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(54) CYLINDER HEAD, INTERNAL COMBUSTION ENGINE EQUIPPED WITH SAME, AND CORE FOR MOLDING INTAKE PORT

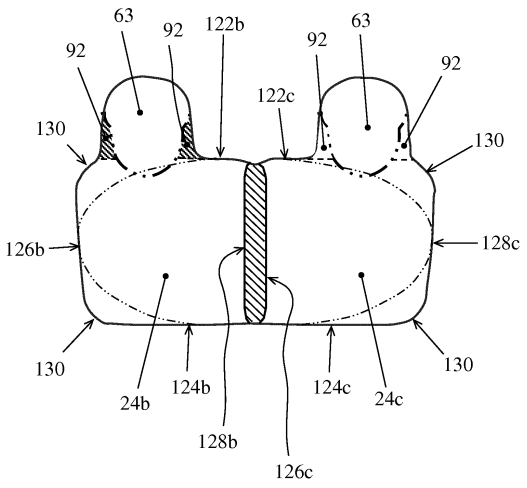
(57) [Object]

To provide a technique for further improving fuel economy.

[Solution]

An intake port 24 has a quadrangular port region that is substantially quadrangular in a cross section perpendicular to a longitudinal direction (flowing direction of intake air), and openings of injector attachment holes 26 to branch ports 24b and 24c are nearly entirely provided in upper flat wall portions 122b and 122c in quadrangular port regions of the branch ports 24b and 24c. Thus, the size of a dead volume 92 can be made smaller than when the injector attachment holes are provided in an intake port of circular cross section. Therefore, turbulence of intake air flowing in the intake port 24, particularly in the branch ports 24b and 24c can be suppressed, and mixability of fuel and intake air can be enhanced to improve combustion efficiency. As a result, fuel economy can be improved further.

【FIG.12】



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Description

Technical Field

[0001] The present invention relates to a cylinder head including a combustion-chamber forming part configured to form a combustion chamber, an intake port communicating with the combustion-chamber forming part, and an attachment hole at which an injector configured to inject fluid is attached, an internal combustion engine equipped with the cylinder head, and an intake-port molding core configured to mold the intake port in the cylinder head.

Background Art

[0002] As a cylinder head of this type, there has hitherto been proposed a structure in which one combustion chamber is provided with two intake ports and injectors can be disposed at the respective intake ports (see, for example, PTL 1).

[0003] In an engine equipped with this cylinder head, the amounts of fuel to be injected from the injectors can be controlled according to the flow rates of intake air passing through the intake ports. Hence, excessive injection of fuel to the intake ports can be prevented. This is intended to improve fuel economy.

Citation List

Patent Literature

[0004] PTL 1: Japanese Patent No. 5083565

Summary of Invention

Technical Problem

[0005] In general, the shape of a cross section of an intake port perpendicular to the flowing direction of intake air is circular or elliptic to obtain a smooth flow of intake air. Further, an injector is attached at an angle to the axis of the intake port to inject fuel along the flow of intake air so that the flow of intake air is not disturbed by the fuel injected from the injector. Here, since an attachment hole at which the injector is attached to the cylinder head needs to be worked at an angle to the axis of the intake port, a boss part for working of the attachment hole (working receiving boss) is generally formed integrally with an intake-port molding core in consideration of workability. Since the boss part forms a recessed portion in the intake port, it preferably has the minimum shape, for example, has a circular cross section perpendicular to the extending direction of the boss part. However, when the boss part having the circular cross section is formed in the intake-port molding core having a circular cross section, a large undercut portion is formed, and this deteriorates productivity. In consideration of productivity, the boss part can be formed integrally with the intake-port molding core so that the undercut portion is not provided. However, a large portion unnecessary as the function of the boss part (a portion that fills the undercut portion) is formed in the boss part, and the large unnecessary portion forms a large dead volume at an attachment hole of a cylinder head as a product. Since the large dead volume disturbs the flow of intake air in the intake port, and mixing failure of fuel and intake air occurs. This reduces combustion efficiency and deteriorates fuel economy. In this regard, there is more room for improvement in the above-described cylinder head.

[0006] The present invention has been made in view of the above, and an object of the invention is to provide a technique that can further improve fuel economy.

Solution to Problem

[0007] A cylinder head, an internal combustion engine equipped with the cylinder head, and an intake-port molding core according to the present invention adopt the following means to achieve the above object.

[0008] A cylinder head according to a preferred mode of the present invention includes a combustion-chamber forming part configured to form a combustion chamber, an intake port communicating with the combustion-chamber forming part, and an attachment hole at which an injector configured to inject fuel is attached. The intake port has a flat portion that forms a straight line in a cross section perpendicular to a longitudinal direction of the intake port. At least a part of a connecting portion of the attachment hole to the intake port is provided in the flat portion, the connecting portion being a part connecting to the intake port.

[0009] According to the present invention, since at least a part of the connecting portion of the attachment hole to the intake port is provided in the flat portion, at least a part of an opening of the attachment hole in the intake port is provided in the flat portion of the intake port. That is, when the attachment hole is formed using an intake-port molding core provided integrally with a boss part for working of the attachment hole in consideration of workability of the attachment hole, at least a part of the boss part for working of the attachment hole is formed in a flat portion of the intake-port molding core corresponding to the flat portion of the intake port. Hence, an unnecessary portion formed in the boss part, that is, a portion that fills an undercut portion can be made smaller than when the boss part is entirely formed in an intake-port molding core of circular cross section. Therefore, the size of a dead volume formed at the attachment hole can be minimized. Thus, turbulence of intake air flowing in the intake port can be suppressed, and mixability of fuel and intake air can be enhanced to enhance combustion efficiency. As a result, fuel economy can be improved further.

[0010] According to another mode of the cylinder head of the present invention, the cylinder head is configured

such that a center axis of the attachment hole intersects the flat portion.

[0011] According to this mode, at least a part of the connecting portion of the attachment hole to the intake port can be provided in the flat portion.

[0012] According to a further mode of the cylinder head of the present invention, the intake port has a quadrangular port region that is substantially quadrangular in a cross section perpendicular to the longitudinal direction of the intake port. The flat portion includes an upper flat portion, a lower flat portion, a left flat portion, and a right flat portion that form an upper part, a lower part, a left part, and a right part, respectively, of the intake port when the intake port is viewed from the longitudinal direction of the intake port. The quadrangular port region is defined by the upper flat portion, the lower flat portion, the left flat portion, and the right flat portion.

[0013] According to this mode, since the quadrangular port region that is substantially quadrangular in the cross section perpendicular to the longitudinal direction of the intake port is formed in the intake port by the flat portions, a passage cross-sectional area larger than that of the intake port of circular cross section can be ensured in the same space. Thus, it is possible to enhance filling efficiency of intake air while suppressing the increase in size of the cylinder head itself.

[0014] According to a further mode of the cylinder head of the present invention, the intake port includes first and second intake ports communicating with the same combustion-chamber forming part. The flat portion includes a first flat portion provided at the first intake port and a second flat portion provided at the second intake port. Further, the attachment hole includes a first attachment hole and a second attachment hole. The cylinder head is configured such that a center axis of the first attachment hole intersects the first flat portion, and a center axis of the second attachment hole intersects the second flat portion.

[0015] According to this mode, since an injector is disposed at each intake port, the amount of fuel to be injected from the injector can be controlled according to the flow rate of intake air passing through the intake port. Thus, excessive injection of fuel into each intake port can be prevented, and fuel economy can be improved. Moreover, since the center axis of each attachment hole intersects the corresponding flat portion, an opening of the attachment hole in the intake port is at least partly formed in the flat portion of the intake port. That is, when the attachment holes are formed using an intake-port molding core provided integrally with boss parts for working of the attachment holes in consideration of workability of the attachment holes, the boss parts are at least partly provided in the flat portions of the intake-port molding core. Hence, an unnecessary portion formed in each boss part, that is, a portion that fills an undercut portion can be minimized. Therefore, the size of a dead volume formed in each attachment hole can be suppressed. Thus, turbulence of intake air flowing in each intake port can be further suppressed, and mixability of fuel and intake air can be enhanced to improve combustion efficiency. As a result, fuel economy can be improved further.

[0016] According to a further mode of the cylinder head of the present invention, the first and second intake ports have first and second quadrangular port regions that are substantially quadrangular in cross sections perpendicular to longitudinal directions of the first and second intake ports, respectively. The first and second flat portions have first and second upper flat portions, first and second lower flat portions, first and second left flat portions, and first and second right flat portions that form upper, lower, left, and right parts of the first and second intake ports, respectively, when the first and second intake ports are viewed from the longitudinal directions of the first and second intake ports. The first and second quadrangular port regions are defined by the first and second upper flat portions, the first and second lower flat portions, the first and second left flat portions, and the first and second right flat portions, respectively, and are arranged in parallel so that the first right flat portion and the second left flat portion are adjacent to each other.

[0017] According to this mode, the intake ports have their respective quadrangular port regions, and the quadrangular port regions are arranged in parallel so that the first right flat portion that defines the first quadrangular port region and the second left flat portion that defines the second quadrangular intake port region are adjacent to each other. Hence, it is possible to adjacently arrange the intake ports while ensuring cross-sectional areas of the intake ports. Thus, it is possible to enhance filling efficiency of intake air while suppressing the increase in size of the cylinder head itself.

[0018] According to a further mode of the cylinder head of the present invention, an opening of the first attachment hole to the first intake port is formed in the first upper flat portion, and an opening of the second attachment hole to the second intake port is formed in the second upper flat portion.

[0019] In a general internal combustion engine of an air-fuel mixture combustion type like a gasoline engine, mixability of fuel and intake air is enhanced by applying a tumble flow to a fuel-air mixture. In this case, more intake air flows on the upper side of an intake port than on the lower side. According to this mode, the first and second attachment holes are open in the first and second upper flat portions on the upper sides of the intake ports where much intake air flows. Hence, mixability of the fuel and intake air can be further enhanced in the intake ports. This can further improve combustion efficiency.

[0020] According to a further mode of the cylinder head of the present invention, an opening of the attachment hole to the intake port is entirely formed in the flat portion. In this mode, "an opening to the intake port is entirely formed in the flat portion" suitably encompasses not only a form in which the opening to the intake port is entirely formed in the flat portion to the letter, but also a form in which the opening to the intake port is nearly entirely

formed in the flat portion.

[0021] According to this mode, since the opening of the attachment hole to the intake port is entirely formed in the flat portion, when the attachment hole is formed using an intake-port molding core provided integrally with a boss part for working of the attachment hole, the boss part for working of the attachment hole is entirely formed in the flat portion of the intake-port molding core. For this reason, an unnecessary portion formed in the boss part, that is, a portion that fills an undercut portion can be minimized further. Therefore, the size of a dead volume formed at the attachment hole can be further limited. Thus, turbulence of intake air flowing in the intake port can be further suppressed, and mixability of the fuel and the intake air can be further enhanced to further improve combustion efficiency. As a result, fuel economy can be improved further.

[0022] According to a still further mode of the cylinder head of the present invention, the opening of the attachment hole to the intake port is formed in the upper flat portion. In a general internal combustion engine of an air-fuel mixture combustion type like a gasoline engine, mixability of fuel and intake air is enhanced by applying a tumble flow to a fuel-air mixture. In this case, more intake air flows on the upper side of an intake port than on the lower side.

[0023] According to this mode, the attachment hole is open in the upper flat portion provided on the upper side of the intake port where much intake air flows. Hence, mixability of fuel and intake air can be further enhanced. This can further enhance combustion efficiency.

