(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 674 538 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
01.07.2020 Bulletin 2020/27

(51) Int Cl.:
F02F 1/24 *(2006.01)* ***F02F 1/40*** *(2006.01)*

(21) Application number: **19215976.2**

(22) Date of filing: **13.12.2019**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **27.12.2018 JP 2018244931**

(71) Applicant: **YAMAHA HATSUDOKI KABUSHIKI KAISHA**
Iwata-shi, Shizuoka 438-8501 (JP)

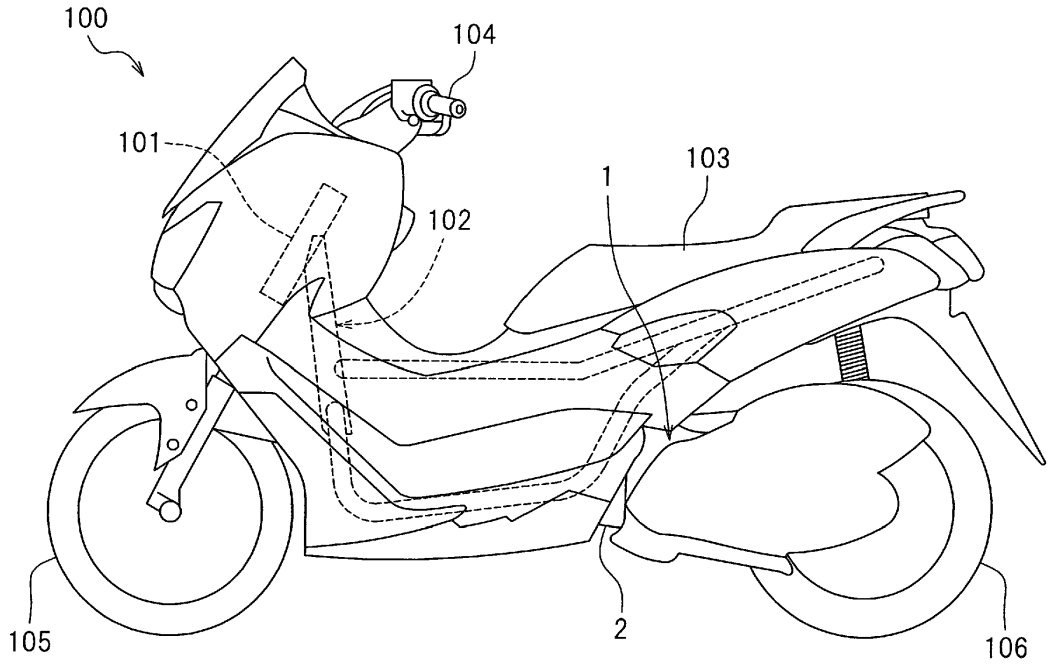
(72) Inventor: **OGAWA, Soraki**
Iwata-shi,, Shizuoka 438-8501 (JP)

(74) Representative: **Grünecker Patent- und Rechtsanwälte**
PartG mbB
Leopoldstraße 4
80802 München (DE)

(54) **INTERNAL COMBUSTION ENGINE AND STRADDLED VEHICLE HAVING THE SAME**

(57) As viewed along a cylinder axial line **CA** so that a center **51C** of a first intake opening **51A** is located leftward and upward of the cylinder axial line **CA,** an axial line **55C** of a plug hole **55** is inclined relative to the cylinder axial line **CA** so as to diverge leftward of the cylinder axial line **CA** while extending away from an ignition opening **55A** along the cylinder axial line **CA.** The plug hole **55** is located between a first intake port **51** and a first exhaust port **61.** A water jacket **10A** includes a middle passage **30** including an inter-port passage **31** that is located between the first exhaust port **61** and a second exhaust port **62** and downward of the cylinder axial line **CA,** and an extension passage **32** extending upward from the inter-port passage **31** to a position that is upward of the cylinder axial line **CA**.

FIG.1



EP 3 674 538 A1

Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to an internal combustion engine including a water jacket, and a straddled vehicle having the same.

Description of the Related Art

[0002] For example, a 4-valve water-cooled internal combustion engine includes a cylinder body having a cylinder, and a cylinder head having two intake ports and two exhaust ports. A water jacket, which provides a passage for the coolant, is formed on the cylinder body and the cylinder head.

[0003] A portion of the cylinder head between two exhaust ports is likely to be hot. Japanese Laid-Open Patent Publication No. 2015-010598 discloses an internal combustion engine in which a passage for the coolant is provided between two exhaust ports in order to suppress the increase in temperature in the portion between the exhaust ports.

[0004] In the internal combustion engine disclosed in Japanese Laid-Open Patent Publication No. 2015-010598, the ignition plug is arranged so that the axial line of the ignition plug and the axial line of the cylinder coincide with each other. The axial line of the plug hole accommodating the ignition plug therein coincides with the cylinder axial line. However, in the cylinder head, the area between the plug hole and the exhaust port is small. By simply forming a passage in the portion between exhaust ports, only a small passage can be formed. Japanese Laid-Open Patent Publication No. 2018-155215 discloses an internal combustion engine in which a plug hole is provided between two intake ports, and the axial line of the plug hole is inclined relative to the cylinder axial line so that the axial line extends toward the intake ports away from the combustion chamber. With the internal combustion engine, the area between the plug hole and the exhaust ports can be made large. Thus, it is possible to enlarge the passage between exhaust ports.

SUMMARY OF THE INVENTION

[0005] However, with the internal combustion engine disclosed in Japanese Laid-Open Patent Publication No. 2018-155215, the coolant tends not to flow smoothly through the passage between exhaust ports.

[0006] The present invention has been made in view of the above, and an object thereof is to provide an internal combustion engine that is capable of effectively cooling a portion of the cylinder head between exhaust ports, and a straddled vehicle having the same.

[0007] An internal combustion engine disclosed herein includes a cylinder body, a cylinder head, a first intake port, a second intake port, a first exhaust port, a second exhaust port, a plug hole, and a water jacket. The cylinder body includes a cylinder formed therein that extends along a cylinder axial line and defines a portion of a combustion chamber. The cylinder head is secured on the cylinder body. The first intake port is formed on the cylinder head and includes a first intake opening facing toward the combustion chamber. An intake air to be taken into the combustion chamber flows through the first intake port. The second intake port is formed on the cylinder head and includes a second intake opening facing toward the combustion chamber. An intake air to be taken into the combustion chamber flows through the second intake port. The first exhaust port is formed on the cylinder head and includes a first exhaust opening facing toward the combustion chamber. An exhaust air to be exhausted from the combustion chamber flows through the first exhaust port. The second exhaust port is formed on the cylinder head and includes a second exhaust opening facing toward the combustion chamber. An exhaust air to be exhausted from the combustion chamber flows through the second exhaust port. The plug hole is formed on the cylinder head and includes an ignition opening facing toward the combustion chamber. An ignition plug is accommodated in the plug hole. The water jacket is formed on the cylinder head. A coolant flows through the water jacket. As viewed along the cylinder axial line so that a center of the first intake opening is located leftward and upward of the cylinder axial line, a center of the second intake opening is located rightward and upward of the cylinder axial line, a center of the first exhaust opening is located leftward and downward of the cylinder axial line, and a center of the second exhaust opening is located rightward and downward of the cylinder axial line. As viewed as described above, an axial line of the plug hole is inclined relative to the cylinder axial line so as to diverge leftward of the cylinder axial line while extending away from the ignition opening along the cylinder axial line. As viewed as described above, the plug hole is located between the first intake port and the first exhaust port. As viewed as described above, the water jacket includes a middle passage, wherein the middle passage includes an inter-port passage that is located between the first exhaust port and the second exhaust port and downward of the cylinder axial line, and an extension passage that extends upward from the inter-port passage to a position that is upward of the cylinder axial line.

[0008] With the internal combustion engine described above, since the plug hole is inclined from the cylinder axial line, the area between the first exhaust port and the second exhaust port can be made large. Therefore, it is possible to ensure a sufficient size of the inter-port passage. The plug hole is provided between the first intake port and the first exhaust port. Therefore, it is possible to ensure a sufficient area where a passage can be formed between the first intake port and the second intake port. The extension passage extending from the in-

ter-port passage is provided in this area. Thus, the coolant having flown through the inter-port passage can continue to flow straight through the extension passage. Therefore, it is possible to smooth the coolant flow through the inter-port passage. Therefore, it is possible to effectively cool the portion of the cylinder head between the first exhaust port and the second exhaust port.

[0009] According to one preferred aspect, as viewed along the cylinder axial line so that the center of the first intake opening is located leftward and upward of the cylinder axial line, the water jacket includes a first right passage that is located rightward and downward relative to a center of the second exhaust port, a second right passage that is located upward relative to the center of the second exhaust port and is connected to the first right passage and the middle passage, and a third right passage that is located upward relative to the second right passage and downward relative to a center of the second intake port and is connected to the middle passage. The second right passage and the third right passage are partitioned from each other in an up-down direction in a portion that is leftward relative to the center of the second intake opening and the center of the second exhaust opening.

[0010] According to this aspect, the coolant having flown through the second right passage flows into the third right passage via the middle passage. The second right passage and the third right passage are partitioned from each other in the up-down direction in the portion that is leftward relative to the center of the second intake opening and the center of the second exhaust opening. Therefore, the coolant having flown through the second right passage merges with the coolant flowing through the middle passage after flowing to a point that is leftward relative to the center of the second exhaust opening. Thus, the coolant in the second right passage and the coolant in the middle passage can be merged together without significantly hindering the straight flow of the coolant through the inter-port passage and the extension passage. Therefore, it is possible to further smooth the coolant flow through the inter-port passage. It is also possible to effectively cool the portion around the second exhaust port.

[0011] According to one preferred aspect, along a predetermined section that is parallel to a straight line that connects together the center of the first exhaust opening and the center of the second exhaust opening and is parallel to the cylinder axial line, a ratio of a dimension of the inter-port passage in a direction that is parallel to the cylinder axial line to a dimension thereof in a direction that is perpendicular to the cylinder axial line is greater than 1.

[0012] In the cylinder head, the dimension between the first exhaust port and the second exhaust port is relatively small. According to this aspect, however, along the section, the dimension of the inter-port passage in a direction parallel to the cylinder axial line is greater than the dimension thereof in a direction perpendicular to the cylinder axial line (i.e., the dimension between the first exhaust port and the second exhaust port). Therefore, it is possible to ensure a sufficient passage cross-sectional area of the inter-port passage. Therefore, it is possible to effectively cool the portion of the cylinder head between the first exhaust port and the second exhaust port.

[0013] According to one preferred aspect, along the predetermined section, the inter-port passage has a side that is parallel to the cylinder axial line.

[0014] According to this aspect, it is possible to effectively cool the portion of the cylinder head between the first exhaust port and the second exhaust port.

[0015] According to one preferred aspect, as viewed along the cylinder axial line so that the center of the first intake opening is located leftward and upward of the cylinder axial line, the water jacket includes a first left passage that is located downward relative to a center of the first exhaust port, a second left passage that is located leftward and upward relative to the center of the first exhaust port and is connected to the first left passage, and a third left passage that is located leftward and downward relative to a center of the first intake port and is connected to the second left passage.

