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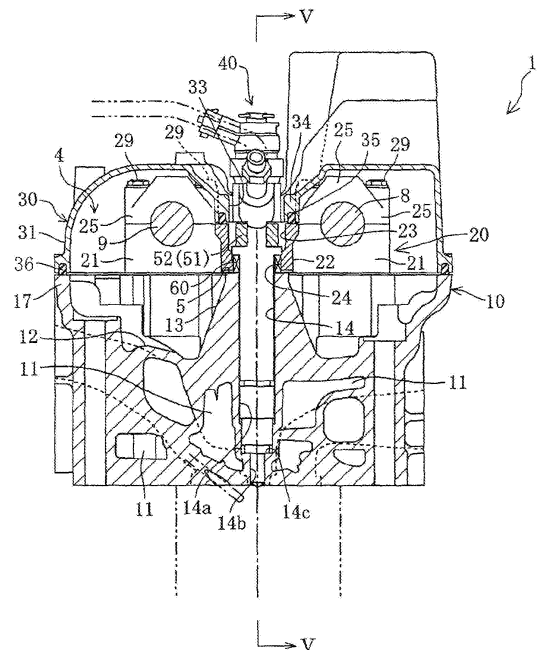
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(54) **Cylinder head structure for direct-injection diesel engine**

(57) The peripheral region (10a) of each injector hole (14) in the top surface of a cylinder head (10) and the peripheral region (20a) of an associated insertion hole (injector insertion hole) (24) in the bottom surface of a cam holder (20) face each other with an annular clearance (5) left therebetween and a seal (60) is disposed between the insertion hole (24) and an associated injector (40). The seal (60) includes a seal body (61) and first to third sealing parts (62-64). The first sealing part (62) is engaged against the injector (40), the second sealing part (63) protrudes downward beyond the insertion hole (24) and is engaged against the peripheral region (10a) of the injector hole (14), and the third sealing part (64) is expanded in diameter and engaged against the inner periphery of the insertion hole (24) by compressively deforming the second sealing part (63).

FIG. 4



Description

Technical Field

[0001] This invention relates to a cylinder head structure for a direct-injection diesel engine in which fuel injectors are disposed generally vertically through a cylinder head and a cam holder mounted on top of the cylinder head.

Background Art

[0002] In an example of conventional vehicle-mounted direct-injection diesel engines, as disclosed in Published Japanese Patent Application No. 2005-180277, two camshafts are disposed above a cylinder head, a cam holder journaling the camshafts is fixedly mounted on the top surface of the cylinder head and a plurality of injectors for directly injecting fuel into a plurality of cylinders individually are disposed generally vertically through the cylinder head and the cam holder.

[0003] In the cylinder head structure of the above direct-injection diesel engine, an upper part of the cylinder head including a valve chamber is held oil-tight against the outside space by a cylinder head cover and the top end of each injector protrudes upward through an opening formed in the cylinder head cover. This provides improved workability in the maintenance of each injector, namely, serviceability.

[0004] The cylinder head is formed with a plurality of injector holes, while the cam holder is formed with a plurality of insertion holes. Each pair of an injector hole and an insertion hole is used to insert an injector in them. In order to ensure a sealing property around each injector, an annular seal is fitted between the inner periphery of each insertion hole and the injector. In addition, the peripheral region of each injector hole in the top surface of the cylinder head comes into contact with the peripheral region of the associated insertion hole in the bottom surface of the cam holder and an O-ring is fitted between both the peripheral regions so as to be fitted in an annular groove formed in one of the peripheral regions (the peripheral region of the insertion hole in the cylinder head top surface).

[0005] According to the above sealing structure, it can be prevented that water and dust enter from outside into inside of the engine through the insertion holes and the injector holes and oil leaks out of the valve chamber through the insertion holes and the injector holes.

Problems to Be Solved by the Invention

[0006] In the above conventional cylinder head structure, since the peripheral region of each injector hole in the top surface of the cylinder head comes into contact with the peripheral region of the associated insertion hole in the bottom surface of the cam holder, the O-ring is fitted in a compressed manner by and between both the

peripheral regions to bring itself into tight contact with both the peripheral regions, thereby ensuring the sealing property. However, on the other hand, since the peripheral region of each injector hole (i.e., the cylinder head) is located right above a combustion chamber, it undergoes a large upthrust force caused by explosion. The upthrust force directly and repeatedly acts on the peripheral region of the associated insertion hole in the cam holder, which may cause cracks in the cam holder.

[0007] To cope with this, it can be considered to provide an annular clearance between the top surface of the cylinder head (i.e., the peripheral region of each injector hole) and the bottom surface of the cam holder (i.e., the peripheral region of the associated insertion hole). However, if such a clearance is provided, both the peripheral regions in turn cannot apply a sufficient sealing pressure to the O-ring, resulting in another problem of the difficulty in ensuring the sealing property. If in this case the O-ring is upsized, its fittability is deteriorated. In the result, it is difficult to ensure a sufficient sealing property around each injector.

[0008] With the foregoing in mind, an object of the present invention is to provide a cylinder head structure that prevents the occurrence of cracks in the cam holder due to explosive power in cylinders and concurrently ensures a sufficient sealing property around each injector.

Disclosure of the Invention

[0009] A first aspect of the present invention is directed to a cylinder head structure for a direct-injection diesel engine in which a camshaft is disposed above a cylinder head and a plurality of injectors are disposed generally vertically through the cylinder head.

[0010] In the cylinder head structure, a cylinder head cover covering the top of the cylinder head in an oil-tight manner is formed with an opening through which the top ends of the plurality of injectors protrude upward, the top surface of the cylinder head is formed with injector holes each of which is associated with one of a plurality of cylinders and in each of which an associated one of the plurality of injectors is inserted, and a cam holder journaling the camshaft is fixedly mounted on the top surface of the cylinder head. The cam holder includes a plurality of bearings and a connecting part connecting the bearings and the connecting part is formed with injector insertion holes each communicated with an associated one of the injector holes. An elastic seal is disposed between each injector insertion hole and the injector inserted therein. An annular clearance is formed between a peripheral region of each injector hole in the top surface of the cylinder head and a peripheral region of the associated injector insertion hole in the bottom surface of the cam holder.

[0011] Furthermore, the seal comprises: a seal body fitted between the inner periphery of each injector insertion hole and the associated injector; a first sealing part formed on the inside of the seal body and engaged

against the injector; a second sealing part extending downward from the seal body to protrude downward beyond the injector insertion hole and engaged against the peripheral region of the associated injector hole in the top surface of the cylinder head; and a third sealing part that deforms to expand its diameter and engage against the inner periphery of the injector insertion hole when the second sealing part compressively deforms upon engagement against the peripheral region of the injector hole.

[0012] In the above cylinder head structure, injectors are inserted and fitted into the associated injector holes in the cylinder head and the associated injector insertion holes in the cam holder and disposed generally vertically through the cylinder head, whereby the injectors inject fuel directly into the combustion chambers of the associated cylinders. Since the top ends of the injectors protrude upward through the opening in the cylinder head cover, this improves workability in their maintenance, namely, serviceability.

[0013] Furthermore, the peripheral region of each injector hole in the top surface of the cylinder head and the peripheral region of the associated injector insertion hole in the bottom surface of the cam holder face each other with an annular clearance left therebetween. Therefore, even if the peripheral region of the injector hole (i.e., the cylinder head) is located right above the combustion chamber and undergoes a large upthrust force caused by explosion in the cylinder, the upthrust force does not directly act on the peripheral region of the associated injector insertion hole (i.e., the cam holder).

