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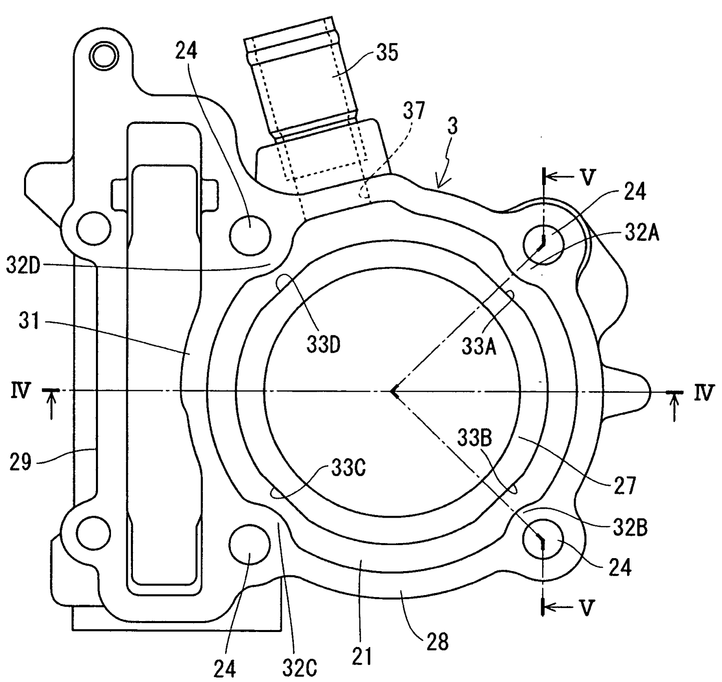
(54) ENGINE

(57) In a water-cooled, one-cylinder engine formed with a water jacket 21 along the whole circumference between a cylinder bore wall 27 and a cylinder body outer wall 28, a bolt through-hole 24 for inserting a through bolt 5 which couples a cylinder body 3 with a cylinder head 4 is formed in the cylinder body outer wall 28. Parts of areas around the bolt through-holes 24 are extruded into a water jacket 21 and make projections 32A to 32D. Areas on the cylinder bore wall 27 that face the projections 32A to 32D are cut in an axial direction to make thin wall portions 33A to 33D. Thereby, it is possible to downsize an engine without lowering the engine capacity.

[FIG. 3]



EP 2 131 031 A1

Description

[Technical Field]

[0001] The present invention relates to an engine.

[Background Art]

[0002] Conventionally, a water-cooled engine among engines of motorcycles is formed with a water jacket between a cylinder bore wall and a cylinder body outer wall, and circulates cooling water between an interior of the jacket and a radiator. Generally, there are many engines with a structure in which a cylinder body and a cylinder head are secured and tightened by a through bolt, which is made to pass through along an axial direction, and the aforementioned water-cooled engine is provided with a bolt through-hole in a cylinder body outer wall. An example of such an engine is disclosed in the following Patent Document 1.

[0003]

[Patent Document 1]
JP-A-2006-144559

[Disclosure of the Invention]

[Problem to be Solved by the Invention]

[0004] Now, in a case of a motorcycle, a request for downsizing an engine is highly intensive because a mounting space for the engine is extremely limited. Thus, even if engine displacement is increased, that is, even if an inside diameter of a cylinder bore wall becomes larger, a cylinder body cannot be simply enlarged as a whole. For example, if the cylinder bore wall is enlarged, it directly affects forming positions of bolt through-holes in a cylinder body outer wall side. The bolt through-holes are disposed in a plurality of places around the cylinder bore wall, and if these holes step back outward at once along with the enlargement of the cylinder bore wall, both the cylinder body and a cylinder head will grow in size. Due to such circumstances, it has been conventionally difficult to easily response to the request for downsizing the engine.

[0005] The invention is made in view of the above circumstance and aims to accomplish downsizing of an engine.

[Means for Solving the Problem]

[0006] In order to accomplish the object above, the invention has a structure including: a cylinder body having a cylinder bore wall, whose inner peripheral surface is formed in a circular shape, for accommodating a piston to be slidable, a cylinder body outer wall disposed so as to surround the whole circumference of the cylinder bore wall and formed with a bolt through-hole along an axial direction, and a coolant storing groove between the cylinder bore wall and the cylinder body outer wall; a cylinder head mounted on one end of the cylinder body in the axial direction and formed with a bolt hole coaxially connected to the bolt through-hole in the cylinder body side; a through bolt inserted in the bolt hole and the bolt through-hole for securing and tightening the cylinder body and the cylinder head; a projection formed such that a part of a wall around the bolt through-hole on the cylinder body outer wall projects to the coolant storing groove along the axial direction; and a thin wall portion disposed in a portion on the cylinder bore wall, which faces the projection in a radial direction and formed thinner in a radial direction than a portion of the cylinder bore wall that does not face the projection.

[0007] According to this structure, even if a portion of the wall around the bolt through-hole projects to the coolant storing section, it is unnecessary to move the position where the bolt through-hole is provided outwardly along with enlargement of a bore diameter (inside diameter of the cylinder bore wall). It is because the thin wall portion is formed in a facing position in the cylinder bore wall side. Therefore, it is possible to downsize the engine. Conversely, the engine displacement can be increased while the engine size (external form) is retained as is.

[0008] An example of a preferred configuration is characterized that a part of the projection that bulges out the most into the coolant storing groove and a thinnest part of the thin wall portion face each other in the radial direction of the cylinder body.

[0009] According to this configuration, because of a positional relationship that the part of the projection that projects the most and the thinnest part of the thin wall portion face each other in the radial direction, it is possible to effectively avoid a bulge of the projection.

[0010] Another example of the preferred configuration is characterized that the thin wall portion and the projection are formed throughout the entire depth of the coolant storing groove.

[0011] According to this configuration, because the projection and the thin wall portion face each other throughout an entire depth range of the coolant storing groove, it is possible to effectively avoid the bulge of the projection in a depth direction of the coolant storing groove.

[0012] Another example of the preferred configuration is characterized that the thin wall portion is formed nearly in the same width as the projection.

[0013] According to this configuration, it is possible to effectively avoid the bulge of the projection in a width direction.

[0014] Another example of the preferred configuration is characterized that a surface of the thin wall portion that faces the projection is a flat surface.

[0015] According to this configuration, it is possible to simplify a mold shape because the thin wall portion has the flat surface irrespective of a contour shape of the projection.

[0016] Another example of the preferred configuration is characterized that the whole circumference of the coolant storing groove is formed to be open toward the cylinder head side.

[0017] According to this configuration, because the entire cylinder body can be formed by forming dies in a simple structure that open and close along an opening direction of the coolant storing groove, it is possible to facilitate manufacture of the engine.

[0018] Another example of the preferred configuration is characterized that plural places where the projection and the thin wall portion face each other in the radial direction are provided in a circumferential direction in the coolant storing groove. The groove depth of the coolant storing groove is relatively shallow in at least one place, and the rest of the places in the coolant storing groove are formed relatively deep.

[0019] In this configuration, the groove depth of the coolant storing groove is not equal in the whole circumference. Among areas that correspond with the places where the projections are formed, some places are set shallower than the others. The reason is as follows. When the coolant storing groove is shaped, it is common to set a "draft" for dies cutting such that a bottom surface side of the coolant storing groove, that is, a tip side of forming dies is thin, and an open side of the groove, that is, a root side of the forming dies is thick. On the other hand, a groove width (opening width) of the coolant storing groove may occasionally be slightly narrower in the place where the projection is formed than the other places even when the thin wall portion is set in the cylinder bore side. In such a case, if the groove depth is made equal for the whole circumference, the lack of strength becomes a concern at the tip of the forming dies, which becomes sharper in the place where the projection is formed in relation to drafting and the groove width is narrow than the other places.

[0020] However, according to the above structure, the groove depth is made shallower in the place where the projection is formed and where the groove width is narrower than the other places; therefore, the tip of a die structure part that shapes the projection does not become too narrow. Consequently, it is possible to retain the strength of the forming dies for shaping the projection.

[0021] Another example of the preferred configuration is characterized that a hollow chain housing section for housing a cam chain capable of driving a camshaft is continuously provided in the cylinder body outer wall, that a portion of the cylinder body outer wall projects into the chain housing section to be a bulging part, and that the bulging part is disposed away from a track of the cam chain.