[0024] According to a still further mode of the cylinder head of the present invention, openings of the first and second attachment holes to the first and second intake ports are entirely formed in the first and second flat portions, respectively. In this mode, "openings to the intake ports are entirely formed in the first and second flat portions" suitably encompasses not only a form in which the openings to the first and second intake ports are entirely formed in the first and second flat portions to the letter, but also a form in which the openings to the first and second intake ports are nearly entirely formed in the first and second flat portions.

[0025] According to this mode, since the openings of the attachment holes to the intake ports are entirely formed in the flat portions, when the attachment holes are formed using an intake-port molding core provided integrally with boss parts for working of the attachment holes in consideration of workability of the attachment holes, the boss parts are entirely provided in flat portions of the intake-port molding core. For this reason, an unnecessary portion formed in each boss part, that is, a portion that fills an undercut portion can be minimized. Therefore, the size of a dead volume formed at each attachment hole can be further reduced. Thus, turbulence of intake air flowing in the intake ports can be further suppressed, and mixability of the fuel and the intake air can be further enhanced to further improve combustion efficiency. As a result, fuel economy can be improved further.

[0026] According to a still further mode of the cylinder head of the present invention, the first upper flat portion and the first left flat portion are connected by a first curved portion. The second upper flat portion and the second right flat portion are connected by a second curved portion. The opening of the first attachment hole to the first intake port is formed at a position near the first left flat portion in a range out of the first curved portion. The opening of the second attachment hole to the second intake port is formed at a position near the second right flat portion in a range out of the second curved portion.

[0027] According to this mode, the openings of the attachment holes to the intake ports are in a positional relationship such that the openings are separate from each other in the ranges out of the curved portions. Hence, interference of the injectors can be prevented when the injectors are attached at the attachment holes. Thus, it is possible to improve assemblability while enhancing filling efficiency of intake air.

[0028] An internal combustion engine according to a preferred mode of the present invention includes the cylinder head according to any of the above-described modes of the present invention, and an injector attached at the attachment hole of the cylinder head. In the internal combustion engine, fuel is injected from the injector toward intake air flowing in the intake port of the cylinder head to introduce a mixture of the intake air and the fuel into the combustion chamber.

[0029] According to the present invention, since the cylinder head according to any of the above-described modes of the present invention is included, effects similar to those of the cylinder head of the present invention can be provided, for example, turbulence of intake air flowing in the intake port can be suppressed, and mixability of fuel and intake air can be enhanced to improve combustion efficiency.

[0030] An intake-port molding core according to a preferred mode of the present invention includes a body part configured to form an intake port in a cylinder head and a boss part configured to form an attachment hole at which an injector is to be attached. In the intake-port molding core, the body part has a core flat portion. The boss part is provided integrally with the body part, and at least a part of a connecting portion of the boss part to the body part is provided in the flat portion.

[0031] According to the present invention, since at least a part of the boss part is provided in the core flat portion of the intake-port molding core, an unnecessary portion formed in the boss part, that is, a portion that fills an undercut portion can be made smaller than when the boss part is entirely provided in an intake-port molding core of circular cross section. Therefore, in a cylinder head as a product, the size of a dead volume formed at the attachment hole can be limited. Thus, turbulence of intake air flowing in the intake port can be suppressed, and mixability of fuel and intake air can be enhanced to

improve combustion efficiency. As a result, fuel economy can be improved further.

[0032] According to a further mode of the intake-port molding core of the present invention, a center axis of the boss part intersects the core flat portion.

[0033] According to this mode, at least a part of the boss part can be provided in the core flat portion of the intake-port molding core.

Advantageous Effects of Invention

[0034] According to the present invention, it is possible to provide a technique for further improving fuel economy.

Brief Description of Drawings

[0035]

[Fig. 1] Fig. 1 is a structural view illustrating an outline of a structure of an internal combustion engine 1 equipped with a cylinder head 20 according to an embodiment of the present invention.

[Fig. 2] Fig. 2 is a side view of the cylinder head 20 as viewed from a side surface.

[Fig. 3] Fig. 3 is a schematic plan view of the cylinder head 20 as viewed from above.

[Fig. 4] Fig. 4 is a cross-sectional view taken along line A-A of Fig. 2.

[Fig. 5] Fig. 5 is an enlarged principal cross-sectional view illustrating the principal part in a cross section taken along line B-B of Fig. 4.

[Fig. 6] Fig. 6 is an external view illustrating an outer appearance of an intake-port molding core 60.

[Fig. 7] Fig. 7 is a side view of the intake-port molding core 60 as viewed from a side surface.

[Fig. 8] Fig. 8 is a cross-sectional view taken along line C-C of Fig. 6.

[Fig. 9] Fig. 9 is a cross-sectional view taken along line D-D of Fig. 6.

[Fig. 10] Fig. 10 is an explanatory view illustrating a manner in which an intake port 24 is molded using the intake-port molding core 60.

[Fig. 11] Fig. 11 is a cross-sectional view illustrating a cross section of a core molding die.

[Fig. 12] Fig. 12 is a cross-sectional view taken along line E-E of Fig. 10.

[Fig. 13] Fig. 13 is a cross-sectional view taken along line F-F of Fig. 10.

[Fig. 14] Fig. 14 is an explanatory view illustrating a state of dead volumes formed in an intake port having an elliptic cross section.

[Fig. 15] Fig. 15 is an explanatory view illustrating a state of the dead volumes formed in the intake port having an elliptic cross section.

Description of Embodiments

[0036] Next, a best mode for carrying out the present invention will be described in conjunction with an embodiment.

Embodiment

[0037] Fig. 1 is a structural view illustrating an outline of a structure of an internal combustion engine 1 equipped with a cylinder head 20 according to an embodiment of the present invention. As illustrated in Fig. 1, the internal combustion engine 1 equipped with the cylinder head 20 of the embodiment includes the cylinder head 20 of the embodiment, a rocker cover 2 attached to an upper part of the cylinder head 20, an intake manifold 4 attached to a side wall of the cylinder head 20, an injector 6 attached to the side wall of the cylinder head 20 near the intake manifold 4, a cylinder block 8 attached to a lower part of the cylinder head 20, an upper oil pan 10 attached to a lower part of the cylinder block 8, and a lower oil pan 12 attached to a lower part of the upper oil pan 10. In the embodiment, the internal combustion engine 1 is configured as an in-line four-cylinder engine in which four cylinders are arranged in line. In the embodiment, for convenience, a side of the rocker cover 2, that is, an upper side of the plane of Fig. 1 is defined as "upper side" or "upward side", and a side of the lower oil pan 12, that is, a lower side of the plane of Fig. 1 is defined as "lower side" or "downward side."

[0038] As illustrated in Figs. 2 to 4, combustion-chamber forming recesses 22 that form combustion chambers CC are provided in a bottom surface of the cylinder head 20. The cylinder head 20 also includes intake ports 24 that are each open at one end to the corresponding combustion-chamber forming recess 22 and are each open at the other end to the outside of the cylinder head 20. Each of the intake ports 24 is composed of a collection port 24a provided on the upstream side in the flowing direction of intake air and two branch ports 24b and 24c branching off from the collection port 24a and independently communicating with the corresponding combustion-chamber forming recess 22. The collection port 24a is open in a flange surface 25a of an intake-manifold attachment part 25 provided in the cylinder head 20. The combustion-chamber forming recesses 22 are provided as an example of an implementation corresponding to "combustion-chamber forming part" in the present invention, and the branch ports 24b and 24c are provided as an example of an implementation corresponding to "first intake port" and "second intake port" in the present invention.

[0039] As illustrated in Figs. 2, 3, and 5, each intake port 24 has a quadrangular port region that is substantially quadrangular in a cross section perpendicular to the longitudinal direction (flowing direction of intake air). The quadrangular port region extends from the collection port 24a to the branch ports 24b and 24c in the intake

port 24.

[0040] As illustrated in Fig. 5, in the collection port 24a, the quadrangular port region is defined by an upper flat wall portion 122a that forms an upper part of the port, a lower flat wall portion 124a that forms a lower part of the port, a left flat wall portion 126a that forms a left part of the port, and a right flat wall portion 128a that forms a right part of the port.

[0041] In the branch ports 24b and 24c, as illustrated in Fig. 5, quadrangular port regions are defined by upper flat wall portions 122b and 122c that form upper parts of the ports, lower flat wall portions 124b and 124c that form lower parts of the ports, left flat wall portions 126b and 126c that form left parts of the ports, and right flat wall portions 128b and 128c that form right parts of the ports.

[0042] The upper flat wall portions 122a and 122b and the left flat wall portions 126a and 126b are connected by curved wall portions 130, the upper flat wall portions 122a and 122c and the right flat wall portions 128a and 128c are connected by curved wall portions 130, the lower flat wall portions 124a and 124b and the left flat wall portions 126a and 126b are connected by curved wall portions 130, and the lower flat wall portions 124a and 124c and the right flat wall portions 128a and 128c are connected by curved wall portions 130. The curved wall portions 130 are provided as an example of an implementation corresponding to "first curved portion" and "second curved portion" in the present invention.

[0043] Here, the right flat wall portion 128b and the left flat wall portion 126c are adjacently arranged as right and left wall portions of a common wall part that separates the branch ports 24b and 24c. Thus, the branch ports 24b and 24c are arranged in parallel. By thus forming the quadrangular port regions in the collection port 24a and the branch ports 24b and 24c, the branch ports 24b and 24c can be adjacently arranged, and a passage cross-sectional area larger than that of an intake port having a circular cross section can be ensured in the same space. As a result, it is possible to enhance filling efficiency of intake air while suppressing the increase in size of the cylinder head itself.

[0044] The cross-sectional shape of each intake port 24 gradually changes from the substantially quadrangular shape in the branch ports 24b and 24c, and the intake port 24 finally opens with a circular cross section to the corresponding combustion-chamber forming recess 22. The quadrangular port region is provided as an example of an implementation corresponding to "quadrangular port region" and "first and second quadrangular port regions" in the present invention. The upper flat wall portions 122a, 122b, and 122c, the lower flat wall portions 124a, 124b, and 124c, the left flat wall portions 126a, 126b, and 126c, and the right flat wall portions 128a, 128b, and 128c are provided as examples of implementations corresponding to "flat portion" or corresponding to "upper flat portion", "lower flat portion", "left flat portion", and "right flat portion" in the present invention, respectively. Further, the upper flat wall portions 122b and 122c, the lower flat wall portions 124b and 124c, the left flat wall portions 126b and 126c, and the right flat wall portions 128b and 128c are provided as examples of implementations corresponding to "first and second flat portions" or corresponding to "first and second upper flat portions", "first and second lower flat portions", "first and second left flat portions", and "first and second right flat portions" in the present invention, respectively.

[0045] As illustrated in Figs. 2 to 4, the cylinder head 20 includes injector attachment holes 26 at which injectors 6 are to be attached. The injector attachment holes 26 penetrate the cylinder head 20 from an upper part of the intake-manifold attachment part 25 to the intake ports 24. One injector attachment hole 26 is provided in each of the branch ports 24b and 24c.

[0046] That is, the cylinder head 20 is configured as a so-called twin-injector system in which fuel can be injected from the injectors 6 via the branch ports 24b and 24c. In the embodiment, a large quantity fuel can be supplied without reducing fuel atomizing performance by adopting the twin-injector system. This can stabilize combustion efficiency.

[0047] Since the fuel injection amount from the injectors 6 can be controlled according to the flow rate of intake air passing through the branch ports 24b and 24c, excessive injection of fuel to the branch ports 24b and 24c can be prevented. This can improve fuel economy. Further, in the embodiment, the intake manifold 4 is provided with an unillustrated tumble control valve to improve mixability of fuel and intake air. Hence, more intake air flows on the upper sides of the intake ports 24 (collection port 24a, branch ports 24b and 24c) than on the lower side.

