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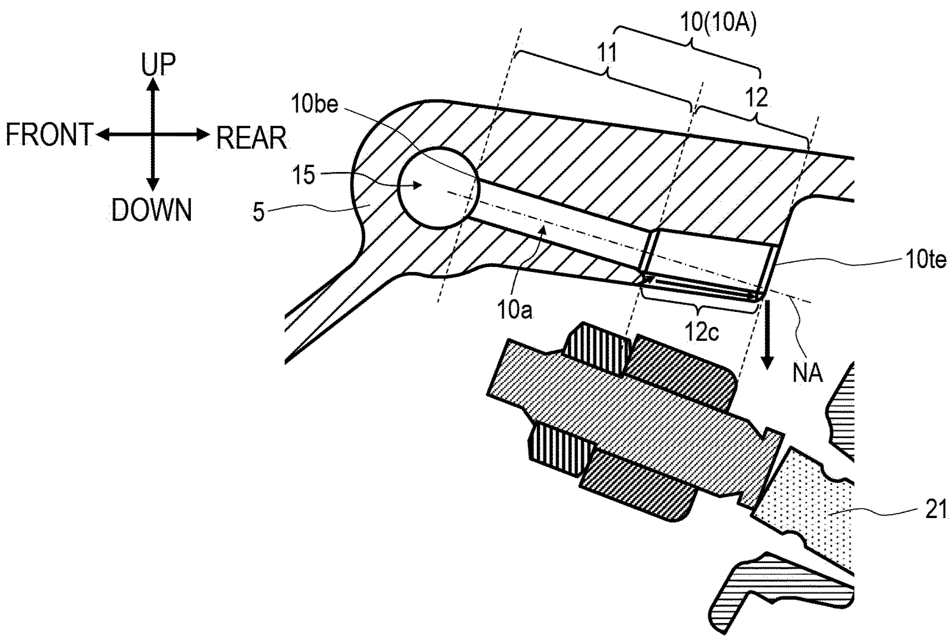
(54) **INTERNAL COMBUSTION ENGINE AND STRADDLED VEHICLE**

(57) There is disclosed an internal combustion engine (1) including a cylinder body **(3);** a cylinder head **(4)** connected with the cylinder body; a cylinder head cover (5) connected with the cylinder head; and a valvetrain provided in the cylinder head and the cylinder head cover; the internal combustion engine further including a nozzle **(10)** provided in the cylinder head cover and located so as to allow oil to be supplied to the valvetrain; the nozzle including a first nozzle portion **(11)** extending from a base end **(10be)** of the nozzle toward a tip end **(10te)** of the nozzle (10), and a second nozzle portion **(12)** extending from a tip end of the first nozzle portion (11) to the tip end of the nozzle (10) and having a cutout portion **(12c),** facing the valvetrain, formed as a result of the second nozzle portion (12) being partially cut out in the circumferential direction.

FIG.12



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Description

Technical Field

[0001] The present invention relates to an internal combustion engine and a straddled vehicle.

Prior art

[0002] A straddled vehicle such as a motorcycle or the like may have an internal combustion engine (engine) mounted thereon such that a cylinder is inclined forward significantly. For example, Japanese Laid-Open Patent Publication No. Hei 4-81525 discloses a scooter-type motorcycle including an engine mounted on a swing unit such that a cylinder is inclined forward significantly.

[0003] In the motorcycle disclosed in Japanese Laid-Open Patent Publication No. Hei 4-81525, a valvetrain chamber in a cylinder head is supplied with oil from an oil pipe extending forward in an area below a cylinder body and connected with a center of a top portion of the cylinder head. In the case where the oil is supplied to the valvetrain chamber in this manner, the oil is sufficiently supplied to a bottom portion of the valvetrain but is not sufficiently supplied to a top portion of the valvetrain.

[0004] Under such circumstances, it is conceivable to provide a nozzle above the valvetrain and to supply oil to the valvetrain via the nozzle. Japanese Laid-Open Patent Publication No. 2020-105969 shows a structure in which oil is supplied to the valvetrain via a nozzle provided inside a cylinder head cover.

[0005] However, regarding the structure in which the oil is supplied to the valvetrain via the nozzle provided in the cylinder head cover, it has been found out by the studies made by the present inventors that the following occurs in a state where the engine has a low temperature (that is, the oil also has a low temperature) and furthermore, the engine is rotated at a low rotation rate and the oil is injected in a small amount (e.g., in an idling state after cold start). The oil has a high viscosity, and therefore, the oil cannot be injected vigorously from a tip of the nozzle, and the oil may possibly not be supplied to a desired position in the valvetrain.

Description of the invention

[0006] An embodiment of the present invention made in light of the above-described problem has an object of providing an internal combustion engine capable of supplying oil in a preferred manner to a desired position in a valvetrain in a cylinder head even in a state where the oil has a relatively high viscosity.

[0007] This specification discloses an internal combustion engine and a straddled vehicle described in the following claims.

[Claim 1]

[0008] An internal combustion engine, comprising:

a cylinder body;
a cylinder head connected with the cylinder body;
a cylinder head cover connected with the cylinder head; and
a valvetrain provided in the cylinder head and the cylinder head cover,
wherein the internal combustion engine further includes a nozzle provided in the cylinder head cover and located so as to allow oil to be supplied to the valvetrain, and
wherein the nozzle includes a first nozzle portion extending from a base end of the nozzle toward a tip end of the nozzle, and a second nozzle portion extending from a tip end of the first nozzle portion to the tip end of the nozzle and having a cutout portion, facing the valvetrain, formed as a result of the second nozzle portion being partially cut out in the circumferential direction.

[0009] The internal combustion engine according to an embodiment of the present invention includes the nozzle provided in the cylinder head cover and located so as to allow oil to be supplied to the valvetrain. The nozzle includes the first nozzle portion extending from the base end of the nozzle toward the tip end of the nozzle, and the second nozzle portion extending from the tip end of the first nozzle portion to the tip end of the nozzle and having the cutout portion, facing the valvetrain, formed as a result of the second nozzle portion being partially cut out in the circumferential direction. In the internal combustion engine according to an embodiment of the present invention, when the oil has a relatively high viscosity and the engine is rotated at a relatively low rotation rate, the oil flows along a portion of the second nozzle portion that is not cut out and flows down from the tip end of the nozzle. The second nozzle portion has the cutout portion, facing the valvetrain, formed therein. Therefore, the oil having a high viscosity is guided to a desired position in the valvetrain without the nozzle interfering with a movable component of the valvetrain.

[Claim 2]

[0010] The internal combustion engine of Claim 1, wherein the cutout portion is formed to occupy a range of 70 degrees or larger in the circumferential direction at the tip end of the nozzle.

[0011] From the point of view of avoiding the interference between the movable component of the valvetrain and the nozzle, it is preferred that the cutout portion of the second nozzle portion is formed to occupy a range of 70 degrees or larger in the circumferential direction at the tip end of the nozzle.

[Claim 3]

[0012] The internal combustion engine of Claim 1 or 2, wherein the cutout portion is formed to occupy a range smaller than 180 degrees in the circumferential direction at the tip end of the nozzle.

[0013] From the point of view of allowing the oil to flow down from the tip end of the nozzle in a preferred manner, it is preferred that the cutout portion of the second nozzle portion is formed to occupy a range smaller than 180 degrees in the circumferential direction at the tip end of the nozzle.

[Claim 4]

[0014] The internal combustion engine of any one of Claims 1 to 3, wherein the cutout portion is formed to occupy a range, in the circumferential direction, enlarging from a base end toward a tip end of the second nozzle portion.

[0015] The cutout portion of the second nozzle portion may be formed to occupy a range, in the circumferential direction, enlarging from the base end toward the tip end of the second nozzle portion.

[Claim 5]

[0016] The internal combustion engine of any one of Claims 1 to 4, wherein the second nozzle portion has an inner circumferential surface of a tapering shape such that an inner diameter of the second nozzle portion increases from a base end toward a tip end of the second nozzle portion.

