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**Polttomoottorin sylinterikansi ja polttomoottori**

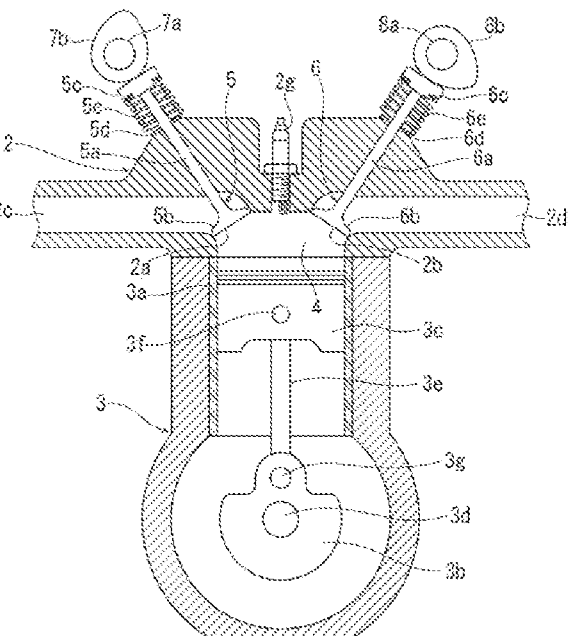
**Cylinderlock för en förbränningsmotor och förbränningsmotor**

**Cylinder head of internal combustion engine and internal combustion engine**

(57) Tiivistelmä - Sammandrag - Abstract

Esitetään sylinterinkansi ja polttomoottori, jotka voivat ehkäistä nakutusta, joka johtuu ennenaikaisesta sytytyksestä polttomoottorin palamistilassa, jossa käytetään dekarbonoitua polttoainetta, joka sisältää vetyä. Polttomoottorin sylinterinkansi (2) käsittää lautastyyppisen tuloventtiilin (5) ja poistoventtiilin (6), joissa kummassakin on akselin pään puolelle muodostettu sateenvarjo-osa (5b, 6b) ja jotka on sovitettu vastaavasti avaamaan ja sulkemaan tuloaukko (2a) ja poistoaukko (2b), jotka ovat auki palamistilaan, jossa sylinterinkansi (2) käyttää dekarbonoitua polttoainetta, joka sisältää vetyä, poistoventtiili (6) on jäähdytysainetta sisältävä ontto venttiili, joka sisältää vettä (10) jäähdytysaineena ontossa osassa (9), joka ulottuu sateenvarjo-osasta (6b) akselin pään puolelle, ja tuloventtiili (5) on umpinainen venttiili, jossa sateenvarjo-osan koko pohjapinnalle (5b4) on järjestetty ulkonemia (11), jota ovat tasonäkymässä ruudukkomuodossa, jonka määrittää suuri

Provided are a cylinder head and an internal combustion engine capable of preventing knocking due to preignition in a combustion chamber of the internal combustion engine using a decarbonized fuel including hydrogen. A cylinder head (2) of an internal combustion engine includes a poppet-type intake valve (5) and an exhaust valve (6) each having an umbrella portion (5b, 6b) formed on a shaft end side and configured to respectively open and close an intake port (2a) and an exhaust port (2b) that are open to a combustion chamber, in which the cylinder head (2) uses a decarbonized fuel including hydrogen, the exhaust valve (6) is a refrigerant-containing hollow valve in which water (10) is enclosed as a refrigerant in a hollow portion (9) extending from the umbrella portion (6b) to the shaft end side, and the intake valve (5) is a solid valve in which protrusions (11) having a grid shape in a plan view defined by a large number of parallel intersecting grooves (12) are provided on an entire bottom surface (5b4) of the umbrella portion.



DESCRIPTION

Title of Invention: CYLINDER HEAD OF INTERNAL COMBUSTION ENGINE AND INTERNAL COMBUSTION ENGINE

Technical Field

[0001] The present invention relates to a cylinder head of an internal combustion engine and an internal combustion engine having the cylinder head, and more particularly to a cylinder head of an internal combustion engine and an internal combustion engine using a non-fossil fuel including hydrogen.

