the center 39c of the arc 38a is located downward of the center 31c of the arc 37a. While the arc 38a may be only a portion of the first outer contour 351 that is between the first depressed portion 71 and the second depressed portion 72, the arc 38a is herein the entirety of the first outer contour 351 between the first depressed portion 71 and the second depressed portion 72.

[0052] The positional relationship between the second inner contour 362 and the second outer contour 352 and the positional relationship between the third inner contour 363 and the third outer contour 353 are similar to the positional relationship between the first inner contour 361 and the first outer contour 351. A portion or whole of the second inner contour 362 is an arc 37b that is centered at the center 32c of the second cylinder 32 and that has the first curvature. A portion or whole of the third inner contour 363 is an arc 37c that is centered at the center 33c of the third cylinder 33 and that has the first curvature. A portion or whole of the second outer contour 352 between the depressed portion 73 and the depressed portion 74 is an arc 38b whose center is off the center 32c of the second cylinder 32 and that has the second curvature. A portion or whole of the third outer contour 353 between the depressed portion 75 and the depressed portion 76 is an arc 38c whose center is off the center 33c of the third cylinder 33 and that has the second curvature.

[0053] As shown in FIG. 5, the length N1 of the first straight line L1 between the first cylinder 31 and the water jacket 12W is longer than the length N2 thereof between the first hole 41 and the water jacket 12W. In the vicinity of the first hole 41, the area of the second opposing surface 52 is relatively large.

[0054] FIG. 7 is a partial cross-sectional view of the cylinder body 12 taken along the first straight line L1. On a cross-section of the cylinder body 12 that includes the first straight line L1, a contour 55 of the bottom portion of the water jacket 12W has an outer curve portion 55a that is located on the side of the first hole 41 and an inner curve portion 55b that is located on the side of the first cylinder 31. The outer curve portion 55a is more gently curved than the inner curve portion 55b. The curvature of the outer curve portion 55a is smaller than the curvature of the inner curve portion 55b. Note that the curvature of the outer curve portion 55a and the curvature of the inner curve portion 55b may each be constant or not constant. Where the curvature of the outer curve portion 55a and the curvature of the inner curve portion 55b are not constant, they refer to the mean curvature of the outer curve portion 55a and the mean curvature of the inner curve portion 55b.

[0055] FIG. 8 is a plan view of the gasket 28. The gasket 28 has holes 31h to 33h that correspond to the first to third cylinders 31 to 33, and first to fourth holes 41h to 44h into which the bolts 29 are inserted. The gasket 28 also has the holes 28a and 28b through which the coolant passes. The hole 28a is arranged over the water jacket 121 of the cylinder body 12. The holes 28b are arranged over the water jacket 12W of the cylinder body 12. The coolant in the water jacket 121 flows into the water jacket 13W of the cylinder head 13 (see an arrow in FIG. 3) through the hole 28a. The coolant in the water jacket 13W flows into the water jacket 12W of the cylinder body 12 (see arrows in FIG. 3) through the holes 28b. The cylinder body 12 and the cylinder head 13 are cooled by the coolant flowing through the water jacket 121, the water jacket 13W and the water jacket 12W in this order.

[0056] The engine 10 is configured as described above. As described above, the cylinder head 13 is fastened to the cylinder body 12 by the bolts 29 (see FIG. 6). The first opposing surface 51 and the second opposing surface 52 of the cylinder body 12 are pressed against the cylinder head 13. The first opposing surface 51 and the second opposing surface 52 are under a pressure from the cylinder head 13 (hereinafter referred to as the surface pressure). The engine 10 repeatedly goes through a cycle of intake, compression, combustion and exhaust. During the combustion stroke, the mixture of fuel and air combusts in the combustion chamber 58. This combustion creates a force such as to lift the cylinder head 13 off the cylinder body 12. During this process, the surface pressure applied to the first opposing surface 51 and the second opposing surface 52 fluctuates. One possible way to suppress the fluctuation of the surface pressure is to increase the fastening force of the bolts 29. However, in order to increase the fastening force of the bolts 29, the cylinder body 12 and the cylinder head 13 need to be designed so that they can endure such an increased fastening force. Without some countermeasures, this will lead to an increase in cost and size of the engine 10.

[0057] According to the present embodiment, however, the outer contour 35 of the water jacket 12W has the depressed portions 70 to 77 as the cylinder body 12 is seen along the cylinder axial line 31c as shown in FIG. 4. The outer contour 35 of the water jacket 12W is partially depressed in the vicinity of the first to fourth holes 41 to 44 into which the bolts 29 are inserted. Therefore, as compared with a case where the depressed portions 70 to 77 are absent, the area of the first opposing surface 51 is smaller in the vicinity of the first to fourth holes 41 to 44. In the vicinity of the first to fourth holes 41 to 44, the ratio of the area of the second opposing surface 52 with respect to the total area of the first opposing surface 51 and the second opposing surface 52 is larger as compared with a case where the depressed portions 70 to 77 are absent. Therefore, with the engine 10 according to the present embodiment, the rigidity of the second opposing surface 52 is relatively larger than the rigidity of the first opposing surface 51. Thus, the surface pressure between the first opposing surface 51 and the cylinder head 13 decreases, but the surface pressure between the second opposing surface 52 and the cylinder head 13 increases. Therefore, it is possible to suppress the fluctuation of the surface pressure applied to portions of the cylinder body 12 around the first to third cylinders 31 to 33 during the combustion of the mixture. According to the present embodiment, since it is possible to suppress the fluctuation of the surface pressure of the cylinder body 12, there is no need to increase the fastening force of the bolts 29 as compared with conventional techniques. A fastening force of the bolts 29 similar to those of conventional techniques is sufficient. Therefore, it is possible to suppress an increase in cost and size of the engine 10.

[0058] According to the present embodiment, a portion of the outer contour 35 of the water jacket 12W between the first depressed portion 71 and the second depressed portion 72 is the arc 38a whose center 39c is off the center 31c of the cylinder 31 as the cylinder body 12 is seen along the cylinder axial line 31c as shown in FIG. 4. Moreover, the curvature of the arc 38a (the second curvature) is smaller than the curvature of the arc 37a of the inner contour 36 (the first curvature). Therefore, the width of the water jacket 12W increases and the area of the first opposing surface 51 decreases, as compared with a case where a portion of the outer contour 35 that is between the first depressed portion 71 and the second depressed portion 72 is an arc that is centered at the center 31c of the cylinder 31 and that has the first curvature. This further relatively increases the rigidity of the second opposing surface 52 and further increases the surface pressure between the second opposing surface 52 and the cylinder head 13. Therefore, it is possible to further suppress an increase in cost and size of the engine 10.

[0059] While there is no particular limitation on the position of the first depressed portion 71 of the outer contour 35, the position is such that the angle θ is 5° to 15°, wherein θ is the angle between the first straight line L1 that connects between the center 31c of the first cylinder 31 and the center 41c of the first hole 41 and the second straight line L2 that connects between the center 31c of the first cylinder 31 and a point along the first depressed portion 71 that is farthest away from the center 31c of the first cylinder 31 as the cylinder body 12 is seen along the cylinder axial line 31c as shown in FIG. 5 in the present embodiment. The provision of the first depressed portion 71 near the first hole 41 enhances the advantageous effects described above. Note that this similarly applies also to the other depressed portions 70 and 72 to 77.

[0060] According to the present embodiment, the length N1 of the first straight line L1 between the first cylinder 31 and the water jacket 12W is longer than the length N2 thereof between the first hole 41 and the water jacket 12W as the cylinder body 12 is seen along the cylinder axial line 31c as shown in FIG. 5. In the vicinity of the first hole 41, the area of the second opposing surface 52 is larger. This increase the rigidity of the second opposing surface 52 and the surface pressure between the second opposing surface 52 and the cylinder head 13 in the vicinity of the first hole 41. Therefore, it is possible to further suppress an increase in cost and size of the engine 10. Note that although the description is omitted, this similarly applies also to portions in the vicinity of the other holes 42 to 44.

[0061] According to the present embodiment, as shown in FIG. 7, on a cross-section of the cylinder body 12 that includes the cylinder axial line 31c and the center line 41c of the first hole 41, the contour 55 of the bottom portion of the water jacket 12W includes the outer curve portion 55a that is located on the side of the first hole 41 and the inner curve portion 55b that is located on the side of the first cylinder 31. Since the bolt 29 is inserted in the first hole 41, a portion of the cylinder body 12 that is close to the first hole 41 is bound by the bolt 29. During the combustion of the mixture, there may occur a large local stress on a portion that is close to the first hole 41. According to the present embodiment, however, the curvature of the outer curve portion 55a is smaller than the curvature of the inner curve portion 55b. The curve of a portion of the bottom portion of the water jacket 12W that is close to the first hole 41 is more gentle than the curve of a portion thereof that is close to the cylinder 31. Therefore, it is possible to reduce the stress on the portion of the bottom portion of the water jacket 12W that is close to the first hole 41. Thus, it is possible to improve the durability of the cylinder body 12.