[0017] In the case where the inner circumferential surface of the second nozzle portion has a tapering shape such that the inner diameter of the second nozzle portion increases from the base end toward the tip end of the second nozzle portion, the oil is supplied in a more preferred manner when the oil is injected in a large amount (e.g., in a maximum amount).

{Claim 6]

[0018] A straddled vehicle, comprising the internal combustion engine of any one of Claims 1 to 5.

[Claim 7]

[0019] The straddled vehicle of Claim 6, wherein the nozzle is located above the valvetrain in a vertical direction.

[0020] An embodiment of the present invention provides an internal combustion engine capable of supplying oil in a preferred manner to a desired position in a valvetrain in a cylinder head even in a state where the oil has a relatively high viscosity.

Brief description of the drawings

[0021]

FIG. **1** is a left side view schematically showing a motorcycle **100** according to an embodiment of the present invention.

FIG. **2** is a side view of an engine **1** included in the motorcycle **100.**

FIG. **3** is a plan view of the engine **1.**

FIG. **4** is a cross-sectional view of the engine **1** taken along line **4A-4A'** in FIG. **3.**

FIG. **5** is a cross-sectional view of the engine **1** taken along line **5A-5A'** in FIG. **4.**

FIG. **6** is a cross-sectional view of the engine **1** taken along line **6A-6A'** in FIG. **4.**

FIG. **7** is a cross-sectional view of the engine **1** taken along line **7A-7A'** in FIG. **4.**

FIG. **8** is a cross-sectional view schematically showing a nozzle **10** (left nozzle **10A**) included in the engine **1,** and is an enlarged view of the nozzle **10** and the vicinity thereof in FIG. **4.**

FIG. **9** is a cross-sectional view schematically showing the nozzle **10** (left nozzle **10A**) included in the engine **1,** and is an enlarged view of the nozzle **10** and the vicinity thereof in FIG. **6.**

FIG. **10** is a rear view of the nozzle **10** (left nozzle **10A**).

FIG. **11** shows a structure in which a comparative example nozzle **910** is provided in a cylinder head cover **5.**

FIG. **12** shows how oil is supplied to an axial end of an intake valve **21** via the nozzle **10.**

Embodiments of the invention

[0022] Hereinafter, a straddled vehicle according to an embodiment of the present invention will be described with reference to the drawings. The straddled vehicle is a vehicle on which a rider rides while straddling. In the following description, a motorcycle will be described as an example of straddled vehicle according to an embodiment of the present invention. There is no limitation on the type of the motorcycle, and the motorcycle may be any vehicle of a so-called scooter type, a moped type, an off-road type, an on-road type or the like. The straddled vehicle according to an embodiment of the present invention is not limited to a motorcycle, and may be an ATV (All Terrain Vehicle), a quad bike or the like.

[0023] With reference to FIG. **1,** an overall structure of a motorcycle **100** according to this embodiment will be described. FIG. 1 is a left side view schematically showing the motorcycle **100.** In the following description, the terms "front", "rear", "left", "right", "up" and "down" respectively refer to front, rear, left, right, up and down as seen from a rider sitting on a seat of the motorcycle **100.** The terms "up" and "down" respectively refer to up and down in a vertical direction in a state where the motorcycle **100** is at a stop on a horizontal plane. The abovementioned directions will also be used to describe components of an engine. Therefore, the terms "front", "rear", "left", "right", "up" and "down" used regarding the engine respectively refer to front, rear, left, right, up and down of the engine mounted on the motorcycle **100.**

[0024] As shown in FIG. **1,** the motorcycle **100** includes a body frame **102** including a head pipe **101,** a seat **103** supported by the body frame **102,** an engine (internal combustion engine) **1** supported by the body frame **102,** a handle **104** pivotably supported by the head pipe **101,** a front wheel **105,** and a rear wheel **106** drivable by the engine **1.**

[0025] With reference to FIG. **2** through FIG. **7,** a structure of the engine **1** will be described. FIG. **2** and FIG. **3** are respectively a side view and a plan view of the engine **1.** FIG. **4** is a cross-sectional view taken along line **4A-4A'** in FIG. **3.** FIG. **5,** FIG. **6** and FIG. **7** are cross-sectional views respectively taken along lines **5A-5A', 6A-6A'** and **7A-7A'** in FIG. **4.** The terms "front", "rear", "left", "right", "up" and "down" shown in FIG. **2** through FIG. **7** refer to front, rear, left, right, up and down in a state where the engine **1** is mounted on the motorcycle **100.**

[0026] The engine **1** is a four-stroke, water-cooled engine. The engine **1** includes a crankcase **2** (only shown in FIG. **2**) accommodating a crankshaft (not shown), a cylinder body **3** connected with the crankcase **2,** a cylinder head **4** connected with the cylinder body **3,** a cylinder head cover **5** connected with the cylinder head **4,** and a valvetrain (including intake valves **21,** exhaust valves **22,** and the like described below) provided in the cylinder head **4** and the cylinder head cover **5.**

[0027] A transmission case **7** accommodating a transmission (e.g., a CVT (Continuously Variable Transmission)) is located to the left of the crankcase **2.**

[0028] A cylinder **6** is formed in the cylinder body **3.** The cylinder **6** extends along a cylinder axial line **CA.** The cylinder axial line **CA** is inclined forward significantly with respect to the vertical direction (up-down direction). That is, the cylinder **6** extends forward from the crankcase **2.** In this embodiment, the term "forward" is used in a broad sense, and the expression that "the cylinder **6** extends forward" encompasses a case where the cylinder **6** extends forward in a horizontal direction and a case where the cylinder **6** is inclined with respect to the horizontal direction. In this embodiment, the engine **1** is a single-cylinder engine including one cylinder **6.** Alternatively, the engine **1** may be a multicylinder engine including a plurality of cylinders.

[0029] The cylinder **6** accommodates a piston (not shown). The cylinder **6** demarcates a part of a combustion chamber **8.** The piston is coupled with the crankshaft via a conrod (not shown). The cylinder body **3** and the crankcase **2** may be formed separately from each other, or may be formed integrally with each other.

[0030] The cylinder head **4** is located to the front of the cylinder body **3,** and is connected with a front portion of the cylinder body **3.** The cylinder head **4** has two intake ports **31** and two exhaust ports **32** formed therein. The two intake ports **31** each have an intake opening **31A** opened toward the combustion chamber **8.** Air to be absorbed into the combustion chamber **8** flows through the intake ports **31.** The two exhaust ports **32** each have an exhaust opening **32A** opened toward the combustion chamber **8.** Air discharged from the combustion chamber **8** flows through the exhaust ports **32.**

[0031] In the cylinder head **4** and the cylinder body **3,** a water jacket **9,** in which cooling water flows, is formed. The water jacket **9** includes a portion **9A** formed in the cylinder head **4** and a portion **9B** formed in the cylinder body **3.**

[0032] The cylinder head cover **5** is located to the front of the cylinder head **4,** and is connected with a front portion of the cylinder head **4.** The cylinder head **4** and the cylinder head cover **5** may be formed separately from each other as shown in the figures, or may be formed integrally with each other.

[0033] The valvetrain of the engine **1** includes two intake valves **21,** two exhaust valves **22,** a cam shaft **23,** and two locker arms **24.**

[0034] The two intake valves **21** each open or close the corresponding intake opening **31A.** The two exhaust valves **22** each open or close the corresponding exhaust opening **32A.**

[0035] The cam shaft **23** is rotatably supported by the cylinder head **4.** The cam shaft **23** crosses the cylinder axial line **CA.** The cam shaft **23** is located in a cam chamber **34** and a cam chain chamber **35.** The cam chamber **34** is a space defined by the cylinder head **4** and the cylinder head cover **5.** The cam chain chamber **35** is a space defined by the crankcase **2,** the cylinder body **3,** the cylinder head **4** and the cylinder head cover **5.** In the example shown in the figures, the cam chain chamber **35** is located to the left of the cylinder **6.** The cam chain chamber **35** may be located to the right of the cylinder **6.** The cam chain chamber **35** and the cam chamber **34** are in communication with each other.