[0014] In order to ensure a sealing property around each injector, an elastic seal including a seal body and first to third sealing parts is disposed between each injector insertion hole in the cam holder and the injector. The seal body is fitted between the inner periphery of the injector insertion hole and the injector and the first sealing part formed on the inside of the seal body is engaged against the injector. The second sealing part extends downward from the seal body to protrude downward beyond the injector insertion hole and is engaged against the peripheral region of the associated injector hole in the top surface of the cylinder head. With compressive deformation of the second sealing part upon engagement against the peripheral region of the injector hole, the third sealing part deforms to expand its diameter and engage against the inner periphery of the injector insertion hole.

[0015] Thus, while an annular clearance is formed between the peripheral region of each injector hole in the top surface of the cylinder head and the peripheral region of the associated injector insertion hole in the bottom surface of the cam holder, the seal having the above structure provides firm seal between each injector and the cam holder and between the cam holder and the cylinder head.

[0016] The first aspect of the invention may have the following configurations.

[0017] The clearance may be formed between the pe-

ripheral region of each injector insertion hole in the bottom surface of the cam holder and the top surface of the cylinder head facing the peripheral region of the injector insertion hole by forming a recess surrounding the injector insertion hole in the peripheral region of the injector insertion hole (a second aspect of the present invention).

[0018] Furthermore, the seal may be provided with an annular carrier of L-shaped cross section bonded to the outer periphery and bottom of the seal body. In this case, the annular carrier is fitted in the injector insertion hole, the third sealing part is provided under the annular carrier, and the second sealing part is provided under the third sealing part (a third aspect of the present invention). Moreover, the cam holder may be fastened at its bearings and connecting part to the cylinder head by a plurality of bolts.

[0019] As described so far, the cylinder head structure according to the first aspect of the present invention is configured so that between the top surface of the cylinder head and the bottom surface of the cam holder fixedly mounted thereon, an annular clearance is provided between the peripheral region of each injector hole and the peripheral region of the associated injector insertion hole. Therefore, though the peripheral region of each injector hole in the cylinder head, located right above the combustion chamber, undergoes a large upthrust force caused by explosion, the upthrust force does not directly act on the cam holder (the peripheral region of the injector insertion hole), which improves the durability of the cam holder and thereby prevents the occurrence of cracks in the cam holder.

[0020] If such a clearance as described above were formed in the known art (as disclosed in Published Japanese Patent Application No. 2005-180277), this would make it difficult for the O-ring to ensure the sealing property between both the peripheral regions. In contrast, in the above first aspect, the seal is disposed between each injector insertion hole in the cam holder and the associated injector, the seal body is fitted between the inner periphery of the injector insertion hole and the injector, the first sealing part formed on the inside of the seal body is engaged against the injector, the second sealing part extending downward from the seal body is protruded downward beyond the injector insertion hole and engaged against the peripheral region of the associated injector hole in the top surface of the cylinder head, the third sealing part is deformed to expand its diameter by compressive deformation of the second sealing part caused by engagement against the peripheral region of the injector hole and thereby engaged against the inner periphery of the injector insertion hole.

[0021] Thus, firm seal can be provided between each injector and the cam holder and between the cam holder and the cylinder head without processing the peripheral region of the injector hole in the top surface of the cylinder head for the purpose of fitting the seal.

[0022] More specifically, in spite of formation of such clearances as described above, a sufficient sealing prop-

erty is provided around each injector, which prevents water and dust from entering from outside through the injector insertion holes and the injector holes and prevents oil from leaking out through the injector insertion holes and the injector holes.

[0023] With the cylinder head structure according to the second aspect, since the annular clearance is formed between the peripheral region of each injector insertion hole in the bottom surface of the cam holder and the top surface of the cylinder head by forming a recess in the peripheral region of the injector insertion hole in the cam holder bottom surface, the top surface of the cylinder head (the peripheral region of the injector hole) can be flat. Therefore, by simply slightly changing the shape of the cam holder, the clearance can be easily formed without increasing the production cost.

[0024] In the cylinder head structure according to the third aspect, the seal is provided with an annular carrier of L-shaped cross section, the annular carrier is bonded to the outer periphery and bottom of the seal body and fitted into the associated injector insertion hole, the third sealing part is provided under the annular carrier and the second sealing part is provided under the third sealing part. This structure increases the unity of the seal including the seal body and the first to third sealing parts and stabilizes the retention of the seal and the sealing property of the first to third sealing parts.

[0025] With the cylinder head structure according to the fourth aspect, since the cam holder is fastened at its bearings and connecting part to the cylinder head by the plurality of bolts, the cam holder can be fixedly mounted on the top surface of the cylinder head with high stability.

Brief Description of Drawings

[0026]

Figure 1 is a plan view showing a cylinder head structure according to an embodiment of the present invention.

Figure 2 is a view corresponding to Figure 1 when a cylinder head cover and some elements are removed from the above cylinder head structure.

Figure 3 is a view corresponding to Figure 2 when a cam holder and some elements are further removed from the above cylinder head structure.

Figure 4 is a cross-sectional view taken along the line IV-IV in Figure 1.

Figure 5 is a cross-sectional view taken along the line V-V in Figure 4.

Figure 6 is a plan view of a cam holder.

Figure 7 is a front view of an injector.

Figure 8 is a plan view of an injector holder.

Figure 9 is a cross-sectional view of an essential part containing part of the cam holder and part of a cylinder head.

Figure 10 is a cross-sectional view of a seal.

Figure 11 is a cross-sectional view of a necessary

part of the seal when fitted in an injector insertion hole.

Figure 12 is a cross-sectional view showing a state that the injector is inserted through the seal in the injector insertion hole and an associated injector hole.

Best Mode for Carrying Out the Invention

[0027] A cylinder head structure for a direct-injection diesel engine according to the present invention is configured so that the peripheral region of each of injector holes in the top surface of a cylinder head faces the peripheral region of an associated one of injector insertion holes in the bottom surface of a cam holder with an annular clearance left therebetween and a seal having the following structure is disposed between the injector insertion hole of the cam holder and an associated injector.

[0028] Specifically, the seal includes: a seal body fitted between the inner periphery of each injector insertion hole and the associated injector; a first sealing part formed on the inside of the seal body and engaged against the injector; a second sealing part extending downward from the seal body to protrude downward beyond the injector insertion hole and engaged against the peripheral region of the associated injector hole in the top surface of the cylinder head; and a third sealing part that deforms to expand its diameter and engage against the inner periphery of the injector insertion hole when the second sealing part compressively deforms upon engagement against the peripheral region of the injector hole.

[0029] An embodiment of the present invention will be described below in detail. Figure 1 is a general plan view showing the cylinder head structure of a direct-injection diesel engine 1. Figure 2 is a plan view of the cylinder head structure when a cylinder head cover 30, injectors 40, seals 60 and some elements are removed therefrom. Figure 3 is a plan view of the cylinder head structure when a cam holder 20, camshafts 8 and 9 and some elements are further removed from the state shown in Figure 2. Figure 4 is a cross-sectional view taken along the line IV-IV in Figure 1. Figure 5 is a cross-sectional view taken along the line V-V in Figure 4. The direct-injection diesel engine 1 is an in-line four-cylinder engine having four cylinders 3 arranged along the longitudinal direction thereof to directly inject fuel into the combustion chambers in these cylinders 3. The following description is given on the assumption that the arrow a in Figures 1 to 3 and 5 is directed to the frontward direction.