[0048] In the embodiment, since the injectors 6 are attached to the upper side of the intake ports 24 (branch ports 24b and 24c) where much intake air flows, mixability of the fuel and the intake air can be enhanced. This can further enhance combustion efficiency. The injector attachment holes 26 are provided as an example of an implementation corresponding to "attachment hole", "first attachment hole", and "second attachment hole" in the present invention.

[0049] As illustrated in Figs. 4 and 5, the injector attachment holes 26 have center axes CL1 and CL2. The injector attachment holes 26 open to the branch ports 24b and 24c in a manner such that the center axes CL1 and CL2 intersect the upper flat wall portions 122b and 122c of the branch ports 24b and 24c, respectively.

[0050] That is, the openings of the injector attachment holes 26 to the branch ports 24b and 24c are nearly entirely provided in the upper flat wall portions 122b and 122c. Further, the injector attachment hole 26 at the branch port 24b is provided at a position near the left flat wall portion 126b, and the injector attachment hole 26 at the branch port 24c is provided at a position near the right flat wall portion 128c.

[0051] By virtue of this structure, the distance between the injectors 6 can be ensured when the injectors 6 are attached at the injector attachment holes 26, and this can

prevent interference. Thus, it is possible to enhance assemblability while increasing filling efficiency of intake air. The center axes CL1 and CL2 are provided as an example of an implementation corresponding to "center axis", "first center axis", and "second center axis" in the present invention.

[0052] Next, a description will be given of a method for forming the injector attachment holes 26 in the cylinder head 20. The injector attachment holes 26 are formed in the cylinder head 20 by using an intake-port molding core 60 illustrated in Figs. 6 and 7. The intake-port molding core includes a body part 62 for forming an intake port 24 in the cylinder head 20 and boss parts 64 for forming injector attachment holes 26 in the cylinder head 20.

[0053] As illustrated in Fig. 6, the body part 62 includes a collection-port forming portion 62a for forming a collection port 24a in the cylinder head 20 and branch-port forming portions 62b and 62c for forming branch ports 24b and 24c. The body part 62 has a quadrangular region that is substantially quadrangular in a cross section perpendicular to the longitudinal direction (right-left direction in Fig. 6) and that extends from the collection-port forming portion 62a to the branch-port forming portions 62b and 62c.

[0054] The collection-port forming portion 62a has an upper flat portion 162a, a lower flat portion 164a, a left flat portion 166a, and a right flat portion 168a for forming an upper flat wall portion 122a, a lower flat wall portion 124a, a left flat wall portion 126a, and a right flat wall portion 128c, respectively, in the collection port 24a of the intake port 24.

[0055] The branch port forming portions 62b and 62c respectively have upper flat portions 162b and 162c, lower flat portions 164b and 164c, left flat portions 166b and 166c, and right flat portions 168b and 168c for forming upper flat wall portions 122b and 122c, lower flat wall portions 124b and 124c, left flat wall portions 126b and 126c, and right flat wall portions 128b and 128c in the branch ports 24b and 24c of the intake port 24. The branch-port forming portions 62b and 62c are configured so that the cross-sectional shape thereof gradually changes from a substantially quadrangular shape to a circular shape toward distal ends (sides opposite from the collection-port forming portion 62a).

[0056] As illustrated in Fig. 6, in the body part 62, the upper flat portions 162a, 162b, and 162c are connected to the left flat portions 166a, 166b, and 166c and the right flat portions 168a, 168b, and 168c by curved portions 170. Similarly, the lower flat portions 164a, 164b, and 164c are connected to the left flat portions 166a, 166b, and 166c and the right flat portions 168a, 168b, and 168c by curved portions 170.

[0057] By the curved portions 170, curved wall portions 130 are formed in the intake port 24 (collection port 24a, branch ports 24b and 24c) of the cylinder head 20. The upper flat portions 162a, 162b, and 162c, the lower flat portions 164a, 164b, and 164c, the left flat portions 166a, 166b, and 166c, and the right flat portions 168a, 168b, and 168c are provided as an example of an implementation corresponding to "flat portion" in the present invention.

[0058] As illustrated in Figs. 6 and 7, the boss parts 64 project integrally from the upper flat portions 162b and 162c of the branch-port forming portions 62b and 62c. The boss parts 64 have center axes CL3 and CL4 corresponding to the center axes CL1 and CL2 of the injector attachment holes 26. As illustrated in Figs. 8 and 9, connecting portions 68 of the boss parts 64 to the branch-port forming portions 62b and 62c are nearly entirely provided in the upper flat portions 162b and 162c.

[0059] In the boss part 64 of the branch-port forming portion 62b, the connecting portion 68 to the branch-port forming portion 62b is provided at a position near the left flat portion 166b, the connecting portion 68 being a part connecting to the branch-port forming portion 62b. In the boss part 64 of the branch-port forming portion 62c, the connecting portion 68 to the branch-port forming portion 62c is provided at a position near the right flat portion 168c, the connecting portion 68 being a part connecting to the branch-port forming portion 62c.

[0060] By setting the intake-port molding core 60 having this structure in an unillustrated cylinder-head molding die for molding the cylinder head 20, clamping the cylinder-head molding die, and pouring molten metal, as illustrated in Fig. 10, an intake port 24 and recessed portions 63 that form parts of injector attachment holes 26 are formed in the cylinder head 20.

[0061] The injector attachment holes 26 are formed by boring with an unillustrated drill from an upper part of the intake-manifold attachment part 25 to the recessed portions 63 (two-dot chain line in Fig. 10). The recessed portions 63 are formed as receiving holes in the cylinder head 20 beforehand in order to improve workability of the injector attachment holes 26 to be worked at an angle to the branch ports 24b and 24c.

[0062] The size of cross sections of the recessed portions 63 perpendicular to the center axes CL1 and CL2 is slightly larger than the outer size of the injectors 6. By thus making the size of the cross sections of the recessed portions 63 perpendicular to the center axes CL1 and CL2 slightly larger than the outer size of the injectors 6, for example, cutter breakage due to one-side contact of the drill can be prevented even in consideration of working variation.

[0063] Next, a description will be given of a method for molding the intake-port molding core 60. As illustrated in Fig. 11, the intake-port molding core 60 is molded by a core molding die 80. The core molding die 80 includes an upper die 82 having an upper cavity UC for molding an upper part of the intake-port molding core 60 including the boss parts 64, and a lower die 84 having a lower cavity LC for molding a lower part of the intake-port molding core 60. The core molding die 80 is configured so that the parting direction is the up-down direction, that is, the projecting direction of boss-part cavities BC for molding the boss parts 64 (up-down direction in Fig. 10).

[0064] Here, the cross-sectional shape of the boss parts 64 of the intake-port molding core 60 (cross-sectional shape of the boss parts 64 perpendicular to the center axes CL3 and CL4) is preferably a substantially circular shape concentric with the outer shape of the distal end portions of the injectors 6 (two-dot chain thin lines in Fig. 11), as shown by two-dot chain thick lines in Fig. 11.

[0065] In Fig. 11, the cross sections of the boss parts 64 are shaped like a longitudinal circle because they are perpendicular to the longitudinal direction of the intake-port molding core 60. However, when the cross-sectional shape of the boss parts 64 is circular, the boss parts 64 and the body part 62 are connected to form undercut portions 90 at between the boss parts 64 and the body part 62, and the intake-port molding core 60 cannot be molded only by the upper die 82 and the lower die 84. To mold the intake-port molding core 60, it is necessary to add a slide die to the core molding die 80.

[0066] If the core molding die 80 includes the slide die in addition to the upper die 82 and the lower die 84 in this way, not only the structure of the die is complicated, but also moldability of the intake-port molding core 60 deteriorates. This leads to an increase in cost.

[0067] To avoid the above inconvenience, the boss-part cavities BC are not provided with undercut portions 90 in the embodiment. Thus, as illustrated in Figs. 8 and 9, the boss parts 64 of the intake-port molding core 60 are provided with portions 64a that are unnecessary as the function of the boss parts 64.

[0068] As illustrated in Figs. 12 and 13, the unnecessary portions 64a formed in the boss parts 64 form portions that are not related to working of the injector attachment holes 26 and attachment of the injectors 6, that is, so-called dead volumes 92 in the intake port 24, particularly in the recessed portion 63. Since the dead volumes 92 disturb the flow of intake air in the intake port 24, particularly in the branch ports 24b and 24c, it is preferable to limit the size of the dead volumes 92.

[0069] In the embodiment, the openings of the recessed portions 63 to the branch ports 24b and 24c, in other words, the openings of the injector attachment holes 26 to the branch ports 24b and 24c are nearly entirely formed in the upper flat wall portions 122b and 122c. Hence, the size of the dead volumes 92 can be limited.

[0070] That is, when recessed portions 63A for improving workability of the injectors 6 are formed by the boss parts in an intake port 24A having an elliptic cross section perpendicular to the longitudinal direction (flowing direction of intake air) as in a conventional structure, the recessed portions 63A are open in curved surfaces as illustrated in Figs. 14 and 15. Therefore, the connection distance of the recessed portions 63A to the intake port 24A becomes long, and this increases the size of dead volumes 92A.

[0071] In contrast, in the embodiment, since the recessed portions 63 are open in flat surfaces or substantially flat surfaces, as illustrated in Figs. 12 and 13, the connection distance of the recessed portions 63 to the intake port 24 can be made shorter than in the conventional structure (intake port of circular cross section). As a result, the size of the dead volumes 92 can be limited.

[0072] Thus, it is possible to suppress turbulence of intake air flowing in the intake port and to enhance mixability of fuel and intake air to improve combustion efficiency, compared with the conventional structure. As a result, fuel economy can be improved further.

[0073] According to the above-described internal combustion engine 1 equipped with the cylinder head 20 of the embodiment of the present invention, each intake port 24 has a quadrangular port region that is substantially quadrangular in the cross section perpendicular to the longitudinal direction (flowing direction of intake air), and the openings of the injector attachment holes 26 to the branch ports 24b and 24c are nearly entirely provided in the upper flat wall portions 122b and 122c in the quadrangular port regions of the branch ports 24b and 24c. Hence, the size of the dead volumes 92 can be made smaller than when the injector attachment holes are formed in the intake port having a circular cross section perpendicular to the longitudinal direction (flowing direction of intake air). Thus, it is possible to suppress turbulence of intake air flowing in the intake port 24, particularly in the branch ports 24b and 24c, and to enhance mixability of fuel and intake air to improve combustion efficiency. As a result, fuel economy can be improved further.

[0074] According to the embodiment, since the quadrangular port region is provided in each intake port 24, a passage cross-sectional area larger than that of the intake port of circular cross section can be ensured in the same space. Moreover, since the branch ports 24b and 24c also have the quadrangular port regions, they can be adjacently arranged. Thus, it is possible to improve filling efficiency of intake air while suppressing the increase in size of the cylinder head 20 itself.

[0075] Further, according to the embodiment, the intake manifold 4 is provided with the unillustrated tumble control valve, and the injectors 6 are attached to the upper side of the intake ports 24 (branch ports 24b and 24c). Hence, fuel can be injected at the upper side of the intake ports 24 (branch ports 24b and 24c) through which much intake air flows, and mixability of the fuel and the intake air can be enhanced. This can further improve combustion efficiency.

[0076] According to the embodiment, the cylinder head 20 adopts the so-called twin injector system in which two branch ports 24b and 24c are connected to one combustion chamber CC and the injector 6 is attached to each of the branch ports 24b and 24c. Hence, a large amount of fuel can be supplied without reducing fuel atomizing performance, and combustion efficiency can be stabilized. Further, since the amount of fuel to be injected from the injector 6 can be controlled according to the flow rate of intake air passing through the branch ports 24b and 24c, excessive injection of fuel to the branch ports 24b

and 24c can be prevented. Thus, fuel economy can be improved further.