[0036] Each of the intake valves **21** and the corresponding exhaust valve **22** are in engagement with the cam shaft **23** via the corresponding locker arm **24.** The intake valve **21** and the exhaust valve **22** are opened or closed in accordance with a rotation of the cam shaft **23.** The number of the intake valve(s) **21** and the number of the exhaust valve(s) **22** are not limited to two as described as an example in this embodiment. For example, in the case where the number of the intake port(s) **31** is one and the number of the exhaust port(s) **32** is one, the number of the intake valve(s) **21** may also be one and the number of the exhaust valve(s) **22** may also be one.

[0037] The cam shaft **23** extends in a left-right direction. A driven sprocket (cam chain sprocket) **23S** is attached to a left end of the cam shaft **23.** The driven sprocket **23S** is located in the cam chain chamber **35,** and is rotatable integrally with the cam shaft **23.** A cam chain (not shown) is wound around the driven sprocket **23S** and a driving sprocket (not shown) attached to the crankshaft. The driving sprocket is located in the cam chain chamber **35,** and is rotatable integrally with the crankshaft. The cam chain is associated with the crankshaft and the cam shaft **23.**

[0038] The engine **1** further includes a plurality of (two in this embodiment) nozzles **10** provided in the cylinder head cover **5.** The nozzles **10** are located so as to allow oil to be supplied to the valvetrain. As shown in FIG. **4,** the nozzles **10** are located above the valvetrain in the vertical direction. Hereinafter, among the two nozzles **10,** a nozzle located to the left of the other nozzle may be referred to as a "left nozzle **10A",** and a nozzle located to the right of the other nozzle may be referred to as a "right nozzle **10B",** for the sake of convenience.

[0039] The left nozzle **10A** is located to the front of, and above, the left intake valve **21.** The position of the left nozzle **10A** in the left-right direction is substantially the same as the position of the left intake valve **21** in the left-right direction. The right nozzle **10B** is located to the front of, and above, the right intake valve **21.** The position of the right nozzle **10B** in the left-right direction is substantially the same as the position of the right intake valve **21** in the left-right direction.

[0040] With reference to FIG. **8,** FIG. **9** and FIG. **10,** a structure of the nozzle **10** will be described. FIG. **8** and FIG. **9** are each a cross-sectional view schematically showing the nozzle **10** (left nozzle **10A**). FIG. **8** is an enlarged view of the nozzle **10** and the vicinity thereof shown in FIG. **4.** FIG. **9** is an enlarged view of the nozzle **10** and the vicinity thereof shown in FIG. **6.** FIG. **10** is a rear view of the nozzle **10** (left nozzle **10A**).

[0041] The nozzle **10** includes a first nozzle portion **11** and a second nozzle portion **12.** A nozzle hole (hollow portion) **10a,** through which oil flows, is formed in the entirety of the nozzle **10,** that is, through both of the first nozzle portion **11** and the second nozzle portion **12.** The nozzle hole **10a** is in communication with an oil supply path **15** at a base end **10be** of the nozzle **10.** An axial line **NA** of the nozzle **10** extends rearward and slightly downward from the side of the base end **10be** of the nozzle **10.**

[0042] The first nozzle portion **11** extends from the base end **10be** of the nozzle **10** toward a tip end **late** of the nozzle **10.** The second nozzle portion **12** extends from a tip end of the first nozzle portion **11** to the tip end **late** of the nozzle **10.** The second nozzle portion **12** is partially cut out in a circumferential direction. That is, the second nozzle portion **12** has a cutout portion **12c** formed therein. The cutout portion **12c** faces the valvetrain. In other words, the cutout portion **12c** is formed at least below the second nozzle portion **12.**

[0043] In this specification, the range of the second nozzle portion **12** occupied by the cutout portion **12c** will be represented with angle θ (see FIG. **10**) in the circumferential direction. In the example shown in the figures, the cutout portion **12c** is formed to occupy a range smaller than 180 degrees in the circumferential direction at the tip end **10te** of the nozzle **10.** As shown in FIG. **9** and FIG. **10,** the cutout portion **12c** is formed to occupy a range, in the circumferential direction, enlarging from a base end toward a tip end of the second nozzle portion **12.**

[0044] As shown in FIG. **8,** the first nozzle portion **11** has an inner diameter substantially the same in the entirety thereof. By contrast, the second nozzle portion **12** has a tapering shape such that an inner diameter of the second nozzle portion **12** increases from the base end toward the tip end of thereof.

[0045] As described above, with the structure in which oil is supplied to the valvetrain via a nozzle provided in the cylinder head cover, the following occurs in a state where the engine has a low temperature (that is, the oil also has a low temperature) and furthermore, the engine is rotated at a low rotation rate and the oil is injected in a small amount (e.g., in an idling state after cold start). The oil has a high viscosity, and therefore, the oil cannot be injected vigorously from a tip of the nozzle, and the oil may possibly not be supplied to a desired position in the valvetrain. It is conceivable to make the nozzle longer to guide the oil to a desired position. However, there are restrictions caused by the layout in the engine. For example, there may be an undesirable possibility that the longer nozzle and a movable component of the valvetrain interfere with each other. For this reason, the structure in which the nozzle is made longer may be unusable.

[0046] By contrast, the nozzle **10** included in the engine **1** according to this embodiment includes the first nozzle portion **11** extending from the base end **10be** of the nozzle **10** toward the tip end **10te** of the nozzle **10,** and the second nozzle portion **12** extending from the tip end of the first nozzle portion **11** to the tip end **late** of the nozzle **10** having the cutout portion **12c,** facing valvetrain, formed as a result of the second nozzle portion **12** being partially cut out in the circumferential direction. Therefore, with the engine **1** according to this embodiment, the oil flows as follows when the viscosity of the oil is relatively high and the rotation rate of the engine **1** is relatively low. As represented by the arrows in FIG. **10,** the oil flows along a portion of the second nozzle portion **12** that is not cut out and flows down from the tip end **late** of the nozzle **10.** The second nozzle portion **12** has the cutout portion **12c** facing the valvetrain. Therefore, the oil having a high viscosity is guided to a desired position in the valvetrain without the nozzle **10** interfering with the movable component of the valvetrain.

[0047] FIG. **11** shows a structure in which a comparative example nozzle **910** is provided in the cylinder head cover **5.** The comparative example nozzle **910** has a nozzle hole **910** formed in the entirety thereof. The comparative example nozzle **910** does not have a cutout portion facing the valvetrain. That is, the comparative example nozzle **910** dose not have a portion corresponding to the second nozzle portion **12** in the nozzle **10** of the engine **1** according to this embodiment.

[0048] In the case where the comparative example nozzle **910** is provided, oil is injected vigorously from a tip of the nozzle **910** as represented with the arrow with the dotted line, after sufficient warm-up driving or when the rotation rate of the engine **1** is relatively high. Therefore, the oil is supplied in a sufficient amount to the axial end of the intake valve **21.** However, when the viscosity of the oil is high and the rotation rate of the engine **1** is low, the oil cannot be injected vigorously from the tip of the nozzle **910** as represented by the arrow with the solid line. Therefore, the oil cannot be supplied in a sufficient amount to the axial end of the intake valve **21.**

[0049] By contrast, referring to FIG. **12,** with the engine **1** according to this embodiment, when the viscosity of the oil is high and the rotation rate of the engine **1** is low, the oil flows along a portion of the second nozzle portion **12** that is not cut out and flows down from the tip end **late** of the nozzle **10.** Therefore, the oil is supplied in a sufficient amount to the axial end of the intake valve **21.** With the engine **1** according to this embodiment, while the oil is injected vigorously from the tip end **late** of the nozzle **10** (after sufficient warm-up driving or when the rotation rate of the engine **1** is relatively high), the oil may also be supplied to an area to the rear of the axial end of the intake valve **21.** The oil supplied to the area to the rear of the intake valve **21,** for example, reaches the cam shaft **23** and is splashed in the cylinder head **4** as droplets by the rotation of the cam shaft **23** to lubricate the inside of the cylinder head **4.**

[0050] There is no specific limitation on the range (angle θ shown in FIG. **10**) of the second nozzle **12** occupied by the cutout portion **12.** From the point of view of avoiding the interference between the movable component of the valvetrain and the nozzle **10,** it is preferred that the range occupied by the cutout portion **12c** is of a certain size or larger. Specifically, from the above-described point of view, it is preferred that the cutout portion **12c** is formed to occupy a range of 70 degrees or larger in the circumferential direction at the tip end **late** of the nozzle **10.**

[0051] However, from the point of view of allowing the oil to flow down from the tip end **late** of the nozzle **10** in a preferred manner, it is preferred that the cutout portion **12c** of the second nozzle portion **12** is formed to occupy a range smaller than 180 degrees in the circumferential direction at the tip end **late** of the nozzle **10.** In other words, it is preferred that the second nozzle **12** is formed such that the portion thereof other than the cutout portion **12c** extends to be present in an area below a part of a lower half of the nozzle hole **10a.**

[0052] The cutout portion **12c** of the second nozzle portion **12** may be formed to occupy a range, in the circumferential direction, enlarging from the base end toward the tip end of the second nozzle portion **12** as described above as an example.