[0030] As shown in Figures 1 to 5, the cylinder head structure of this embodiment is formed so that a pair of camshafts 8 and 9 having their length along the front-to-rear direction of the vehicle are disposed above a cylinder head 10 and four injectors 40 each for injecting fuel directly into an associated one of the combustion chambers of the four cylinders 3 are disposed generally vertically through the cylinder head 10.

[0031] The cylinder head 10 has four vertical injector holes 14 opened at its top surface. Each of the four injectors 40 is inserted and fitted into an associated one of the four injector holes 14. The top of the cylinder head 10 is covered with a cylinder head cover 30 in an oil-tight manner against the outside space. The cylinder head cover 30 is formed with an opening 33 through which the top ends of the injectors 40 protrude upward. Further, a cam holder 20 is fixedly mounted on the top surface of the cylinder head 10 and journals the pair of camshafts 8 and 9. The cam holder 20 is formed with four vertical insertion holes 24 (injector insertion holes) in each of which an associated one of the four injectors 40 is inserted. Four elastic seals 60 are disposed, each between an associated one of the four insertion holes 24 and an associated one of the four injectors 40.

[0032] As shown in Figures 3 to 5, the cylinder head 10 is formed with a water jacket 11 and a middle deck 12 separating the water jacket 11 from a valve chamber 4 and four bosses 13 are formed integrally with the middle deck 12 to protrude upward therefrom. The four bosses 13 are juxtaposed in the widthwise middle of the cylinder head 10 at spaced intervals in the front-to-rear direction of the vehicle and located above the respective combustion chambers of the four cylinders 3. The four injector holes 14 are formed to open into the smooth top surfaces of the four bosses 13, respectively, with each injector hole 14 vertically passing through the middle deck 12 and the boss 13 on the center line of the associated cylinder 3. Each injector hole 14 is composed of a large-diameter part 14a constituting most thereof including an upper part thereof and a small-diameter part 14b formed to extend downward from the lower end of the large-diameter part 14a through a shoulder 14c.

[0033] The middle deck 12 of the cylinder head 10 is formed with four bolt holes 15 screwed on four associated bolts 59 for fixing the four associated injectors 40 and a plurality of bolt holes 16 screwed on the same number of associated bolts 29 for fixing the cam holder 20. Each bolt hole 15 is located behind the associated injector hole 14 and one pair of the plurality of bolt holes 16 are located near behind each bolt hole 15 and on the right and left sides thereof. The cylinder head 10 has an outer peripheral wall 17 formed integrally with the middle deck 12 over the entire circumstance of its periphery to extend upward from the middle deck 12. The outer peripheral wall 17 is formed with a plurality of fastening holes 18 screwed on the same number of associated fastening elements 32 for fixing an outer peripheral wall 31 of the cylinder cover 30.

[0034] Figure 6 is a plan view of the cam holder 20. As shown in Figures 2 and 4 to 6, the cam holder 20 includes five pairs of bearings 21 for four cylinders, each pair arranged widthwise, for journaling the pair of camshafts 8 and 9, and a connecting part 22 connecting the pairs of bearings 21. The plurality of bearings 21 are integrally formed with the connecting part 22. The connecting part 22 extends in the front-to-rear direction of the vehicle and

is formed slightly shorter than the length of the cylinder head 10. The connecting part 22 has an elongated recess 23 formed from above and along the front-to-rear direction of the vehicle and the four insertion holes 24 opening into the smooth bottom surface of the recess 23 at lengthwise spaced intervals to vertically pass through the connecting part 22.

[0035] The five pairs of bearings 21 are formed to extend widthwise from portions of the connecting part 22 offset in the front-to-rear direction with respect to the four insertion holes 24 so that, out of the five pairs of bearings 21, two pairs at the front and rear ends are located frontward and rearward of the four insertion holes 24. The connecting part 22 has bolt insertion holes 26 each formed behind the associated insertion hole 24 to receive the associated bolt 59. Raised holder supports 27 are formed behind the associated bolt insertion holes 26. Each bolt support 27 is formed with a pin hole 27a in which a positioning pin 55 is fitted to protrude upward.

[0036] Ten bearings 21 in total composed of five pairs are engaged to associated bearing caps 25 from above and each bearing cap 25 is fixed to the associated bearing 21 by the associated bolts 29. The camshaft 8 is journaled in the left-side bearings 21 and bearing caps 25 and the camshaft 9 is journaled in the right-side bearings 21 and bearing caps 25. Each bearing 21 of the cam holder 20 is fastened together with the associated bearing cap 25 to the cylinder head 10 by the associated bolts 29. Thus, the cam holder 20 is fixedly mounted on the cylinder head 10 in place so that the plurality of insertion holes 24 are centered with the center lines of the associated cylinders 3. As a result, these insertion holes 24 are communicated with the associated injector holes 14 in the cylinder head 10.

[0037] Figure 9 is a cross-sectional view of an essential part containing the insertion hole 24 in the cam holder 20 and part of the injector hole 14 in the cylinder head 10. As shown in Figures 4, 5 and 9, each insertion hole 24 is formed to have a larger diameter than each injector hole 14 (its large-diameter part 14a) in the cylinder head 10. Specifically, each insertion hole 24 is composed of, in order from top to bottom, a top end hole 24a of maximum diameter, an upper hole 24b smaller in diameter than the top end hole 24a, a tapered hole 24c tapered downward from the lower end of the upper hole 24b, and a main hole 24d of the same diameter as that of the lower end of the tapered hole 24c. The depth of the main hole 24d is approximately two-thirds of the total depth of the insertion hole 24.

[0038] The top surfaces of the bosses 13 of the cylinder head 10 are formed flatly, whereas the bottom surface of the cam holder 20 has annular recesses each formed in the peripheral region 20a of the associated insertion hole 24 and the bottoms of the recesses are located above the bottom surface of the cam holder 20 (the bottom surface thereof located outwardly of the peripheral regions 20a). Thus, an annular clearance 5 having a diameter approximately twice as large as each injector hole

14 is formed between the peripheral region 10a of each injector hole 14 and the associated peripheral region 20a, namely, both the peripheral regions 10a and 20a face each other with the clearance 5 left therebetween.

[0039] As shown in Figures 1 and 4, the cylinder head cover 30 is formed in the shape of an open-bottom box and mounted on the cylinder head 10 from above. The bottom end surface of its outer peripheral wall 31 is connected in an oil-tight manner to the top end surface of the outer peripheral wall 17 of the cylinder head 10 by a seal 36. The cylinder head cover 30 and the cylinder head 10 are fastened together by the plurality of fastening elements 32. The cylinder head cover 30 has a slit opening 33 formed in the widthwise middle thereof to extend in the front-to-rear direction of the vehicle, whereby the entire recess 23 in the connecting part 22 of the cam holder 20 is exposed through the opening 33 to the outside.

[0040] The bottom end surface of an inner peripheral wall 34 defining the opening 33 of the cylinder head cover 30 is connected in an oil-tight manner to the top surface of the connecting part 22 of the cam holder 20 in the peripheral region of the recess 23 by a seal 35. Thus, with the recess 23 in the connecting part 22 of the cam holder 20 exposed through the opening 33 to the outside, the upper part of the cylinder head 10 including the valve chamber 4, together with the parts of the cam holder 20 other than the recess 23 and the pair of camshafts 8 and 9, is held oil-tight against the outside space by the cylinder head cover 30.