[0077] According to the embodiment, the opening of the injector attachment hole 26 to the branch port 24b in the branch port 24b is provided at the position near the left flat wall portion 126b, and the opening of the injector attachment hole 26 to the branch port 24c in the branch port 24c is provided at the position near the right flat wall portion 128c. Hence, it is possible to prevent interference between the injectors 6 when the injectors 6 are attached at the injector attachment holes 26. Thus, it is possible to enhance assemblability while improving filling efficiency of intake air.

[0078] While the intake ports 24 have quadrangular port regions in the embodiment, it is only necessary that the intake ports 24 should have flat wall portions for forming straight lines on the attachment side of the injectors 6 in the cross-sectional shape perpendicular to the longitudinal direction (flowing direction of intake air). The intake ports 24 do not always need to have quadrangular port regions.

[0079] In the embodiment, the injector attachment holes 26, more specifically, the openings of the recessed portions 63 to the branch ports 24b and 24c are nearly entirely provided in the upper flat wall portions 122b and 122c. However, it is only necessary that the openings of the recessed portions 63 to the branch ports 24b and 24c should be at least partly provided in the upper flat wall portions 122b and 122c. The openings do not always need to be nearly entirely provided in the upper flat wall portions 122b and 122c.

[0080] However, to reduce the dead volumes 92, it is preferable that the center axes CL1 and CL2 of the injector attachment holes 26 should intersect the upper flat wall portions 122b and 122c and that the openings are provided at least more than half in the upper flat wall portions 122b and 122c. It is the best that the openings are entirely provided in the upper flat wall portions 122b and 122c.

[0081] While the injector attachment holes 26, more specifically, the recessed portions 63 are open to the branch ports 24b and 24c in the upper flat wall portions 122b and 122c in the embodiment, the structure is not limited thereto. For example, the recessed portions 63 may be open to the branch ports 24b and 24c in the lower flat wall portions 124b and 124c, may be open to the branch ports 24b and 24c in the left flat wall portions 126b and 126c, or may be open to the branch ports 24b and 24c in the right flat wall portions 128b and 128c.

[0082] In the embodiment, the opening of the injector attachment hole 26 to the branch port 24b is provided at the position near the left flat wall portion 126b, and the opening of the injector attachment hole 26 to the branch port 24c is provided at the position near the right flat wall portion 128c. That is, the injector attachment holes 26 are provided at the positions as distant from each other as possible. However, the structure is not limited thereto.

[0083] For example, the opening of the injector attachment hole 26 to the branch port 24b may be provided at a position near the left flat wall portion 126b, and the opening of the injector attachment hole 26 to the branch port 24c may be provided at a position near the left flat wall portion 126c. Conversely, the opening of the injector attachment hole 26 to the branch port 24b may be provided at a position near the right flat wall portions 128b, and the opening of the injector attachment hole 26 to the branch port 24c may be provided at a position near the right flat wall portion 128c. Alternatively, the opening of the injector attachment hole 26 to the branch port 24b may be provided at a position near the right flat wall portion 128b, and the opening of the injector attachment hole 26 to the branch port 24c may be provided at a position near the left flat wall portion 126c. That is, the injector attachment holes 26 may be provided at the positions close to each other.

[0084] While the boss parts 64 of the intake-port molding core 60 are provided to form the recessed portions 63 serving as the receiving holes that improve workability of the injector attachment holes 26 in the embodiment, the boss parts 64 may be provided to form the entire injector attachment holes 26.

[0085] While the so-called twin-injector system in which two branch ports 24b and 24c are connected to one combustion chamber CC and the injectors 6 are attached to the branch ports 24b and 24c in the above-described embodiment, the present invention is not limited thereto. For example, the present invention can be applied to a structure in which one intake port is connected to one combustion chamber CC and one injector is attached to the intake port.

(Correspondences between Components of Embodiment and Components of Invention)

[0086] The embodiment shows an example of a mode for carrying out the present invention. Therefore, the present invention is not limited to the constitution of the embodiment.

Reference Signs List

[0087]

1 internal combustion engine (internal combustion engine)
2 rocker cover
4 intake manifold
6 injector (injector)
8 cylinder block
10 upper oil pan
12 lower oil pan
20 cylinder head (cylinder head)
22 combustion-chamber forming recess (combustion-chamber forming part)
24 intake port (intake port)
24A intake port (intake port)

24a collection port
24b branch port (first intake port)
24c branch port (second intake port)
25 intake-manifold attachment part
25a flange surface
26 injector attachment hole (attachment hole, first attachment hole, second attachment hole)
60 intake-port molding core (intake-port molding core)
62 body part (body part)
62a collection-port forming portion
62b branch-port forming portion
62c branch-port forming portion
63 recessed portion
63A recessed portion
64 boss part (boss part)
64a unnecessary portion
68 connecting portion (connecting portion)
80 core molding die
82 upper die
84 lower die
90 undercut portion
92 dead volume
92A dead volume
122a upper flat wall portion (flat portion, upper flat portion)
124a lower flat wall portion (flat portion, lower flat portion)
126a left flat wall portion (flat portion, left flat portion)
128a right flat wall portion (flat portion, right flat portion)
122b upper flat wall portion (flat portion, upper flat portion, first flat portion, first upper flat portion)
124b lower flat wall portion (flat portion, lower flat portion, first flat portion, first lower flat portion)
126b left flat wall portion (flat portion, lower flat portion, first flat portion, first left flat portion)
128b right flat wall portion (flat portion, lower flat portion, first flat portion, first right flat portion)
122c upper flat wall portion (flat portion, upper flat portion, second flat portion, second upper flat portion)
124c lower flat wall portion (flat portion, lower flat portion, second flat portion, second lower flat portion)
126c left flat wall portion (flat portion, lower flat portion, second flat portion, second left flat portion)
128c right flat wall portion (flat portion, lower flat portion, second flat portion, second right flat portion)
130 curved wall portion (first curved portion, second curved portion)
162a upper flat portion (core flat portion)
164a lower flat portion (core flat portion)
166a left flat portion (core flat portion)
168a right flat portion (core flat portion)
162b upper flat portion (core flat portion)
164b lower flat portion (core flat portion)
166b left flat portion (core flat portion)
168b right flat portion (core flat portion)
162c upper flat portion (core flat portion)
164c lower flat portion (core flat portion)
166c left flat portion (core flat portion)
168c right flat portion (core flat portion)
170 curved portion
CC combustion chamber (combustion chamber)
CL1 center axis (center axis)
CL2 center axis (center axis)
CL3 center axis
CL4 center axis
UC upper cavity
LC lower cavity
BC boss-part cavity

Claims

1. A cylinder head comprising a combustion-chamber forming part configured to form a combustion chamber, an intake port communicating with the combustion-chamber forming part, and an attachment hole at which an injector configured to inject fuel is attached,
wherein
the intake port has a flat portion that forms a straight line in a cross section perpendicular to a longitudinal direction of the intake port, and
at least a part of a connecting portion of the attachment hole to the intake port is provided in the flat portion, the connecting portion being a part connecting to the intake port.

2. The cylinder head according to Claim 1, wherein the cylinder head is configured such that a center axis of the attachment hole intersects the flat portion.

3. The cylinder head according to Claim 1 or 2,
wherein
the intake port has a quadrangular port region that is substantially quadrangular in a cross section perpendicular to the longitudinal direction of the intake port,
the flat portion includes an upper flat portion, a lower flat portion, a left flat portion, and a right flat portion that form an upper part, a lower part, a left part, and a right part, respectively, of the intake port when the intake port is viewed from the longitudinal direction of the intake port, and
the quadrangular port region is defined by the upper flat portion, the lower flat portion, the left flat portion, and the right flat portion.

4. The cylinder head according to Claim 1 or 2,
wherein
the intake port includes first and second intake ports communicating with the same combustion-chamber forming part,
the flat portion includes a first flat portion provided

at the first intake port and a second flat portion provided at the second intake port,
the attachment hole includes a first attachment hole and a second attachment hole, and
the cylinder head is configured such that a center axis of the first attachment hole intersects the first flat portion and a center axis of the second attachment hole intersects the second flat portion.

5. The cylinder head according to Claim 4, wherein
the first and second intake ports have first and second quadrangular port regions that are substantially quadrangular in cross sections perpendicular to longitudinal directions of the first and second intake ports, respectively,
the first and second flat portions have first and second upper flat portions, first and second lower flat portions, first and second left flat portions, and first and second right flat portions that form upper, lower, left, and right parts of the first and second intake ports, respectively, when the first and second intake ports are viewed from the longitudinal directions of the first and second intake ports, and
the first and second quadrangular port regions are defined by the first and second upper flat portions, the first and second lower flat portions, the first and second left flat portions, and the first and second right flat portions, respectively, and are arranged in parallel so that the first right flat portion and the second left flat portion are adjacent to each other.

6. The cylinder head according to Claim 5, wherein
an opening of the first attachment hole to the first intake port is formed in the first upper flat portion, and an opening of the second attachment hole to the second intake port is formed in the second upper flat portion.

7. The cylinder head according to Claim 1 or 2, wherein an opening of the attachment hole to the intake port is entirely formed in the flat portion.

8. The cylinder head according to Claim 3, wherein the opening of the attachment hole to the intake port is entirely formed in the upper flat portion.

9. The cylinder head according to Claim 4, wherein openings of the first and second attachment holes to the first and second intake ports are entirely formed in the first and second flat portions, respectively.

10. The cylinder head according to Claim 6, wherein
the first upper flat portion and the first left flat portion are connected by a first curved portion,
the second upper flat portion and the second right flat portion are connected by a second curved portion,
the opening of the first attachment hole to the first intake port is formed at a position near the first left flat portion in a range out of the first curved portion, and
the opening of the second attachment hole to the second intake port is formed at a position near the second right flat portion in a range out of the second curved portion.

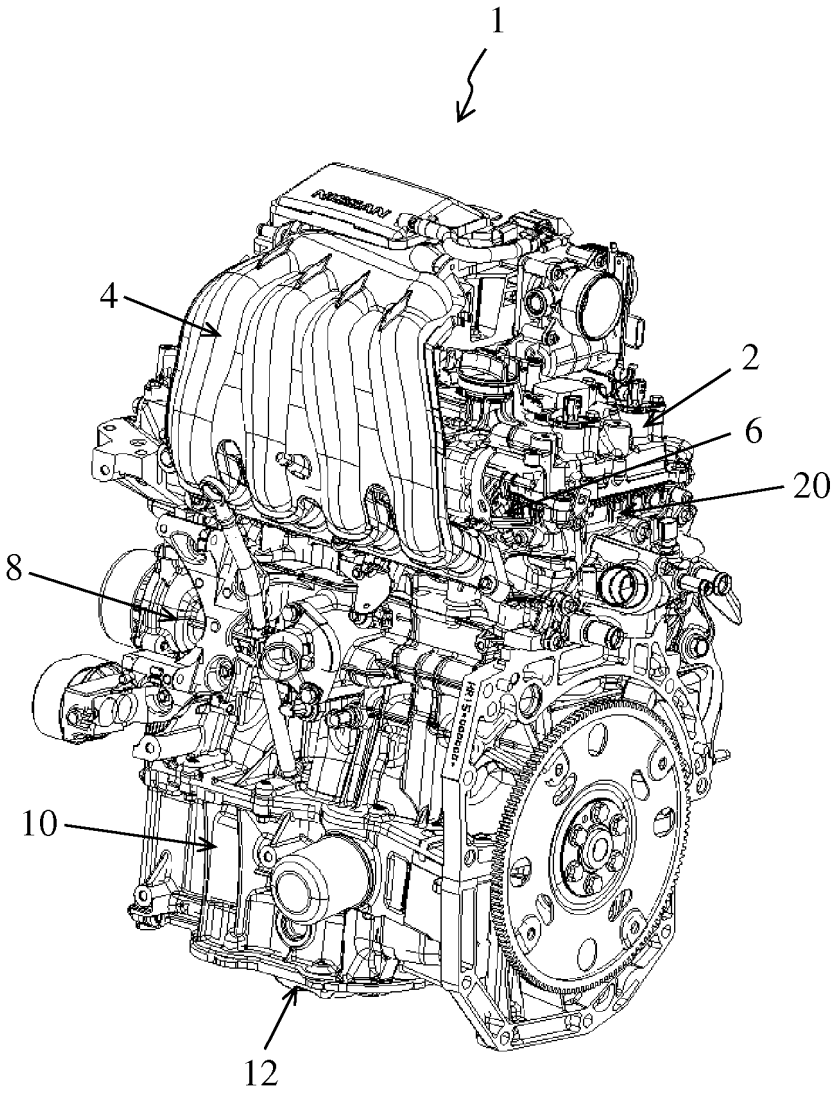
11. An internal combustion engine comprising:

the cylinder head according to any one of Claims 1 to 10; and
an injector attached at the attachment hole of the cylinder head,
wherein fuel is injected from the injector toward intake air flowing in the intake port of the cylinder head to introduce a mixture of the intake air and the fuel into the combustion chamber.