[0062] The engine 10 is manufactured by manufacturing the cylinder body 12 and the cylinder head 13, and fastening the cylinder body 12 and the cylinder head 13 together by the bolts 29. Although there is no particular limitation on the method for manufacturing the cylinder body 12, it can be manufactured as follows, for example.

[0063] First, a mold 112 is prepared. As shown in FIG. 9, the mold 112 has cylinder molding portions 131 to 133 having the same shape as the first to third cylinders 31 to 33, water jacket molding portions 1121 and 112W having the same shape as the water jackets 121 and 12W, and bolt hole molding portions 141 to 144 having the same shape as the first to fourth holes 41 to 44. Although not shown in FIG. 9, cooling passages, through which a coolant such as water flows, are formed inside the water jacket molding portion 112W and the bolt hole molding portions 141 to 144. FIG. 10 is a perspective view drawn so that cooling passages 101 and 102 formed inside the water jacket molding portion 112W and cooling passages 103 formed inside the bolt hole molding portions 141 to 144 are visible. In the following description, the cooling passages 101 and 102 may be referred to as the first cooling passage and the second cooling passage, respectively.

[0064] When manufacturing the cylinder body 12, the mold 112 is prepared, and then a metal material is injected into the mold 112. Note that there is no particular limitation on the metal material, and the metal material may be any of various metal materials known in the art, e.g. aluminium. Then, a coolant is supplied to flow through the cooling passages 101 to 103, thereby cooling the mold 112 and the metal material. Note that as to when to start supplying the coolant through the cooling passages 101 to 103, it may be before, during or after the process of injecting a metal material into the mold 112. Thus, it is possible to mold the cylinder body 12 while cooling the mold 112.

[0065] FIG. 11 is a plan view of the cylinder body 12, showing the positions of the first cooling passages 101 and the second cooling passages 102. The first cooling passages 101 are formed next to the depressed portions 70 to 77. The second cooling passages 102 are formed next to the connecting portion between the first cylinder 31 and the second cylinder 32 and the connecting portion between the second cylinder 32 and the third cylinder 33.

[0066] Now, in order to form cooling passages inside the mold 112, there is a need for space for cooling passages. However, since the width of the water jacket 12W is relatively small, the width of the water jacket molding portion 112W is small. FIG. 12 is a plan view of a cylinder body (reference example) having no depressed portions 70 to 77 along the outer contour 35 of the water jacket 12W. Where the depressed portions 70 to 77 are absent, the width K1 is large in the vicinity of the boundary 3612 between the inner contour 361 and the inner contour 362 and in the vicinity of the boundary 3623 between the inner contour 362 and the inner contour 363, but the width K2 is small in other areas. Therefore, when the depressed portions 70 to 77 are absent, cooling passages can be provided only in the vicinity of the boundary 3612 and in the vicinity of the boundary 3623. Cooling passages can be provided next to only the connecting portion between the first cylinder 31 and the second cylinder 32 and the connecting portion between the second cylinder 32 and the third cylinder 33.

[0067] According to the present embodiment, however, as shown in FIG. 11, the outer contour 35 of the water jacket 12W has the depressed portions 70 to 77. Therefore, the width K3 of the water jacket 12W is large in the vicinity of the depressed portions 70 to 77. Thus, it is possible not only to provide the second cooling passages 102 next to the connecting portion between the first cylinder 31 and the second cylinder 32 and the connecting portion between the second cylinder 32 and the third cylinder 33, but also to provide the first cooling passages 101 in the vicinity of the depressed portions 70 to 77. Thus, it is possible to increase the number of cooling passages. This increases the amount of the coolant that can be supplied during the molding process, allowing the mold 112 to be cooled more effectively. According to the present embodiment, it is possible to more reliably prevent the mold 112 from being burnt during the molding process. Therefore, it is possible to desirably mold the cylinder body 12.

[0068] Note that the temperature of the mold 112 is likely to be particularly high at the connecting portion between the first cylinder 31 and the second cylinder 32 and the connecting portion between the second cylinder 32 and the third cylinder 33. According to the present embodiment, however, the first cooling passages 101 and the second cooling passages 102 are provided in the vicinity of the connecting portion between the first cylinder 31 and the second cylinder 32 and in the vicinity of the connecting portion between the second cylinder 32 and the third cylinder 33. According to the present embodiment, it is possible to effectively cool portions that are likely to be particularly hot during the molding process. Therefore, it is possible to desirably mold the cylinder body 12.

[0069] Although one embodiment has been described above, the embodiment described above is merely an example, and various other embodiments are possible.

[0070] In the embodiment described above, the depressed portions 70 to 77 are provided in the vicinity of all of the holes 41 to 44 into which the bolts 29 are inserted to fasten together the cylinder body 12 and the cylinder head 13. However, the depressed portions of the outer contour 35 do not always need to be provided in the vicinity of all of the holes 41 to 44. The depressed portions of the outer contour 35 may be provided in the vicinity of only some of the holes.

[0071] In the embodiment described above, the length N1 of the first straight line L1 between the cylinder 31 and the water jacket 12W is longer than the length N2 thereof between the first hole 41 and the water jacket 12W as the cylinder body 12 is seen along the cylinder axial line 31c as shown in FIG. 5. However, there is no limitation thereto. N1 may be equal to N2. N1 may be shorter than N2.

[0072] In the embodiment described above, as shown in FIG. 7, the contour 55 of the bottom portion of the water jacket 12W has the outer curve portion 55a and the inner curve portion 55b, and the curvature of the outer curve portion 55a is smaller than the curvature of the inner curve portion 55b. However, there is no limitation thereto. The curvature of the outer curve portion 55a may be equal to the curvature of the inner curve portion 55b. The curvature of the outer curve portion 55a may be larger than the curvature of the inner curve portion 55b.

[0073] The engine 10 according to the embodiment described above is a multi-cylinder engine including three cylinders 31 to 33. However, the number of cylinders of the engine 10 is not limited to three. The number of cylinders may be two or four or more. The engine 10 may be a single-cylinder engine including only one cylinder.

[0074] The motorcycle 1 according to the embodiment described above is an example of a straddled vehicle. A straddled vehicle refers to a vehicle that is straddled by a passenger. However, the straddled vehicle is not limited to the motorcycle 1. For example, the straddled vehicle may be an auto tricycle, an ATV (All Terrain Vehicle), or a snowmobile.

REFERENCE SIGNS LIST

[0075]

1	Motorcycle (straddled vehicle)
3	Rear wheel (driving wheel)
7	Chain (power transmitting member)
10	Internal combustion engine
12	Cylinder body
12W	Water jacket
13	Cylinder head
29	Bolt
31	First cylinder (cylinder)
32	Second cylinder (another cylinder)
35	Outer contour
36	Inner contour
37a	Arc having first curvature
38a	Arc having second curvature
41	First hole
42	Second hole
43	Third hole
51	First opposing surface
52	Second opposing surface
55	Contour of bottom portion of water jacket
55a	Outer curve portion
55b	Inner curve portion
71	First depressed portion
72	Second depressed portion
74	Third depressed portion
101	First cooling passage
102	Second cooling passage
112	Mold
112W	Water jacket molding portion

Claims

1. An internal combustion engine (10) comprising:

a cylinder body (12) comprising a cylinder (31), a water jacket (12W) formed around the cylinder (31), a first hole (41) that is formed outward of the water jacket (12W) in a radial direction of the cylinder (31) and that extends parallel to an axial line (31c) of the cylinder (31);

a cylinder head (13) that comprises a hole extending on a center line (41c) of the first hole (41) and that covers the cylinder (31); and

a first bolt (29) that is inserted into the first hole (41) and the hole of the cylinder head (13) to fasten together the cylinder head (13) and the cylinder body (12), wherein:

as the cylinder body (12) is seen along the axial line (31c) of the cylinder (31), the cylinder body (12) comprises an outer contour (35) that defines an outer side of the water jacket (12W) in the radial direction of the cylinder (31), an inner contour (36) that defines an inner side of the water jacket (12W) in the radial direction of the cylinder (31), a first opposing surface (51) that is located outward of the outer contour (35) in the radial direction of the cylinder (31) and that opposes the cylinder head (13), and a second opposing surface (52) that is located inward of the inner contour (36) in the radial direction of the cylinder (31) and that opposes the cylinder head (13); and

as the cylinder body (13) is seen along the axial line (31c) of the cylinder (31), the outer contour (35) comprises a first depressed portion (71) that is located radially outward of the first hole (41) and that is depressed in a direction radially outward of the cylinder (31).