[0022] According to this configuration, a part (bulging part) of the cylinder body outer wall is designed to cut in an interior of the chain housing section in which the chain housing section of the cam chain is continuously provided in the cylinder body outer wall. Thereby, it is effective for downsizing the engine because the chain housing section is positioned to overlap with the cylinder body outer wall in an aligned direction.

[0023] Another example of the preferred configuration is characterized that an inlet of coolant is formed to be open into the coolant storing groove in the cylinder body outer wall and is disposed in an area where the groove depth of the coolant storing groove is relatively deep.

[0024] According to this configuration, the coolant inlet is disposed in a portion where the groove depth is deep. On the contrary, if the coolant inlet is disposed in a shallow portion of the groove depth, inflow resistance of the coolant from the coolant inlet becomes large; therefore, it may prevent smooth circulation movement of the coolant. However, with placement as described above, the inflow resistance of the coolant is little, and thus, it is possible to smoothly circulate the coolant.

[0025] Another example of the preferred configuration is characterized that at least the cylinder bore wall is made of aluminum alloy, and that the inner wall of the cylinder bore wall is formed with a hard layer whose hardness is higher than a base layer of the cylinder bore wall.

[0026] According to this configuration, it is possible to enhance abrasion resistance of a sliding contact surface on the cylinder bore wall with a piston.

[0027] Another example of the preferred configuration is characterized that a liner made of aluminum alloy is provided on the inner surface of the cylinder bore wall and that the hard layer is formed on an inner surface of the liner.

[0028] Also, with this configuration, it is possible to enhance the abrasion resistance of the sliding contact surface with the piston.

[0029] Another example of the preferred configuration is characterized that the hard layer is a plating layer containing a silicon component. According to this configuration, it is possible to enhance the abrasion resistance of the surface that slidingly contacts the piston due to the plating layer containing the silicon component.

[0030] Another example of the preferred configuration is characterized that the hard layer is the plating layer containing a nickel component. According to this configuration, it is possible to enhance the abrasion resistance of the sliding contact surface with the piston due to the plating layer containing the nickel component.

[0031] Another example of the preferred configuration is characterized that the hard layer is a dispersed plating layer of Ni-P-SiC. According to this configuration, it is possible to enhance the abrasion resistance of the sliding contact surface with the piston due to the dispersed plating layer of Ni-P-SiC.

[0032] Another example of the preferred configuration is characterized that at least the cylinder bore wall is a vacuum die-casting piece made of aluminum alloy containing 13 to 22 wt% of silicon.

[0033] According to this configuration, it is possible to enhance the abrasion resistance of the sliding contact surface on the cylinder bore wall without forming the plating layer.

[0034] Another example of the further preferred configuration is characterized that at least the cylinder bore wall is the vacuum die-casting piece made of aluminum alloy containing 18 to 22 wt% of silicon. This configuration enables to further enhance the abrasion resistance.

[0035] Another example of the preferred configuration is characterized that a silica crystal projects from the inner surface of the cylinder bore wall.

[0036] According to this configuration, the silica crystal projected from the inner wall of the cylinder bore wall contacts the piston and forms the sliding contact surface, and lubricating oil can be spread over a surrounding portion of silica crystal that is relatively dented. Therefore, it is able to enhance the abrasion resistance.

[Brief Description of Drawings]

[0037]

Fig. 1 is a cross-sectional view of an engine.
Fig. 2 is a cross-sectional view of a place where a through bolt appears.
Fig. 3 is a plain view of a cylinder body by itself.
FIG. 4 is a cross-sectional view taken along the line IV-IV in FIG. 3.
FIG. 5 is a cross-sectional view taken along the line V-V in FIG. 3.
Fig. 6 is a cross-sectional view showing a shaping condition with respect to a deep portion of a water jacket.
Fig. 7 is a cross-sectional view showing the shaping condition with respect to a shallow portion of the water jacket.
FIG. 8 is an enlarged cross-sectional view of a cylinder liner portion according to the second embodiment.

[Description of Reference Numerals]

[0038]

3: cylinder body
4: cylinder head
5: through bolt
21: water jacket (coolant storing groove)
24: bolt through-hole
27: cylinder bore wall
29: chain housing section
32A-32D: projection
33A-33D: thin wall portion
34: formed pin
35: inlet pipe

[Description of the Preferred Embodiment]

[0039] A first to a fourth embodiments according to the invention will be hereinafter described.

<First embodiment>

[0040] A description is made of the first embodiment of the invention with reference to FIG.1 to FIG.7. FIG. 1 illustrates the configuration surrounding an engine of a motorcycle. The engine is a water-cooled, four-stroke, one-cylinder engine and is configured by including a crankcase 2 for supporting a crankshaft 1 for rotation, a cylinder body 3 attached to the crankcase 2, and a cylinder head 4 attached to a front side of the cylinder body 3 in an axial direction. These three components are tightened and secured by a through bolt 5, which will be described later.

[0041] The crankshaft 1 is configured by including a symmetrical pair of crank webs 6, and a crank pin 7 for connecting the crank webs 6 with each other. A piston 9 is connected to the crank pin 7 via a connecting rod 8. Also, an automatic gear change mechanism 10 of a V-belt winding type for driving a rear wheel is disposed to the left end of a vehicle body from the crankshaft 1. In addition, a cam chain drive sprocket 11 is fitted between a coupling portion of the connecting rod 8 with the crankshaft 1 and the automatic gear change mechanism 10, and makes a camshaft 12 rotatable by a cam chain 14, which runs between the cam chain sprocket 11 and a cam chain driven sprocket 13 fitted to the camshaft 12.

[0042] Meanwhile, a flywheel magneto 15 for power generation and a fan 16 are arranged in parallel with each other axially at a right end of the vehicle body from the crankshaft 1. Further, a radiator 17 for cooling off the engine with cooling water is disposed in a lateral side of the fan 16 and is covered with a cover from the side.

[0043] One end of a first cooling water tube 18 is connected to a lower tank side of the radiator 17, and the other end of the first cooling water tube 18 is connected to a suction side of a water pump 19, which drives in conjunction with the camshaft 12. Also, one end of a second cooling water tube 20 is connected to an upper tank side of the radiator 17, and the other end of the second cooling water tube 20 is connected to a water jacket 37 in the cylinder head 4. Furthermore, a discharge side of the water pump 19 and a water jacket 21 in the cylinder body 3 side (hereinafter the water jacket 21 in the cylinder body 3 side will be simply referred to as the water jacket 21 unless otherwise noted) are connected by a third cooling water tube 22. Thereby, the cooling water can be circulated between the radiator 17 and the water jacket 21.

[0044] A valve operating device for driving a suction valve and an exhaust valve by the camshaft 12, a spark plug, and the like are integrated in the cylinder head 4. In addition, in the cylinder head 4, plural bolt holes 23 for making the through bolt 5 pass through, are formed along the axial direction. Each of the bolt holes 23 fits together with corresponding one of bolt through-holes 24 provided in the same number as the bolt holes 23 in the cylinder body 3 and can be linked coaxially. The bolt through-holes 24 are, as shown in FIG. 3, disposed in approximately equally-spaced four places around a central axis of a cylinder bore wall 27. However, such an angle spacing is adjustable in accordance with a surrounding structure, and the holes need not be necessarily disposed equally-spaced.

[0045] Each of the bolt through-holes 24 can fit together with a screw hole 25 formed in a similar manner as the bolt through-hole 24 in the crankcase 2 side. The through bolt 5, both ends of which are formed with screw parts 5A, is loosely inserted in the bolt holes 23, the bolt through-hole 24 and the screw hole 25, all of which coaxially fit together. One screw part 5A is screwed in the screw hole 25 while the other screw part 5A projects from an exterior surface of the crankcase 2 and is tightened by a nut 26. Thereby, the cylinder head 4 and the cylinder body 3 are tightened and secured to the crankcase 2.

[0046] The cylinder body 3 is polymerized to a foreside of the crankcase 2 in a vehicle body direction, and in this embodiment, is formed in one by aluminum alloy. As shown in FIG. 3, the cylinder bore wall 27 for accommodating the piston 9 to be slidable is formed in an interior of the cylinder body 3. The cylinder bore wall 27 is roughly formed in a cylindrical shape, and both ends thereof in the axial direction are concurrently formed to be open. On the periphery of the cylinder bore wall 27, a cylinder body outer wall 28 is provided so as to coaxially surround the cylinder bore wall 27. A chain housing section 29 for housing the cam chain 14 is continuously provided in a sidepiece of the cylinder body outer wall 28. The chain housing section 29 is also formed hollow with both ends in the axial direction open, and both of the open ends respectively connect to a cam chain housing space 30 in the crankcase 2 side and the cylinder head 4 side.