[0041] As shown in Figures 1, 4, 5 and 7, each injector 40 has a fuel introduction part 40a at the top and a fuel injection port 40b at the bottom end. Furthermore, the injector 40 also has a holder engaging part 41 formed into a narrow neck of substantially rectangular cross section slightly above the vertical middle thereof. A flange 42 is formed at the lower end of the holder engaging part 41. Below the flange 42, a large-diameter cylindrical part 43 is formed that has an approximately half length of the total length of the injector 40. A small-diameter cylindrical part 44 is formed to protrude downward from the lower end of the large-diameter cylindrical part 43 through a shoulder 45. The fuel injection port 40b is formed in the small-diameter cylindrical part 44.

[0042] Each injector 40 is detachably inserted and fitted from above into the insertion hole 24 in the cam holder 20 and the injector hole 14 in the cylinder head 10. The shoulder 45 of the injector 40 abuts from above on the shoulder 14c of the injector hole 14, whereby the injector 40 is vertically positioned. Thus, the top end of the injector 40 protrudes upward through the opening 33 in the cylinder head cover 30 and the fuel injection port 14b is presented to the combustion chamber of the associated cylinder 3. In this state, each injector 40 is disengageably locked by a locking mechanism 50 as described below.

[0043] As shown in Figures 1, 4, 5 and 8, the locking mechanism 50 has an injector holder 51 and one of the above-mentioned bolts 59. The injector holder 51 has a two-pronged arm 52 formed at the front, a fulcrum part

53 formed at the rear and a bolt insertion hole 54 formed in the lengthwise middle. The arm 52 is engaged with the holder engaging part 41 of the injector 40 and the fulcrum part 53 is put on and supported to the holder support 27 of the cam holder 20 while being positioned by the positioning pin 55. The bolt insertion hole 54 receives a bolt 59 inserted from above. The bolt 59 is loosely fitted into the bolt insertion hole 26 in the cam holder 20 and its lower end is screwed into the bolt hole 15 in the cylinder head 10.

[0044] When the bolt 59 is tightened, the arm 52 of the injector holder 51 undergoes a force to rotate it downward about the fulcrum part 53. Therefore, the injector 40 is pushed downward with the flange 42 by the arm 52 and thereby fixed with its shoulder 45 tightly engaged against the shoulder 14c of the injector hole 14. Furthermore, the connecting part 22 of the cam holder 20 is fastened to the cylinder head 10 through the injector holders 51 by the plurality of bolts 59. The peripheral region of each bolt insertion hole 26 in the top surface of the cam holder 20 is sealed against the bottom surface of the associated injector holder 51 and the associated bolt 59 by an annular seal 56.

[0045] According to the above structure, since the injector holders 51 are mounted on the recess 23 in the cam holder 20, the injector holders 51 and the bolts 59 are presented to the outside space through the opening 33 in the cylinder cover 30. Therefore, locking and unlocking of the locking mechanism 50 and removal of the injector 40 and the locking mechanism 50 can be made as the cylinder head cover 30 is mounted. This improves the workability in the maintenance of each injector 40, namely, serviceability.

[0046] Next, a description is given of the seal 60.

[0047] Figure 10 is a cross-sectional view of the seal 60. Figure 11 is a cross-sectional view of a necessary part of the seal 60 when fitted in the insertion hole 24. Figure 12 is a cross-sectional view showing a state that the injector 40 is inserted through the seal 60 in the insertion hole 24 and the injector hole 14. As described above, the seal 60 is disposed between the insertion hole 24 in the cam holder 20 and the injector 40.

[0048] As shown in Figures 4, 5 and 10 to 12, each seal 60 has a seal body 61 fitted between the inner periphery of each insertion hole 24 in the cam holder 20 and the associated injector 40, a first sealing part 62 formed on the inside of the seal body 61 and engaged against the injector 40, a second sealing part 63 extending downward from the seal body 61 to protrude downward beyond the insertion hole 24, and a third sealing part 64 that deforms to expand its diameter and engage against the inner periphery of the insertion hole 24 in the cam holder 20 when the second sealing part 63 is vertically compressed upon engagement against the peripheral region 10a of the injector hole 14 in the top surface of the cylinder head 10. These seal body 61 and first to third sealing parts 62 to 64 are formed annularly.

[0049] Furthermore, the seal 60 is provided with an

annular carrier 65 of L-shaped cross section that is made of metal, such as steel or stainless steel, and bonded to the outer periphery and bottom of the seal body 61. The seal 60 is fitted with the annular carrier 65 into the insertion hole 24 in the cam holder 20. The third sealing part 64 is provided under the annular carrier 65 and the second sealing part 63 is provided under the third sealing part 64. A detailed description is given below of the seal 60 and the annular carrier 65.

[0050] The annular carrier 65 is composed of a cylindrical part 65a, an annular flange 65b protruding radially outward from the upper end of the cylindrical part 65a, and an annular inward extension 65c including a tapered part 65d and extending radially inward from the lower end of the cylindrical part 65a. The cylindrical part 65a, the flange 65b and the inward extension 65c are integrally formed by pressing or other processings. The cylindrical part 65a is formed to have substantially the same outer diameter as the diameter of the main hole 24d of the insertion hole 24 and approximately two-thirds of the depth of the insertion hole 24. The outer periphery of the flange 65b is formed to have a diameter equal to or smaller than the diameter of the upper hole 24b of the insertion hole 24. The inner periphery of the inward extension 65c is formed to have a diameter equal to or smaller than the diameter of the large-diameter hole 14a of the injector hole 14.

[0051] In the seal 60, the seal body 61 and the first sealing part 62 are formed integrally with each other but separately from the second and third sealing parts 63 and 64. The second and third sealing parts 63 and 64 are formed integrally with each other. The outer periphery and bottom of the seal body 61 are bonded to the inner periphery of the cylindrical part 65a and the top surface of the inward extension 65c, respectively, of the annular carrier 65a and the top surface of the second sealing part 63 is bonded to the bottom surface of the inward extension 65c. Thus, the seal body 61 and the first to third sealing parts 62 to 64 are united, thereby forming the seal 60.

[0052] The seal body 61 is formed in the shape of a relatively thick cylinder allowing the insertion of the large-diameter part 43 of the injector 40 with a slight clearance left therebetween, and also formed so that when it is bonded to the annular carrier 65, its top surface is flush with the top surface of the flange 65a and its inner periphery is flush with the inner periphery of the inward extension 65c. The first sealing part 62 is formed to protrude inward from the vertical middle portion of the inner periphery of the seal body 61.

[0053] The second and third sealing parts 63 and 64 have a total length of approximately half of the length of the seal body 61. The third sealing part 64 has substantially the same thickness at the top end as the radial thickness of the seal body 61 and are entirely bonded to the bottom surface of the inward extension 65c. The inner peripheries of the third and second sealing parts 64 and 63 are formed into a continuous tapered surface gradu-

ally increasing its inner diameter downward. The radial thickness of the second sealing part 63 at its bottom end is smaller than the radial thickness of the seal body 61. The outer periphery of the second sealing part 63 is formed into a tapered surface gradually increasing its diameter upward and continues to the substantially straight outer periphery of the third sealing part 64 via a shoulder radially outwardly extending from the top end of the tapered outer periphery of the second sealing part 63.