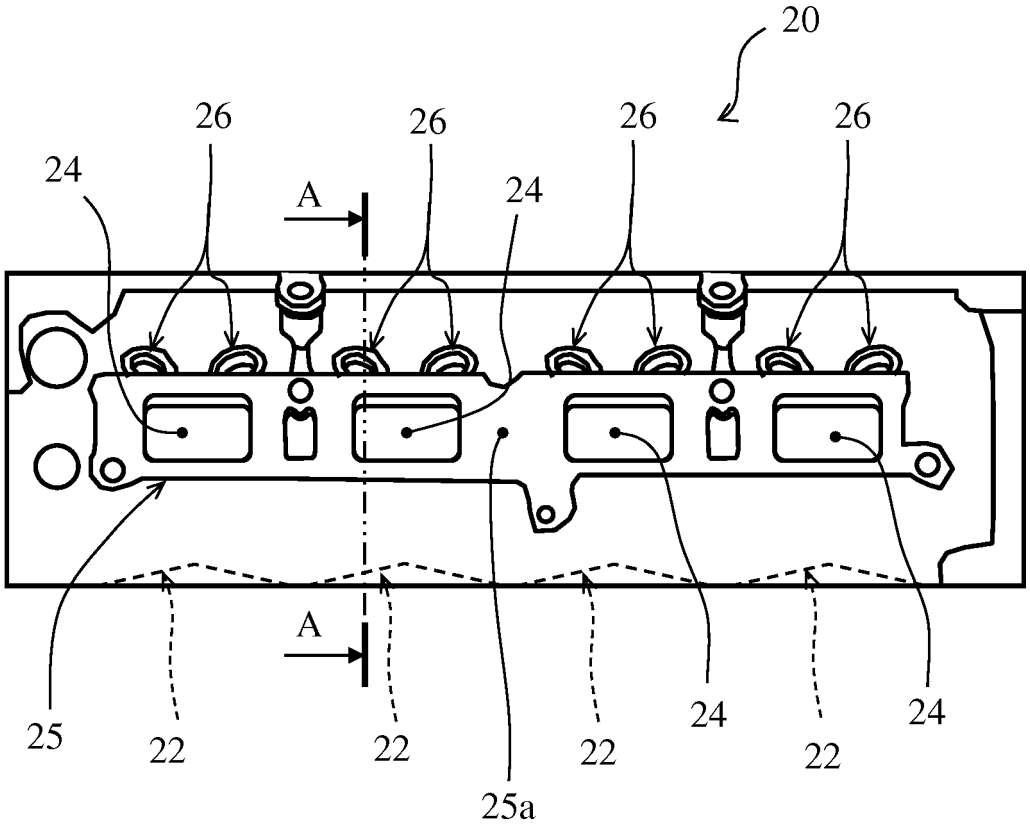
12. An intake-port molding core comprising a body part configured to form an intake port in a cylinder head and a boss part configured to form an attachment hole at which an injector is to be attached, wherein
the body part has a core flat portion, and
the boss part is provided integrally with the body part, and at least a part of a connecting portion of the boss part to the body part is provided in the flat portion.

13. The intake-port molding core according to Claim 12, wherein a center axis of the boss part intersects the core flat portion.