[0016] According to this aspect, it is possible to effectively cool the portion leftward of the first exhaust port.

[0017] According to one preferred aspect, the extension passage and the second left passage are not directly connected to each other, and the extension passage and the third left passage are not directly connected to each other.

[0018] If the extension passage is directly connected to the second left passage or the third left passage, there is formed a passage that extends in the left-right direction from the second right passage or the third right passage to the second left passage or the third left passage, and such a passage will be substantially orthogonal to the inter-port passage. In that case, the coolant flow through the inter-port passage is likely to be disturbed by the coolant flow through the substantially orthogonal passage. As a result, it may be more difficult for the coolant to flow smoothly through the inter-port passage. According to this aspect, however, the extension passage is not directly connected to either the second left passage or the third left passage. Thus, the coolant can smoothly flow through the inter-port passage. Therefore, it is possible to effectively cool the portion of the cylinder head between the first exhaust port and the second exhaust port.

[0019] According to one preferred aspect, as viewed along the cylinder axial line so that the center of the first intake opening is located leftward and upward of the cylinder axial line, the second left passage extends rightward and upward toward the third left passage, and the third left passage extends rightward and downward toward the second left passage.

[0020] According to this aspect, it is possible to effectively cool the portion around the first exhaust port.

[0021] According to one preferred aspect, along a predetermined section that is parallel to a straight line that

connects together the center of the first exhaust opening and the center of the second exhaust opening and is parallel to the cylinder axial line, a ratio of a dimension of the inter-port passage in a direction that is parallel to the cylinder axial line to a dimension thereof in a direction that is perpendicular to the cylinder axial line is greater than the ratio for the first right passage and is greater than the ratio for the first left passage.

[0022] In the cylinder head, the dimension between the first exhaust port and the second exhaust port is relatively small. According to this aspect, along the section, however, the ratio of the dimension of the inter-port passage in a direction parallel to the cylinder axial line to the dimension thereof in a direction perpendicular to the cylinder axial line (i.e., the dimension between the first exhaust port and the second exhaust port) is large. Therefore, it is possible to ensure a sufficient passage cross-sectional area of the inter-port passage. Therefore, it is possible to effectively cool the portion of the cylinder head between the first exhaust port and the second exhaust port.

[0023] As viewed along the cylinder axial line so that the center of the first intake opening is located leftward and upward of the cylinder axial line, the water jacket may include an inlet opening that is located rightward and downward relative to the second exhaust opening, wherein the coolant flows in through the inlet opening.

[0024] As viewed along the cylinder axial line so that the center of the first intake opening is located leftward and upward of the cylinder axial line, the water jacket may include an inlet opening that is located rightward and downward relative to the second exhaust opening, wherein the coolant flows in through the inlet opening, and the first left passage may include a diameter-constricted portion that constricts the coolant flow.

[0025] When the inlet opening is provided rightward and downward relative to the second exhaust opening, the coolant that has flown in through the inlet opening tends to flow leftward and upward. According to this aspect, the first left passage includes the diameter-constricted portion that constricts the coolant flow. Therefore, the coolant is prevented from excessively flowing into the first left passage. A sufficient amount of the coolant flows into the inter-port passage. Therefore, it is possible to effectively cool the portion of the cylinder head between the first exhaust port and the second exhaust port.

[0026] The internal combustion engine may include an inlet opening for guiding the coolant from an outside of the internal combustion engine to an inside of the internal combustion engine, and the inlet opening may be formed on the cylinder head.

[0027] The internal combustion engine may include an inlet opening for guiding the coolant from an outside of the internal combustion engine to an inside of the internal combustion engine and an exit opening for guiding the coolant to the outside of the internal combustion engine, and the inlet opening and the exit opening may be formed on the cylinder head.

[0028] According to one preferred aspect, the internal combustion engine includes a camshaft that is rotatably supported on the cylinder head and crosses the cylinder axial line. An axial line of the camshaft is located between the center of the first intake opening and the center of the first exhaust opening and is located between the center of the second intake opening and the center of the second exhaust opening.

[0029] Since the plug hole is inclined relative to the cylinder axial line, it is possible to ensure a sufficient space for arranging the camshaft that crosses the cylinder axial line and extends in the left-right direction without increasing the size of the cylinder head, as viewed along the cylinder axial line as described above. Therefore, it is possible to reduce the size of the cylinder head.

[0030] According to one preferred aspect, the cylinder head is a cast product.

[0031] According to this aspect, it is possible to relatively easily form the water jacket configured as described above.

[0032] A straddled vehicle disclosed herein includes the internal combustion engine as set forth above.

[0033] According to the present invention, it is possible to provide an internal combustion engine that is capable of effectively cooling a portion of the cylinder head between exhaust ports, and a straddled vehicle having the same.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034]

FIG. **1** is a side view of a motorcycle according to an embodiment.

FIG. **2** is a view of a portion of an internal combustion engine according to an embodiment, as viewed along the cylinder axial line.

FIG. **3** is a cross-sectional view taken along line III-III of FIG. **2.**

FIG. **4** is a cross-sectional view taken along line IV-IV of FIG. **2.**

FIG. **5** is a cross-sectional view taken along line V-V of FIG. **2.**

FIG. **6** is a cross-sectional view taken along line VI-VI of FIG. **2.**

FIG. **7** is a bottom view of a cylinder head.

FIG. **8** is a view showing walls of a water jacket of the cylinder head.

FIG. **9** is a cross-sectional view of the water jacket of the cylinder head taken in a plane perpendicular to the cylinder axial line.

FIG. **10** is an end view taken along line X-X of FIG. **8.**

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0035] An embodiment will now be described with reference to the drawings. FIG. **1** is a motorcycle **100** ac-

cording to the present embodiment. The motorcycle **100** is an example of the straddled vehicle. A straddled vehicle refers to a vehicle that is straddled by a passenger. A straddled vehicle is not limited to the motorcycle **100.** A straddled vehicle may be an auto tricycle, an ATV (All Terrain Vehicle), or the like.

[0036] The motorcycle **100** includes a body frame **102** having a head pipe **101,** a seat **103** supported on the body frame **102,** an internal combustion engine (hereinafter referred to as an engine) **1** supported on the body frame **102,** a handle **104** pivotally supported on the head pipe **101,** a front wheel **105,** and a rear wheel **106** driven by the engine **1.**

[0037] The engine **1** is a 4-stroke water-cooled engine. The engine **1** includes a crankcase **2** accommodating a crankshaft (not shown) therein, a cylinder body **3** secured on the crankcase **2** (see FIG. **3**), a cylinder head **4** secured on the cylinder body **3,** and a cylinder head cover **5** secured on the cylinder head **4.** FIG. **2** is a view of a portion of the engine **1** as viewed along the cylinder axial line **CA** (see FIG. **4**). FIG. **3** is a cross-sectional view taken along line III-III of FIG. **2.** FIG. **4** is a cross-sectional view taken along line IV-IV of FIG. **2.** FIG. **5** is a cross-sectional view taken along line V-V of FIG. **2.** FIG. **6** is a cross-sectional view taken along line VI-VI of FIG. **2.** Note that although the cylinder axial line **CA** does not exist on the cross sections shown in FIG. **3** and FIG. **5,** the cylinder axial line **CA** is drawn at the center of a cylinder **6** also in FIG. **3** and FIG. **5** for the purpose of illustration.

[0038] As shown in FIG. **4,** the cylinder body **3** includes the cylinder **6** formed therein. The cylinder **6** extends along the cylinder axial line **CA.** A piston **7** is accommodated inside the cylinder **6.** The cylinder **6** defines a portion of a combustion chamber **8.** The piston **7** is linked to the crankshaft via a connected rod (not shown).

[0039] FIG. **7** is a bottom view of the cylinder head **4.** The cylinder head **4** is formed with a first intake port **51,** a second intake port **52,** a first exhaust port **61** and a second exhaust port **62.** The first intake port **51,** the second intake port **52,** the first exhaust port **61** and the second exhaust port **62** have a first intake opening **51A,** a second intake opening **52A,** a first exhaust opening **61A** and a second exhaust opening **62A,** respectively, facing toward the combustion chamber **8.** The intake air to be sucked into the combustion chamber 8 flows through the first intake port **51** and the second intake port **52.** The exhaust air to be exhausted from the combustion chamber **8** flows through the first exhaust port **61** and the second exhaust port **62.** The cylinder head **4** is formed with a plug hole **55** that accommodates an ignition plug **50** therein. The plug hole **55** has an ignition opening **55A** facing toward the combustion chamber **8.** The cylinder head **4** is a cast product. The cylinder head **4** is produced by casting.

[0040] As shown in FIG. **3,** the engine **1** includes a first intake valve **53** that opens/closes the first intake opening **51A,** and a first exhaust valve **63** that opens/closes the first exhaust opening **61A.** As shown in FIG. **5,** the engine **1** includes a second intake valve **54** that opens/closes the second intake opening **52A,** and a second exhaust valve **64** that opens/closes the second exhaust opening **62A.** The engine **1** includes a camshaft **57** that is rotatably supported on the cylinder head **4.** As shown in FIG. **4,** the camshaft **57** crosses the cylinder axial line **CA.** As shown in FIG. **3,** the axial line **57C** of the camshaft **57** is located between the center of the first intake opening **51A** and the center of the first exhaust opening **61A.** As shown in FIG. **5,** the axial line **57C** of the camshaft **57** is located between the center of the second intake opening **52A** and the center of the second exhaust opening **62A.** The first intake valve **53,** the second intake valve **54,** the first exhaust valve **63** and the second exhaust valve **64** are engaged with the camshaft **57** via a rocker arm **58.** The first intake valve **53,** the second intake valve **54,** the first exhaust valve **63** and the second exhaust valve **64** are opened/closed following the rotation of the camshaft **57.**

[0041] The engine **1** is formed with a water jacket **10** through which the coolant flows (see FIG. **5**). The water jacket **10** includes a water jacket **10A** formed on the cylinder head **4,** and a water jacket **10B** formed on the cylinder body **3.**

[0042] FIG. **8** is a view showing walls of the water jacket **10A** of the cylinder head **4,** showing the water jacket **10A** as viewed from the cylinder head cover 5 along the cylinder axial line **CA.** Note that the walls are extracted from the cylinder head 4 in FIG. 8. As viewed along the cylinder axial line **CA** so that the center **51C** of the first intake opening **51A** is located leftward and upward of the cylinder axial line **CA** as shown in FIG. **8,** the center **52C** of the second intake opening **52A** is located rightward and upward of the cylinder axial line **CA,** the center **61C** of the first exhaust opening **61A** is located leftward and downward of the cylinder axial line **CA,** and the center **62C** of the second exhaust opening **62A** is located rightward and downward of the cylinder axial line **CA.** The terms front, rear, left, right, up and down, as used in the description below, refer to these directions as viewed along the cylinder axial line **CA** so that the center **51C** of the first intake opening **51A** is located leftward and upward of the cylinder axial line **CA,** as shown in FIG. **8,** unless specified otherwise.