[0053] In the case where the second nozzle portion **12** has an inner circumferential surface of a tapering shape such that an inner diameter of the second nozzle portion **12** increases from the base end toward the tip end thereof, the oil is supplied in a more preferred manner when the oil is injected in a large amount (e.g., in a maximum amount).

[0054] The second nozzle portion **12** has a length **Ls** (see FIG. **9**) that is not specifically limited. The length **Ls** is, for example, 200 or more of the entire length **L** (see FIG. **9**) of the nozzle **10.**

[0055] In this embodiment, the structure in which the engine **1** has two nozzles **10** is described as an example. The number of the nozzle (s) **10** is not limited to two. One, or three or more, nozzles **10** may be provided in the cylinder head cover **5** in accordance with the specifications of the valvetrain (the number of the valves, etc.).

[0056] There is no specific limitation on the method for producing the cylinder head cover **5** including the nozzles **10.** The cylinder head cover **5** may be produced by, for example, casting. That is, the cylinder head cover **5** may be a cast product.

[0057] As described above, the internal combustion engine **1** according to an embodiment of the present invention includes the cylinder body **3;** the cylinder head **4** connected with the cylinder body **3;** the cylinder head cover **5** connected with the cylinder head **4;** and the valvetrain provided in the cylinder head **4** and the cylinder head cover **5.** The internal combustion engine **1** further includes the nozzle **10** provided in the cylinder head cover **5** and located so as to allow oil to be supplied to the valvetrain. The nozzle **10** includes the first nozzle portion **11** extending from the base end **10be** of the nozzle **10** toward the tip end **10te** of the nozzle **10,** and the second nozzle portion **12** extending from the tip end of the first nozzle portion **11** to the tip end **late** of the nozzle **10** and having the cutout portion **12c,** facing the valvetrain, formed as a result of the second nozzle portion **12** being partially cut out in the circumferential direction.

[0058] The internal combustion engine **1** according to an embodiment of the present invention includes the nozzle **10** provided in the cylinder head cover **5** and located so as to allow oil to be supplied to the valvetrain. The nozzle **10** includes the first nozzle portion **11** extending from the base end **10be** of the nozzle **10** toward the tip end **late** of the nozzle **10,** and the second nozzle portion **12** extending from the tip end of the first nozzle portion **11** to the tip end **10te** of the nozzle **10** and having the cutout portion **12c,** facing the valvetrain, formed as a result of the second nozzle portion **12** being partially cut out in the circumferential direction. In the internal combustion engine **1** according to an embodiment of the present invention, when the viscosity of the oil is relatively high and the rotation rate of the engine **1** is relatively low, the oil flows along the portion of the second nozzle portion **12** that is not cut out and flows down from the tip end **late** of the nozzle **10.** The second nozzle portion **12** has the cutout portion **12c,** facing the valvetrain, formed therein. Therefore, the oil having a high viscosity is guided to a desired position in the valvetrain without the nozzle **10** interfering with the movable component of the valvetrain.

[0059] In one embodiment, the cutout portion **12c** is formed to occupy a range of 70 degrees or larger in the circumferential direction at the tip end **10te** of the nozzle **10.**

[0060] From the point of view of avoiding the interference between the movable component of the valvetrain and the nozzle **10,** it is preferred that the cutout portion **12c** of the second nozzle portion **12** is formed to occupy a range of 70 degrees or larger in the circumferential direction at the tip end **10te** of the nozzle **10.**

[0061] In one embodiment, the cutout portion **12c** is formed to occupy a range smaller than 180 degrees in the circumferential direction at the tip end **late** of the nozzle **10.**

[0062] From the point of view of allowing the oil to flow down from the tip end **10te** of the nozzle **10** in a preferred manner, it is preferred that the cutout portion **12c** of the second nozzle portion **12** is formed to occupy a range smaller than 180 degrees in the circumferential direction at the tip end **late** of the nozzle **10.**

[0063] In one embodiment, the cutout portion **12c** is formed to occupy a range, in the circumferential direction, enlarging from the base end toward the tip end of the second nozzle portion **12.**

[0064] The cutout portion **12c** of the second nozzle portion **12** may be formed to occupy a range, in the circumferential direction, enlarging from the base end toward the tip end of the second nozzle portion **12.**

[0065] In one embodiment, the second nozzle portion **12** has an inner circumferential surface of a tapering shape such that an inner diameter of the second nozzle portion **12** increases from the base end toward the tip end of the second nozzle portion **12.**

[0066] In the case where the inner circumferential surface of the second nozzle portion **12** has a tapering shape such that the inner diameter of the second nozzle portion **12** increases from the base end toward the tip end of the second nozzle portion **12,** the oil is supplied in a more preferred manner when the oil is injected in a large amount (e.g., in a maximum amount).

[0067] A straddled vehicle according to an embodiment of the present invention includes the internal combustion engine **1** having any one of the above-described structures.

[0068] In one embodiment, the nozzle **10** is located above the valvetrain in the vertical direction.

[0069] An embodiment of the present invention provides an internal combustion engine capable of supplying oil in a preferred manner to a desired position in a valvetrain in a cylinder head even in a state where the oil has a relatively high viscosity. The internal combustion engine according to an embodiment of the present invention is preferably usable in any of various straddled vehicles.

Claims

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

   a cylinder body (3);
   a cylinder head (4) connected with the cylinder body (3) ;
   a cylinder head cover (5) connected with the cylinder head (4); and
   a valvetrain provided in the cylinder head (4) and the cylinder head cover (5),
   wherein the internal combustion engine (1) further includes a nozzle (10) provided in the cylinder head cover (5) and located so as to allow oil to be supplied to the valvetrain, and
   wherein the nozzle (10) includes a first nozzle portion (11) extending from a base end (lObe) of the nozzle (10) toward a tip end (10te) of the nozzle (10), and a second nozzle portion (12) extending from a tip end of the first nozzle portion (11) to the tip end of the nozzle (10) and having a cutout portion (12c), facing the valvetrain, formed as a result of the second nozzle portion (12) being partially cut out in the circumferential direction.

2. The internal combustion engine of claim 1, wherein the cutout portion (12c) is formed to occupy a range of 70 degrees or larger in the circumferential direction at the tip end (10te) of the nozzle (10).

3. The internal combustion engine of claim 1 or 2, wherein the cutout portion (12c) is formed to occupy a range smaller than 180 degrees in the circumferential direction at the tip end (10te) of the nozzle (10).

4. The internal combustion engine of any one of claims 1 to 3, wherein the cutout portion (12c) is formed to occupy a range, in the circumferential direction, enlarging from a base end toward a tip end of the second nozzle portion (12).

5. The internal combustion engine of any one of claims 1 to 4, wherein the second nozzle portion (12) has an inner circumferential surface of a tapering shape such that an inner diameter of the second nozzle portion (12) increases from a base end toward a tip end of the second nozzle portion (12).