[0047] Also, as shown in FIG. 3, the sidepiece of the cylinder body outer wall 28 is formed such that a part of the sidepiece (a bulging part 31) is cut into the chain housing section 29. A bulging position of the bulging part 31 is set roughly in the center of the chain housing section 29, and thus, the intervention with the cam chain 14 is avoided. In this way, because a part (the bulging part 31) of the cylinder body outer wall 28 is disposed so as to overlap with the chain housing section 29 in an aligned direction of these, the width measurement of the cylinder body 3 as a whole is to be downsized by the crossover.

[0048] In addition, in the cylinder body 3, the water jacket 21 (a coolant storing groove) is formed in a concentric ring shape around the whole circumference between the cylinder bore wall 27 and the cylinder body outer wall 28. Further, the aforementioned four bolt through-holes 24 are disposed equiangularly around the water jacket 21 in the cylinder body outer wall 28 (the angle spacing is adjustable accordingly, and the holes need not be spaced equiangularly). Furthermore, each of the bolt through-holes 24 is disposed such that a portion of an area surrounding it projects in an arc shape into the water jacket 21, and forms projections 32A to 32D. Each of the projections 32A to 32D is formed throughout the entire depth range of the water jacket 21. Meanwhile, the areas around the two bolt through-holes 24 located on the opposite side of the chain housing section 29 project in the arc shape in a planar view from the cylinder body outer wall 28 to the outside in the radial direction whereas the other two, which are disposed in the chain housing section 29 side, share the areas around the holes with the chain housing section 29.

[0049] On the other hand, the thin wall portions 33A to 33D are formed in portions of an exterior surface of the cylinder bore wall 27, which respectively face the projections 32A to 32D. Each of the thin wall portions 33A to 33D is formed thinner in the radial direction than other portions of the cylinder bore wall 27 except the portions thereof that face each of the projections 32A to 32D. Each of the thin wall portions 33A to 33D is formed with a flat surface in a predetermined width that extends along the axial direction, is formed throughout the entire depth range of the water jacket 21 as the projections 32A to 32D, and is formed nearly in the same width as the projections 32A to 32D. In addition, as shown in FIG. 3, the tips of the projections 32A to 32D that bulge out the most into the water jacket 21 and the centers of the respective thin wall portions 33A to 33D in the width direction, that is, the most dented parts on the exterior surface of the cylinder bore wall 27 against the water jacket 21, are in a positional relationship to face one another in the radial direction of the cylinder body 3.

[0050] The groove width of the water jacket 21 is formed slightly narrow in the area where each of the projections 32A to 32D faces corresponding one of the thin wall portions 33A to 33D compared to the area where these do not face each other except one place (the area where the projection 32B faces the thin wall portion 33B). Also, regarding the groove depth, as shown in FIG. 5, the area where each of the projections 32A to 32D faces corresponding one of the thin portions 33A to 33D is formed shallow compared to the area where these parts do not face each other except one place (the area where the projection 32B faces the thin wall portion 33B). That is, the place where the groove width is either equal to or narrower than a fixed value among the area where each of the projections faces a corresponding one of the thin portions is formed shallow in comparison with the other areas (H1>H2, see FIG.4 and FIG.5). Though not shown in detail, a groove bottom shape of the water jacket 21 is set such that changes in the shape between a shallow portion and a deep portion of the groove depth are gradually made.

[0051] The reason why the groove depth in the water jacket 21 is uneven is as follows (see FIG. 6 and FIG. 7). The water jacket 21 is formed by forming dies which are openable and closable in a direction following the axial direction, and at the time of forming, a formed pin 34, which is corresponds with the water jacket 21, projects from one of the dies. The formed pin 34 is configured with a draft, which is designed to taper in size in relation to "drafting" upon post-shaping. FIG. 6 shows a condition in which the deep portion in the groove depth of the water jacket 21 is shaped. In a shaping portion of the area described above in the formed pin 34 for shaping the water jacket 21, the thickness measurement of the elementary portion is W1, and the draft configured on the formed pin 34 (an angle made by a line drawn parallel to the central axis of the formed pin 34 and a generatrix of the periphery of the formed pin 34) is$\theta 1$. On the other hand, FIG. 7 shows a shaping condition relative to the shallow portion in the groove depth of the water jacket 21 (the areas where the projections 32A, 32C, 32D and the respective thin wall portions 33A, 33C, 33D face each other). In the portion of the formed pin 34 for shaping the areas, the thickness measurement of the elementary portion is set to be thin as W2 (W1>W2); however, it is configured to be roughly equal in terms of the draft$\theta 2$ ($\theta 1=\theta 2$). Therefore, the whole circumference of the formed pin 34 is configured to be roughly equal regarding the draft; however, the thickness measurement and the length measurement are varied between the areas where the projections 32A, 32C, 32D face the respective thin portions 33A, 33C, 33D and the rest of the area. If the length measurement is equalized in the whole circumference, thickness of the tip would become excessively thin in the portions for shaping the areas where the projections 32A, 32C, 32D face the respective thin portions 33A, 33C, 33D compared to the other portions, and it will be concerned that strength of the formed pin 34 is locally weakened. Consequently, in this embodiment, the strength of the formed pin 34 is to be retained by shortening the measurement of the portions for shaping the areas where the projections 32A, 32C, 32D face the respective thin portions 33A, 33C, 33D compared to the other portions.

[0052] By the way, the reason why the groove width of one of the four places where the projections 32A to 32D face the respective thin portions 33A to 33D is wider than the others is because only the place, which corresponds to the projection 32B, has a room in a surrounding space of the cylinder body 3, and a need to push the position of the corresponding bolt through-hole 24 toward the cylinder bore wall 27 side is a little compared to the other bolt through-hole. Thus, only a curvature radius of the periphery of the projection 32B is formed smaller than the other projections 32A, 32C, 32D. Therefore, depending on a surrounding situation of the cylinder body 3, the groove depth of the water jacket 21 may be formed shallow in all the places where the projections are formed.

[0053] In addition, on the cylinder body outer wall 28, an inlet pipe 35, to which the aforementioned third cooling water tube 22 is connected, is formed in one to project outwardly in the radial direction, and is made possible to inlet cooling water from an inlet 37 that opens in the water jacket 21. In more detail, the inlet pipe 35 is disposed in the area where the projections 32A to 32D face the respective thin wall portions 33A to 33D and close to the chain housing section 29. That is, the inlet pipe 35 is disposed in the area where the groove depth of the water jacket 21 is deep. Also, in this embodiment, as shown in FIG. 3, an inlet recess 36 is formed by denting the outer wall of the water jacket 21 outwardly in the predetermined width range in the place where the inlet pipe 35 is disposed. Thereby, cooling water is introduced to the portion of the water jacket 21 where the groove width is wide and the groove depth is deep.

[0054] Next, the operating effects of the first embodiment that is configured as described above is specifically described. As mentioned before, in this embodiment, the radiator 17 is disposed not in front but lateral to the vehicle body from the engine. Thereby, the vehicle length in the longitudinal direction is shortened. On the contrary, the vehicle width is widened by that extent; however, the radiator 17 is located posterior to a leg of a rider or in an unused space where the interference with the rider' s leg does not become a problem. Therefore, the interference caused by widening the vehicle width does not become a problem. Although the front portion of the vehicle where the radiator 17 is disposed laterally, has to avoid the interference with the leg, the width of this portion in the engine of the first embodiment is narrowed as much as possible.

[0055] That is, in this embodiment, in the cylinder body 3, it is configured such that the portions (the projections 32A to 32D) where the areas around the bolt through-holes 24 project into the water jacket 21 are provided, and that the thin wall portions 33A to 33D are provided in the cylinder bore wall 27 side in order to make a dent in the places where the thin portions 33A to 33D face the projections 32A to 32D. By the adoption of such configuration, it is possible to downsize the engine compared to the configuration that does not provide the projections 32A to 32D. Therefore, the interference with the rider's leg is surely avoided, and this configuration contributes to expansion of a space around the engine. This can be said, in other words, that it is possible to enlarge the cylinder bore wall 27 as far as the external form of the engine is the same, thus, to increase the engine capacity.