2. The internal combustion engine (10) according to claim 1, wherein:

the cylinder body (12) comprises a second hole (42) that is formed outward of the water jacket (12W) in the radial direction of the cylinder (31) and that extends parallel to the axial line (31c) of the cylinder (31);

the internal combustion engine (10) comprises a second bolt (29) that is inserted into the second hole (42) to fasten together the cylinder head (13) and the cylinder body (12);

as the cylinder body (12) is seen along the axial line (31c) of the cylinder (31), the outer contour (35) comprises a second depressed portion (72) that is located radially outward of the second hole (42) and that is depressed in a direction radially outward of the cylinder (31);

as the cylinder body (12) is seen along the axial line (31c) of the cylinder (31), the inner contour (36) comprises an arc (37a) that is centered at a center (31c) of the cylinder (31) and that has a first curvature; and as the cylinder body (12) is seen along the axial line (31c) of the cylinder (31), a portion of the outer contour (35) between the first depressed portion (71) and the second depressed portion (72) comprises an arc (38a) whose center (39c) is off the center (31c) of the cylinder (31), and that has a second curvature smaller than the first curvature.

3. The internal combustion engine (10) according to claim 1, wherein as the cylinder body (12) is seen along the axial line (31c) of the cylinder (31), an entirety of a portion of the outer contour (35) between the first depressed portion (71) and the second depressed portion (72) is an arc (38a) whose center (39c) off the center (31c) of the cylinder (31), and that has a second curvature smaller than the first curvature.

4. The internal combustion engine (10) according to any one of claims 1 to 3, wherein as the cylinder body (12) is seen along the axial line (31c) of the cylinder (31), an angle (θ) between a first straight line (L1), which connects between the center (31c) of the cylinder (31) and the center (41c) of the first hole (41), and a second straight line (L2) that connects between the center (31c) of the cylinder (31) and a point along the first depressed portion (71) that is farthest away from the center (31c) of the cylinder (31) is 5° to 15°.

5. The internal combustion engine (10) according to any one of claims 1 to 4, wherein as the cylinder body (12) is seen along the axial line (31c) of the cylinder (31), a length (N1), between the cylinder (31) and the water jacket (12W), of a first straight line (L1) that connects between the center (31c) of the cylinder (31) and the center (41c) of the first hole (41) is longer than a length (N2), between the first hole (41) and the water jacket (12W), of the first straight line (L1).

6. The internal combustion engine (10) according to any one of claims 1 to 5, wherein:

on a cross-section of the cylinder body (12) that comprises the center line (31c) of the cylinder (31) and the center line (41c) of the first hole (41), a contour (55) of a bottom portion of the water jacket (12W) comprises an outer curve portion (55a) that is located on a side of the first hole (41) and an inner curve portion (55b) that is located on a side of the cylinder (31); and
a curvature of the outer curve portion (55a) is smaller than a curvature of the inner curve portion (55b).

7. The internal combustion engine (10) according to any one of claims 1 to 6, wherein:

the cylinder body (12) comprises another cylinder (32) that extends parallel to the cylinder (31), and a third hole (43) that extends parallel to the axial line (31c) of the cylinder (31);
the internal combustion engine (10) comprises a third bolt (29) that is inserted through the third hole (43) to fasten together the cylinder head (13) and the cylinder body (12);
as the cylinder body (12) is seen along the axial line (31c) of the cylinder (31), a straight line (L11) passes through between the first hole (41) and the second hole (42), wherein the straight line (L11) passes through the center (31c) of the cylinder (31) and is perpendicular to a straight line (L3) that passes through the center (31c) of the cylinder (31) and a center (32c) of the other cylinder (32);
as the cylinder body (12) is seen along the axial line (31c) of the cylinder (31), a straight line (L12) passes through between the second hole (42) and the third hole (43), wherein the straight line (L12) passes through the center (32c) of the other cylinder (32) and is perpendicular to the straight line (L3) that connects between the center (31c) of the cylinder (31) and the center (32c) of the other cylinder (32);
the water jacket (12W) is formed around the cylinder (31) and the other cylinder (32); and
as the cylinder body (12) is seen along the axial line (31c) of the cylinder (31), the outer contour (35) includes a third depressed portion (74) that is located radially outward of the third hole (43) and is depressed in a direction radially outward of the other cylinder (32).

8. A straddled vehicle (1) comprising:

the internal combustion engine (10) according to any one of claims 1 to 7; and
a driving wheel (3) that is linked to the internal combustion engine (10) with a power transmitting member (7) therebetween and that is driven by the internal combustion engine (10).

9. A method for manufacturing an internal combustion engine (10) according to any of claims 1 to 7, the method comprising:

preparing a mold (112) comprising a water jacket molding portion (112W) that has the same shape as the water jacket (12W) and that comprises a cooling passage (101) formed therein;
injecting a metal material into the mold (112); and
supplying a coolant to flow through the cooling passage (101), thereby cooling the mold (112).

10. The method for manufacturing an internal combustion engine (10) according to claim 9, wherein the first depressed portion (71) of the cylinder body (12) is formed next to the cooling passage (101) of the water jacket molding portion (112W).

11. The method for manufacturing an internal combustion engine (10) according to claim 7, the method comprising:

preparing a mold (112) comprising a water jacket molding portion (112W) that has the same shape as the water jacket (12W) and that comprises a first cooling passage (101) and a second cooling passage (102) formed therein;
injecting a metal material into the mold (112); and
supplying a coolant to flow through the first cooling passage (101) and the second cooling passage (102), thereby cooling the mold (112), wherein:

the first depressed portion (71) of the cylinder body (12) is formed next to the first cooling passage (101) of the water jacket molding portion (112W); and
a connecting portion between the cylinder (31) and the other cylinder (32) is formed next to the second cooling passage (102) of the water jacket molding portion (112W).