6. A straddled vehicle, comprising the internal combustion engine (10) of any one of claims 1 to 5.

7. The straddled vehicle of claim 6, wherein the nozzle (10) is located above the valvetrain in a vertical direction.

FIG.1

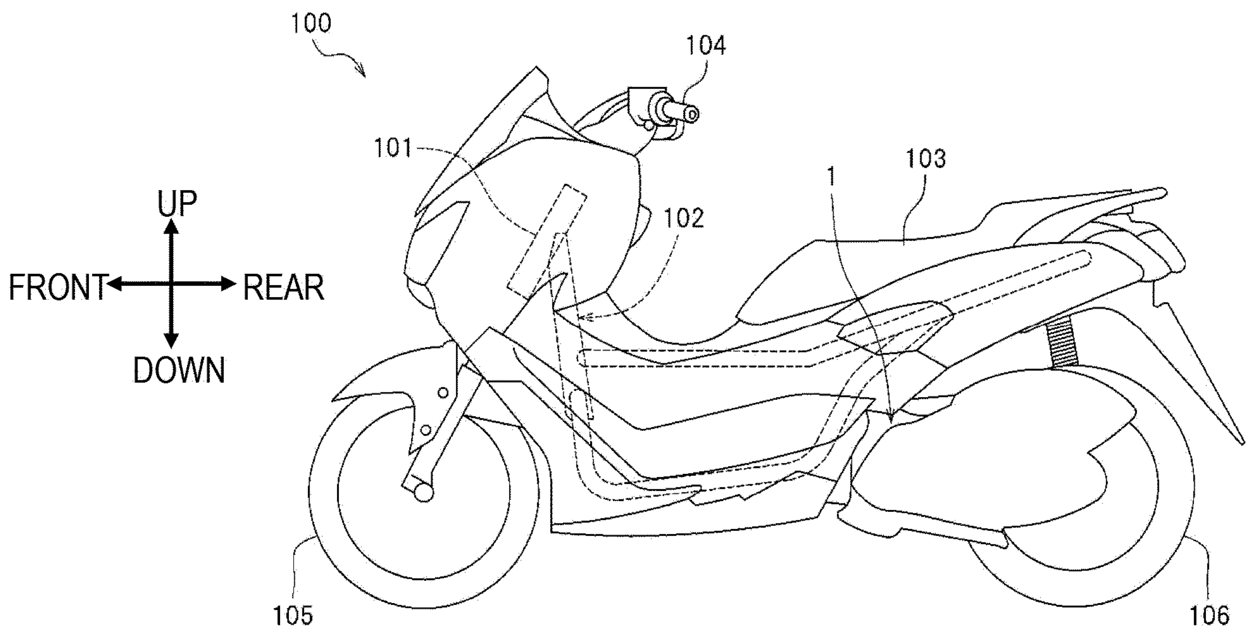


FIG.2

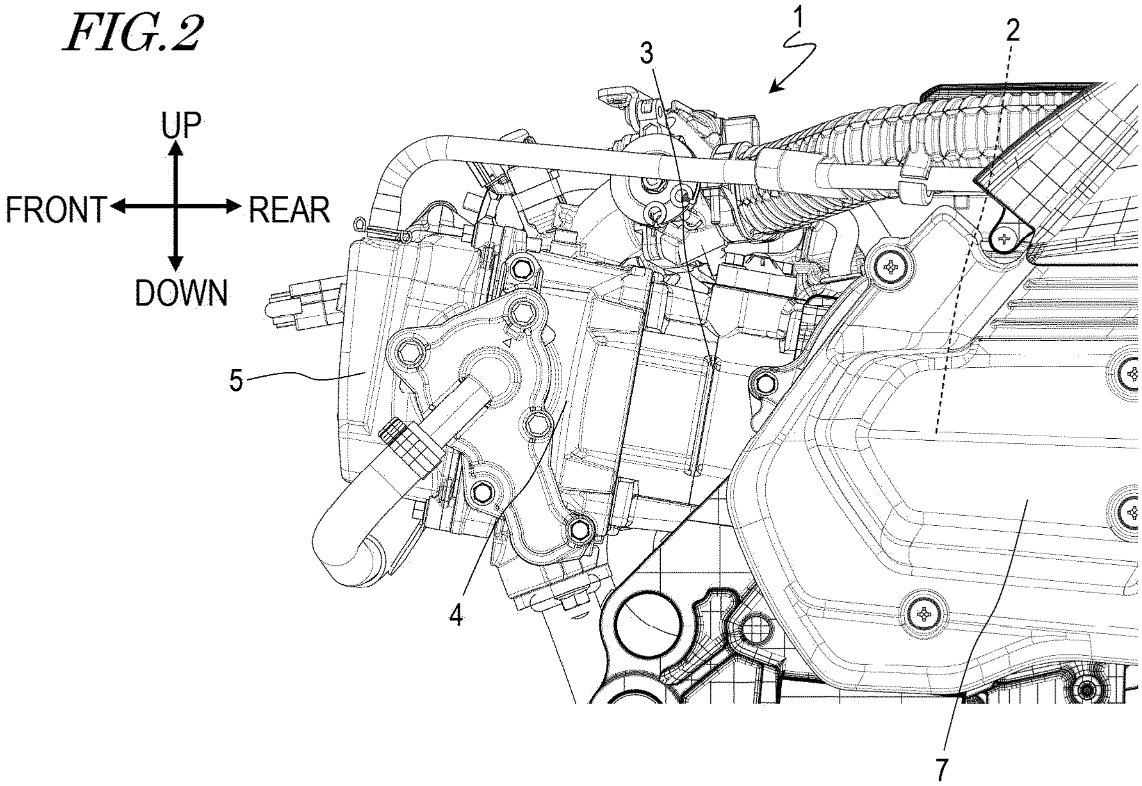