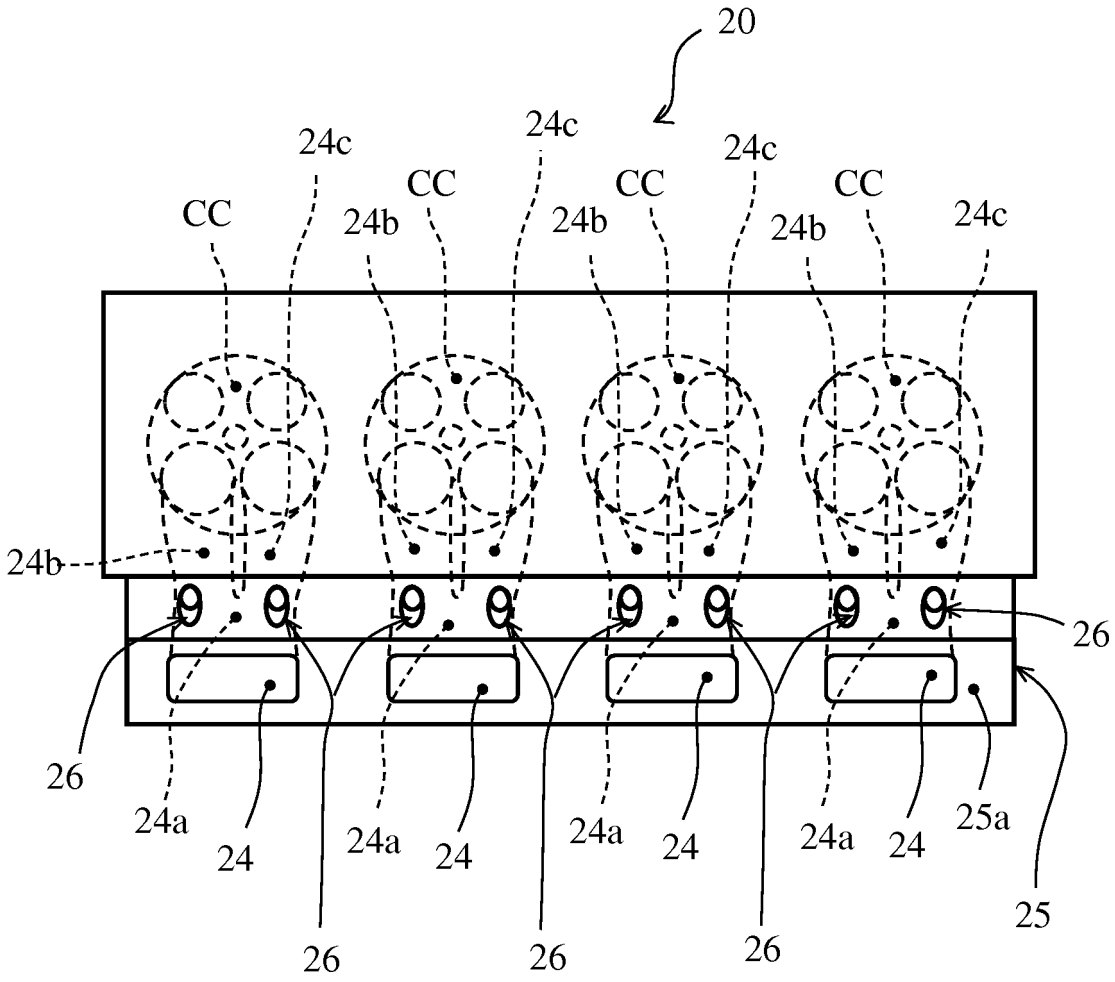
【FIG.1】



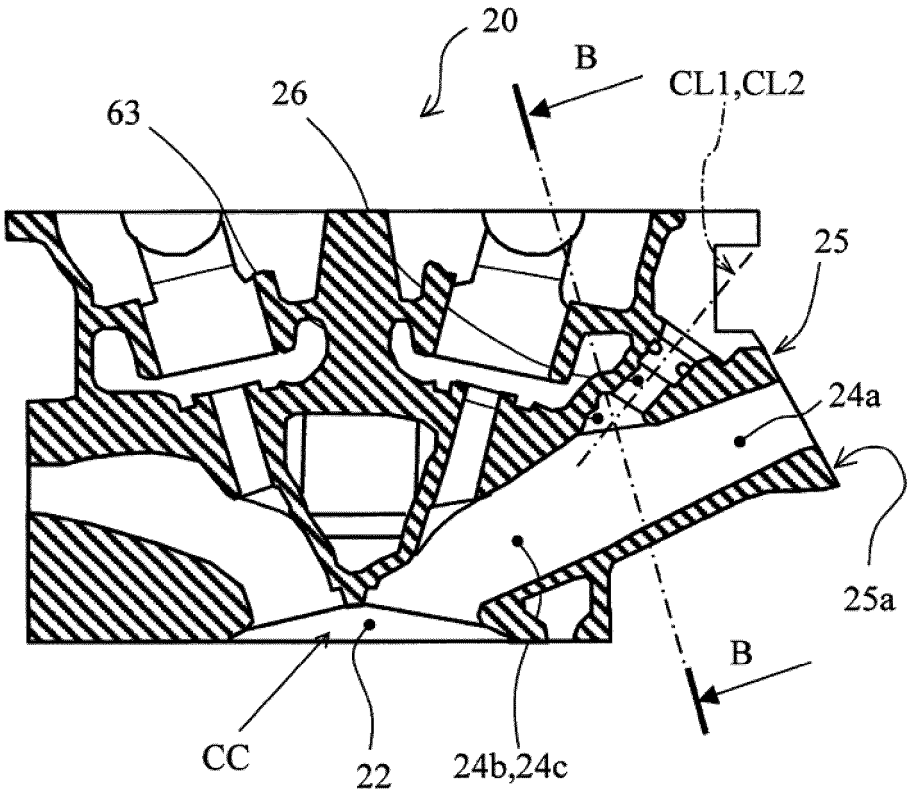
【FIG.2】



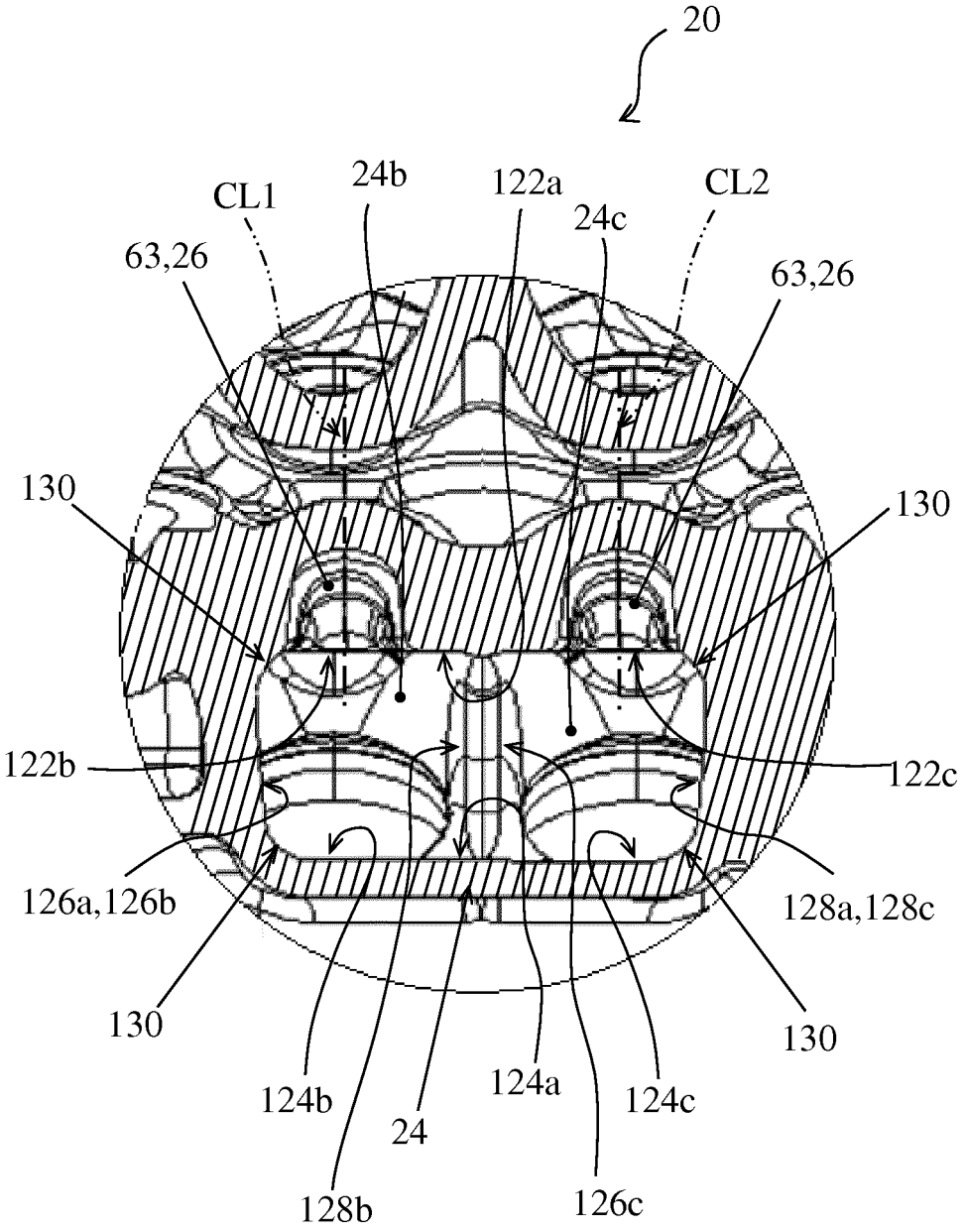
【FIG.3】


20
24c
24c
24c
24c
CC
CC
CC
CC
24b
24b
24b
24b
24c
24b
26
26
24a
24
24a
24
24a
24
24a
24
25a
25
26
26
26