[0056] In addition, aligning the chain housing section 29 and the cylinder body outer wall 28 to be overlapped with each other in the vehicle width direction, by cutting a portion of the cylinder body outer wall 28 into the chain housing section 29 for the cam chain 14, makes the above effect further effective.

[0057] Moreover, in the first embodiment, the effort is made to simplify manufacture of the engine. To begin with, because all the circumference of the water jacket 21 is formed to be open in the cylinder head 4 side, the cylinder body 3 can be shaped by forming dies with a simple structure, which opens and closes in the axial direction. Further, the groove depth of the water jacket 21 is not equalized along all its circumference, but is made shallower in the areas where the projections 32A, 32C, 32D face the respective thin wall portions 33A, 33C, 33D, that is, where the groove width tends to be narrower than the other areas. Therefore, it is possible to retain the strength of the formed pin 34 for shaping the water jacket 21. Furthermore, upon forming the thin wall portions 33A to 33D, although it can be considered to adopt a curvature shape, which suits the contour shapes of the projections 32A to 32D, it makes the shape of the forming dies complicated. Thus, in this embodiment, the thin portions 33A to 33D are formed with flat surfaces. As a result, the shape of the forming dies is kept simple.

[0058] In addition, this embodiment further brings the following effect. That is, because the inlet pipe 35 for introducing cooling water into the water jacket 21 is disposed in the deep portion in the groove depth of the water jacket 21, and also because the groove width of the water jacket 21 is widened by forming the inlet recess 36 in the place where the inlet pipe 35 is disposed, the introduction of cooling water into the water jacket 21 is made smoothly.

<Second embodiment>

[0059] Each of the second to the fourth embodiments shows structural ingenuity for improvement of abrasion resistance of a sliding contact surface on a cylinder body 103, which is made of aluminum alloy, with a piston. Among these embodiments, the second and the third embodiments include a cylinder bore wall made with a hard layer.

[0060] In the second embodiment, a cylinder liner 140 formed in a cylindrical shape is formed by molding on an inner surface of a cylinder bore wall 127. A cylinder liner 140 is made of aluminum alloy in generally the same composition as a cylinder body 103. In addition, a hard layer that is harder (Rockwell hardness) than the cylinder bore wall 127 is formed on an inner surface (sliding contact surface with the piston) of the cylinder liner 140. This hard layer is formed by a plating film (plating layer).

[0061] An alumite film is formed on a surface of the cylinder liner 140 as a base processing prior to a plating treatment. Then, a dispersed plating treatment of Ni-P-SiC is applied, followed by honing.

[0062] In this embodiment, coefficient of thermal expansion of the cylinder liner 140 is set 10% or over 10% smaller than that of the cylinder body 103, and a tightening force of the cylinder body 103 with respect to the cylinder liner 140 is not relaxed by solidification contraction or heat contraction after the solidification. Therefore, a gap is not produced between the cylinder liner 104 and the cylinder bore wall 127. This contributes to securement of high thermal conductivity of the cylinder body 103.

<Third embodiment>

[0063] In the second embodiment, the plating layer is formed on the cylinder liner; however, in this embodiment, the cylinder liner is not used, but the hard layer is formed directly on the inner surface of the cylinder bore wall. More specifically, the plating layer that is harder than a base layer (base material portion) is formed on an inner surface layer of the cylinder bore wall. That is, the inner surface (the area which slidingly contacts the piston) of the cylinder bore wall is plated in a fast plating method (a method in which a plating solution is poured into the cylinder bore at high speed for electroplating). Thereby, the plating layer of either Ni-P-SiC or Ni-SiC is formed on the inner surface of the cylinder bore wall. Then, the honing in which plane roughness is, for example, equal to or less than 1. 0 μ mRz is applied to the surface of the plating layer. If the plane roughness is small as such, it is concerned that a retaining function of lubricating oil on the surface of the plating layer decreases and that seizing resistance decreases. However, as a method to compensate for such problems, a deposited layer of TiN and the like may be formed on a surface of a piston ring.

[0064] In the second embodiment configured as above, the improvement of the abrasion resistance is achieved without the integration of a sleeve and the like into the cylinder bore wall. Therefore, it can contribute to downsizing of the cylinder bore wall, and consequently to further downsizing of the cylinder body.

[0065] In the aforementioned second and third embodiments, the plating layer is described as the hard layer. As the plating layer, one made of nickel plating or chrome plating can also be adopted. In addition, as a means of forming a hard layer in a method other than the plating processing, a method by thermal spraying such as wire explosion spraying and plasma spraying is also possible, and is included in the invention.

<Fourth embodiment>

[0066] In this embodiment, the abrasion resistance to the piston is enhanced by causing a silica crystal to project from the inner surface of the cylinder bore wall without the plating treatment thereon. In other words, the cylinder body in this embodiment is formed by aluminum alloy containing 73.4 wt% to 79. 6 wt% of aluminum, 13 wt% to 22 wt%, preferably, 18 wt% to 22 wt% of silicon, and 2.0 wt% to 3.0 wt% of copper.

[0067] In general, because aluminum alloy with high content of silicon (equal to or over 9 wt%, especially equal to or over 16 wt%) is unsuitable for casting, the volume production by die-casting is considered to be difficult. However, according to a die-casting technology disclosed in WO 2004/002658 pamphlet (submitted by the inventor of this application) and adopted in this embodiment, it is possible to effectively manufacture the cylinder body made of aluminum alloy containing silicon in such a large quantity.

[0068] The cylinder body obtained in the above method includes plural primary crystal silicon grains that make up the sliding surface that contacts the piston, and plural eutectic crystal silicon grains positioned between the plural primary crystal silicon grains. The average grain radius of the plural primary crystal silicon grains is between 12 μm and 50 μm, and that of the plural eutectic crystal silicon grains is equal to or less than 7.5 μm. The Rockwell hardness (HRB) of the sliding surface is between 60 and 80.

[0069] In this embodiment, as in the third embodiment, it is possible to enhance the abrasion resistance without use of the cylinder liner; therefore, it can contribute to downsizing of the cylinder bore wall, and consequently to further downsizing of the cylinder body. Also, because the silicon crystalline particles arise and project from the inner surface of the cylinder bore wall, these arising crystal silicon grains come in contact with the piston to form the sliding contact surfaces, and can spread lubricating oil throughout dented aluminum base surface surrounding the sliding contact surfaces. Therefore, it is also possible to enhance the abrasion resistance from this point of view.

[0070] As a means to enhance the abrasion resistance of the sliding contact surface on the cylinder bore wall with the piston, an iron sleeve may be used instead of the above embodiments. In this case, the iron sleeve is positioned in a predetermined position within the forming dies that form the cylinder body, and is cast along with forming. Accordingly, it is possible to obtain the cylinder body with which the iron sleeve is integrated, and the whole circumference of the iron sleeve is in close contact with the inner surface of the cylinder bore wall.

<Other Embodiments>

[0071] The invention is not limited to the embodiments described above with figures, and for example, the following embodiments are included in the technical scope of the invention. Further, various changes may be made without departing from the scope of the invention besides the embodiments described below.

[0072] (1)In this embodiment, the example in which the invention is adopted to a motorcycle is described; however, it is adoptable to an engine of a motorboat, snow mobile, and the like.

[0073] (2) In this embodiment, it is described with water as a cooling medium, but it can be oil-based.

[0074] (3) In this embodiment, each of the thin wall portions 33A to 33D is formed with a flat surface, but it can be formed with a shape of circular arc and recession, which corresponds with the shape of the respective thin wall portions 33A to 33D.

[0075] (4)A cylinder body and a crankcase need not necessarily be formed separately, and the crankcase can be formed in one with the cylinder body.

Claims

1. An engine comprising:

a cylinder body having a cylinder bore wall, whose inner peripheral surface is in a circular shape, for accommodating a piston to be slidable, a cylinder body outer wall disposed so as to surround the whole circumference of the cylinder bore wall and formed with a bolt through-hole along an axial direction, and a coolant storing groove between the cylinder bore wall and the cylinder body outer wall;

a cylinder head mounted on one end of the cylinder body in the axial direction, and formed with a bolt hole coaxially connected with the bolt through-hole of the cylinder body side;

a bolt inserted in the bolt and the bolt through-hole for securing and tightening the cylinder body and the cylinder head;

a projection formed such that a part of a wall around the bolt through-hole in the cylinder body outer wall projects to the coolant storing groove along the axial direction; and

a thin wall portion disposed in a portion of the cylinder bore wall that faces the projection in a radial direction and formed to be thinner than a portion of the cylinder bore wall that does not face the projection.