[0043] As shown in FIG. **6,** the axial line **55C** of the plug hole **55** is inclined relative to the cylinder axial line **CA** so as to diverge leftward of the cylinder axial line **CA** while extending away from the ignition opening **55A** (i.e., upward in FIG. **6**) along the cylinder axial line **CA.** The plug hole **55** is located between the first intake port **51** and the first exhaust port **61.**

[0044] FIG. **9** is a cross-sectional view of the water jacket **10A** taken along a direction perpendicular to the cylinder axial line **CA.** The water jacket **10A** includes an inlet opening **11** through which the coolant flows in, an inlet passage **13,** a right passage **20,** a middle passage **30,** a left passage **40,** an exit passage **14,** and an exit opening **12** through which the coolant flows out.

[0045] The inlet opening **11** is an opening for guiding the coolant into the water jacket **10** of the engine 1. The exit opening **12** is an opening for guiding the coolant out of the water jacket **10** of the engine **1.** That is, the inlet opening **11** is an opening for guiding the coolant from the outside to the inside of the engine **1,** and the exit opening **12** is an opening for guiding the coolant from the inside to the outside of the engine **1.** The inlet opening **11** and the exit opening **12** are formed on the cylinder head **4.** The inlet opening **11** is located rightward and downward relative to the center **62C** of the second exhaust opening **62A.** The inlet opening **11** is facing rightward. The exit opening **12** is located leftward and upward relative to the center **51C** of the first intake opening **51A.** The exit opening **12** is facing leftward.

[0046] The right passage **20** includes a first right passage **21** that is located rightward and downward relative to the center **62D** of the second exhaust port **62,** a second right passage **22** that is located upward relative to the center **62D** of the second exhaust port **62,** a third right passage **23** that is located upward relative to the second right passage **22** and downward relative to the center **52D** of the second intake port **52,** and a fourth right passage **24** that is located upward relative to the center **52D** of the second intake port **52.** The first right passage **21** is connected to the inlet passage **13.** The second right passage **22** is connected to the first right passage **21** and the middle passage **30.** The third right passage **23** is connected to the middle passage **30.** The fourth right passage **24** is connected to the third right passage **23** and the exit passage **14.** The second right passage **22** and the third right passage **23** are partitioned from each other in the up-down direction in the portion that is leftward relative to the center **52C** of the second intake opening **52A** and the center **62C** of the second exhaust opening **62A.**

[0047] The middle passage **30** includes an inter-port passage **31** and an extension passage **32.** The inter-port passage **31** is formed between the first exhaust port **61** and the second exhaust port **62.** The inter-port passage **31** is located downward of the cylinder axial line **CA.** The extension passage **32** extends upward from the inter-port passage **31** to a position that is upward of the cylinder axial line **CA.** The inter-port passage **31** and the extension passage **32** extend straight upward. The inter-port passage **31** is connected to the inlet passage **13** and the first right passage **21.** The extension passage **32** is connected to the second right passage **22** and the third right passage **23.**

[0048] The left passage **40** includes a first left passage **41** that is located downward relative to the center **61D** of the first exhaust port **61,** a second left passage **42** that is located leftward and upward relative to the center **61D** of the first exhaust port **61,** a third left passage **43** that is located leftward and downward relative to the center **51D** of the first intake port **51,** and a fourth left passage **44** that is located leftward and upward relative to the center **51D** of the first intake port **51.** The first left passage **41** is connected to the inlet passage **13** and the inter-port passage **31.** The second left passage **42** is connected to the first left passage **41.** The third left passage **43** is connected to the second left passage **42.** The fourth left passage **44** is connected to the third left passage **43** and the exit passage **14.** The second left passage **42** extends rightward and upward toward the third left passage **43.** The third left passage **43** extends rightward and downward toward the second left passage **42.** The first left passage **41** includes a diameter-constricted portion **46** that constricts the coolant flow. The passage cross-sectional area of the diameter-constricted portion **46** is smaller than that on the upstream side (the right side in FIG. **9**) of the diameter-constricted portion **46** and that on the downstream side (the left side in FIG. **9**).

[0049] As shown in FIG. **9,** the extension passage **32** and the second left passage **42** are not directly connected to each other. The extension passage **32** and the third left passage **43** are not directly connected to each other. There is no passage through which the coolant passes between the first intake port **51** and the first exhaust port **61.**

[0050] In the present embodiment, the exit passage **14** is provided around a hole **18** through which a bolt (not shown) is inserted. However, the hole **18** may not be necessary. There is no limitation on the shape of the exit passage **14** as long as the exit passage **14** is a passage that connects the fourth right passage **24** and the fourth left passage **44** to the exit opening **12.**

[0051] FIG. **10** is an end view taken along line X-X of FIG. **8.** That is, FIG. **10** is an end view taken along a predetermined section that is parallel to a straight line that connects together the center **61C** of the first exhaust opening **61A** and the center **62C** of the second exhaust opening **62A** and is parallel to the cylinder axial line **CA.** As shown in FIG. **10,** the inter-port passage **31** is vertically elongated along the section. In FIG. **10,** the X direction represents a direction that is perpendicular to the cylinder axial line **CA.** The Y direction represents a direction that is parallel to the cylinder axial line **CA.** Along the section, the dimension Ly of the inter-port passage **31** in the Y direction relative to the dimension Lx thereof in the X direction is greater than 1. Ly/Lx > 1. While there is no particular limitation on the value of Ly/Lx, Ly/Lx = 2 to 4, for example.

[0052] As shown in FIG. **10,** along the section, the inter-port passage **31** is formed substantially in a rectangular shape. Along the section, the inter-port passage **31** has sides **31a** that are parallel to the cylinder axial line **CA.** Note however that the shape shown in FIG. **10** is merely an example, and the shape of the inter-port passage **31** along the section is not limited to a rectangular shape.

[0053] As shown in FIG. **10,** along the section, the dimensions of the first right passage **21** in the X direction and the Y direction are denoted as LRx and LRy, respectively. Along the section, the dimensions of the first left passage **41** in the X direction and the Y direction are denoted as LLx and LLy, respectively. Then, Ly/Lx is

greater than LRy/LRx and greater than LLy/LLx. That is, along the section, the ratio of the dimension of the inter-port passage **31** in a direction parallel to the cylinder axial line **CA** to the dimension thereof in a direction perpendicular to the cylinder axial line **CA** is greater than that for the first right passage **21** and greater than that for the first left passage **41.** Along the section, the inter-port passage **31** is more vertically elongated than the first right passage **21** and the first left passage **41.**

[0054] As shown in FIG. **3** to FIG. **6,** the water jacket **10B** of the cylinder body **3** is formed around the cylinder **6.** As shown in FIG. **7,** the water jacket **10A** of the cylinder head **4** has a plurality of holes **4a** that are facing toward the water jacket **10B** of the cylinder body **3.** A gasket **9** (see FIG. **6**) is interposed between the cylinder body **3** and the cylinder head **4.** The gasket **9** also has a plurality of holes (not shown) similar to the holes **4a** of the water jacket **10A** of the cylinder head **4.** In the present embodiment, the inlet opening **11** for guiding the coolant from the outside of the engine **1** and the exit opening **12** for guiding the coolant to the inside of the engine **1** are both provided on the cylinder head **4.** Therefore, a portion of the coolant flowing in through the inlet opening **11** flows through the water jacket **10A** of the cylinder head **4,** the water jacket **10B** of the cylinder body **3** and the water jacket **10A** of the cylinder head **4,** in this order, and flows out through the exit opening **12.** Specifically, a portion of the coolant in the water jacket **10A** of the cylinder head **4** flows into the water jacket **10B** of the cylinder body **3** through two or more of the plurality of holes **4a.** The coolant of the water jacket **10B** of the cylinder body **3** flows into the water jacket **10A** of the cylinder head **4** through other ones of the plurality of holes **4a.**

[0055] Next, referring to FIG. 9, the flow of the coolant through the water jacket **10A** of the cylinder head **4** will be described. The coolant that has flown into the inlet passage **13** through the inlet opening **11** branches into the first right passage **21,** the inter-port passage **31** and the first left passage **41.** The inlet opening **11** is located rightward and downward of the second exhaust opening **62A,** and the coolant tends to flow leftward and upward in the inlet passage 13. Therefore, the coolant is prevented from excessively flowing into the first right passage **21.** The first left passage **41** includes the diameter-constricted portion **46** that constricts the coolant flow. Therefore, the coolant is prevented from excessively flowing into the first left passage **41.** Therefore, a sufficient amount of the coolant flows into the inter-port passage **31.** The coolant flowing through the right passage **20,** the coolant flowing through the middle passage **30** and the coolant flowing through the left passage **40** will be relatively even.

[0056] In the engine **1,** a hot exhaust gas flows through the first exhaust port **61** and the second exhaust port **62.** A portion of the cylinder head **4** between the first exhaust port **61** and the second exhaust port **62** is likely to be hot. However, the inter-port passage **31** is formed between the first exhaust port **61** and the second exhaust port **62.** The portion between the first exhaust port **61** and the second exhaust port **62** is sufficiently cooled by the coolant flowing through the inter-port passage **31.** Therefore, it is possible to effectively suppress the increase in temperature of the cylinder head **4.**

[0057] In the present embodiment, the middle passage **30** includes the extension passage **32** extending upward from the inter-port passage **31.** The coolant having flown through the inter-port passage **31** can continue to flow straight through the extension passage **32.** In the present embodiment, there is no wall that blocks the coolant having flown through the inter-port passage **31.** That is, in the water jacket **10A,** there is no wall that extends in the left-right direction in the vicinity of the cylinder axial line **CA.** Therefore, it is possible to smooth the coolant flow through the inter-port passage **31,** and to increase the flow rate of the coolant through the inter-port passage **31.** Thus, it is possible to effectively cool the portion of the cylinder head 4 between the first exhaust port **61** and the second exhaust port **62.**

[0058] The coolant having flown through the first right passage **21** flows through the second right passage **22** and then merges with the coolant in the middle passage **30.** After merging, the coolant flows through the third right passage **23** and the fourth right passage **24.** The coolant having flown through the first left passage **41** flows through the second left passage **42,** the third left passage **43** and the fourth left passage **44** in this order. Then, the coolant in the fourth right passage **24** and the coolant in the fourth left passage **44** merge together in the exit passage **14** and flow out through the exit opening **12.**

[0059] As described above, with the engine **1** according to the present embodiment, since the plug hole **55** is inclined from the cylinder axial line **CA** (see FIG. **6**), the area of the cylinder head **4** between the first exhaust port **61** and the second exhaust port **62** can be made large. Therefore, it is possible to ensure a sufficient size of the inter-port passage **31** (see FIG. **4**). The plug hole **55** is provided between the first intake port **51** and the first exhaust port **61** (see FIG. **8**). Therefore, it is possible to ensure a sufficient area where a passage can be formed between the first intake port **51** and the second intake port **52.** The extension passage **32** extending from the inter-port passage **31** is provided in this area (see FIG. **4** and FIG. **9**). Thus, the coolant having flown through the inter-port passage **31** can continue to flow straight through the extension passage **32.** The coolant is not blocked immediately after flowing out of the inter-port passage **31.** Therefore, it is possible to smooth the coolant flow through the inter-port passage **31.** According to the present embodiment, it is possible to effectively cool the portion of the cylinder head **4** between the first exhaust port **61** and the second exhaust port **62.**