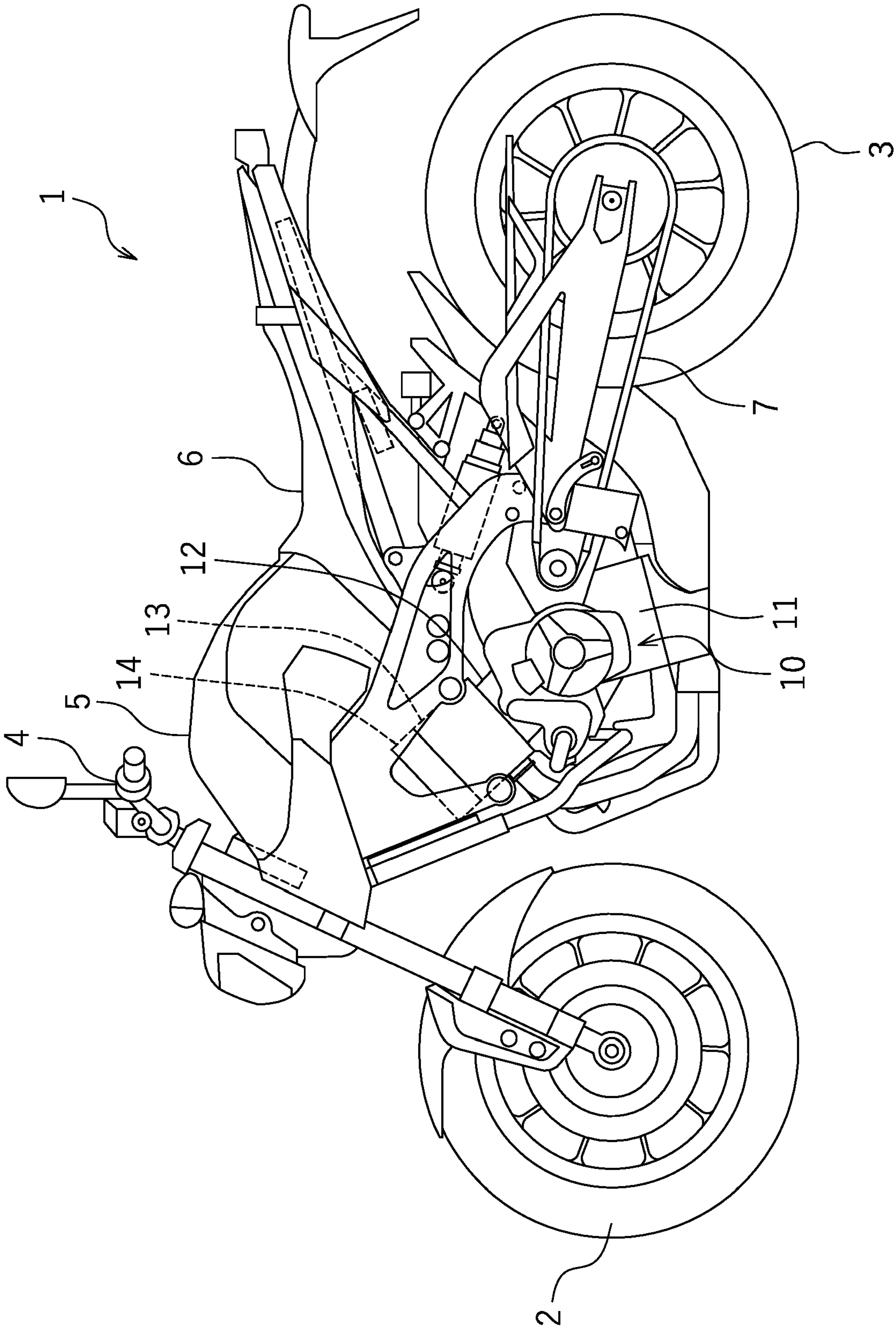
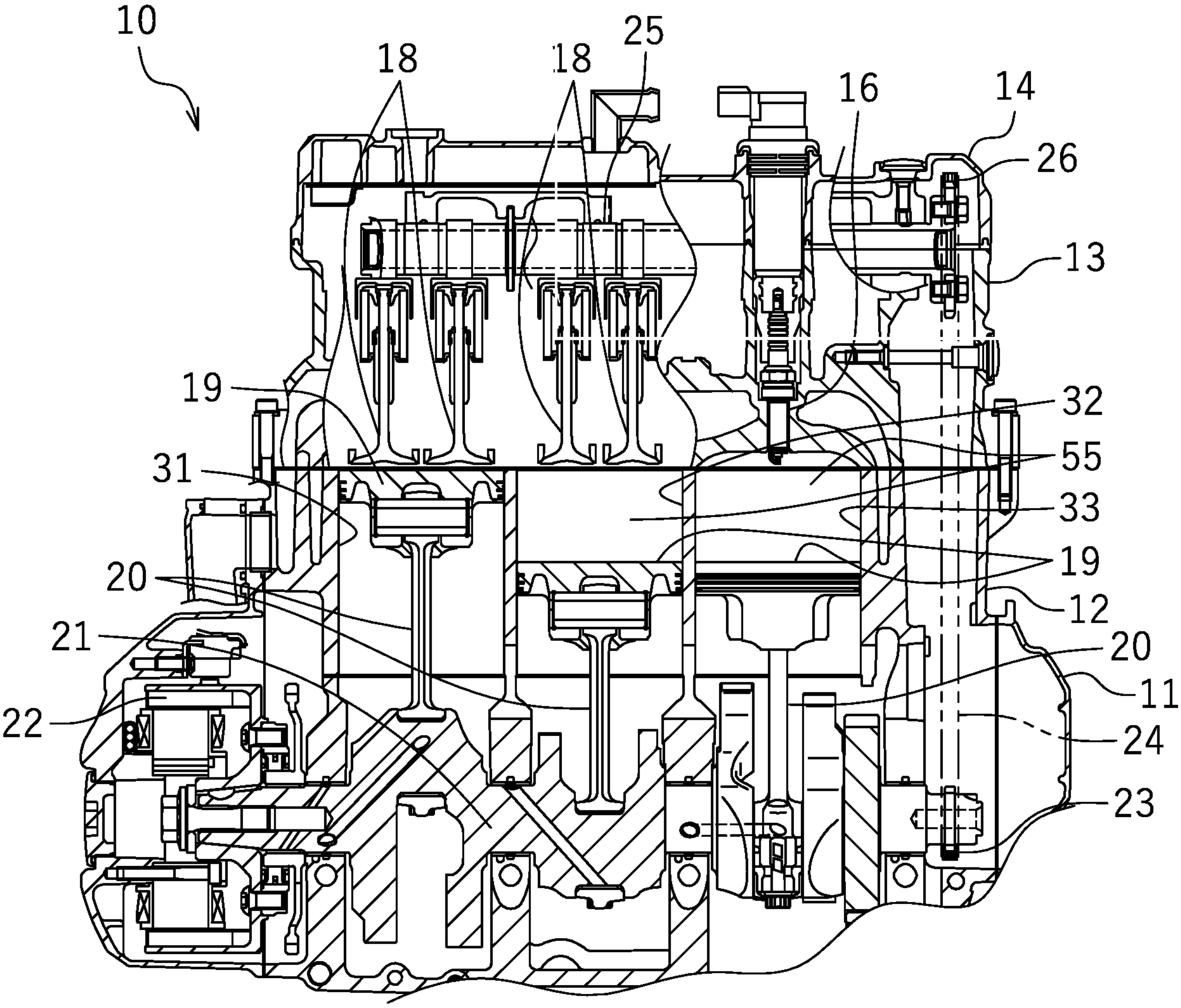


FIG.1

FIG.2



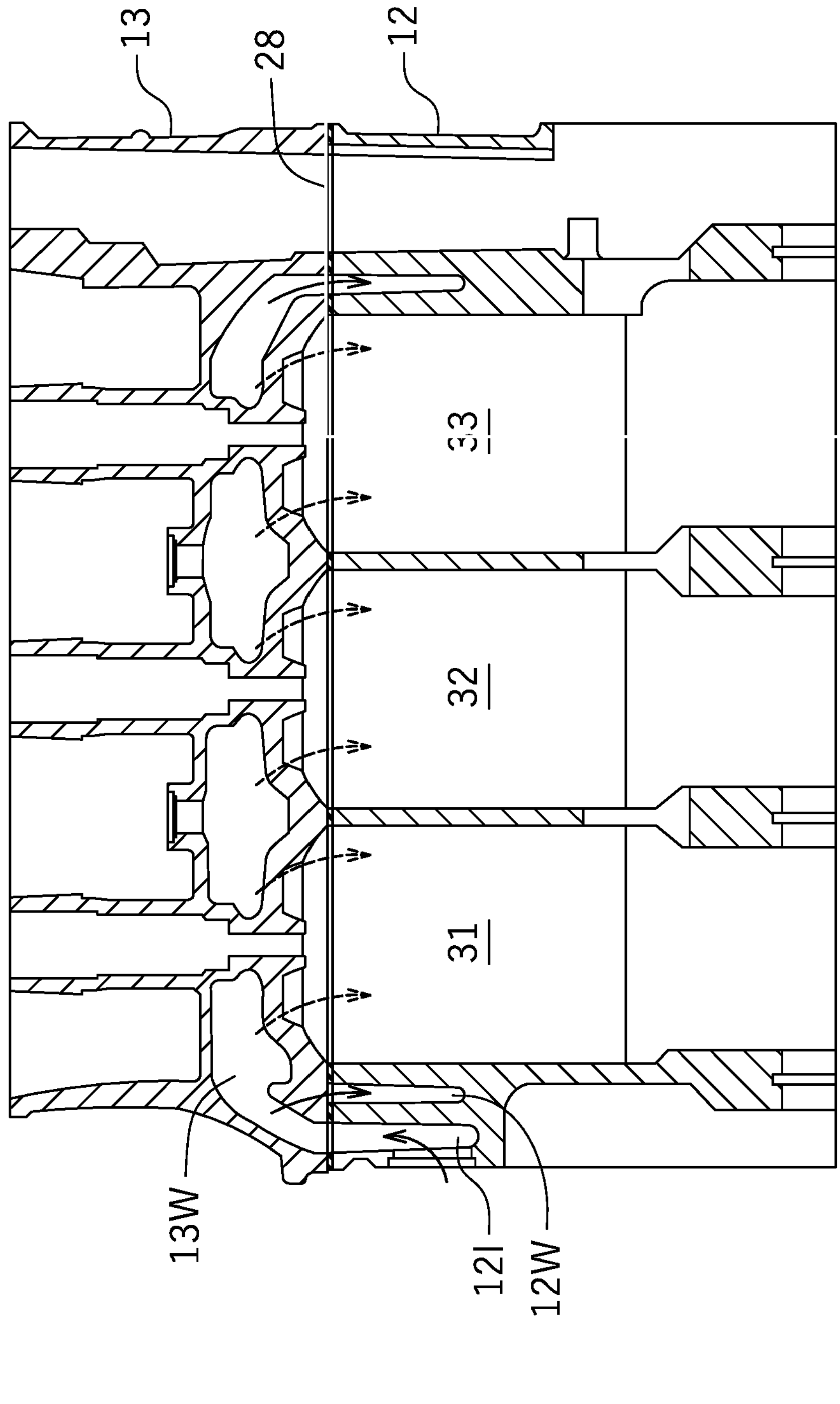
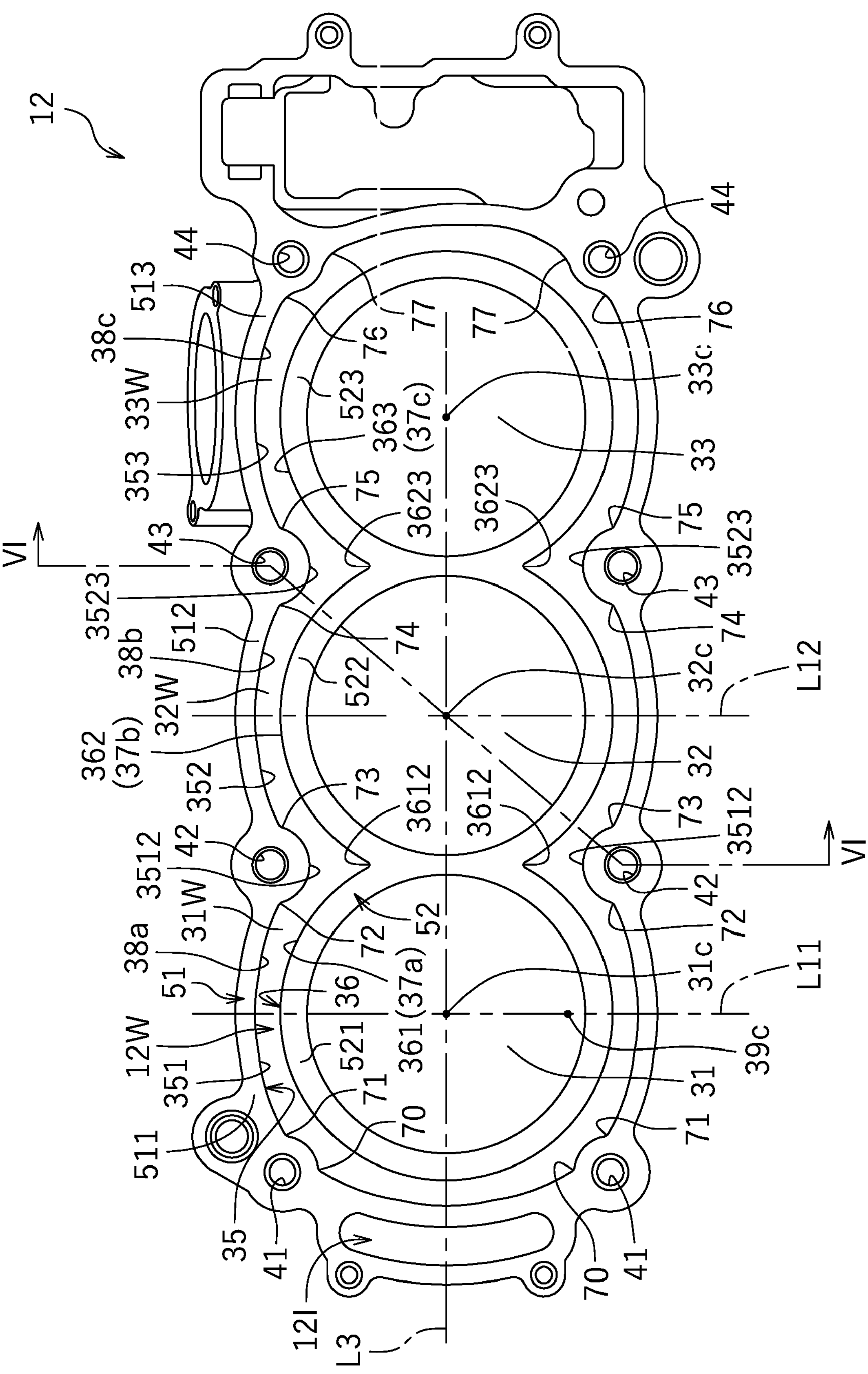