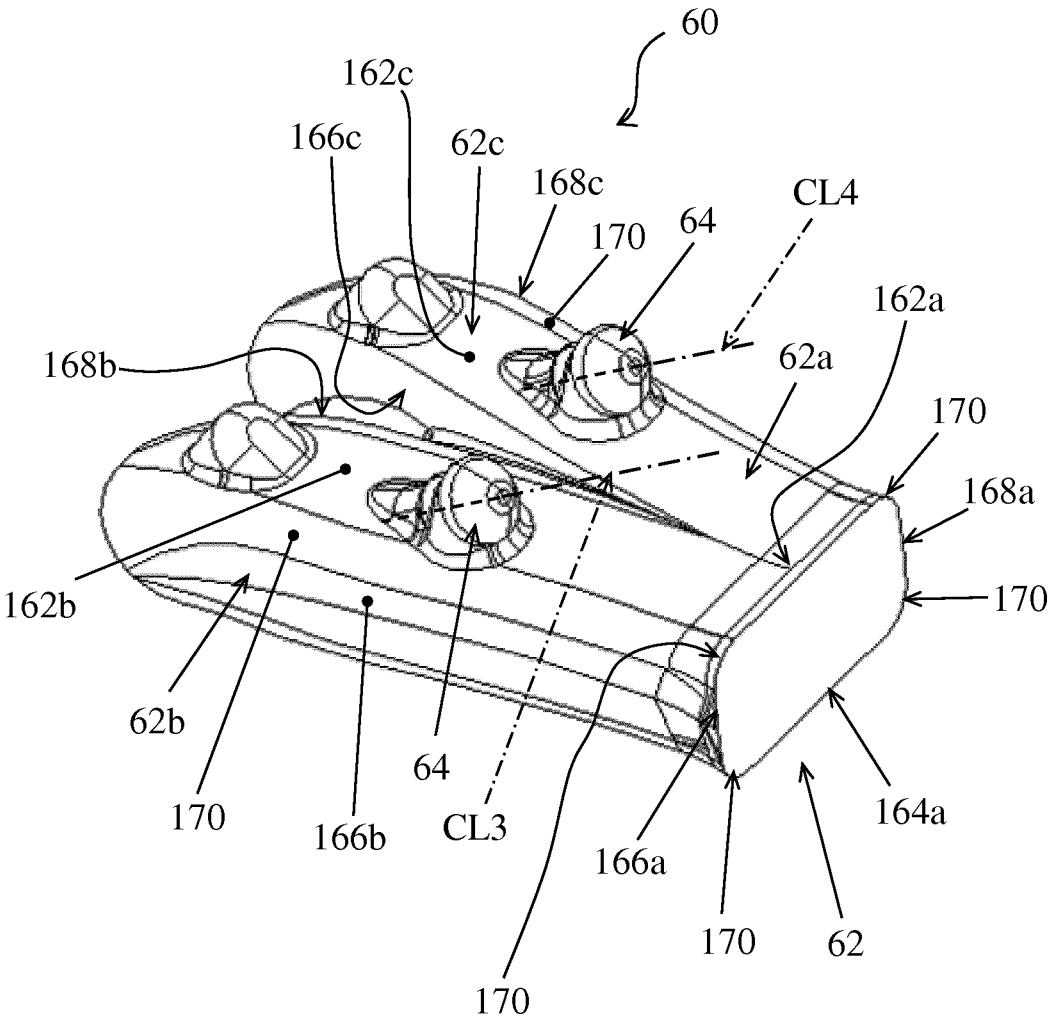
【FIG. 4】



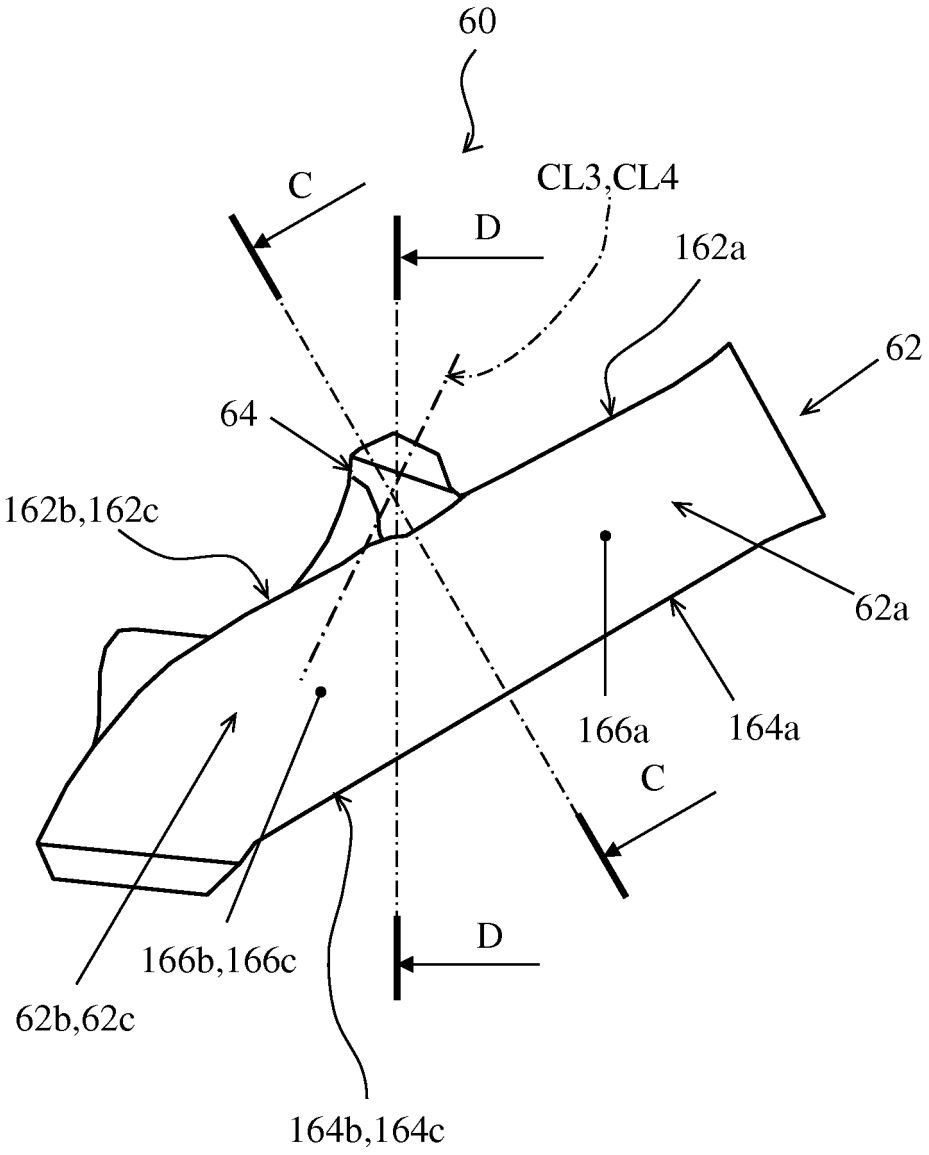
【FIG.5】


20
CL1
24b
122a
24c
CL2
63,26
63,26
130
130
122b
122c
126a,126b
128a,128c
130
130
124b
124a
124c
24
128b
126c

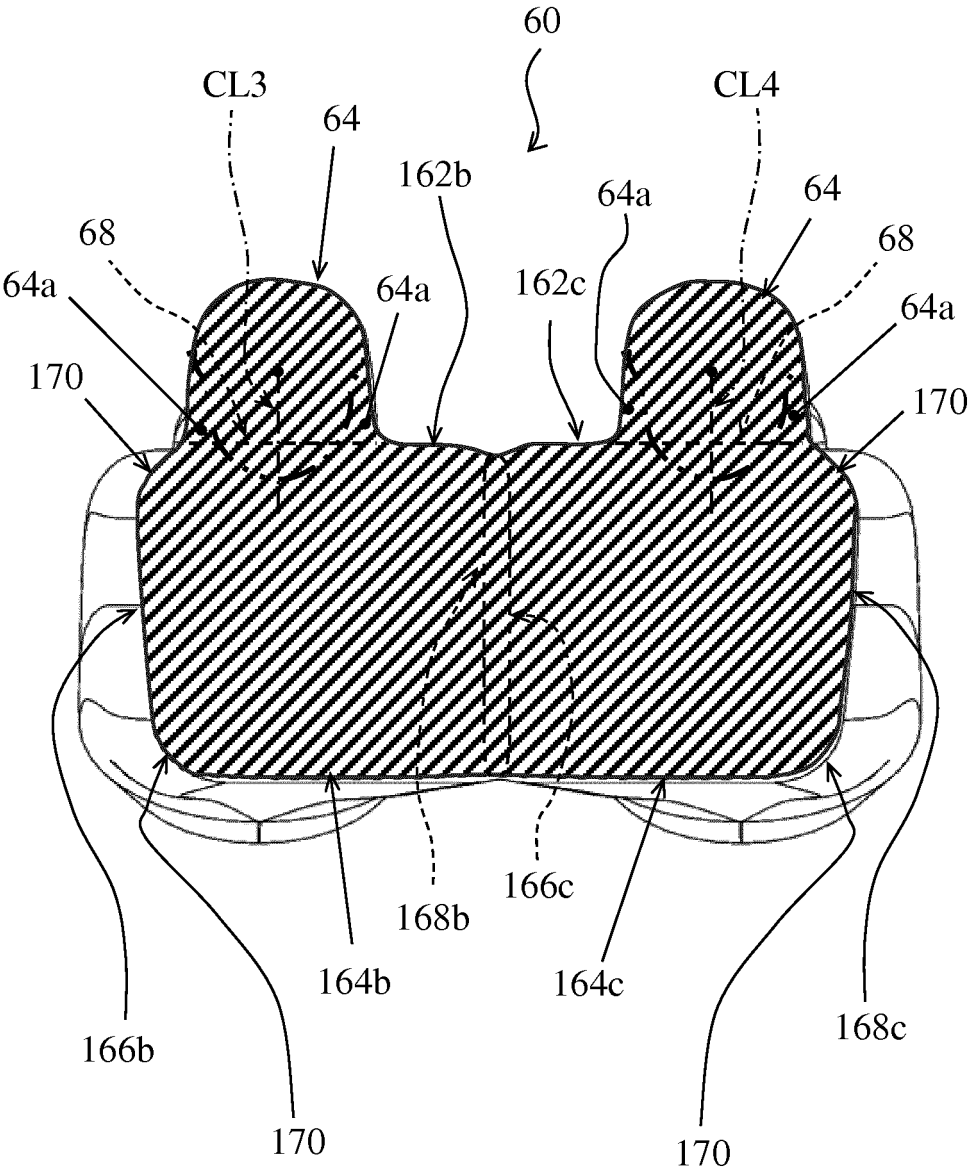
【FIG.6】


60
162c
166c
62c
168c
170
64
CL4
162a
168b
62a
170
168a
170
162b
62b
170
166b
64
CL3
166a
164a
170
62
170

【FIG.7】


60
C
CL3,CL4
D
162a
62
64
162b,162c
62a
166a
164a
C
D
166b,166c
62b,62c
164b,164c

【FIG.8】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CL3
CL4
64
64
162b
64a
68
68
64a
64a
162c
64a
170
170
166c
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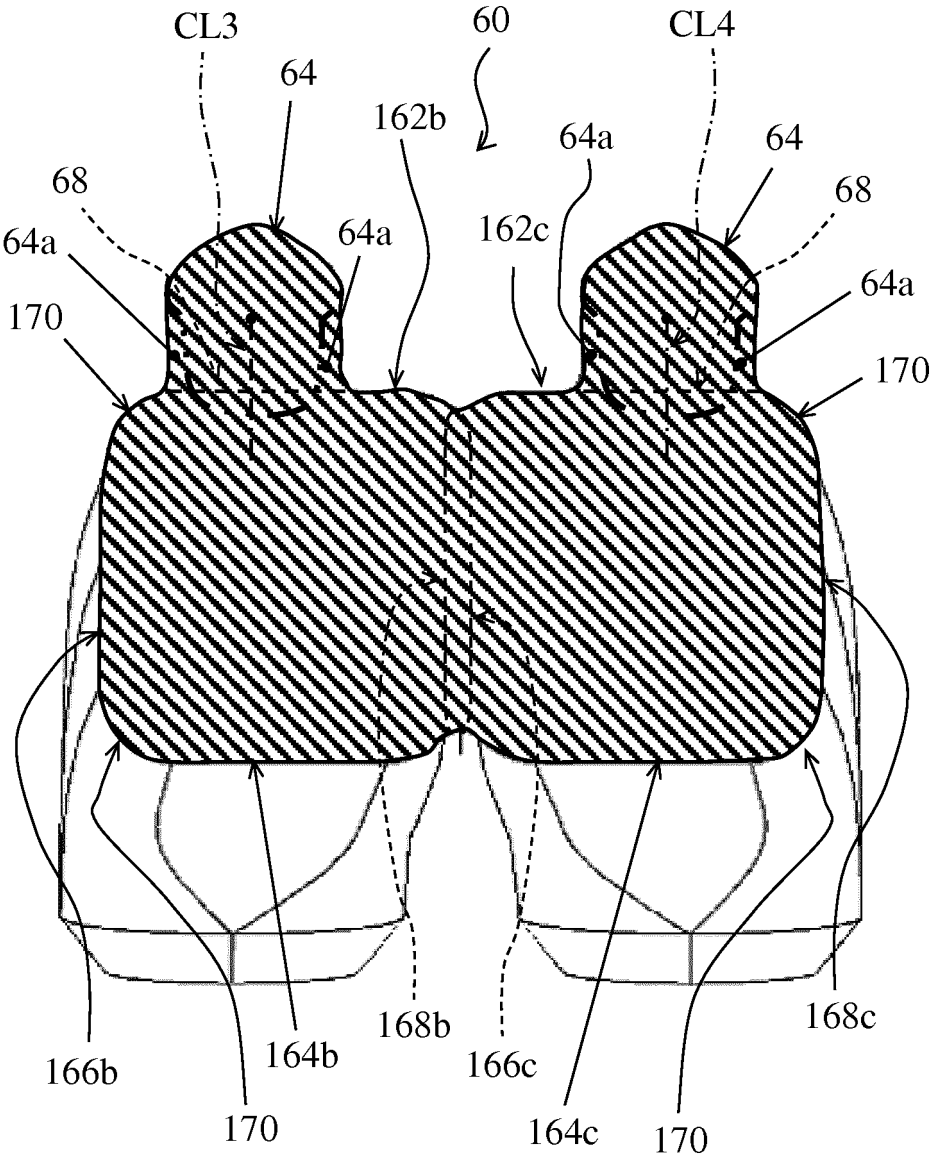
164b
164c
166b
168c
170
170

【FIG.9】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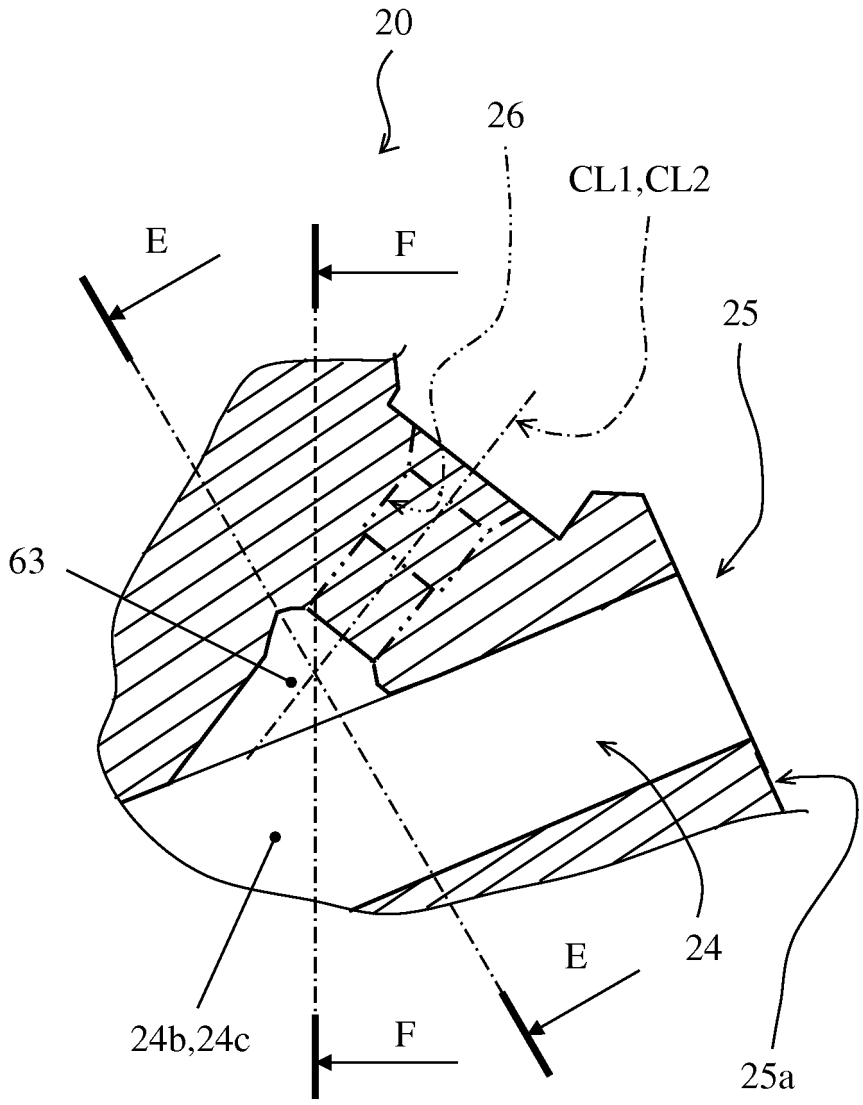
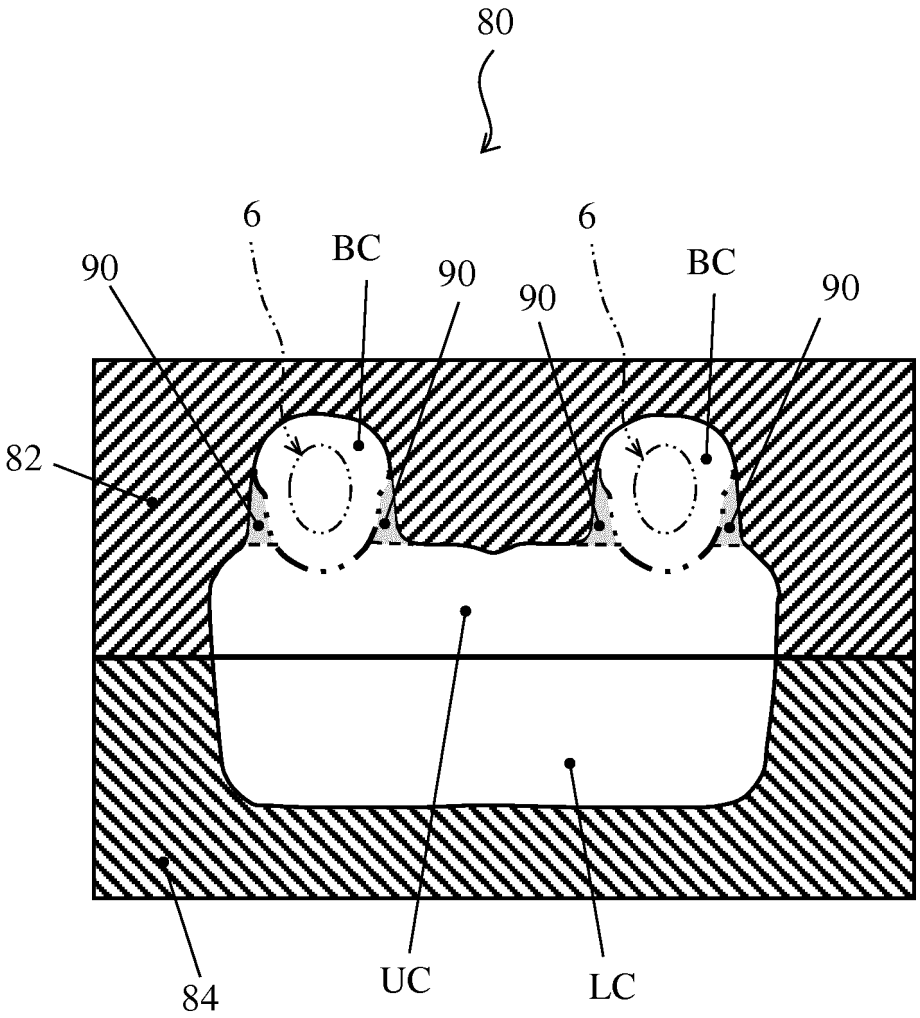
60
CL4
64
162b
64a
64
68
68
64a
64a
162c
64a
170
170
166b
164b
168b
166c
168c
170
164c
170