2. The engine according to Claim 1, wherein a part of the projection that bulges out the most into the coolant storing groove and a thinnest part of the thin wall portion face each other in the radial direction of the cylinder body.

3. The engine according to Claim 1, wherein the thin wall portion and the projection are formed throughout entire depth of the coolant storing groove.

4. The engine according to Claim 1, wherein the thin wall portion is formed nearly in the same width as the projection.

5. The engine according to Claim 1, wherein a surface of the thin wall portion that faces the projection in the radial direction is a flat surface.

6. The engine according to Claim 1, wherein the whole circumference of the coolant storing groove is formed to be open toward the cylinder head side.

7. The engine according to Claim 1, wherein plural places where the projection and the thin wall portion face each other in the radial direction are provided in a circumferential direction in the coolant storing groove,
groove depth of the coolant storing groove is relatively shallow in at least one place, and
rest of the places in the coolant storing groove are formed relatively deep.

8. The engine according to Claim 1, wherein a hollow chain housing section for housing a cam chain capable of driving a camshaft is continuously provided in the cylinder body outer wall, a part of the cylinder body outer wall projects into the chain housing section to be a bulging part, and the bulging part is disposed away from a track of the cam chain.

9. The engine according to Claim 7, wherein an inlet of coolant is formed to be open into the coolant storing groove in the cylinder body outer wall and is disposed in an area where the groove depth of the coolant storing groove is relatively deep.

10. The engine according to Claim 1, wherein at least the cylinder bore wall is made of aluminum alloy, and
an inner surface of the cylinder bore wall is formed with a hard layer whose hardness is higher than a base layer of the cylinder bore wall.

11. The engine according to Claim 1, wherein a liner made of aluminum alloy is provided on the inner surface of the cylinder bore wall, and
the hard layer is formed on an inner surface of the liner.

12. The engine according to Claim 10 or 11, wherein the hard layer is a plating layer containing a silicon component.

13. The engine according to Claim 10 or 11, wherein the hard layer is a plating layer containing a nickel component.

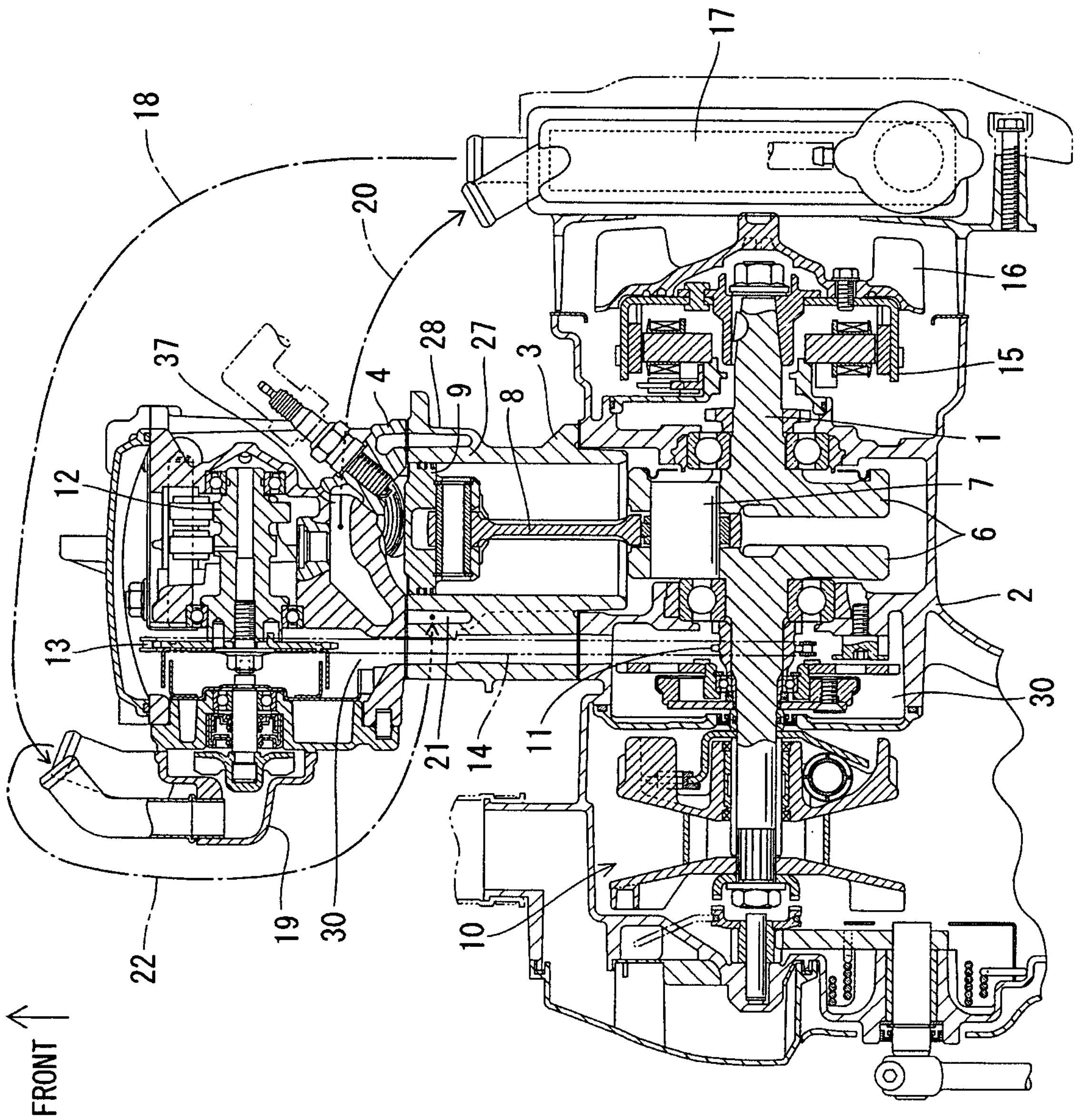
14. The engine according to Claim 10 or 11, wherein the hard layer is a dispersed plating layer of Ni-P-SiC.

15. The engine according to Claim 1, wherein at least the cylinder bore wall is a vacuum die-casting piece made of aluminum alloy containing 13 to 22 wt% of silicon.

16. The engine according to Claim 15, wherein at least the cylinder bore wall is the vacuum die-casting piece made of aluminum alloy containing 18 to 22 wt% of silicon.

17. The engine according to Claim 15 or 16, wherein a silicon crystal projects from the inner surface of the cylinder bore wall.