Background Art

[0002] Patent Literature 1 discloses an internal combustion engine including, in a cylinder head, an intake valve having a hollow portion on an inner side, and an exhaust valve having a refrigerant in a hollow portion provided on an inner side, the exhaust valve having a temperature reduced by causing the refrigerant to absorb heat on an umbrella portion side having a high temperature during driving of the internal combustion engine, repeatedly reciprocating the refrigerant between the umbrella portion side and a shaft side having a low temperature, and transferring the heat to the shaft side.

Citation List

Patent Literature

[0003]

Patent Literature 1: Japanese Patent No. 6356361

Summary of Invention

Technical Problem

[0004] In internal combustion engines, for the purpose of reducing an amount of greenhouse gases, transition from fossil fuels such as gasoline and light oil that have been conventionally used to a decarbonized fuel including hydrogen is predicted, and also in marine engines, transition from heavy oil to a decarbonized fuel including hydrogen is predicted.

[0005] However, since a decarbonized fuel including hydrogen has a combustion speed faster than that of fossil fuels, knocking due to preignition (ignition occurs excessively earlier than the original ignition timing) occurs, and it is considered that such preignition occurs in a hot spot in which the temperature in a combustion chamber is extremely higher than other regions due to temperature deviation depending on locations. An intake valve in an existing internal combustion engine may be forced to be cooled by a vaporized mixed fuel, especially an air-fuel mixture cooled by an intercooler or the like, while an exhaust valve is exposed to a high-temperature exhaust gas even if the temperature is reduced by a refrigerant, and thus becomes much hotter than the intake valve. As a result, in the combustion chamber, a region near a surface side of the umbrella portion of the exhaust valve (hereinafter, simply referred to as an umbrella surface vicinity region) is maintained at a much higher temperature than an umbrella surface vicinity region of the intake valve. Therefore, such a temperature difference between the regions near the umbrella portions of both the intake and exhaust valves in the combustion chamber causes a hot spot in the region near the surface side of the umbrella portion of the exhaust valve, and knocking may easily occur, which is problematic.

[0006] On the other hand, unlike an internal combustion engine used at medium-to-high speed rotation (about several thousand rpm) such as an automobile internal combustion engine, an internal combustion engine used at low speed rotation (about several hundred rpm) such as a marine internal combustion engine has a problem that even when sodium used for an automobile internal combustion engine is used as a refrigerant of a hollow exhaust valve, a sufficient cooling effect cannot be obtained due to poor fluidity caused by an insufficient rotation speed.

[0007] In view of the above problems, the present invention provides a cylinder head and an internal combustion engine capable of reducing a temperature difference between umbrella surface vicinity regions of both an intake valve and an exhaust valve in a combustion chamber of the internal combustion engine using a decarbonized fuel including hydrogen and preventing knocking due to preignition.

Solution to Problem

[0008] The inventors verified, through a dynamic heater ring test, the heat dissipation effect of an exhaust valve in a case where a rotation speed of an automobile engine is set to a plurality of rotation speeds from a low rotation speed to a high rotation speed by using, as exhaust valves, a hollow valve (conventional technique) in which metallic sodium is loaded in a hollow portion and a heat pipe cooling type hollow valve in which water is loaded in a hollow portion as a cooling medium. As a result, as illustrated in FIGS. 2AA to 2AC, it was confirmed that the latter (heat pipe cooling type hollow valve loaded with water) has a superior heat dissipation effect to the former (hollow valve loaded with metallic sodium) at any rotation speed. Therefore, the inventors have considered that, in a cylinder head of an internal combustion engine including an intake valve and an exhaust valve and using a decarbonized fuel including hydrogen, if a heat pipe cooling type hollow valve in which water is loaded in a hollow portion is employed as the exhaust valve, the temperature difference between regions near the umbrella portions of both the intake and exhaust valves in the combustion chamber is reduced according to the temperature of the umbrella surface of the exhaust valve being able to be greatly reduced.

[0009] However, there is a limit to the cooling of the umbrella surface of the exhaust valve (improvement of the heat dissipation effect) only by employing the heat pipe cooling type hollow valve as the exhaust valve. Therefore, it was considered to effectively reduce the temperature difference (prevent the occurrence of knocking) between the regions near the umbrella portions of both the intake and exhaust valves in the combustion chamber by using a structure that suppresses the decrease in the temperature of (the umbrella surface of) the intake valve formed of a solid body in combination with this.