[0054] The seal 60 and the annular carrier 65 are unitarily inserted into the insertion hole 24 from above and thereby fitted therein. In this case, the cylindrical part 65a of the annular carrier 65 is press fitted into the main hole 24d of the insertion hole 24, the flange 65b is loosely fitted into the upper hole 24b of the insertion hole 24 and the second sealing part 63 of the seal 60 protrudes downward beyond the insertion hole 24.

[0055] When the injector 40 is inserted into the seal 60 and the annular carrier 65, in turn into the insertion hole 24 of the cam holder 20 through them and then into the injector hole 14 of the cylinder head 10 and locked by the locking mechanism 50 as described above, the injector 40 is vertically positioned so that the flange 42 comes close to the bottom of the upper end hole 24a of the insertion hole 24.

[0056] The insertion of the injector 40 causes the first sealing part 62 to be engaged against the injector 40 while elastically deforming downward and causes the cylindrical part 65a of the annular carrier 65 to be held press-fitted in the main hole 24d of the insertion hole 24. Thus, the second sealing part 63 protruding downward beyond the insertion hole 24 is engaged against the peripheral region 10a of the injector hole 14 in the top surface of the cylinder head 10. With the compressive deformation of the second sealing part 63 due to the engagement against the peripheral region 10a of the injector hole 14, the third sealing part 64 deforms to expand its diameter and is thereby held engaged against the inner periphery of the insertion hole 24 in the cam holder 20.

[0057] As described so far, the cylinder head structure of this embodiment is configured so that the cam holder 20 is fixedly mounted on the top surface of the cylinder head 10, that the injectors 40 are inserted and fitted in the associated injector holes 14 in the cylinder head 10 and the associated insertion holes 24 in the cam holder 20 to dispose the injectors 40 generally vertically through the cylinder head 10 and that the peripheral region 10a of each injector hole 14 in the top surface of the cylinder head 10 faces the peripheral region 20a of the associated insertion hole 24 in the bottom surface of the cam holder 20 with the annular clearance 5 left therebetween.

[0058] Therefore, though the peripheral region 10a of each injector hole 14 in the top surface of the cylinder head 10, located right above the combustion chamber of the associated cylinder 3 of the direct-injection diesel engine 1, undergoes a large upthrust force caused by explosion in the combustion chamber, the upthrust force

does not directly act on the peripheral region 20a of the insertion hole 24 in the cam holder 20, which improves the durability of the cam holder 20 and thereby prevents the occurrence of cracks in the cam holder 20.

[0059] If the clearance 5 is formed as described above, this would conventionally make it difficult to ensure the sealing property between both the peripheral regions 10a and 20a. However, in the above structure, the seal 60 is disposed between each insertion hole 24 in the cam holder 20 and the associated injector 40, the seal body 61 is fitted between the inner periphery of the insertion hole 24 and the injector 40, the first sealing part 62 formed on the inside of the seal body 61 is engaged against the injector 40, the second sealing part 63 extending downward from the seal body 61 is protruded downward beyond the insertion hole 24 and engaged against the top surface of the cylinder head 10 (the peripheral region 10a of the associated injector hole 14), whereby the third sealing part 64 is expanded in diameter and thereby engaged against the inner periphery of the insertion hole 24.

[0060] Thus, firm seal can be provided between each injector 40 and the cam holder 20 and between the cam holder 20 and the cylinder head 10 without processing the peripheral region 10a of the injector hole 14 in the top surface of the cylinder head 10 for the purpose of fitting the seal. More specifically, in spite of formation of the clearance 5, the seal 60 provides a sufficient sealing property around the associated injector 40, which prevents water and dust from entering from outside through the insertion hole 24 and the injector hole 14 and prevents oil from leaking out through the insertion hole 24 and the injector hole 14.

[0061] Furthermore, the clearance 5 is formed by forming a recess in the peripheral region 20a of the associated insertion hole 24 in bottom surface of the cam holder 20. The formation of the clearance 5 need only slightly change the shape of the cam holder 20 and the top surface of the cylinder head 10 (the peripheral region 10a of the injector hole 14) can be flat. Therefore, the clearance 5 can be easily formed without increasing the production cost.

[0062] Furthermore, the seal 60 is provided with an annular carrier 65 of L-shaped cross section bonded to the outer periphery and bottom of the seal body 61 and fitted into the associated insertion hole 24, the third sealing part 64 is provided under the annular carrier 65 and the second sealing part 63 is provided under the third sealing part 64. This structure increases the unity of the seal 60 including the seal body 61 and the first to third sealing parts 62 to 64 and stabilizes the retention of the seal 60 and the sealing property of the first to third sealing parts 62 to 64.

[0063] In addition, the cam holder 20 is fastened at its plurality of bearings 21 and its connecting part 22 to the cylinder head 10 by the plurality of bolts 29 and 59. Therefore, the cam holder 20 can be fixedly mounted on the top surface of the cylinder head 10 with high stability.

[0064] The above embodiment may be partly modified

as follows.

1) The seal 60, particularly the third and fourth sealing parts 63 and 64, may be of any shape so long as it has the above-mentioned functions.

2) The clearance 5 may be formed by forming an annular recess in the peripheral region 10a of the associated injector hole 14 in the top surface of the cylinder head 10. In this case, the formation of the clearance 5 is implemented by simply slightly changing the shape of the cylinder head 10 and the peripheral region 20a of the insertion hole 24 in the bottom surface of the cam holder 20 can be a flat surface.

3) The inward extension 65c of the annular carrier 65, instead of having an annular shape, may comprise a plurality of inward extensions circumferentially spaced apart from each other and may be inserted and fitted between the seal body 61 and the third sealing part 64 of the seal 60. In this case, the seal body 61 and the first to third sealing parts 62 to 64 can be integrally molded.

4) The cylinder head structure of the present invention is not limited to the application to in-line four-cylinder engines as in the above embodiment and double overhead camshaft (DOHC) engines having a pair of camshafts 8 and 9 and is applicable to various types of direct-injection diesel engines, such as in-line six-cylinder engines and single overhead camshaft (SOHC) engines.

Claims

1. A cylinder head structure for a direct-injection diesel engine (1) in which a camshaft (8, 9) is disposed above a cylinder head (10) and a plurality of injectors (40) are disposed generally vertically through the cylinder head (10), wherein a cylinder head cover (30) covering the top of the cylinder head (10) in an oil-tight manner is formed with an opening (33) through which the top ends of the plurality of injectors (40) protrude upward, the top surface of the cylinder head (10) is formed with injector holes (14) each of which is associated with one of a plurality of cylinders and in each of which an associated one of the plurality of injectors (40) is inserted, a cam holder (20) journaling the camshaft (8, 9) is fixedly mounted on the top surface of the cylinder head (10), the cam holder (20) includes a plurality of bearings (21) and a connecting part (22) connecting the bearings (21), the connecting part (22) being formed with injector insertion holes (24) each communicated with an associated one of the injector holes (14), an elastic seal (60) is disposed between each said injector insertion hole (24) in the cam holder (20) and

the injector (40) inserted therein,
 an annular clearance (5) is formed between a peripheral region (10a) of each said injector hole (14) in the top surface of the cylinder head (10) and a peripheral region (20a) of the associated injector insertion hole (24) in the bottom surface of the cam holder (20),
 the seal (60) comprises:

- a seal body (61) fitted between the inner periphery of each said injector insertion hole (24) and the associated injector (40);
 - a first sealing part (62) formed on the inside of the seal body (61) and engaged against the injector (40);
 - a second sealing part (63) extending downward from the seal body (61) to protrude downward beyond said injector insertion hole (24) and engaged against the peripheral region (10a) of the associated injector hole (14) in the top surface of the cylinder head (10); and
 - a third sealing part (64) that deforms to expand its diameter and engage against the inner periphery of said injector insertion hole (24) when the second sealing part (63) compressively deforms upon engagement against the peripheral region (10a) of the injector hole (14).
2. The cylinder head structure of claim 1, wherein the clearance (5) is formed between the peripheral region (20a) of each said injector insertion hole (24) in the bottom surface of the cam holder (20) and the top surface of the cylinder head (10) facing the peripheral region (20a) of the injector insertion hole (24) by forming a recess surrounding the injector insertion hole (24) in the peripheral region (20a) of the injector insertion hole (24).
3. The cylinder head structure of claim 1 or 2, wherein an annular carrier (65) of L-shaped cross section bonded to the outer periphery and bottom of the seal body (61) is fitted in the injector insertion hole (24), the third sealing part (64) is provided under the annular carrier (65), and the second sealing part (63) is provided under the third sealing part (64).
4. The cylinder head structure of any one of claims 1 to 3, wherein the cam holder (20) is fastened at its bearings (21) and connecting part (20) to the cylinder head (10) by a plurality of bolts (29, 59).