[0060] According to the present embodiment, the coolant having flown through the second right passage **22** flows into the third right passage **23** via the middle passage **30.** The second right passage **22** and the third right passage **23** are partitioned from each other in the up-

down direction in the portion that is leftward relative to the center **52C** of the second intake opening **52A** and the center **62C** of the second exhaust opening **62A.** Therefore, the coolant having flown through the second right passage **22** merges with the coolant flowing through the middle passage **30** after flowing to a point that is leftward relative to the center **62C** of the second exhaust opening **62A.** Thus, the coolant in the second right passage **22** and the coolant in the middle passage **30** can be merged together without significantly hindering the straight flow of the coolant through the inter-port passage **31** and the extension passage **32.** Therefore, it is possible to further smooth the coolant flow through the inter-port passage **31.** It is also possible to effectively cool the portion around the second exhaust port **62.**

[0061] Now, in the cylinder head **4,** the dimension between the first exhaust port **61** and the second exhaust port **62** is relatively small. According to the present embodiment, however, along the section shown in FIG. **10,** the ratio Ly/Lx of the dimension Ly of the inter-port passage 31 in a direction parallel to the cylinder axial line **CA** to the dimension Lx thereof in a direction perpendicular to the cylinder axial line **CA** is greater than 1. That is, along the section, the dimension Ly of the inter-port passage **31** in a direction parallel to the cylinder axial line **CA** is greater than the dimension Lx thereof in a direction perpendicular to the cylinder axial line **CA** (i.e., the dimension between the first exhaust port **61** and the second exhaust port **62**). Therefore, it is possible to ensure a sufficient passage cross-sectional area of the inter-port passage **31** despite the small dimension of the cylinder head **4** between the first exhaust port **61** and the second exhaust port **62.** Therefore, it is possible to effectively cool the portion of the cylinder head **4** between the first exhaust port **61** and the second exhaust port **62.**

[0062] On the section shown in FIG. **10** are the first right passage **21,** the inter-port passage **31** and the first left passage **41.** According to the present embodiment, the inter-port passage **31,** among these passages **21, 31** and **41,** has the largest ratio of the dimension in a direction parallel to the cylinder axial line **CA** to the dimension in a direction perpendicular to the cylinder axial line **CA.** Since the inter-port passage **31** is more vertically elongated as compared with the other passages **21** and **41,** it is possible to ensure a large passage cross-sectional area of the inter-port passage **31.** Therefore, it is possible to effectively cool the portion of the cylinder head **4** between the first exhaust port **61** and the second exhaust port **62.**

[0063] Along the section shown in FIG. **10,** the inter-port passage **31** has sides **31a** that are parallel to the cylinder axial line **CA.** Thus, it is possible to effectively cool the portion of the cylinder head **4** between the first exhaust port **61** and the second exhaust port **62.**

[0064] According to the present embodiment, as shown in FIG. **9,** the water jacket **10A** includes the first left passage **41,** the second left passage **42** and the third left passage **43.** Thus, it is possible to effectively cool the portion leftward of the first exhaust port **61.**

[0065] The second left passage **42** extends rightward and upward toward the third left passage **43,** and the third left passage **43** extends rightward and downward toward the second left passage **42.** Thus, it is possible to effectively cool the portion around the first exhaust port **61.**

[0066] Now, if the extension passage **32** is directly connected to the second left passage **42** or the third left passage **43,** there is formed a passage that extends in the left-right direction from the second right passage **22** or the third right passage **23** to the second left passage **42** or the third left passage **43.** Such a passage will be substantially orthogonal to the inter-port passage **31.** In that case, the coolant flow through the inter-port passage **31** is likely to be disturbed by the coolant flowing through this passage. As a result, it may be more difficult for the coolant to flow smoothly through the inter-port passage **31.** According to the present embodiment, however, the extension passage **32** is not directly connected to either the second left passage **42** or the third left passage **43.** Thus, it is possible to prevent the coolant flow through the inter-port passage **31** from being disturbed. Therefore, it is possible to effectively cool the portion of the cylinder head **4** between the first exhaust port **61** and the second exhaust port **62.**

[0067] In the present embodiment, the inlet opening **11** is provided rightward and downward relative to the second exhaust opening **62A.** The coolant flowing in through the inlet opening **11** tends to flow leftward and upward. According to the present embodiment, the first left passage **41** includes the diameter-constricted portion **46** that constricts the coolant flow. Therefore, the coolant is prevented from excessively flowing into the first left passage **41.** Therefore, a sufficient amount of the coolant flows into the inter-port passage **31.** It is possible to effectively cool the portion of the cylinder head **4** between the first exhaust port **61** and the second exhaust port **62.**

[0068] Now, as shown in FIG. **6,** since the plug hole **55** is inclined relative to the cylinder axial line **CA,** it is possible to ensure a sufficient space for arranging the camshaft **57** that crosses the cylinder axial line **CA** and extends in the left-right direction without increasing the size of the cylinder head **4.** Therefore, according to the present embodiment, it is possible to reduce the size of the cylinder head **4.**

[0069] Although there is no particular limitation on the method for manufacturing the cylinder head **4,** it is cast in the present embodiment. The cylinder head **4** is a cast product. Therefore, it is possible to relatively easily form the water jacket **10A** configured as described above.

[0070] While one embodiment of the present invention has been described above, the present invention is not limited to the embodiment described above but can be embodied in various other embodiments.

[0071] As viewed along the cylinder axial line **CA** so that the center **51C** of the first intake opening **51A** is located leftward and upward of the cylinder axial line **CA,**

the inlet opening **11** does not need to be arranged rightward and downward of the center **62C** of the second exhaust opening **62A,** and the exit opening **12** does not need to be arranged leftward and upward of the center **51C** of the first intake opening **51A.**

[0072] The second right passage **22** and the third right passage **23** may be not partitioned from each other in the up-down direction in the portion that is leftward relative to the center **52C** of the second intake opening **52A** and the center **62C** of the second exhaust opening **62A.** The second right passage **22** and the third right passage **23** may be connected to the middle passage **30** at a position that is rightward relative to the center **52C** of the second intake opening **52A** and the center **62C** of the second exhaust opening **62A.**

[0073] Along a predetermined section (see FIG. **10**) that is parallel to a straight line that connects together the center **61C** of the first exhaust opening **61A** and the center **62C** of the second exhaust opening **62A** and is parallel to the cylinder axial line **CA,** the shape of the inter-port passage **31** is not limited to a rectangular shape. There is no particular limitation on the cross-sectional shape of the inter-port passage **31.**

[0074] In the embodiment described above, as shown in FIG. **9,** the second left passage **42** extends rightward and upward toward the third left passage **43,** and the third left passage **43** extends rightward and downward toward the second left passage **42.** However, the second left passage **42** does not need to extend rightward toward the third left passage **43.** The third left passage **43** does not need to extend rightward toward the second left passage **42.**

[0075] In the embodiment described above, the first left passage **41** includes the diameter-constricted portion **46** that constricts the coolant flow. However, the diameter-constricted portion **46** does not need to be provided in the first left passage **41.** The diameter-constricted portion **46** may be provided in the second left passage **42,** the third left passage **43** or the fourth left passage **44.** The diameter-constricted portion **46** may be absent in any part of the left passages **40.** The diameter-constricted portion **46** may be provided in a part of one or both of the right passage **20** and the middle passage **30.**

[0076] The inlet opening **11** for guiding the coolant from the outside of the engine **1** may be formed on the cylinder body **3.** The exit opening **12** for guiding the coolant to the outside of the engine **1** may be formed on the cylinder body **3.**

[0077] In the embodiment described above, the cylinder head **4** is provided with one camshaft **57** that crosses the cylinder axial line **CA** (see FIG. **4**)**.** The engine **1** is an SOHC (Single OverHead Camshaft)-type internal combustion engine. However, the present invention is not limited to this. The cylinder head **4** may be provided with an intake camshaft that is arranged upward of the intake valves **53** and **54,** and an exhaust camshaft that is arranged upward of the exhaust valves **63** and **64.** The engine **1** may be a DOHC (Double OverHead Camshaft)-type internal combustion engine.

REFERENCE SIGNS LIST

[0078]

1: Internal combustion engine
3: Cylinder body
4: Cylinder head
6: Cylinder
8: Combustion chamber
10A: Water jacket of cylinder head
11: Inlet opening
12: Exit opening
21: First right passage
22: Second right passage
23: Third right passage
30: Middle passage
31: Inter-port passage
32: Extension passage
41: First left passage
42: Second left passage
43: Third left passage
46: Diameter-constricted portion
50: Ignition plug
51: First intake port
51A: First intake opening
52: Second intake port
52A: Second intake opening
55: Plug hole
55A: Ignition opening
55C: Axial line of plug hole
57: Camshaft
57C: Axial line of camshaft
61: First exhaust port
61A: First exhaust opening
62: Second exhaust port
62A: Second exhaust opening
CA: Cylinder axial line
100: Motorcycle (straddled vehicle)

Claims

1. An internal combustion engine **(1)** comprising:

a cylinder body **(3)** includes a cylinder **(6)** formed therein that extends along a cylinder axial line **(CA)** and defines a portion of a combustion chamber **(8);**
a cylinder head **(4)** secured on the cylinder body **(3);**
a first intake port **(51)** formed on the cylinder head **(4)** and including a first intake opening **(51A)** facing toward the combustion chamber **(8),** wherein an intake air to be taken into the combustion chamber **(8)** flows through the first intake port **(51);**

a second intake port **(52)** formed on the cylinder head **(4)** and including a second intake opening **(52A)** facing toward the combustion chamber **(8),** wherein an intake air to be taken into the combustion chamber **(8)** flows through the second intake port **(52);**
a first exhaust port **(61)** formed on the cylinder head **(4)** and including a first exhaust opening **(61A)** facing toward the combustion chamber **(8),** wherein an exhaust air to be exhausted from the combustion chamber **(8)** flows through the first exhaust port **(61);**
a second exhaust port **(62)** formed on the cylinder head **(4)** and including a second exhaust opening **(62A)** facing toward the combustion chamber **(8),** wherein an exhaust air to be exhausted from the combustion chamber **(8)** flows through the second exhaust port **(62);**
a plug hole **(55)** formed on the cylinder head **(4)** and including an ignition opening **(55A)** facing toward the combustion chamber **(8),** wherein an ignition plug **(50)** is accommodated in the plug hole **(55);** and
a water jacket **(10A)** formed on the cylinder head **(4),** wherein a coolant flows through the water jacket **(10A),**
wherein as viewed along the cylinder axial line **(CA)** so that a center **(51C)** of the first intake opening **(51A)** is located leftward and upward of the cylinder axial line **(CA):**

a center **(52C)** of the second intake opening **(52A)** is located rightward and upward of the cylinder axial line **(CA),** a center **(61C)** of the first exhaust opening **(61A)** is located leftward and downward of the cylinder axial line **(CA),** and a center **(62C)** of the second exhaust opening **(62A)** is located rightward and downward of the cylinder axial line **(CA);**
an axial line **(55C)** of the plug hole **(55)** is inclined relative to the cylinder axial line **(CA)** so as to diverge leftward of the cylinder axial line **(CA)** while extending away from the ignition opening **(55A)** along the cylinder axial line **(CA);**
the plug hole **(55)** is located between the first intake port **(51)** and the first exhaust port **(61);**
the water jacket **(10A)** includes a middle passage **(30),** wherein the middle passage **(30)** includes an inter-port passage **(31)** that is located between the first exhaust port **(61)** and the second exhaust port **(62)** and downward of the cylinder axial line **(CA),** and an extension passage **(32)** that extends upward from the inter-port passage **(31)** to a position that is upward of the cylinder axial line **(CA).**