[FIG. 1]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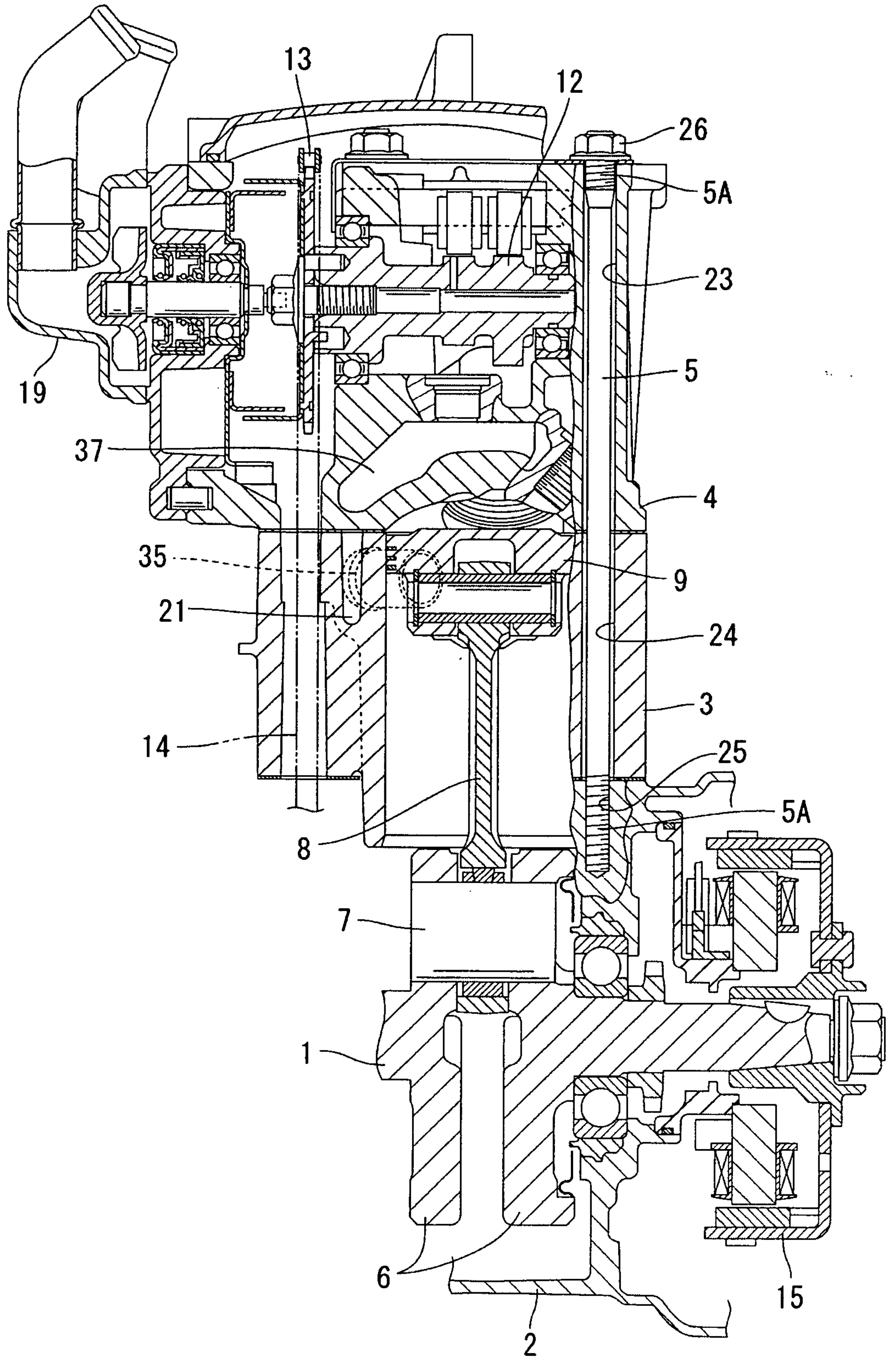
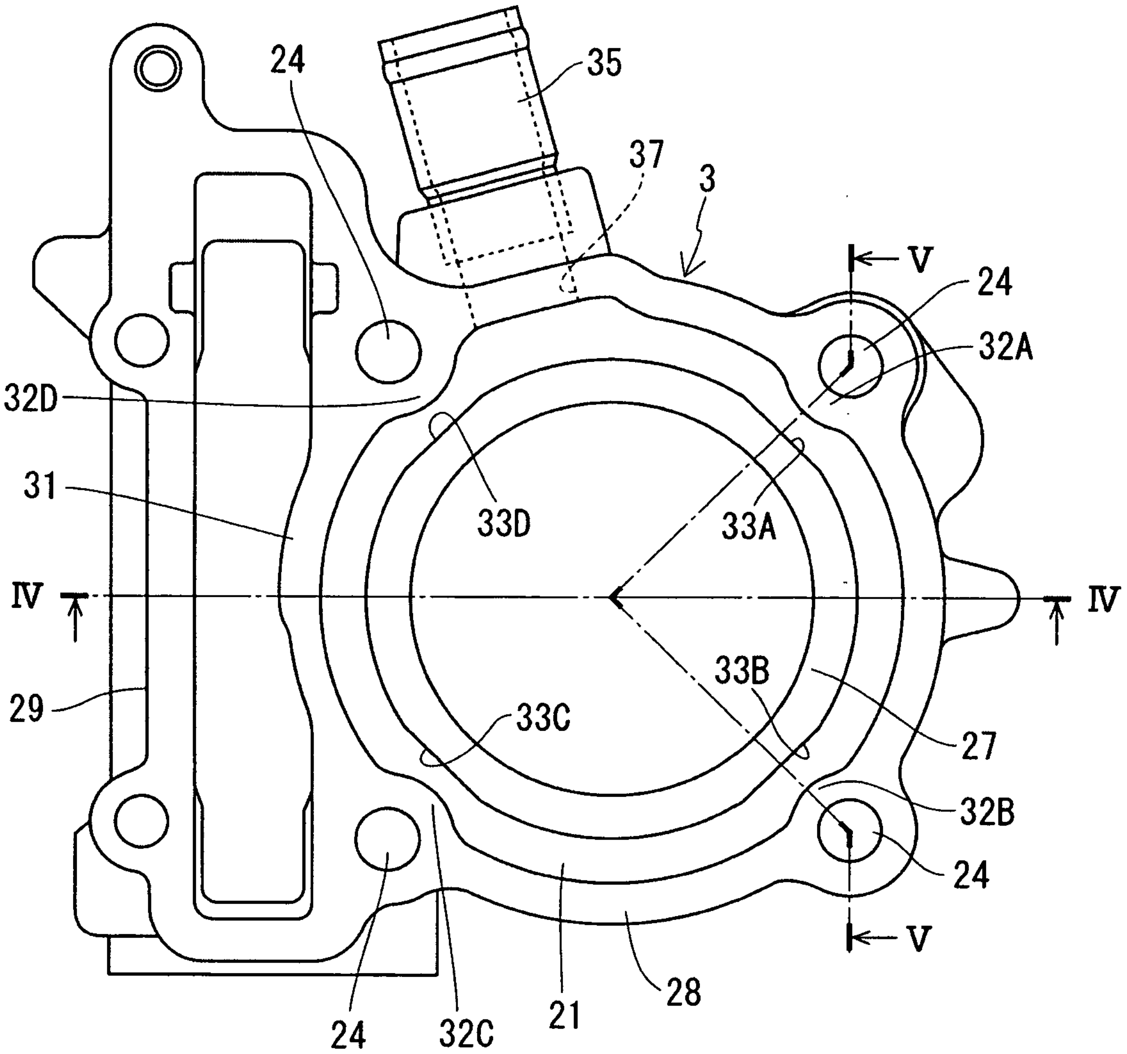
[FIG. 2]