FIG.3


12
44
513
38c
33W
353
43
3523
512
38b
32W
362
(37b)
352
42
3512
31W
38a
51
12W
351
511
35
41
12I
L3
77
76
523
363
(37c)
3623
75
74
522
73
3612
72
52
36
361
(37a)
521
71
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33c
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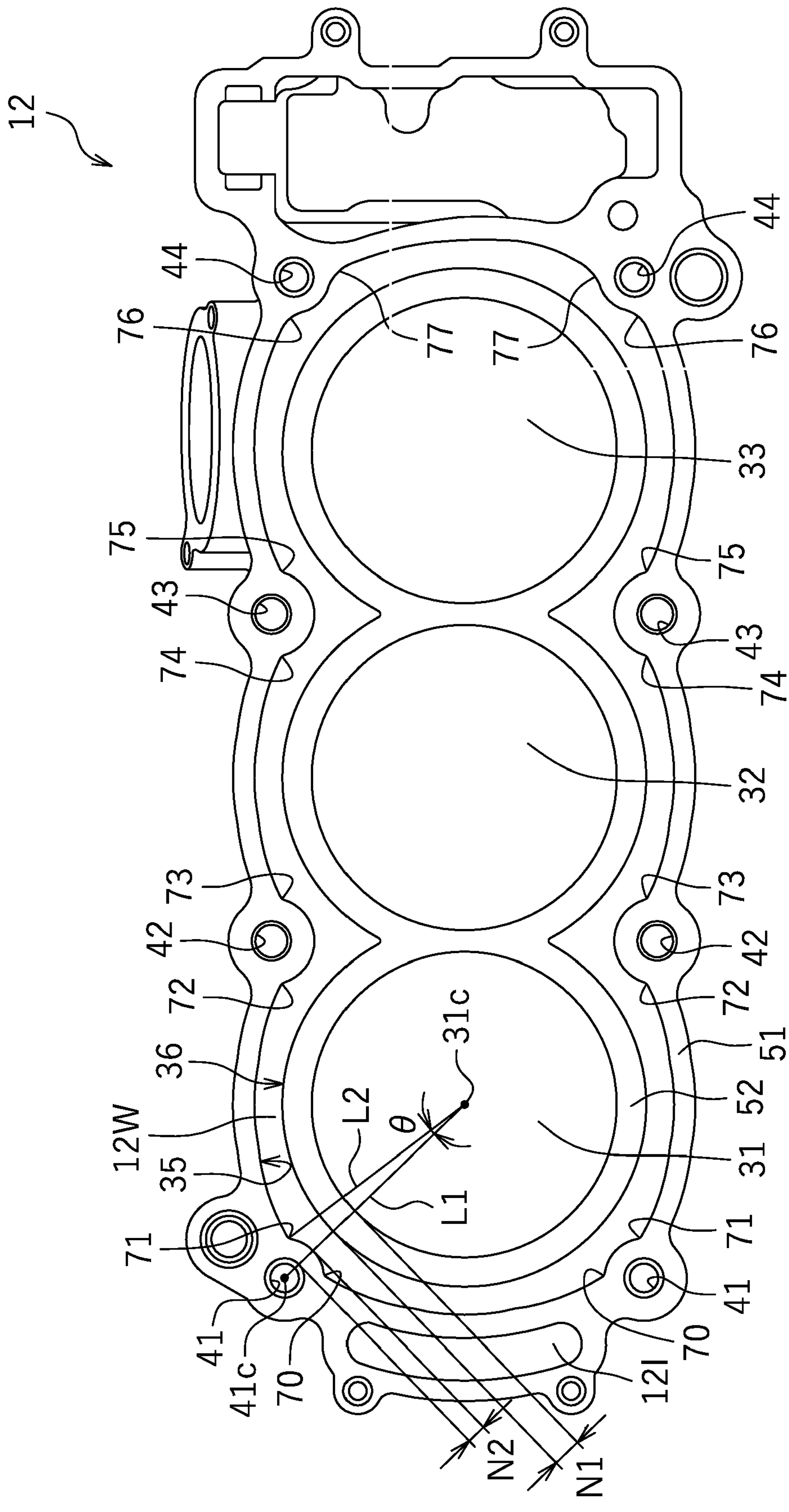
32c
L12
32
31c
L11
39c
31
VI
VI

FIG.4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44
76
76
77
77
33
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43
43
74
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32
73
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72
51
36
52
12W
31c
L2
θ
31
35
L1
71
71
41
41
41c
70
70
12I
N2
N1