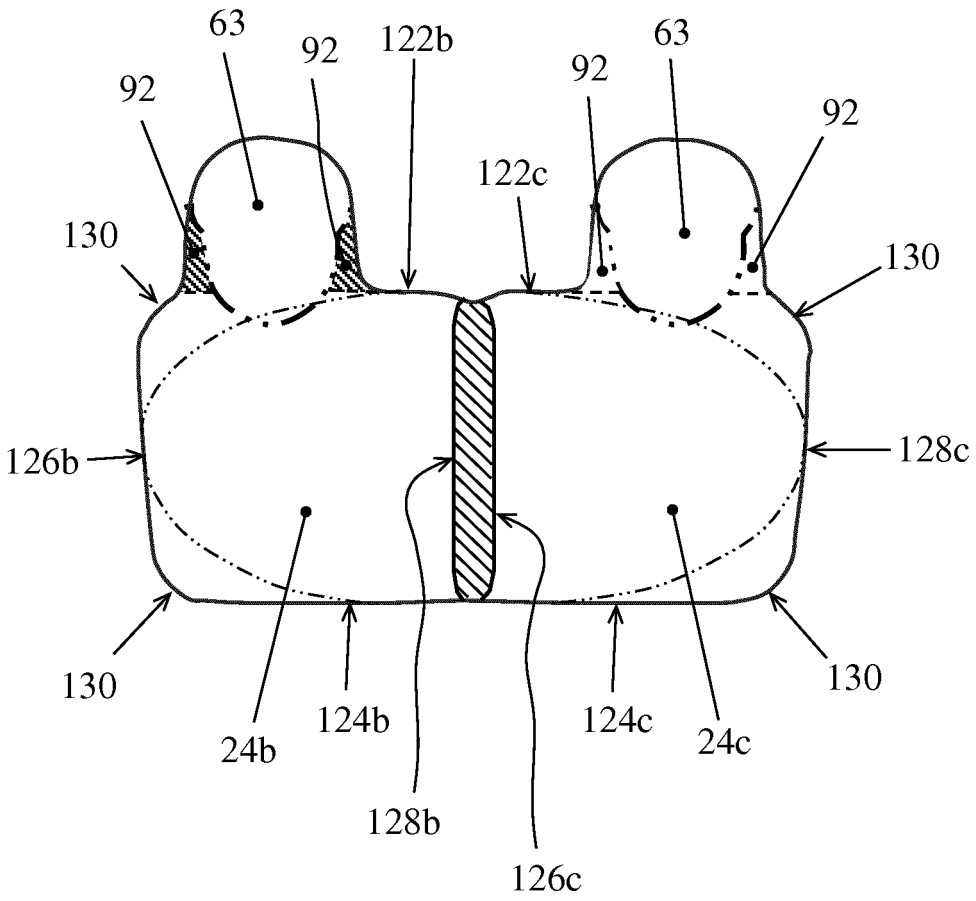
【FIG.10】



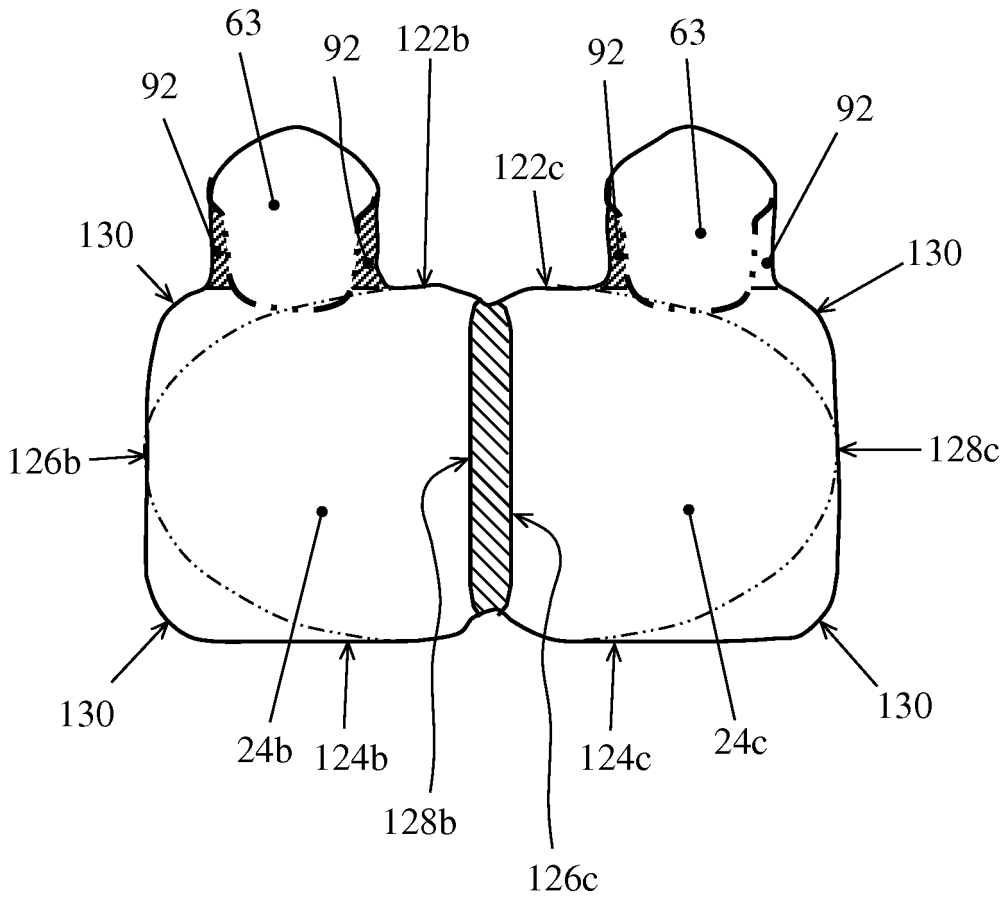
【FIG.11】



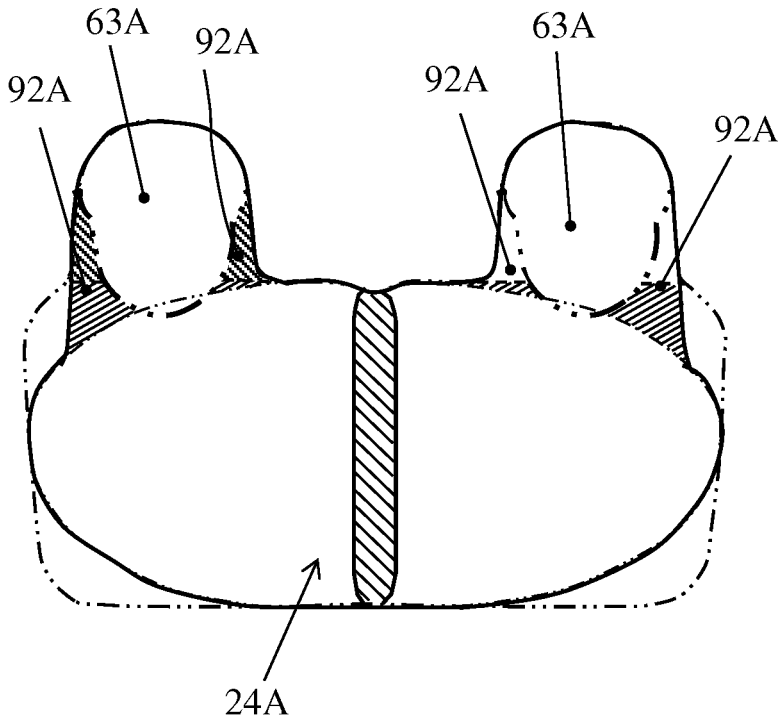
【FIG.12】


63
92
92
122b
92
63
92
122c
130
130
126b
128c
130
130
24b
124b
128b
126c
124c
24c

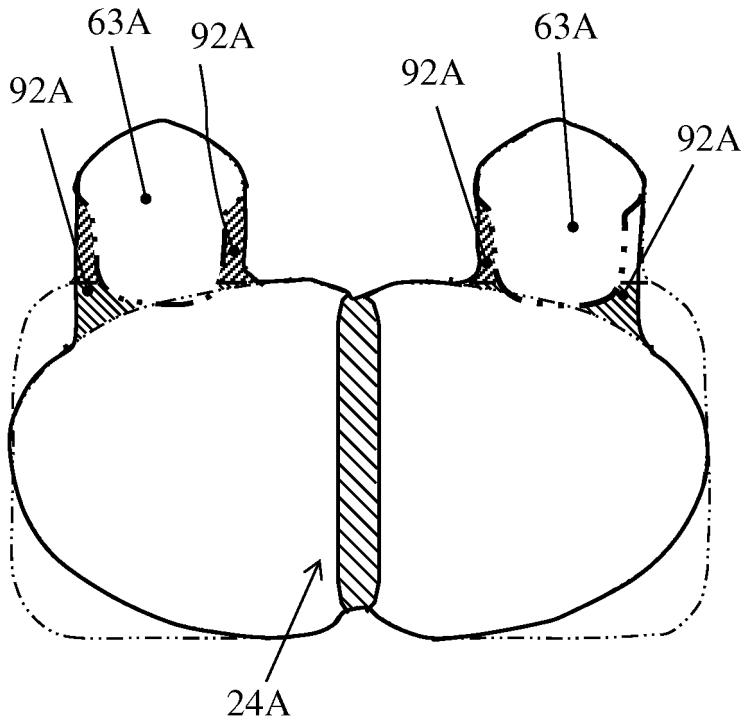
【FIG.13】


63
92
92
122b
92
63
92
122c
130
130
126b
128c
130
24b
124b
128b
126c
124c
24c
130

【FIG.14】



【FIG.15】



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/055349

A. CLASSIFICATION OF SUBJECT MATTER
B22C9/24(2006.01)i, *F02F1/24*(2006.01)i, *F02F1/42*(2006.01)i, *F02M61/14*(2006.01)i, *F02M69/00*(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)
B22C9/24, F02F1/24, F02F1/42, F02M61/14, F02M69/00

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 1996-2015
Kokai Jitsuyo Shinan Koho 1971-2015 Toroku Jitsuyo Shinan Koho 1994-2015

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.
A	JP 2011-149309 A (Toyota Motor Corp.), 04 August 2011 (04.08.2011), paragraphs [0007] to [0029]; fig. 1 to 3 (Family: none)	1-13
A	JP 2006-299894 A (Nissan Motor Co., Ltd.), 02 November 2006 (02.11.2006), paragraphs [0008] to [0078]; fig. 1 to 11 & US 2006/0231067 A1 & EP 1715169 A1 & DE 602006011806 D & KR 10-2006-0110232 A & CN 1853822 A	1-13
A	JP 10-299497 A (Mazda Motor Corp.), 10 November 1998 (10.11.1998), paragraphs [0007] to [0057]; fig. 1 to 15 (Family: none)	1-13

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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26 May 2015 (26.05.15)	02 June 2015 (02.06.15)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/055349

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 6-213069 A (Nissan Motor Co., Ltd.), 02 August 1994 (02.08.1994), paragraphs [0008] to [0029]; fig. 1 to 7 (Family: none)	1-13
A	JP 61-255745 A (Honda Motor Co., Ltd.), 13 November 1986 (13.11.1986), examples; fig. 2 (Family: none)	1-13

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 5083565 B **[0004]**