55

FIG. 1

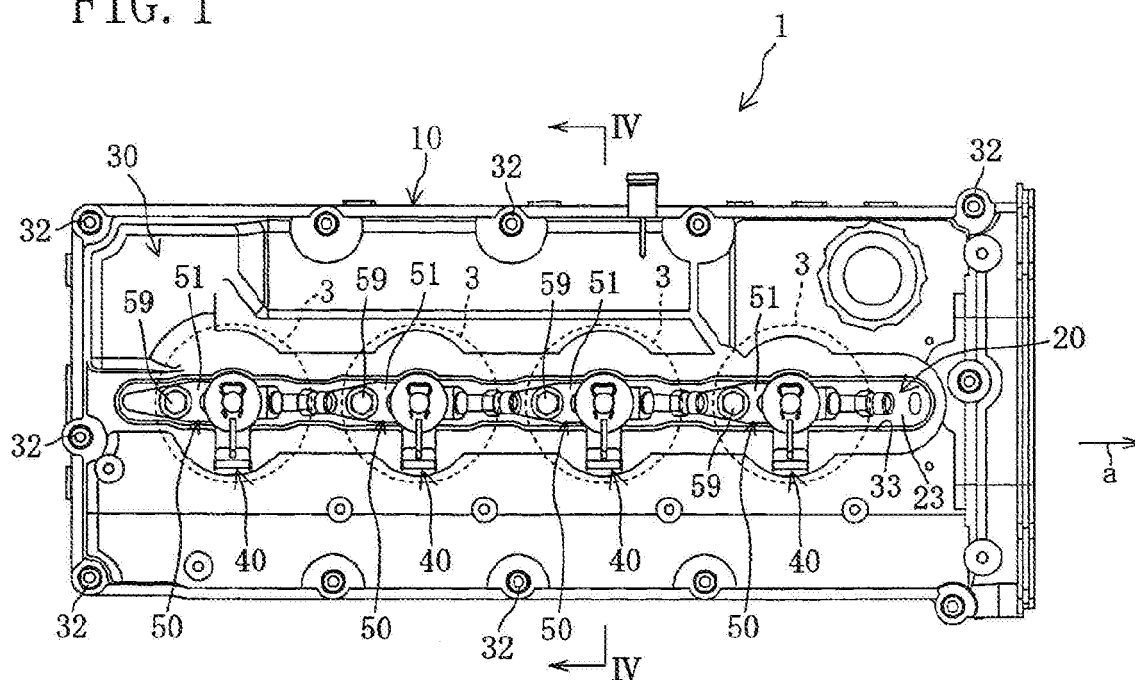


FIG. 2

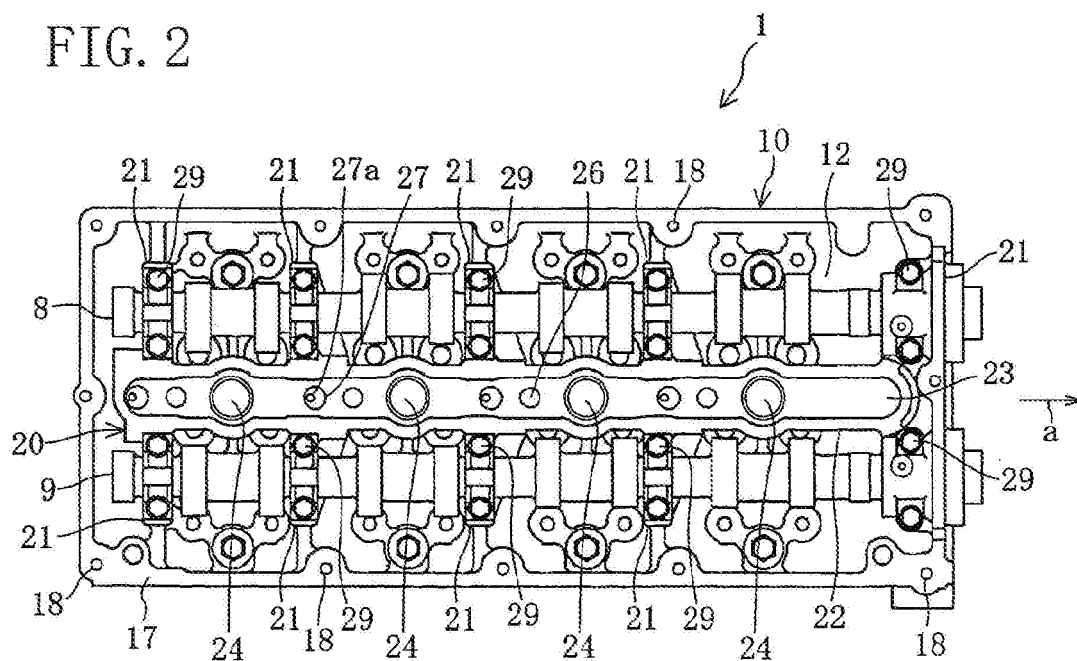


FIG. 3

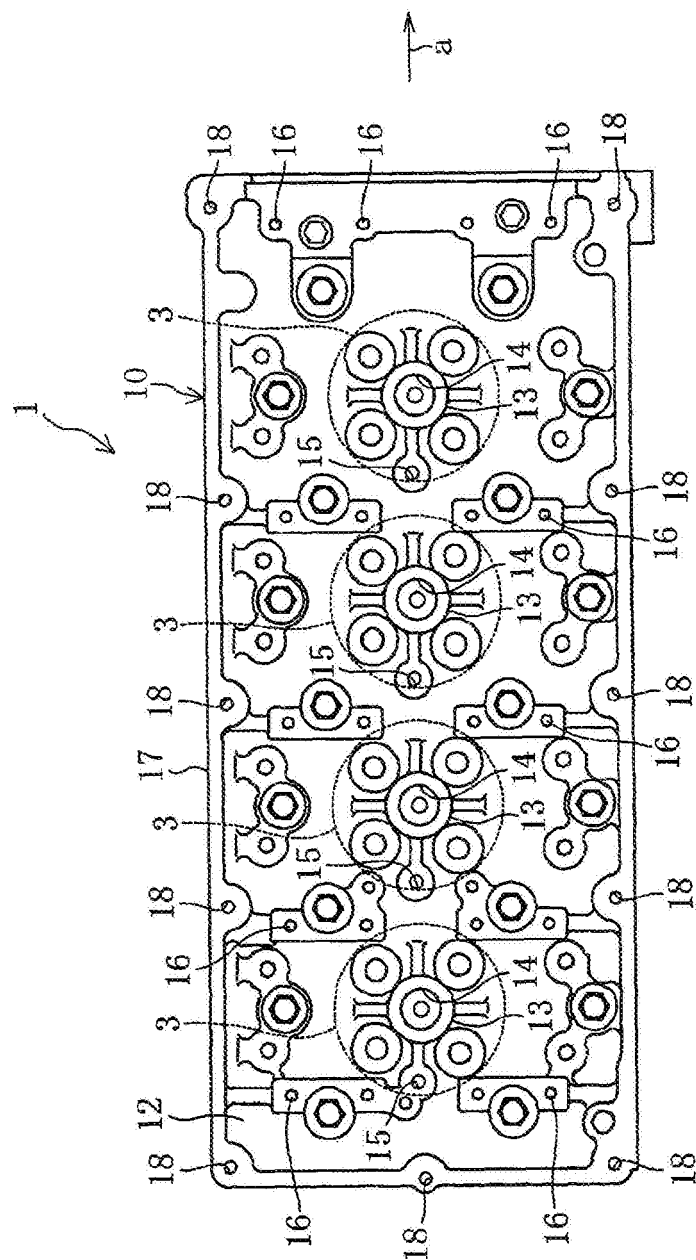


FIG. 4

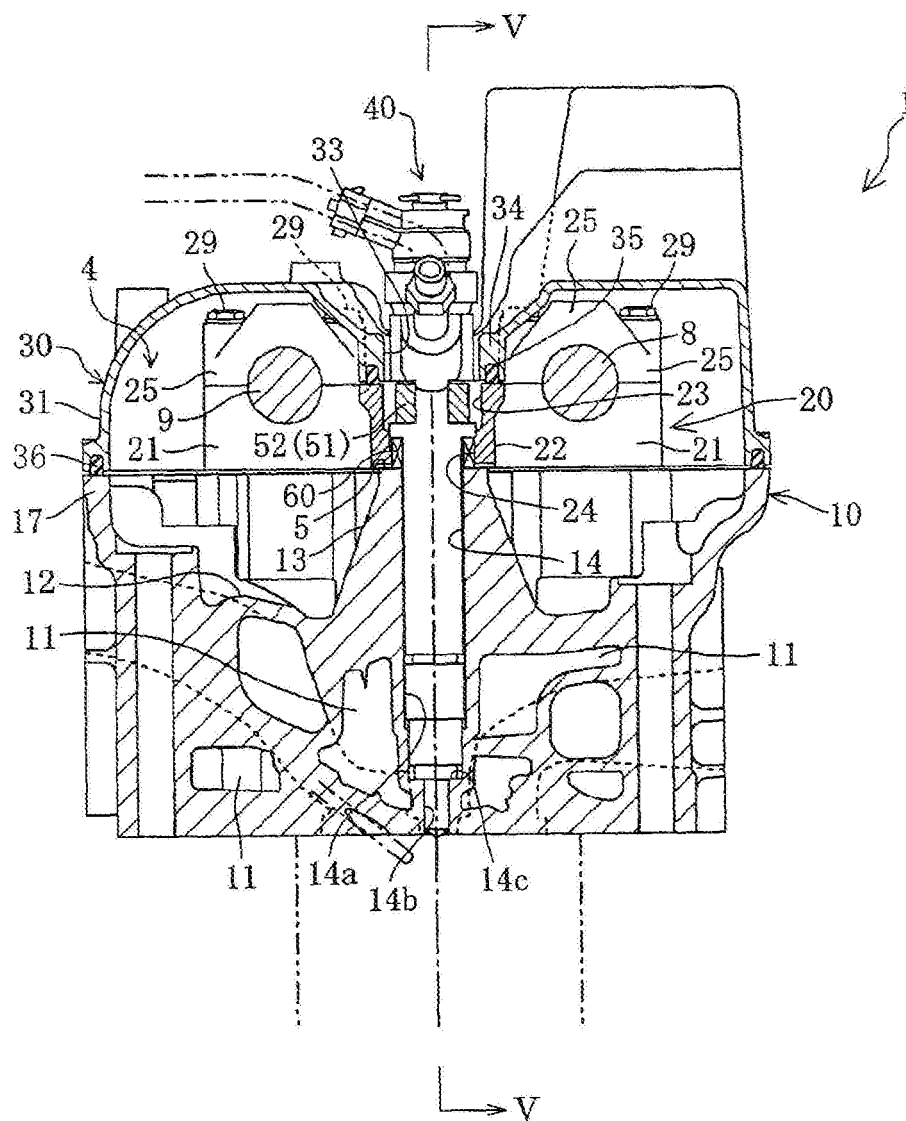


FIG. 5

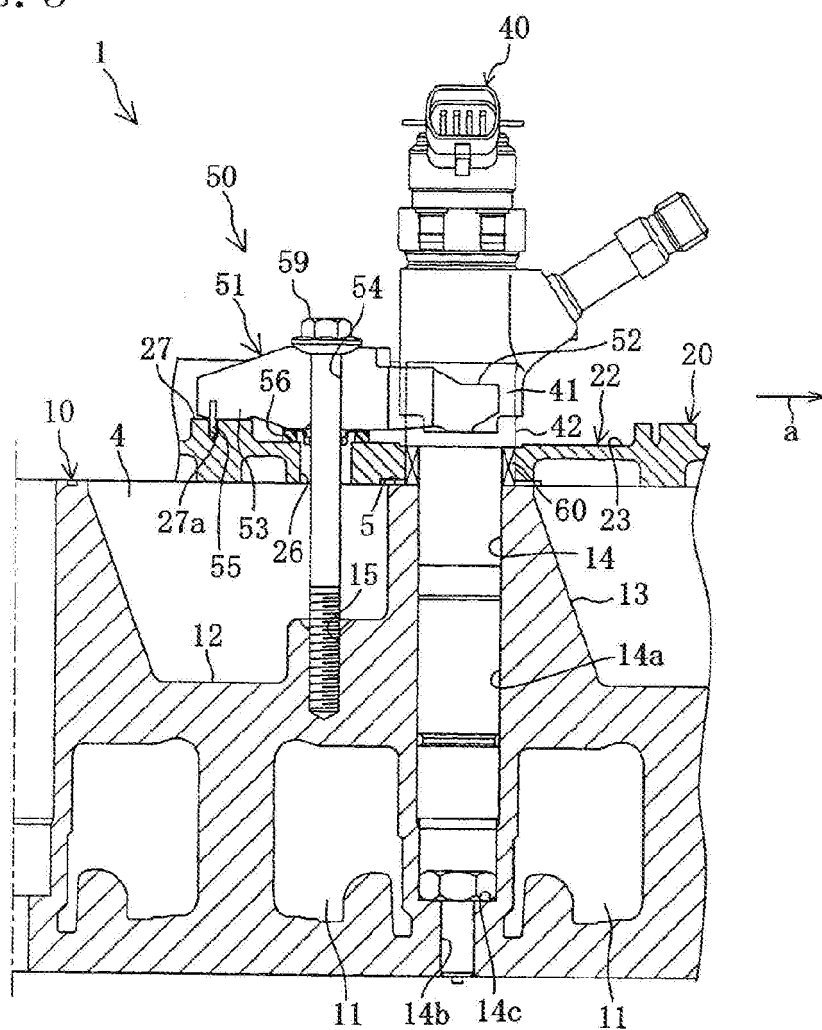


FIG. 6

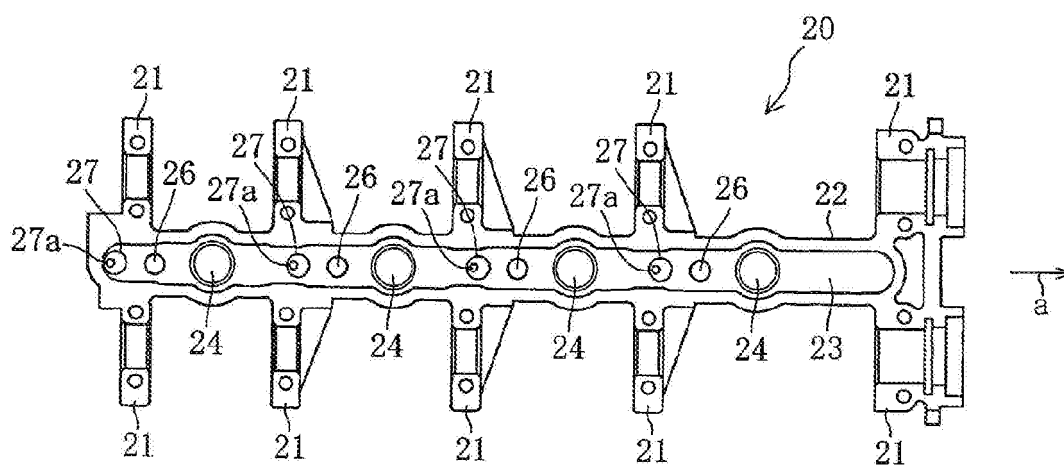


FIG. 7

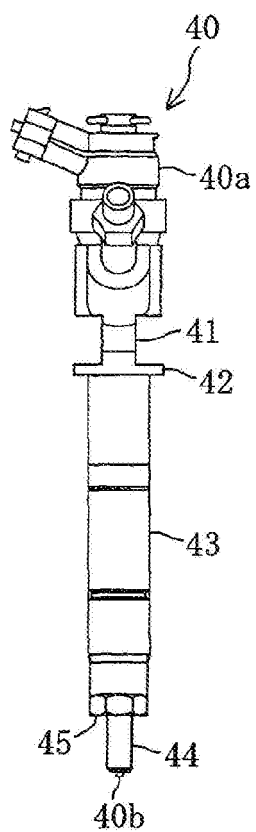