FIG.5

FIG.6

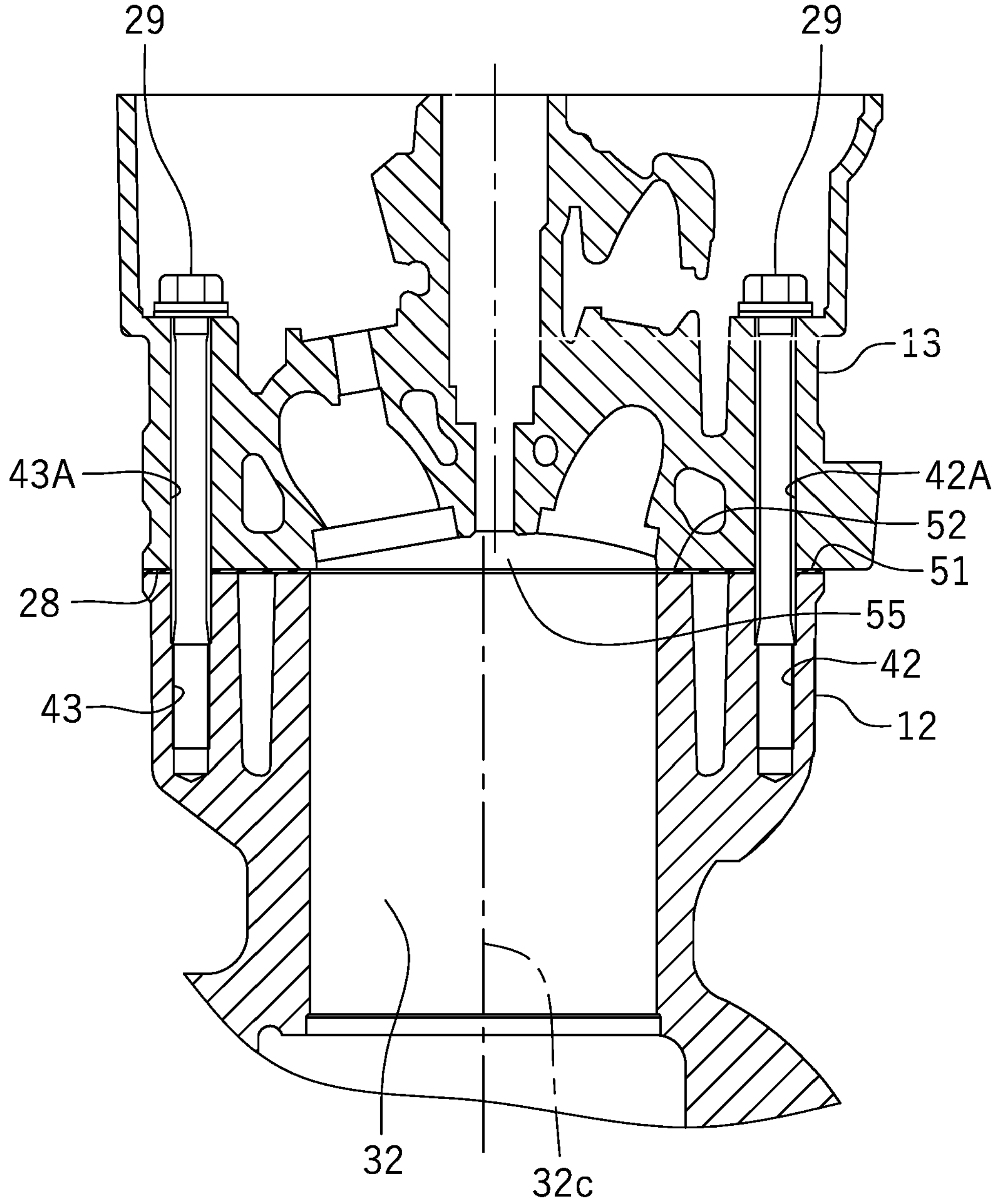
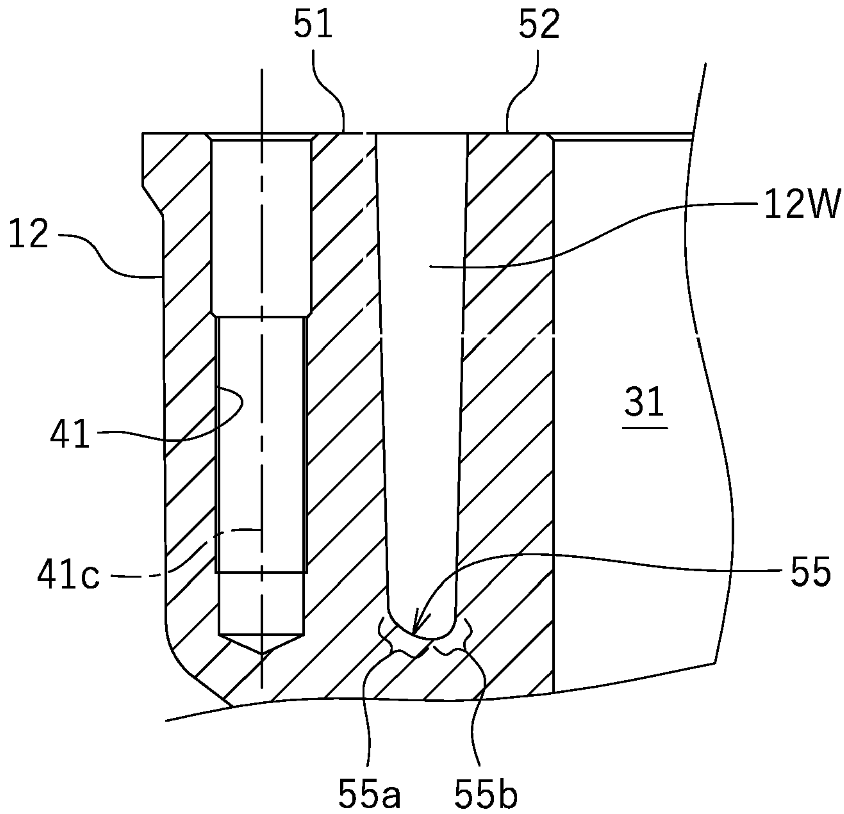
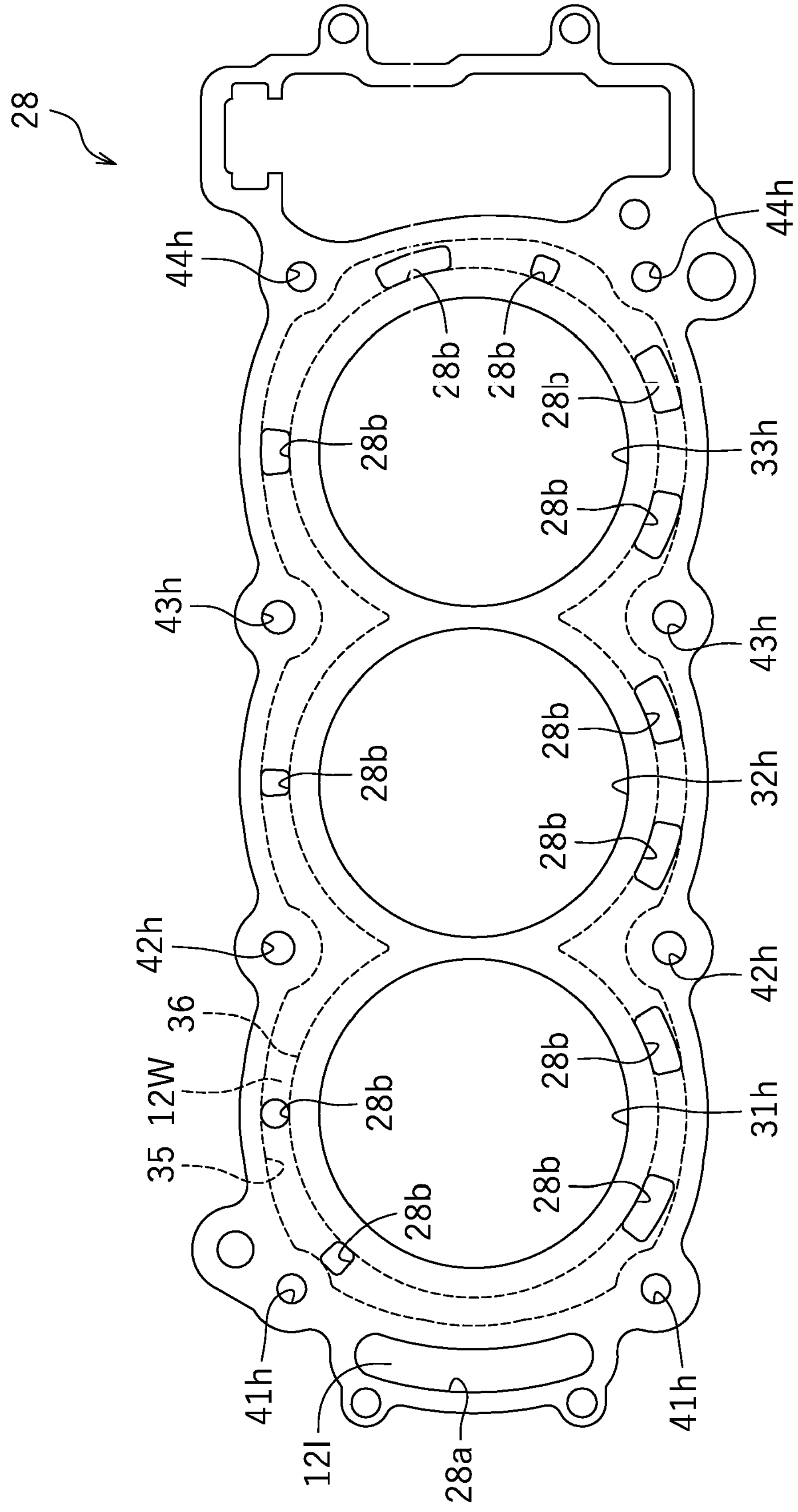