2. The internal combustion engine **(1)** according to claim 1, wherein as viewed along the cylinder axial line **(CA)** so that the center **(51C)** of the first intake opening **(51A)** is located leftward and upward of the cylinder axial line **(CA):**

the water jacket **(10A)** includes a first right passage **(21)** that is located rightward and downward relative to a center **(62D)** of the second exhaust port **(62),** a second right passage **(22)** that is located upward relative to the center **(62D)** of the second exhaust port **(62)** and is connected to the first right passage **(21)** and the middle passage **(30),** and a third right passage **(23)** that is located upward relative to the second right passage **(22)** and downward relative to a center **(52D)** of the second intake port **(52)** and is connected to the middle passage **(30);** and
the second right passage **(22)** and the third right passage **(23)** are partitioned from each other in an up-down direction in a portion that is leftward relative to the center **(52C)** of the second intake opening **(52A)** and the center **(62C)** of the second exhaust opening **(62A).**

3. The internal combustion engine **(1)** according to claim 1 or 2, wherein along a predetermined section **(X-X)** that is parallel to a straight line that connects together the center **(61C)** of the first exhaust opening **(61A)** and the center **(62C)** of the second exhaust opening **(62A)** and is parallel to the cylinder axial line **(CA),** a ratio of a dimension **(Ly)** of the inter-port passage **(31)** in a direction **(Y)** that is parallel to the cylinder axial line **(CA)** to a dimension **(Lx)** thereof in a direction **(X)** that is perpendicular to the cylinder axial line **(CA)** is greater than 1.

4. The internal combustion engine **(1)** according to claim 3, wherein along the predetermined section **(X-X),** the inter-port passage **(31)** has a side **(31a)** that is parallel to the cylinder axial line **(CA).**

5. The internal combustion engine **(1)** according to any one of claims 1 to 4, wherein as viewed along the cylinder axial line **(CA)** so that the center **(51C)** of the first intake opening **(51A)** is located leftward and upward of the cylinder axial line **(CA):**
the water jacket **(10A)** includes a first left passage **(41)** that is located downward relative to a center **(61D)** of the first exhaust port **(61),** a second left passage **(42)** that is located leftward and upward relative to the center **(61D)** of the first exhaust port **(61)** and is connected to the first left passage **(41),** and a third left passage **(43)** that is located leftward and downward relative to a center **(51D)** of the first intake port **(51)** and is connected to the second left passage

(42).

6. The internal combustion engine **(1)** according to claim 5, wherein the extension passage **(32)** and the second left passage **(42)** are not directly connected to each other, and the extension passage **(32)** and the third left passage **(43)** are not directly connected to each other.

7. The internal combustion engine **(1)** according to claim 5 or 6, wherein as viewed along the cylinder axial line **(CA)** so that the center **(51C)** of the first intake opening **(51A)** is located leftward and upward of the cylinder axial line **(CA):**

the second left passage **(42)** extends rightward and upward toward the third left passage **(43);** and
the third left passage **(43)** extends rightward and downward toward the second left passage **(42).**

8. The internal combustion engine **(1)** according to any one of claims 5 to 7, wherein along a predetermined section **(X-X)** that is parallel to a straight line that connects together the center **(61C)** of the first exhaust opening **(61A)** and the center **(62C)** of the second exhaust opening **(62A)** and is parallel to the cylinder axial line **(CA),** a ratio of a dimension **(Ly;LRy;LLy)** in a direction **(Y)** that is parallel to the cylinder axial line **(CA)** to a dimension **(Lx;LRx;LLy)** in a direction **(X)** that is perpendicular to the cylinder axial line **(CA)** is greater for the inter-port passage **(31)** than for the first right passage **(21)** and for the first left passage **(41).**

9. The internal combustion engine **(1)** according to any one of claims 5 to 8, wherein as viewed along the cylinder axial line **(CA)** so that the center **(51C)** of the first intake opening **(51A)** is located leftward and upward of the cylinder axial line **(CA):**

the water jacket **(10A)** includes an inlet opening **(11)** that is located rightward and downward relative to the second exhaust opening **(62A),** wherein the coolant flows in through the inlet opening **(11);** and
the first left passage **(41)** includes a diameter-constricted portion **(46)** that constricts the coolant flow.

10. The internal combustion engine according to any one of claims 1 to 8, wherein as viewed along the cylinder axial line **(CA)** so that the center **(51C)** of the first intake opening (51A) is located leftward and upward of the cylinder axial line **(CA):**
the water jacket **(10A)** includes an inlet opening **(11)** that is located rightward and downward relative to the second exhaust opening **(62A),** wherein the coolant flows in through the inlet opening **(11).**

11. The internal combustion engine **(1)** according to any one of claims 1 to 8, wherein:

the internal combustion engine **(1)** includes an inlet opening **(11)** for guiding the coolant from an outside of the internal combustion engine **(1)** to an inside of the internal combustion engine **(1);** and
the inlet opening **(11)** is formed on the cylinder head **(4).**

12. The internal combustion engine **(1)** according to any one of claims 1 to 8, wherein:

the internal combustion engine **(1)** includes an inlet opening **(11)** for guiding the coolant from an outside of the internal combustion engine **(1)** to an inside of the internal combustion engine **(1)** and an exit opening **(12)** for guiding the coolant to the outside of the internal combustion engine **(1);** and
the inlet opening **(11)** and the exit opening **(12)** are formed on the cylinder head **(4).**

13. The internal combustion engine **(1)** according to any one of claims 1 to 12, wherein:

the internal combustion engine **(1)** includes a camshaft **(57)** that is rotatably supported on the cylinder head **(4)** and crosses the cylinder axial line **(CA);** and
an axial line **(57C)** of the camshaft **(57)** is located between the center **(51C)** of the first intake opening **(51A)** and the center **(61C)** of the first exhaust opening **(61A)** and is located between the center **(52C)** of the second intake opening **(52A)** and the center **(62C)** of the second exhaust opening **(62A).**

14. The internal combustion engine **(1)** according to any one of claims 1 to 13, wherein the cylinder head **(4)** is a cast product.

15. A straddled vehicle **(100)** comprising the internal combustion engine **(1)** according to any one of claims 1 to 14.