FIG.3

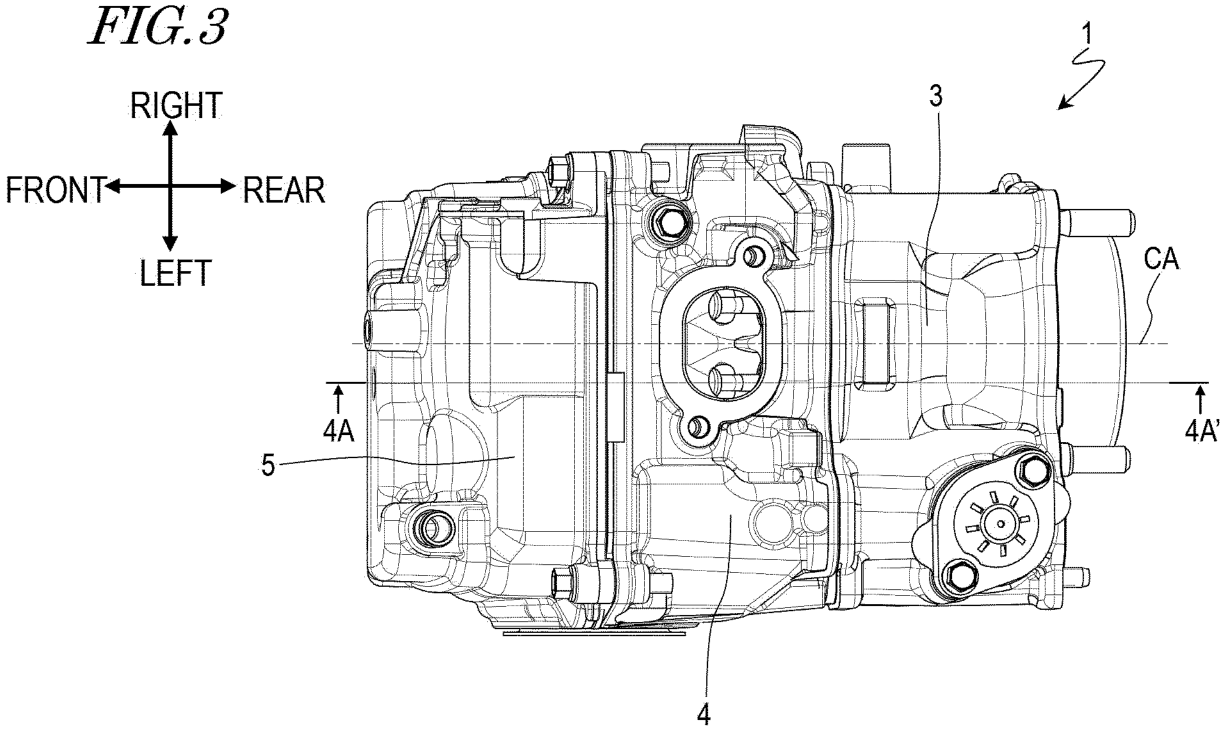
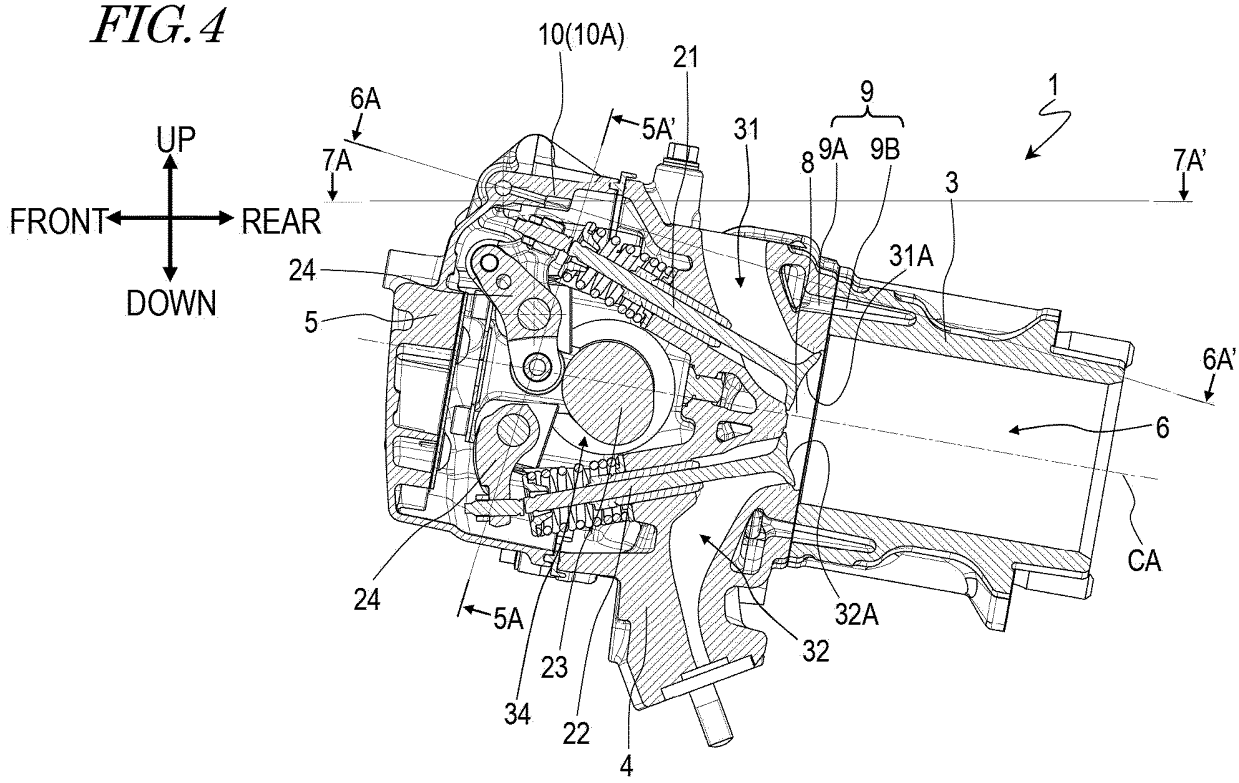
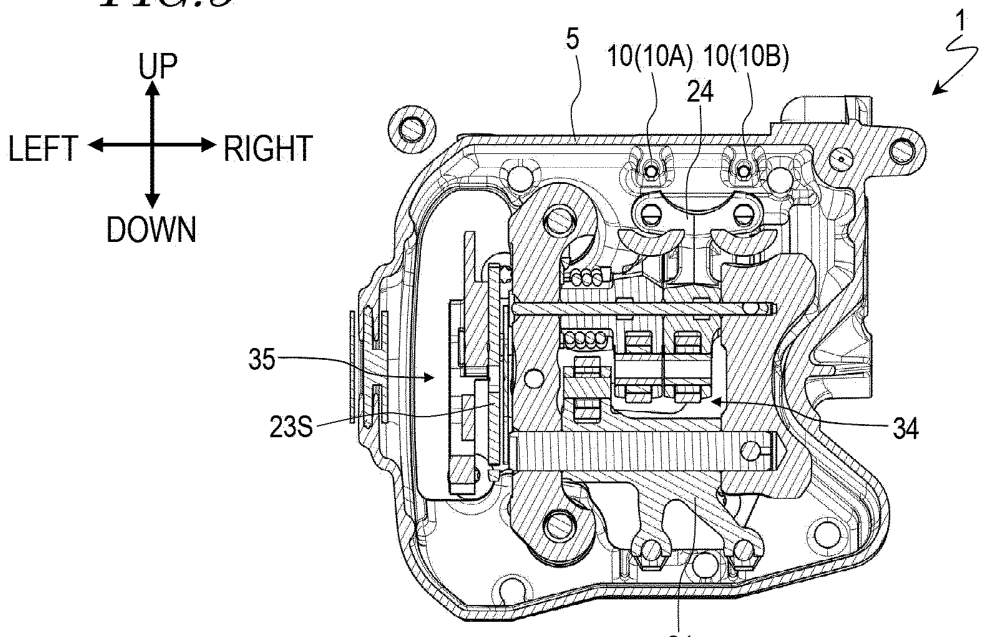


FIG.4



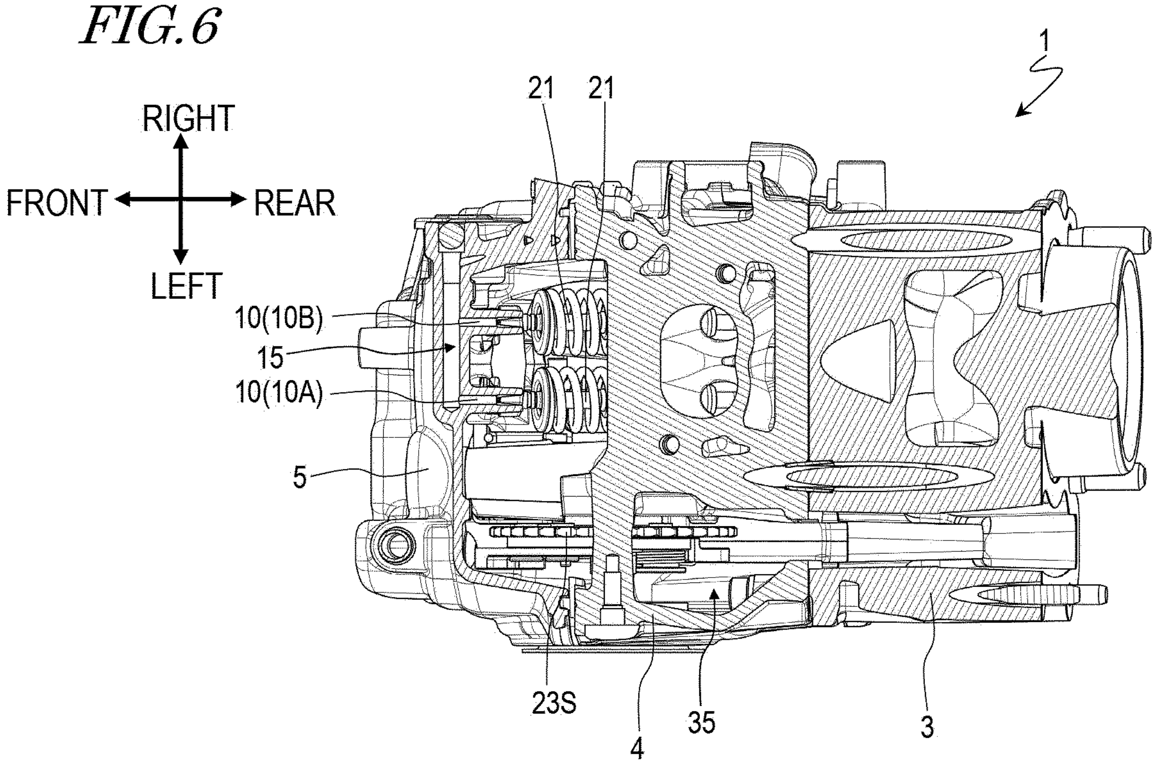
UP
FRONT
REAR
DOWN
10(10A)
21
6A
5A'
9
1
31
9A
9B
7A
8
7A'
3
31A
24
5
6A'
6
CA
24
5A
32A
23
32
34
22
4