[FIG. 3]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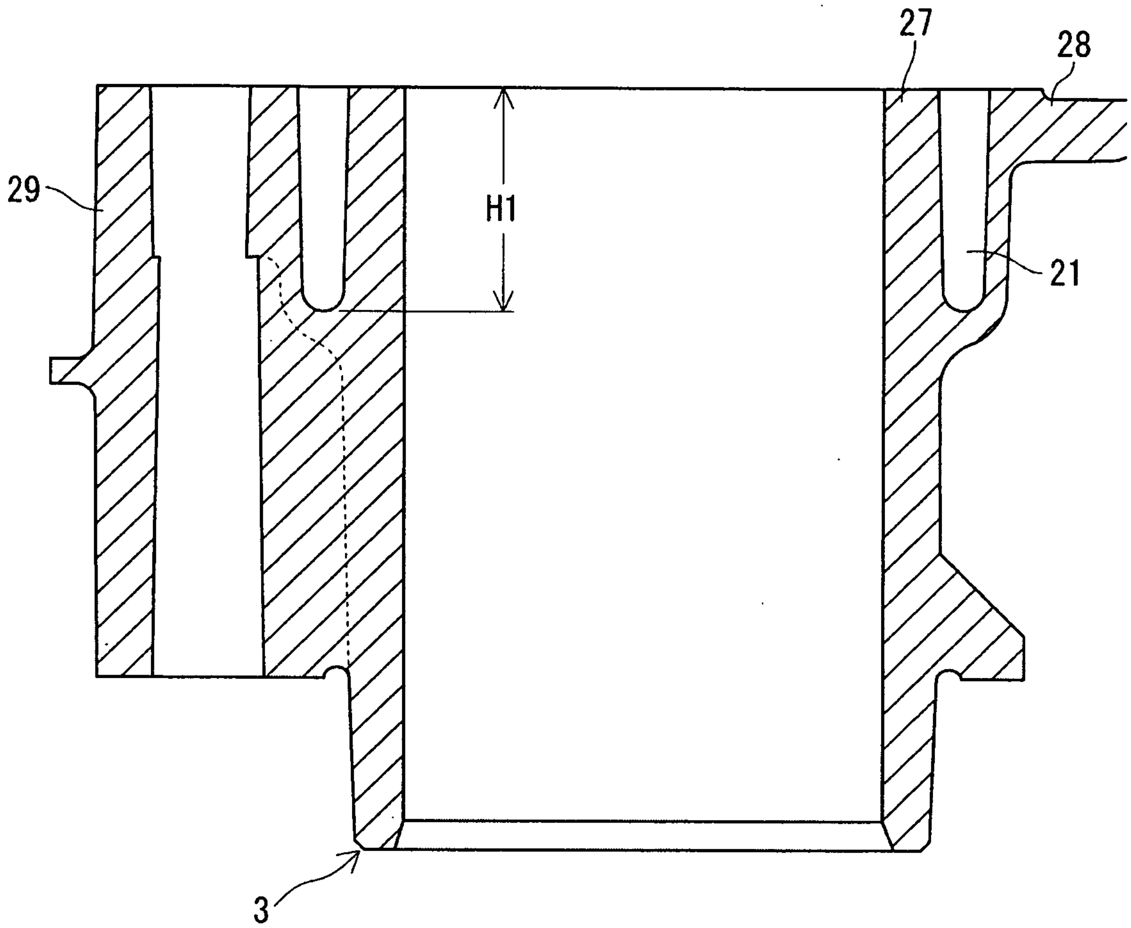
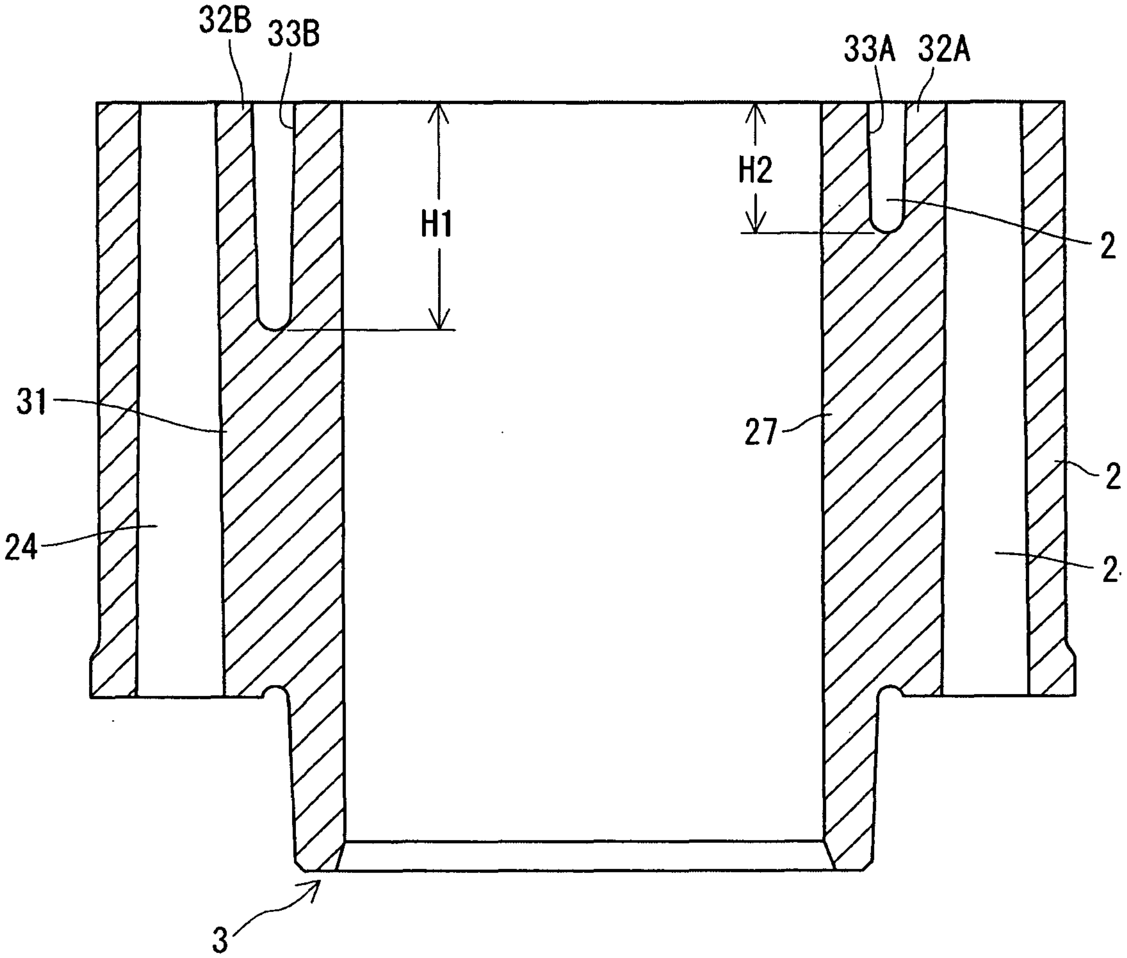
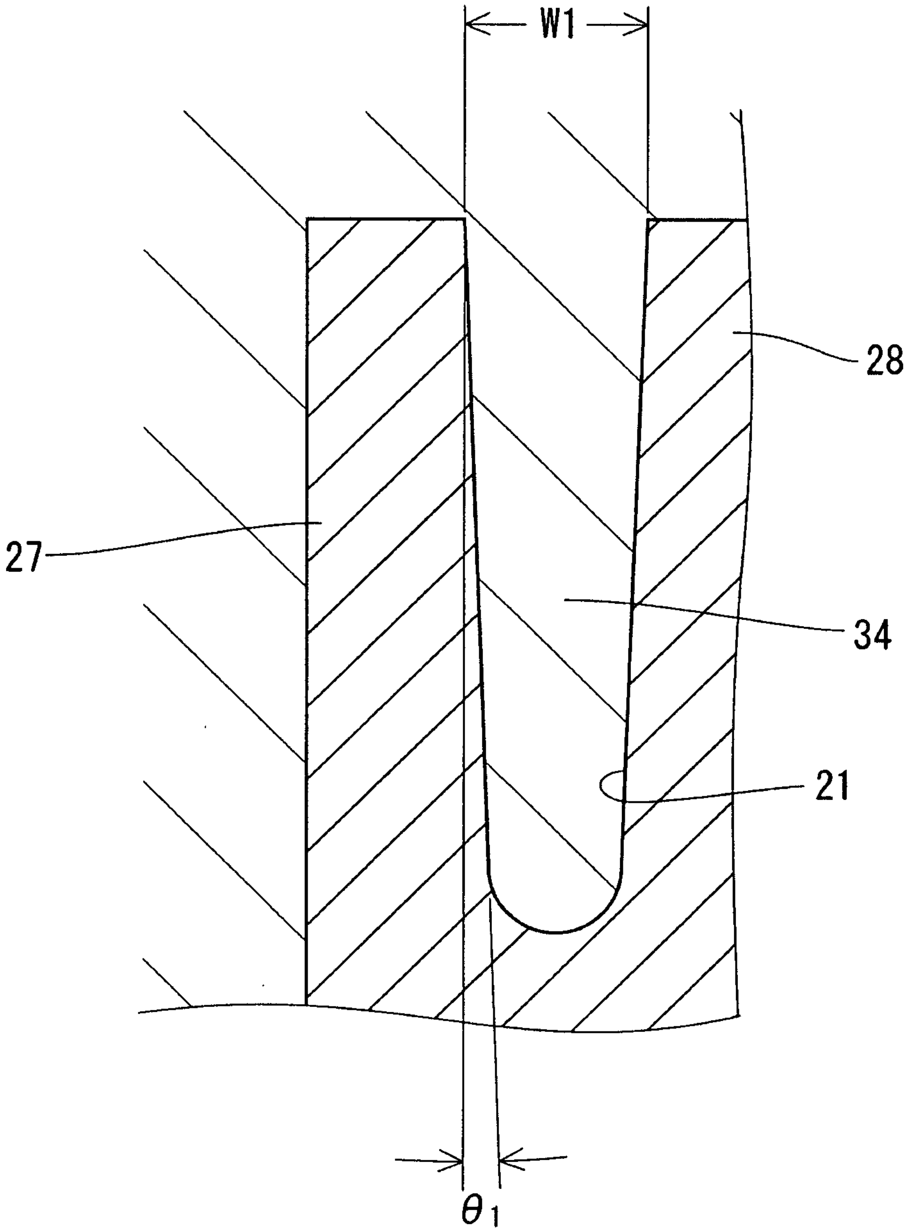
[FIG. 4]