FIG.7

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44h
44h
28b
33h
43h
43h
32h
42h
42h
36
12W
35
31h
41h
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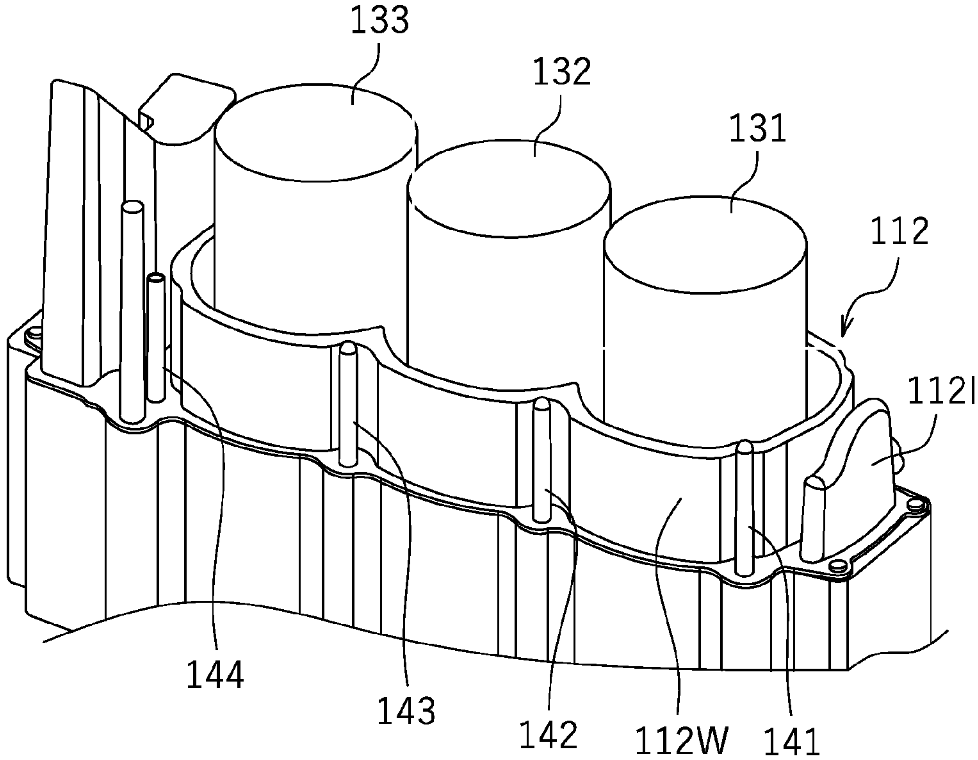
12l
28a

FIG.8

FIG.9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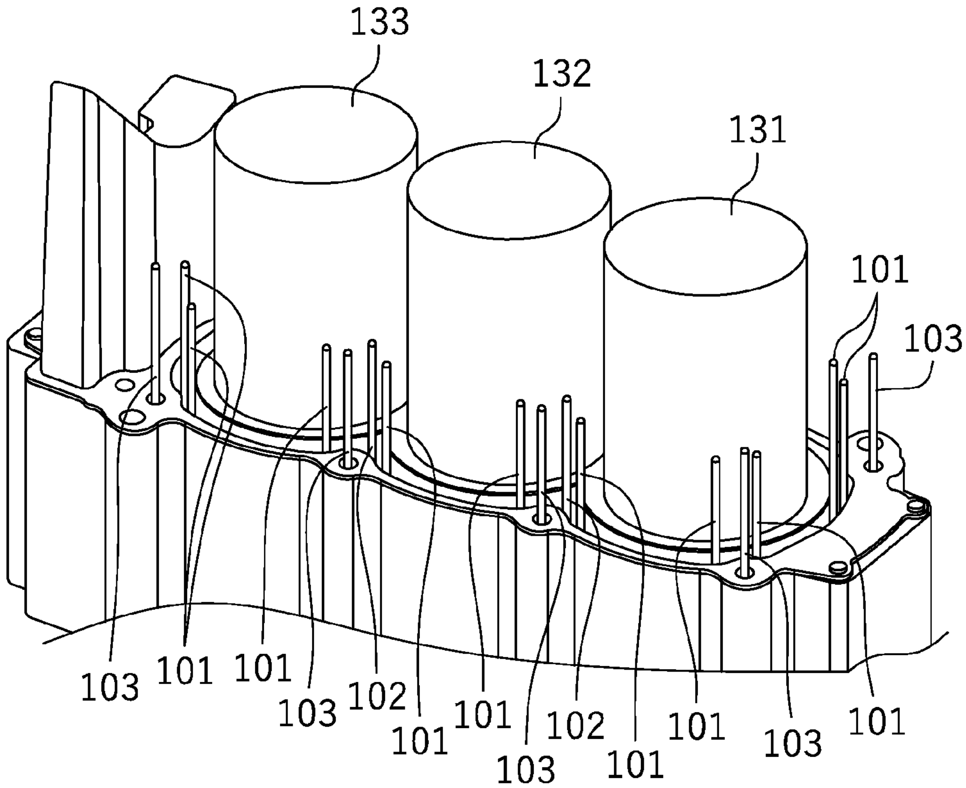
112W
141