FIG.5



UP
LEFT
RIGHT
DOWN
5
10(10A)
10(10B)
1
24
35
23S
34
24

FIG.6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FRONT
REAR
LEFT
1
21
21
10(10B)
15
10(10A)
5
23S
4
35
3

FIG.7

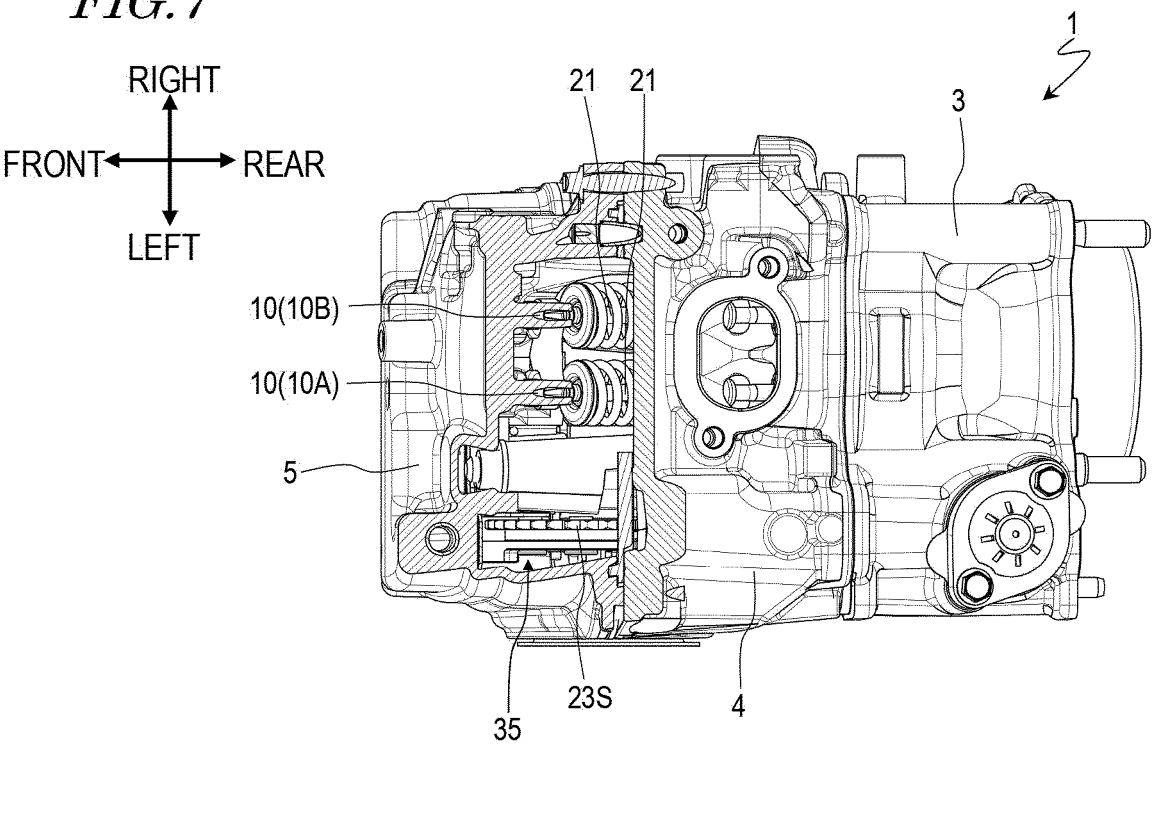

RIGHT
FRONT
REAR
LEFT
1
21
21
3
10(10B)
10(10A)
5
35
23S
4

FIG.8

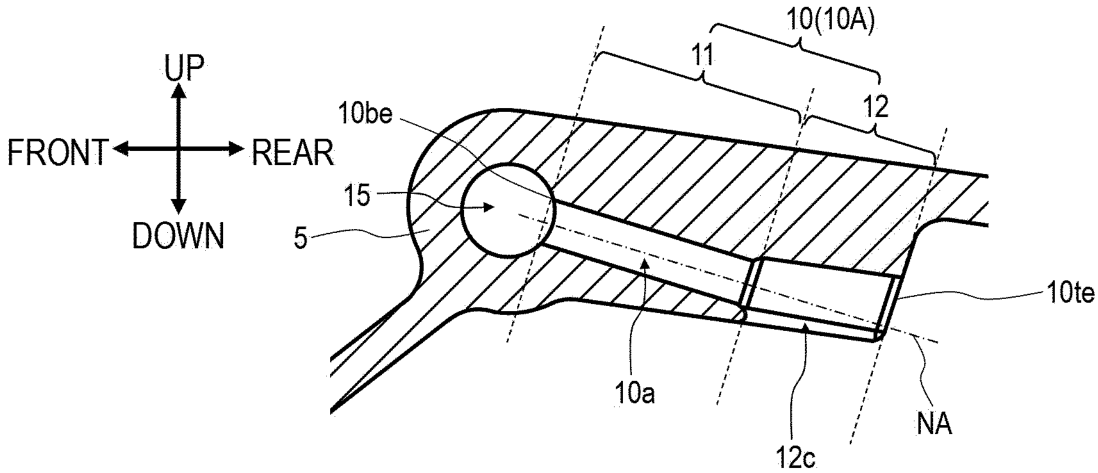

UP
FRONT
REAR
DOWN
10(10A)
11
12
10be
15
5
10te
10a
12c
NA

FIG.9

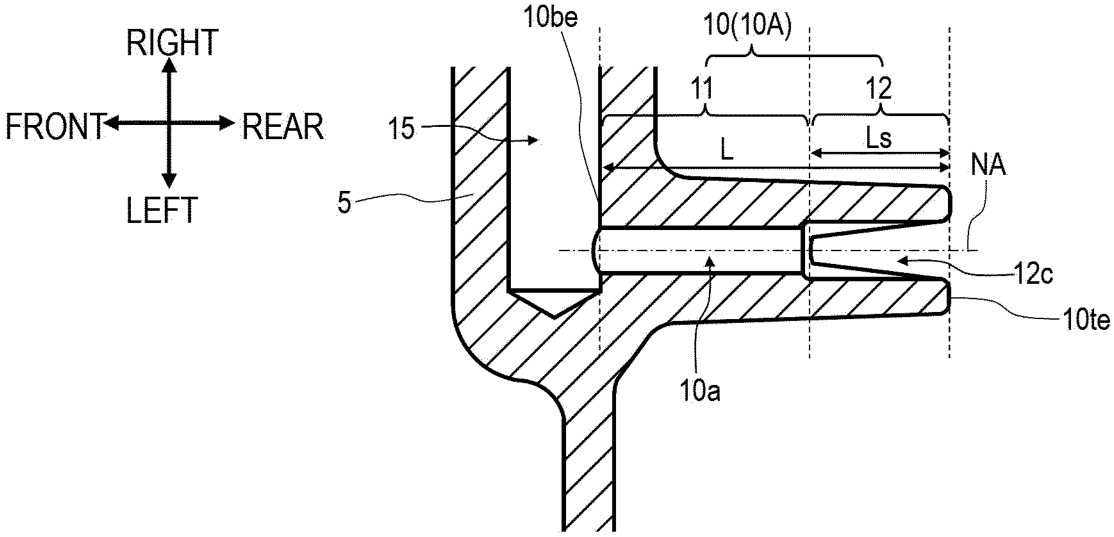

RIGHT
FRONT
REAR
LEFT
10be
10(10A)
11
12
15
L
Ls
NA
5
12c
10te
10a

FIG.10

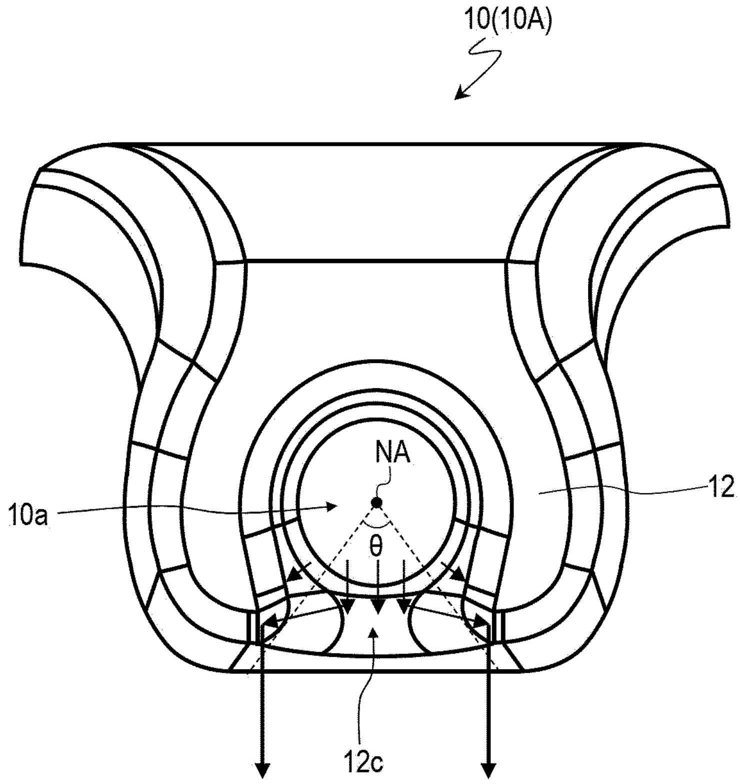


FIG.11

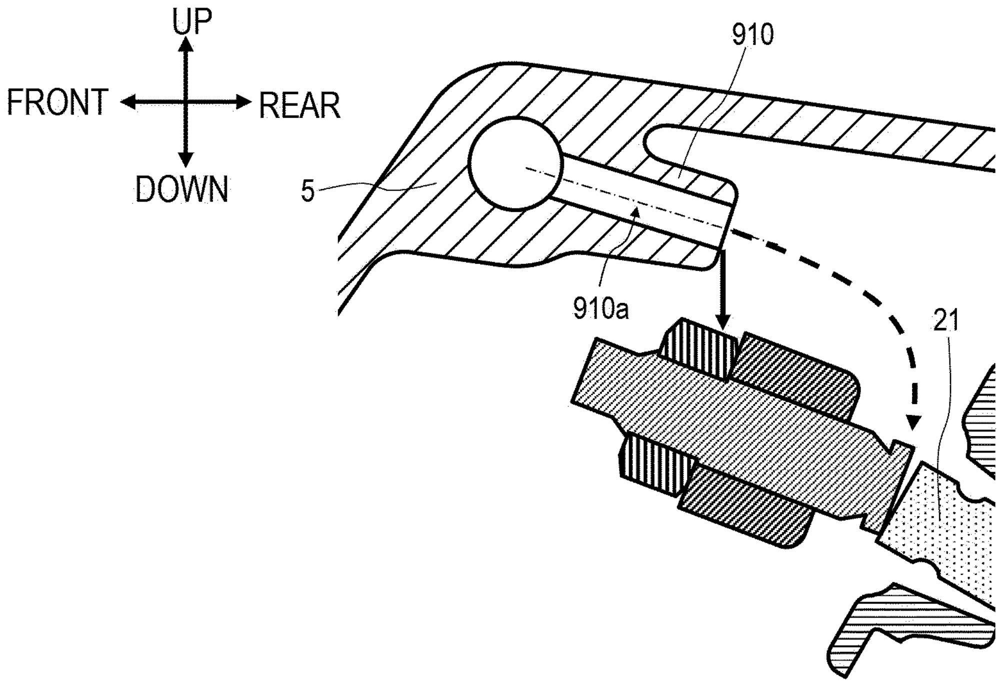
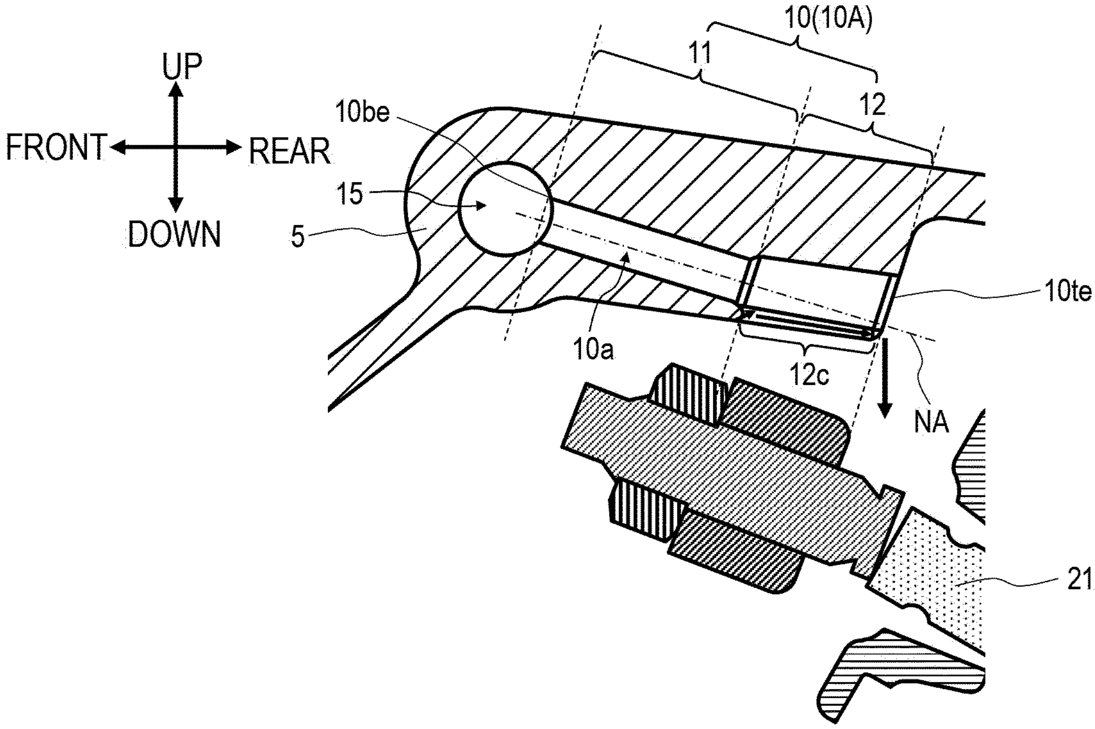

UP
FRONT
REAR
DOWN
910
5
910a
21

FIG.12


UP
FRONT
REAR
DOWN
10(10A)
11
12
10be
15
5
10te
10a
12c
NA
21

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EUROPEAN SEARCH REPORT

Application Number
EP 23 19 3669

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 A	WO 2020/189303 A1 (HONDA MOTOR CO LTD [JP]) 24 September 2020 (2020-09-24) * figures 1-7 * -----	1-4,6,7 5	INV. F01M9/10 F01L1/18 F01M9/08 ADD. F01M5/00
A	JP S57 162911 U (YANMAR) 14 October 1982 (1982-10-14) * figures 1, 3, 4 * -----	1-7	
A	EP 2 527 608 A1 (YAMAHA MOTOR CO LTD [JP]) 28 November 2012 (2012-11-28) * figures 1, 8, 9 * -----	1	
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F01M F01L

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	7 February 2024	Ducloyer, Stéphane

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07-02-2024

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- JP 2020105969 A **[0004]**