FIG. 8

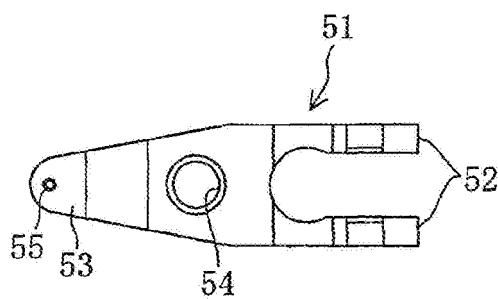


FIG. 9

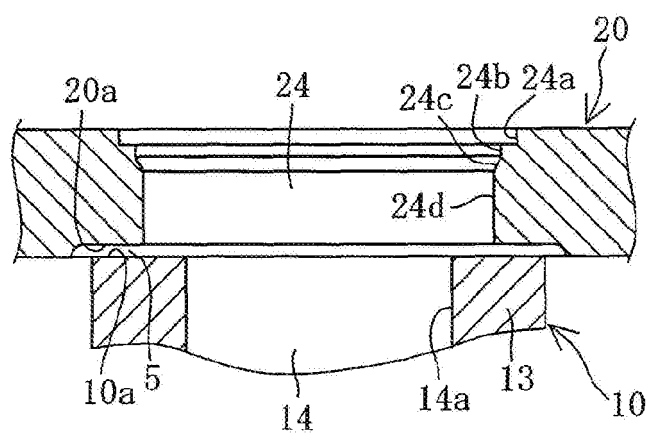


FIG. 10

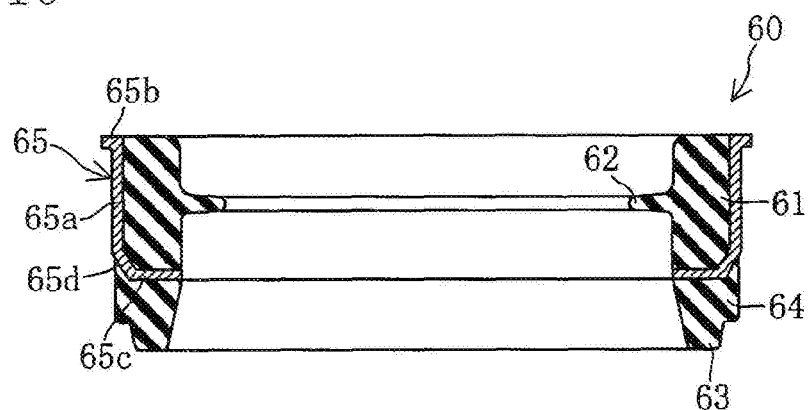


FIG. 11

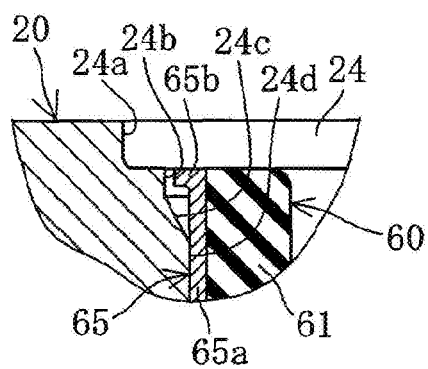
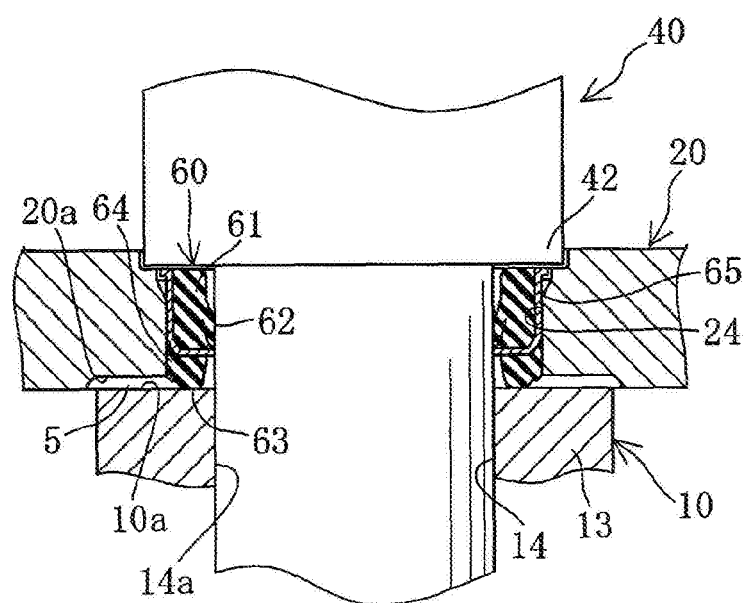


FIG. 12



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2005180277 A [0002] [0020]