FIG. 1

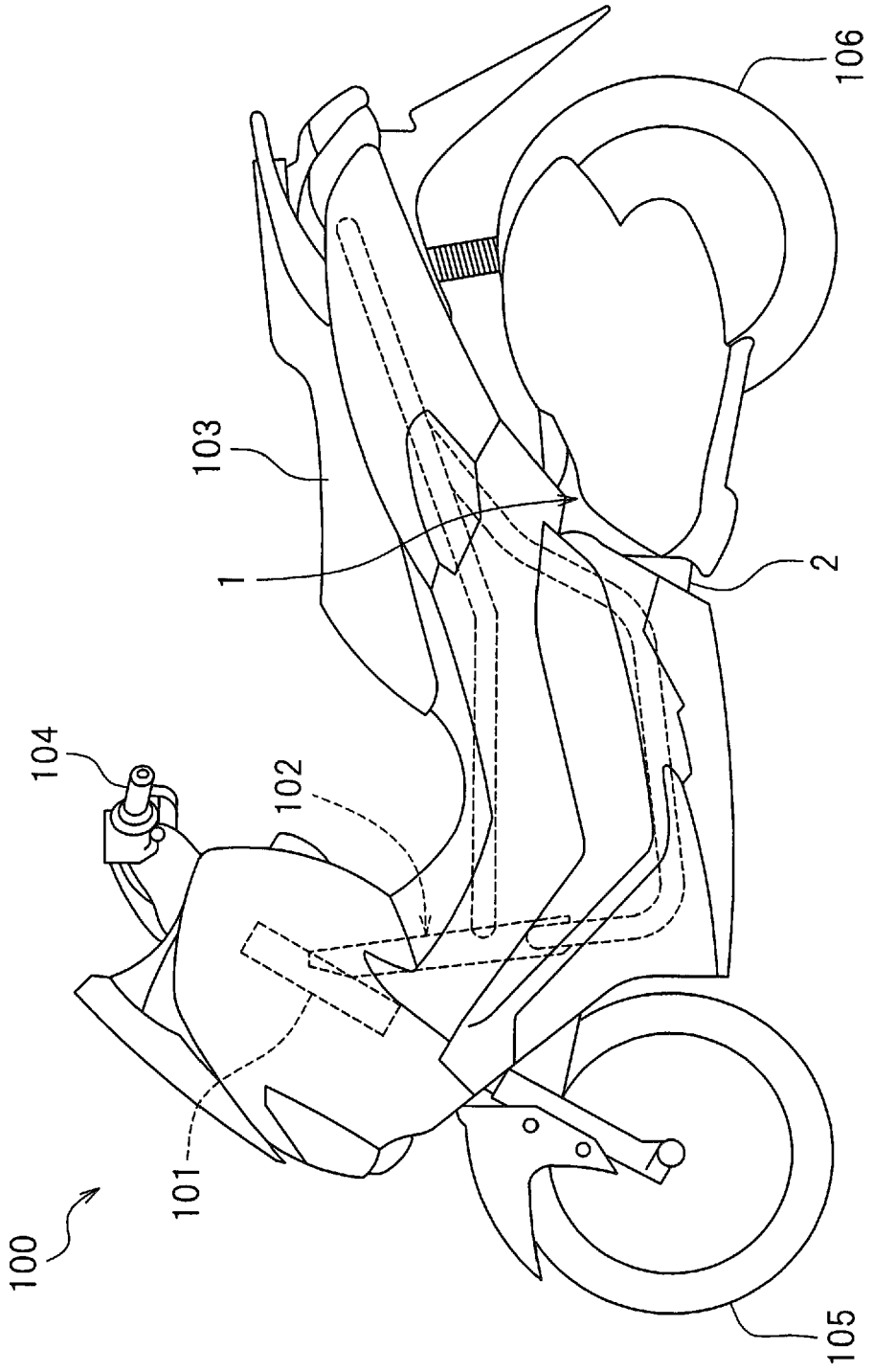


FIG.2

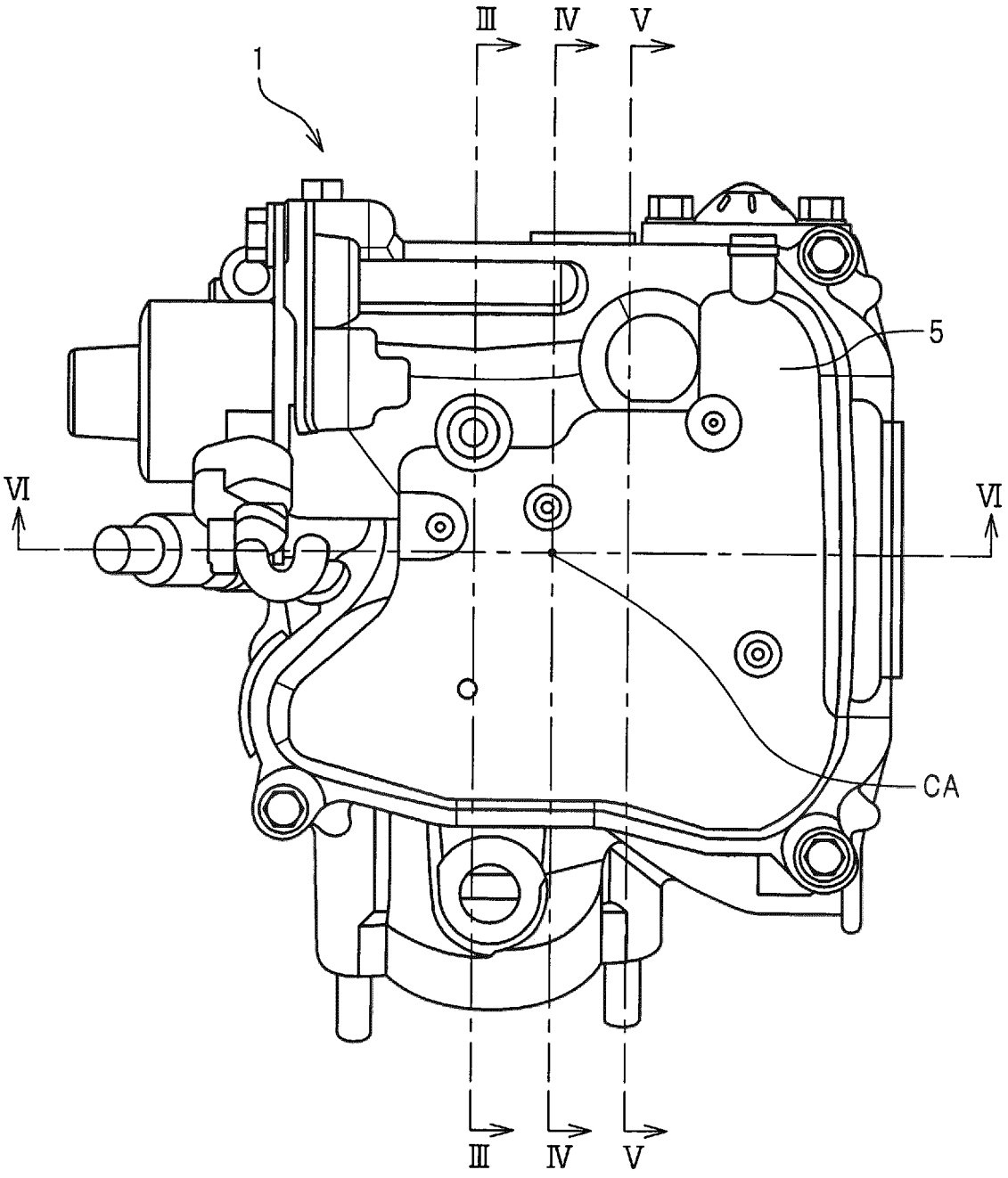


FIG.3

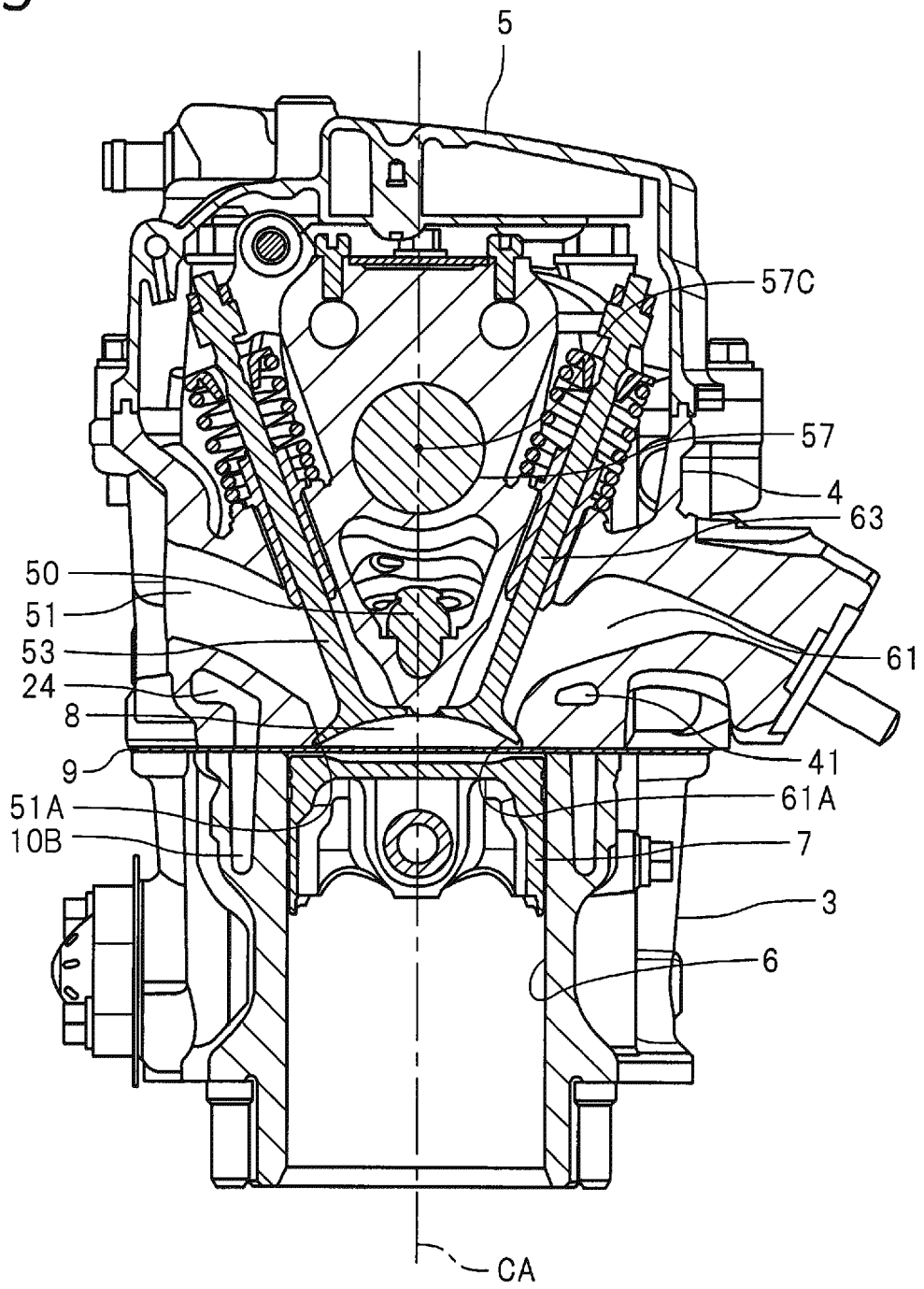


FIG.4

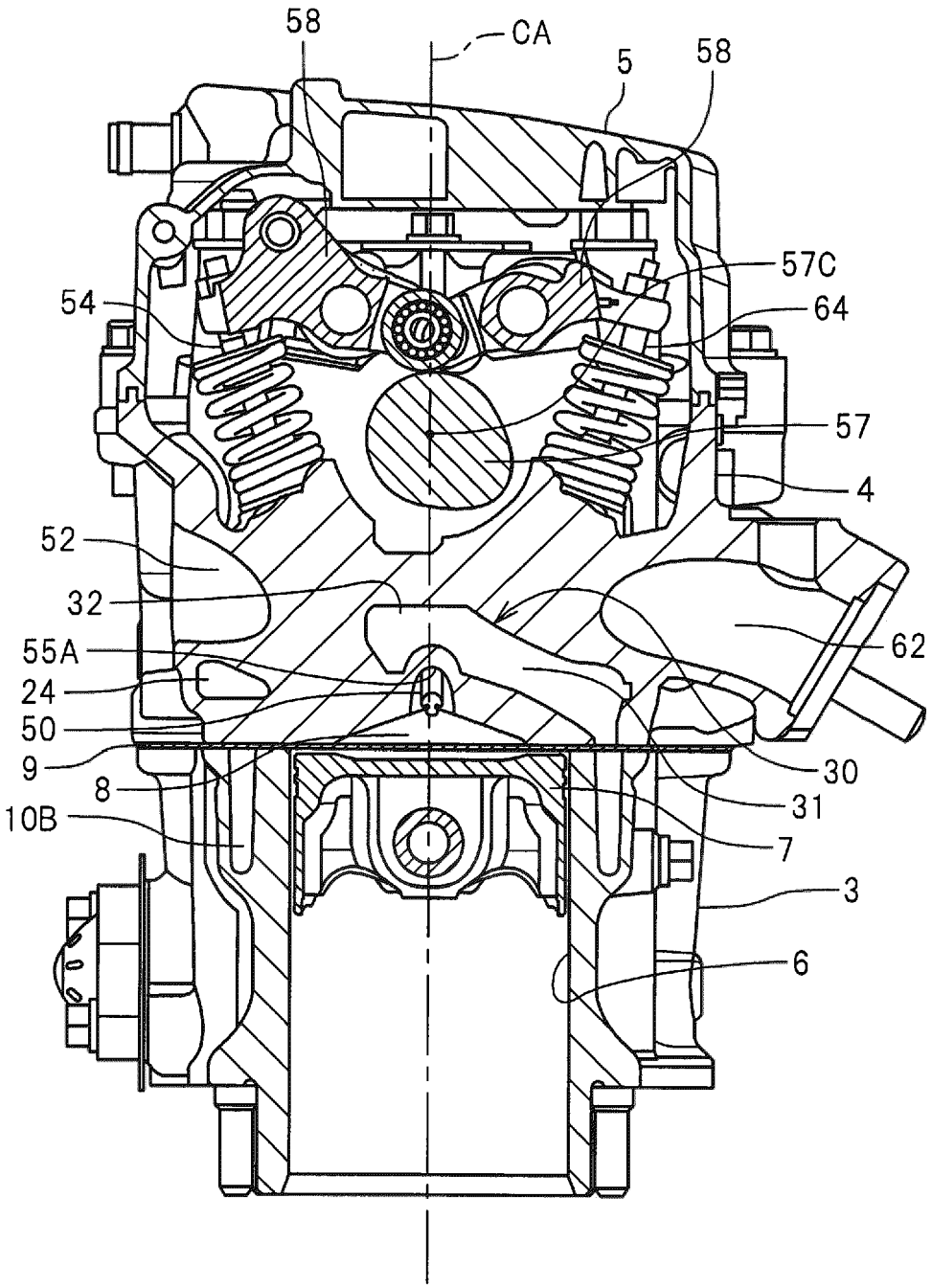


FIG.5

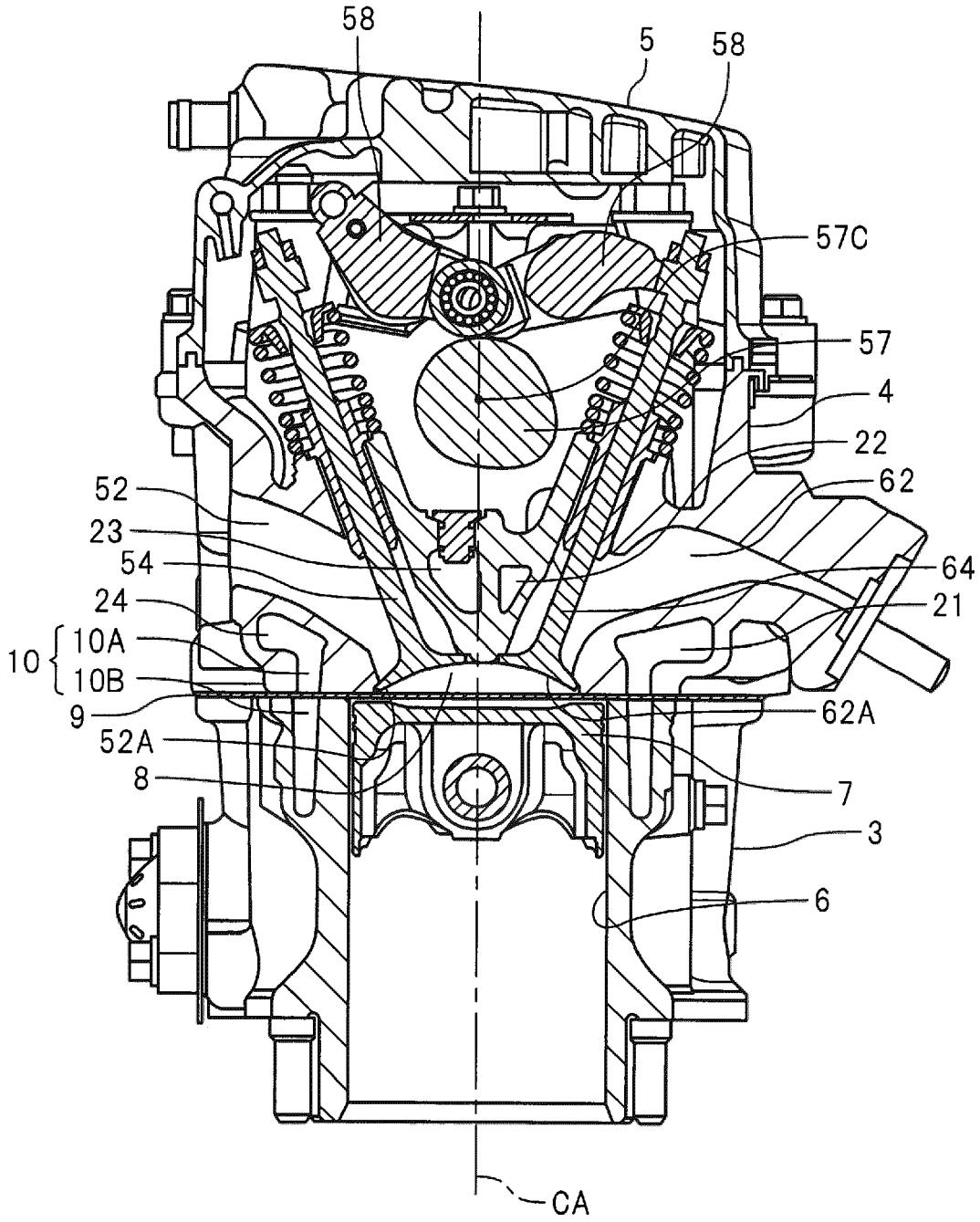


FIG.6

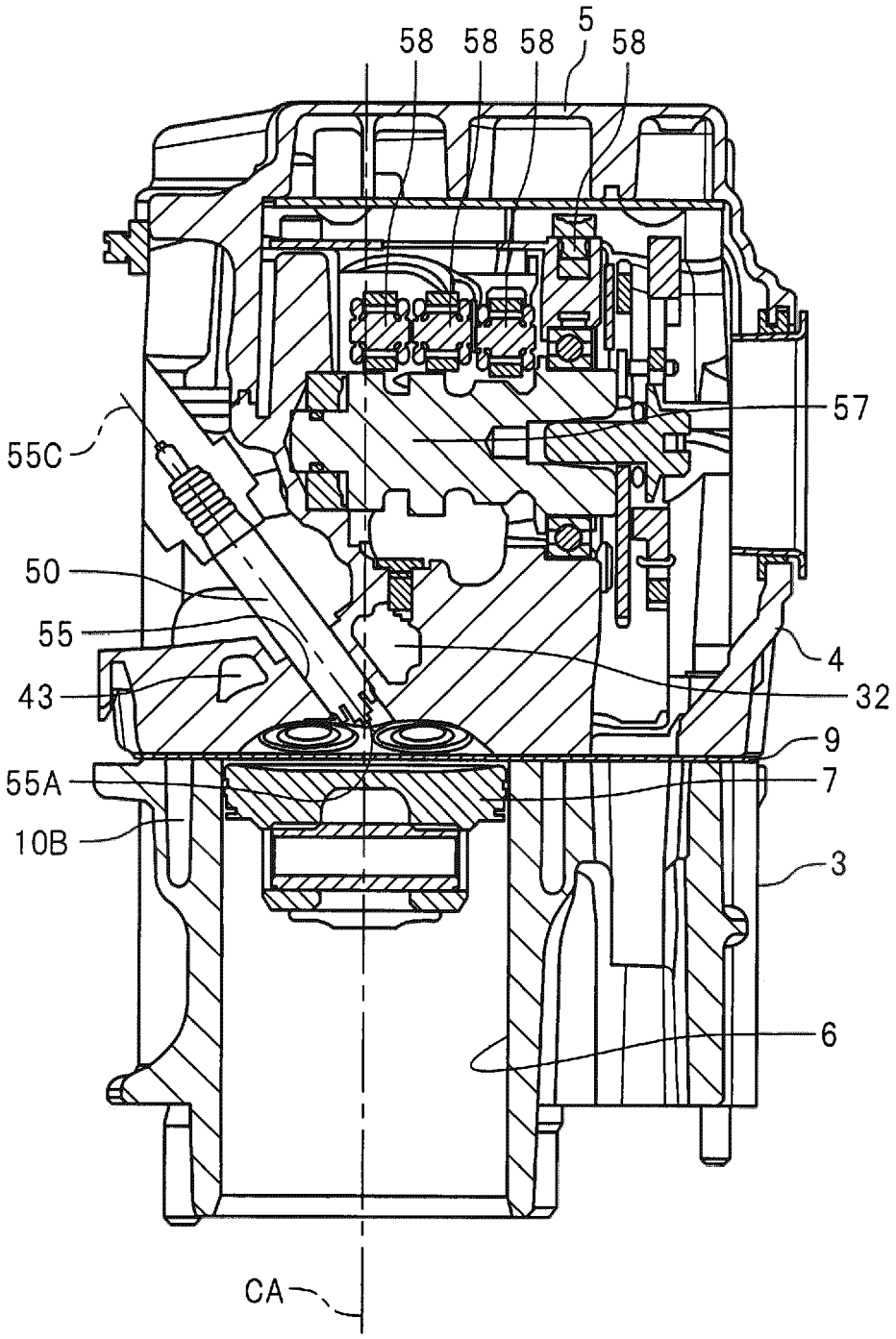


FIG.7

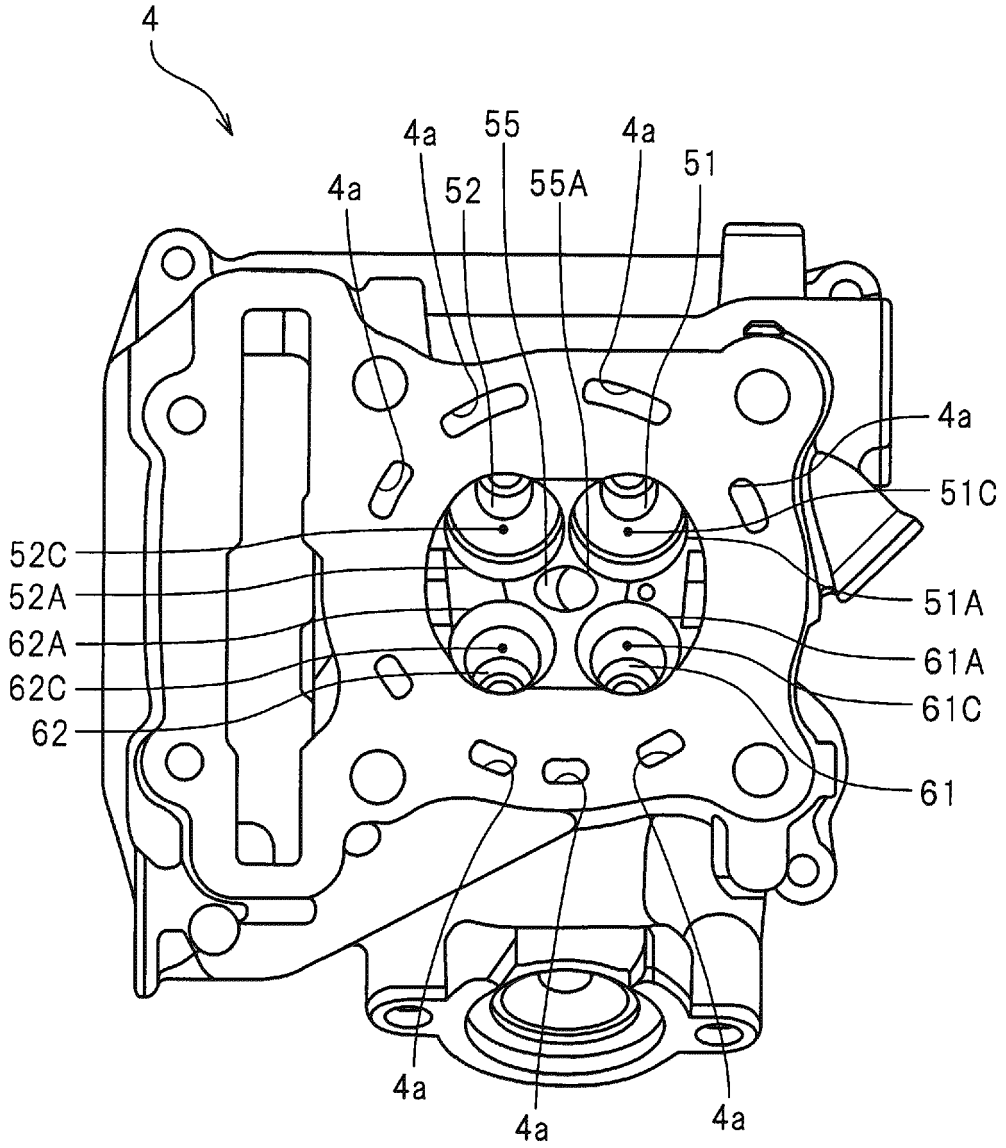

4
4a
55
4a
51
4a
52
55A
4a
51C
52C
52A
51A
62A
61A
62C
61C
62
61
4a
4a
4a

FIG.8

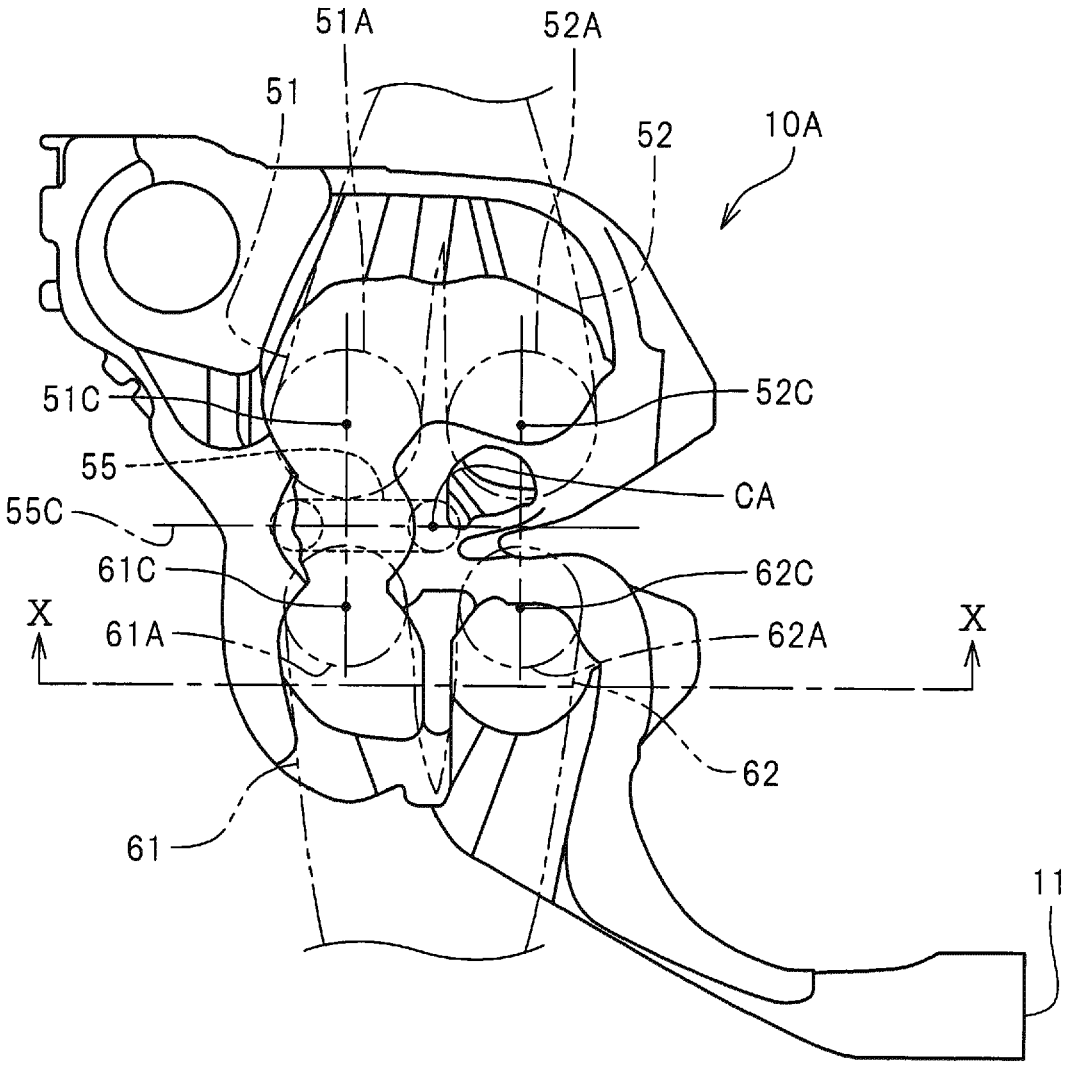


FIG.9

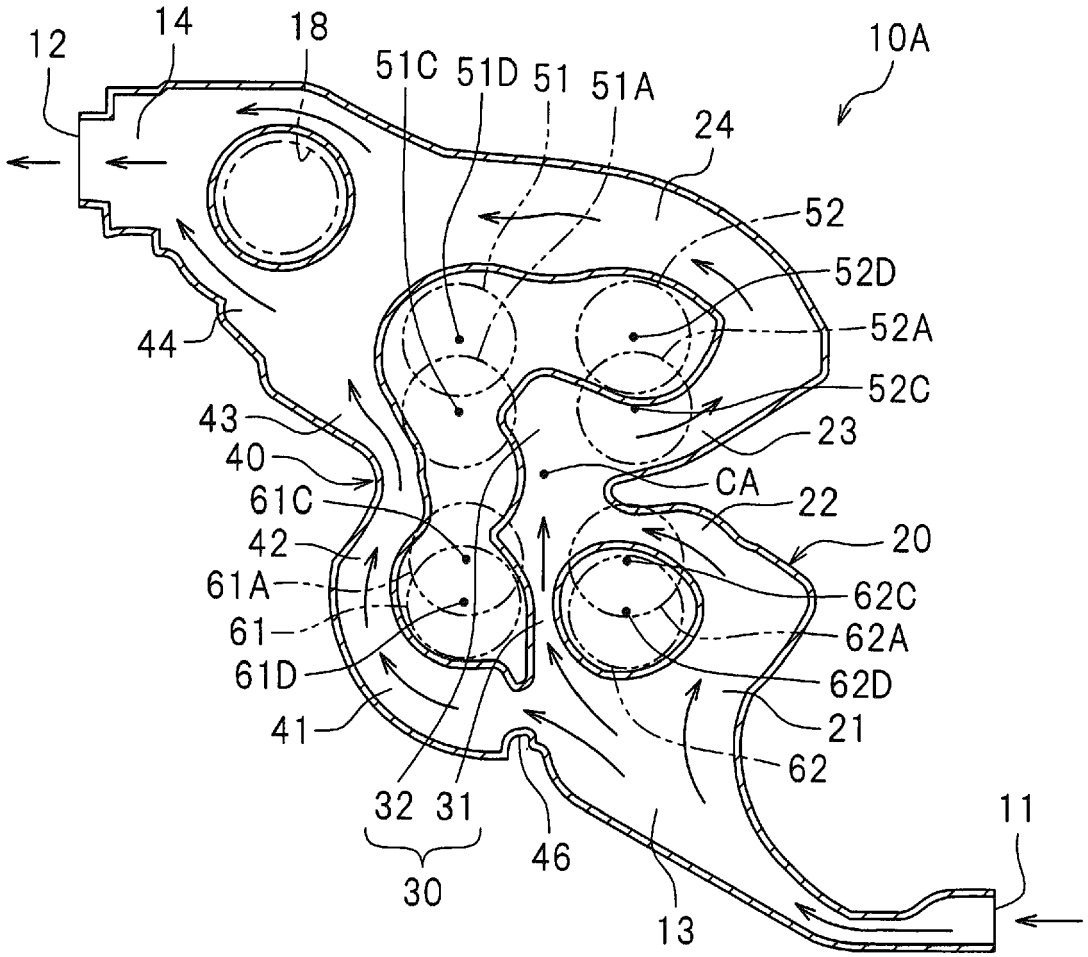
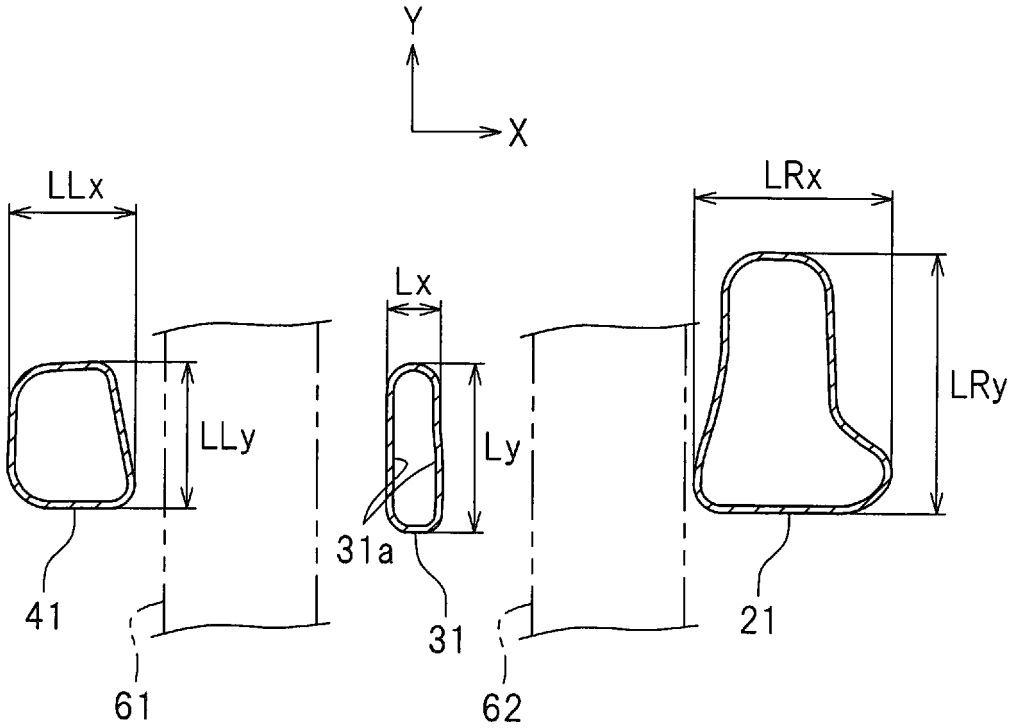

12
14
18
51C
51D
51
51A
10A
24
52
52D
52A
52C
23
CA
22
20
62C
62A
62D