FIG.10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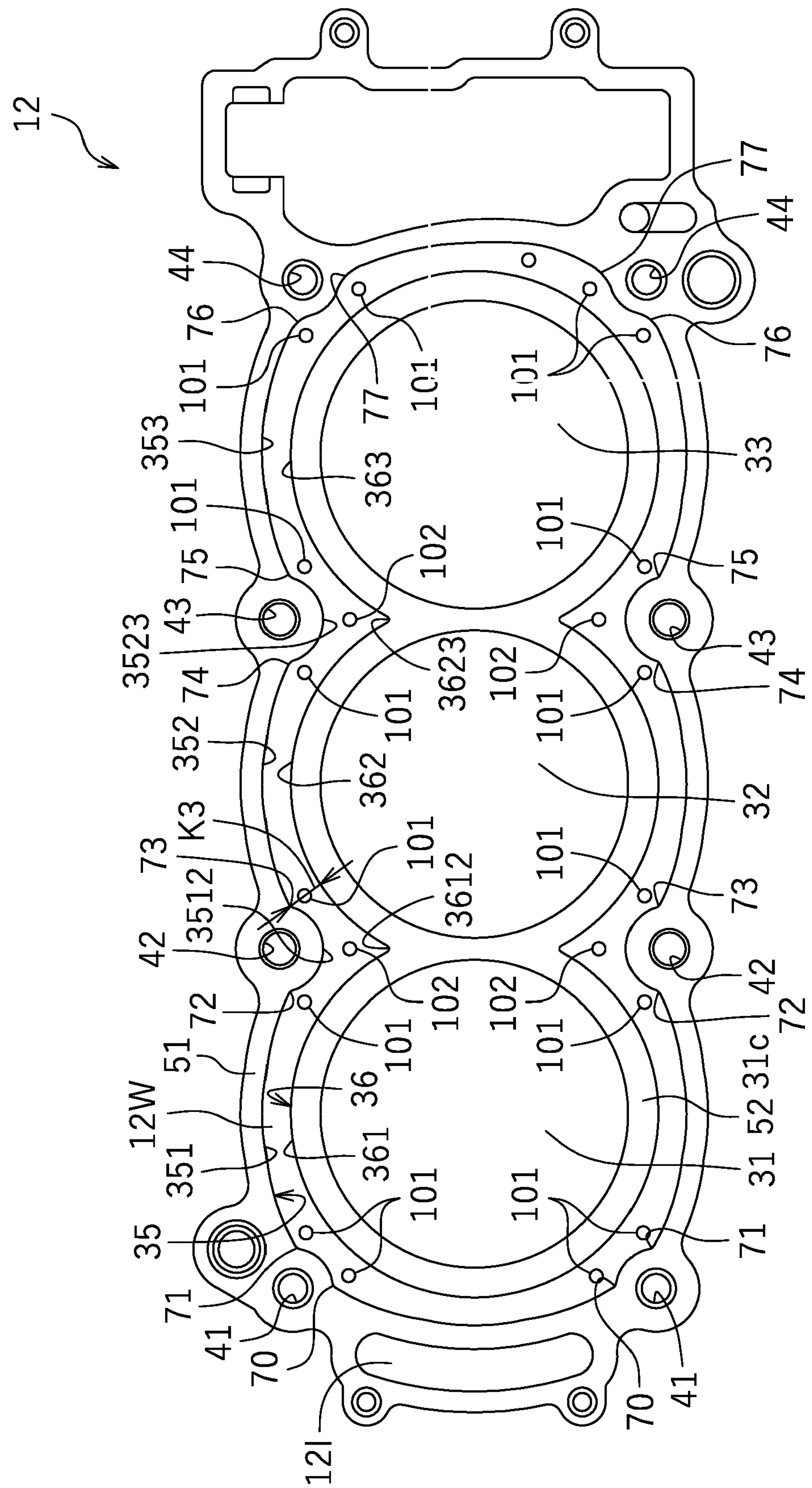
101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12I
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73
74
75
76
77
101
102
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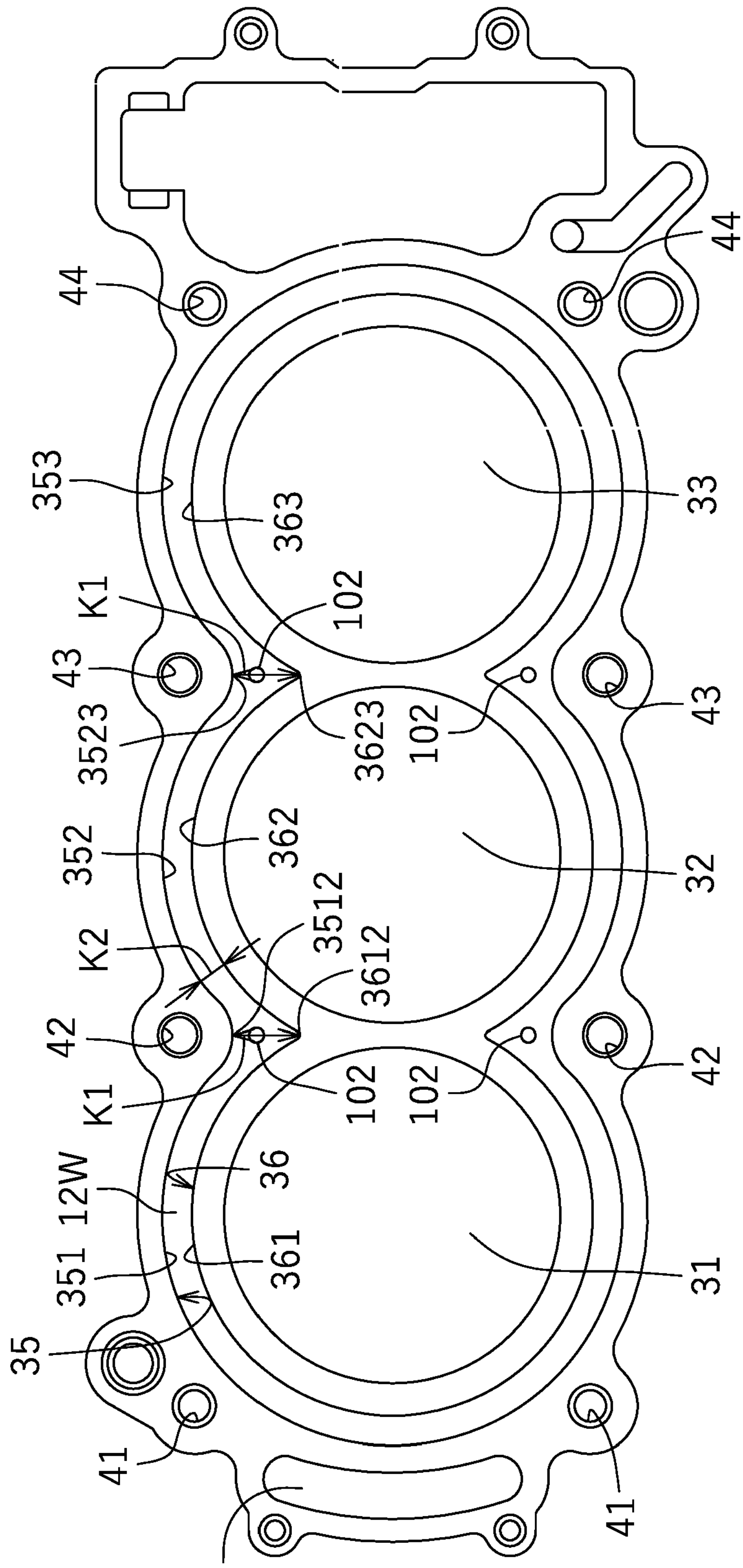
352
353
361
362
363
3512
3523
3612
3623
K3

FIG.11

FIG.12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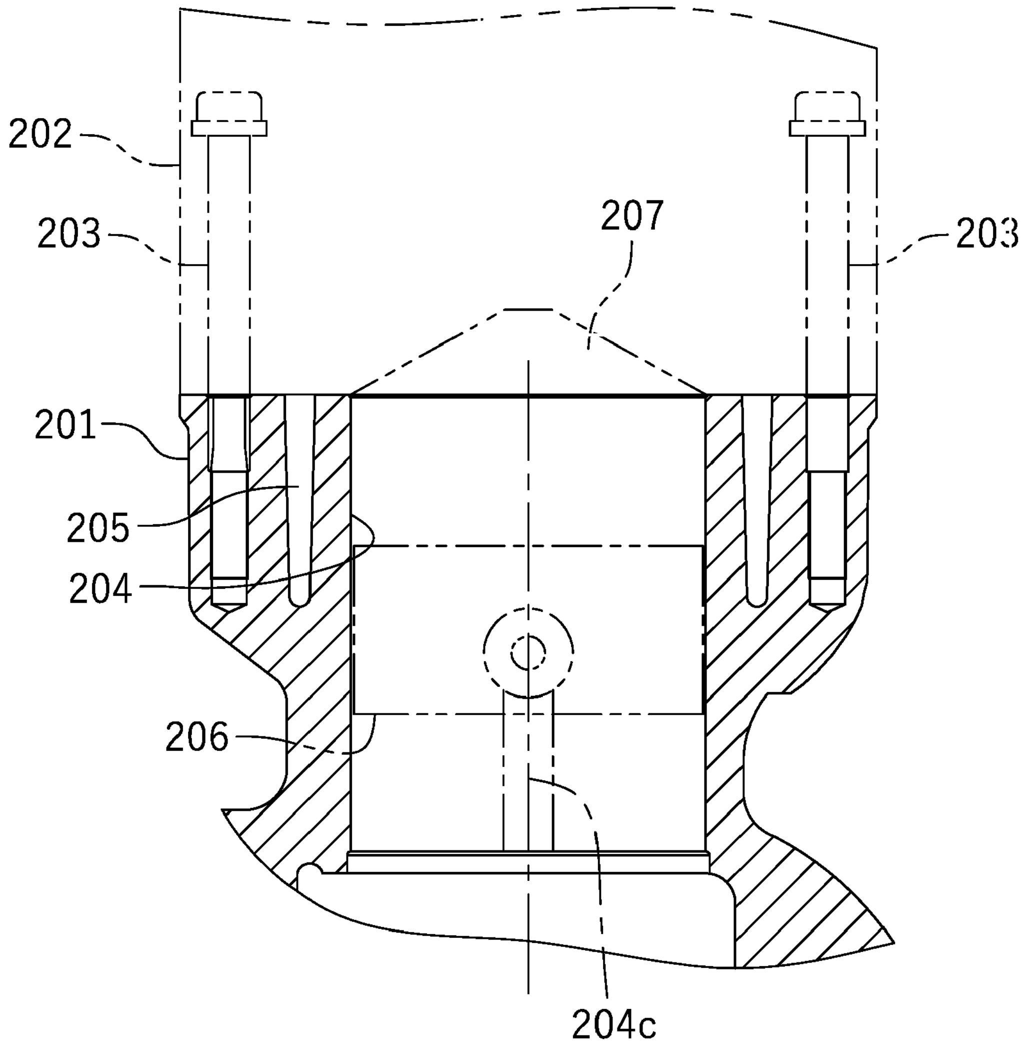
41
41
12I

FIG.13



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EUROPEAN SEARCH REPORT

Application Number
EP 20 20 2139

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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Place of search	Date of completion of the search	Examiner
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