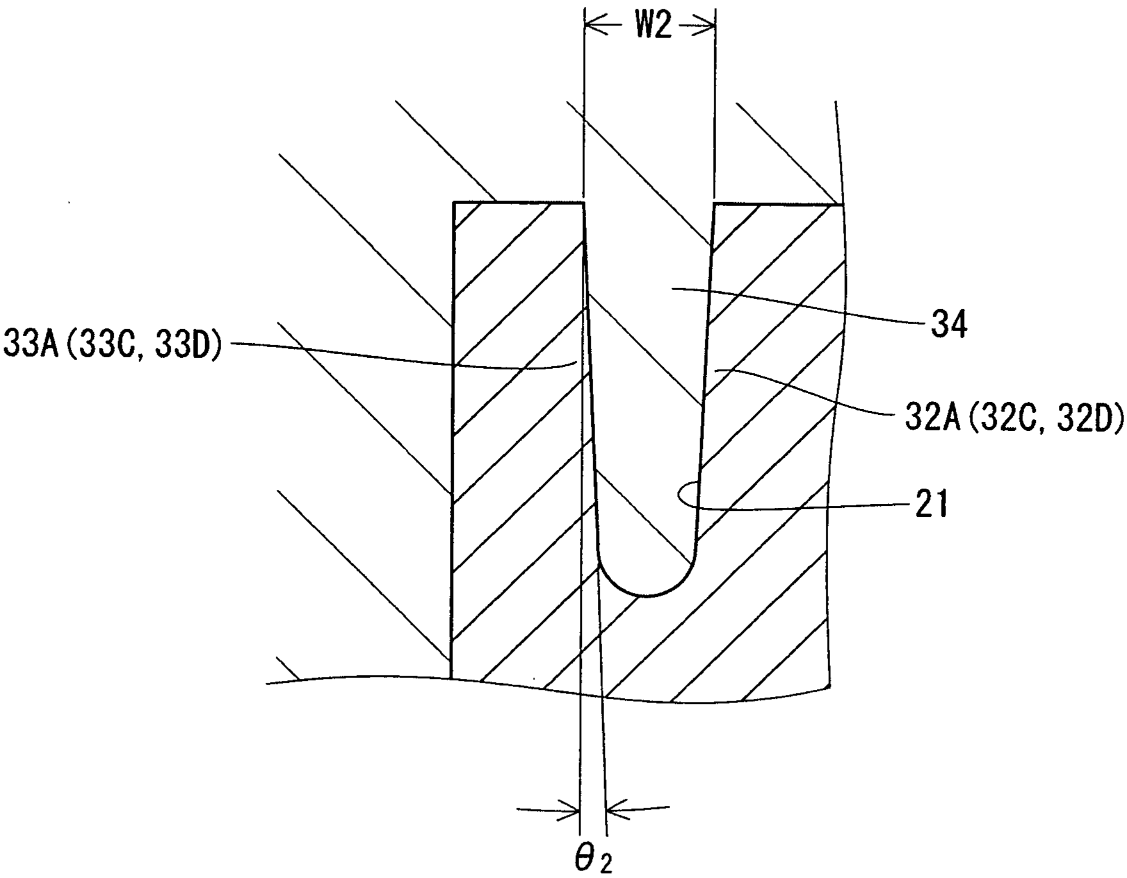
[FIG. 5]



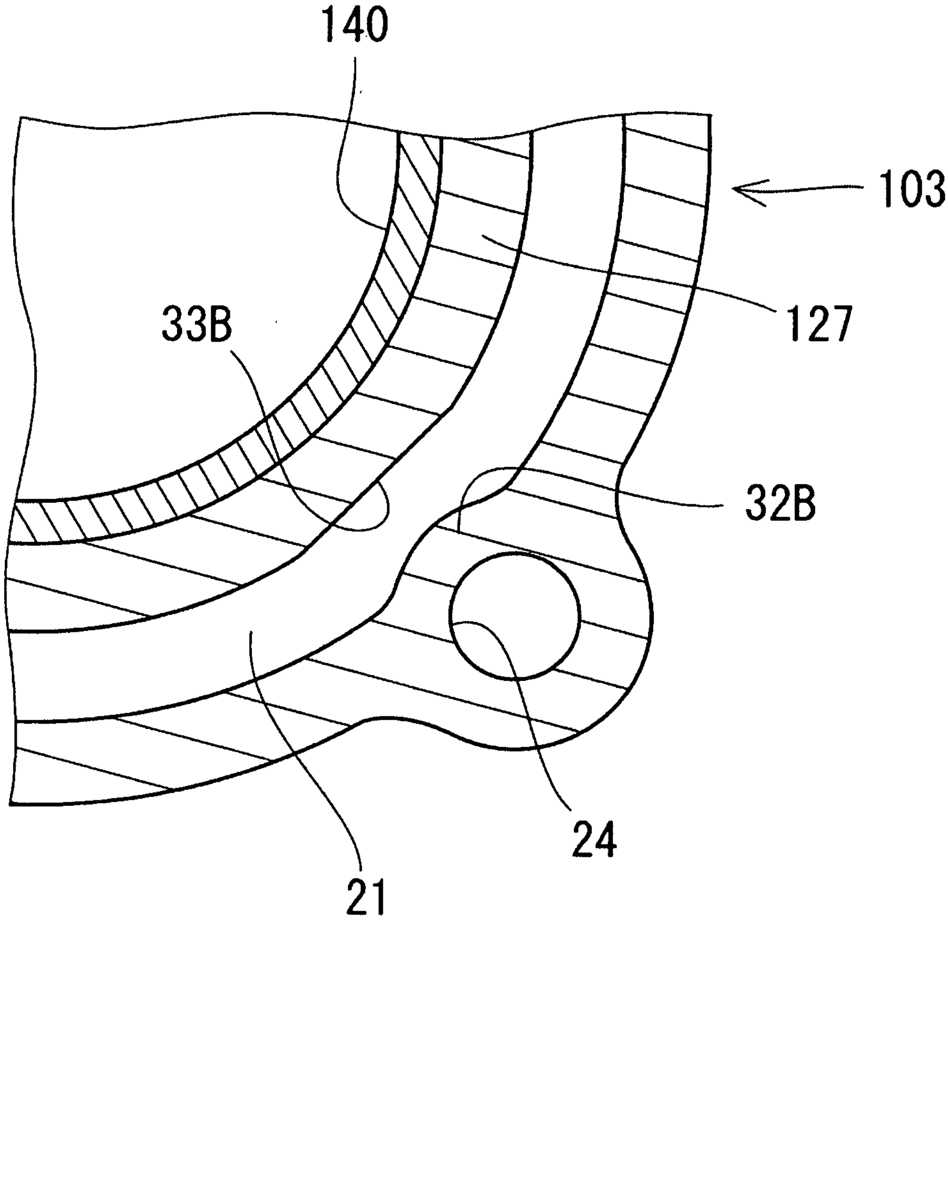
[FIG. 6]



[FIG. 7]



[FIG. 8]



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/054763

A. CLASSIFICATION OF SUBJECT MATTER
F02F1/10(2006.01)i, *F01P3/02*(2006.01)i, *F02F1/00*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F02F1/10, F01P3/02, F02F1/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2008
Kokai Jitsuyo Shinan Koho	1971-2008	Toroku Jitsuyo Shinan Koho	1994-2008

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 11-200942 A (Ricardo Consulting Engineers Ltd.), 27 July, 1999 (27.07.99), Par. Nos. [0013] to [0016]; Figs. 1, 2 & US 6035813 A & EP 911509 A1	1,2

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search 17 June, 2008 (17.06.08)	Date of mailing of the international search report 24 June, 2008 (24.06.08)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/054763

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

The matter common to the inventions of claims 1-17 is the invention of claim 1.

However, the search has revealed that the invention of claim 1 is disclosed in JP 11-200942 A (Ricardo Consulting Engineers Ltd.), 27 July 1999 (27.07.99), paragraphs 0013-0016, Figs. 1 and 2, and therefore, the invention is not novel.

Since claim 1 makes no contribution over the prior art, the common matter is not a special technical feature within the meaning of PCT Rule 13.2, second sentence.

(continued to extra sheet)

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.: 1 and 2

Remark on Protest the

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

Form PCT/ISA/210 (continuation of first sheet (2)) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/054763

Continuation of Box No.III of continuation of first sheet(2)

Since there is no other common matter that can be considered as a special technical feature within the meaning of PCT Rule 13.2, second sentence, no technical relationship within the meaning of PCT Rule 13 between the different inventions can be seen.

Form PCT/ISA/210 (extra sheet) (April 2007)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2006144559 A **[0003]**
- WO 2004002658 A **[0067]**