21
62
11
13
46
32
31
30
41
61D
61
61A
42
61C
40
43
44

FIG.10



Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 19 21 5976

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	DE 10 2016 218707 A1 (BAYERISCHE MOTOREN WERKE AG [DE]) 29 March 2018 (2018-03-29) * figures * -----	1,2,9,14 10-13,15	INV. F02F1/24 F02F1/40
X Y	FR 2 882 791 A1 (RENAULT SAS [FR]) 8 September 2006 (2006-09-08) * figures * -----	1,3-8,14 10-13,15	
X	JP 2005 090297 A (HINO MOTORS LTD) 7 April 2005 (2005-04-07) * figures * -----	1,5,7	
Y	EP 3 361 065 A1 (YAMAHA MOTOR CO LTD [JP]) 15 August 2018 (2018-08-15) * figures * -----	10-13,15	

TECHNICAL FIELDS SEARCHED (IPC)
F02F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	11 May 2020	Matray, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 19 21 5976

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

11-05-2020

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102016218707 A1	29-03-2018	NONE	
FR 2882791 A1	08-09-2006	NONE	
JP 2005090297 A	07-04-2005	NONE	
EP 3361065 A1	15-08-2018	BR 102018002598 A2	30-10-2018
		EP 3361065 A1	15-08-2018
		JP 2018131921 A	23-08-2018
		TW 201833429 A	16-09-2018

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2015010598 A **[0003] [0004]**
- JP 2018155215 A **[0004] [0005]**