[0010] That is, if the surface area of a bottom surface (umbrella surface) of the umbrella portion of the intake valve is increased by uniformly forming irregularities on the entire bottom surface (umbrella surface) of the umbrella portion of the intake valve formed of a solid body or forming longitudinal sectional wave-shaped projecting strips (recessed strips) concentrically, the temperature of (the umbrella surface of) the umbrella portion facing the combustion chamber becomes higher than that in the case where the bottom surface (umbrella surface) of the umbrella portion is a flat surface (conventional structure) due to the increase in the heat receiving area of the umbrella surface. Further, in the conventional structure, when the thickness of the umbrella portion of the intake valve and the thickness of the umbrella portion of the exhaust valve are the same, if the thickness of the umbrella portion of the intake valve is made smaller (thinner) than the thickness of the umbrella portion of the exhaust valve (= the thickness of the umbrella portion of the conventional intake valve), and the heat capacity of the umbrella portion of the intake valve is made smaller (smaller than the heat capacity of the umbrella portion of the conventional intake valve), the temperature of (the umbrella surface of) the umbrella portion facing the combustion chamber increases.

[0011] As described above, the inventors have considered reducing the temperature difference between the regions near the umbrella portions of both the intake and exhaust valves in the combustion chamber by employing the new configuration of "in a cylinder head of an internal combustion engine, a heat pipe cooling type hollow valve in which water is loaded in a hollow portion is employed as an exhaust valve, and irregularities are uniformly formed on an entire bottom surface (umbrella surface) of an umbrella portion of an intake valve formed of a solid body, longitudinal sectional wave-shaped projecting strips (recessed strips) are concentrically formed, or a thickness of the umbrella portion of the intake valve is formed to be smaller than a thickness of the umbrella portion of the exhaust valve (= a thickness of the umbrella portion of a conventional intake valve)".

[0012] That is, in order to solve the above problem, in a first aspect of the invention of a cylinder head of an internal combustion engine that desirably includes a poppet-type intake valve and exhaust valve each having an umbrella portion formed on a shaft end side and configured to respectively open and close an intake port and an exhaust port that are open to a combustion chamber, the cylinder head uses a decarbonized fuel including hydrogen, the exhaust valve includes a refrigerant-containing hollow valve in which water is enclosed as a refrigerant in a hollow portion extending from the umbrella portion to the shaft end side, and the intake valve includes a solid valve in which protrusions having a grid shape in a plan view defined by a large number of intersecting grooves are provided on an entire bottom surface of the umbrella portion.

[0013] (Action) The exhaust valve includes a heat pipe cooling type hollow valve having an excellent heat dissipation effect in which heat on the umbrella portion side is transmitted to the shaft portion side through a phase change of a cooling medium (water) in the hollow portion between a liquid phase and a gas phase, and the heat transmitted to the shaft portion side is further transmitted (radiated) to the cylinder head, so that a temperature increase of the umbrella surface of the exhaust valve is suppressed. As illustrated in FIGS. 2AA to 2AC, the heat pipe cooling type exhaust valve is excellent in heat dissipation effect compared with a conventional hollow valve in which metallic sodium is loaded as a cooling medium in a hollow portion, and thus the temperature of the umbrella surface is reduced. In particular, a rotation speed of an engine of an automobile traveling in an urban area is in a low rotation range, and a rotation speed of an engine of a ship is also premised to be operated in a low rotation range. As apparent from FIGS. 2AA to 2AC, the heat dissipation effect of the intake valve when the internal combustion engine is driven in a low rotation range (for example, 3000rpm or less) is remarkably superior in the heat pipe cooling type hollow valve loaded with water to the metallic sodium loaded hollow valve.

[0014] On the other hand, in the intake valve, since the protrusion having a grid shape in a plan view is formed on the bottom surface of the umbrella portion, that is, on the entire umbrella surface, the surface area (a heat receiving area facing the combustion chamber) of the bottom surface of the umbrella portion is enlarged, and the umbrella portion is easily heated. As a result, while the temperature of the umbrella surface vicinity region of the intake valve in the combustion chamber increases, the temperature of the umbrella surface vicinity region of the exhaust valve is sufficiently reduced, and the temperature difference between the umbrella surface vicinity regions of both the intake and exhaust valves is reliably reduced.

[0015] Further, in a second aspect of the present invention of a cylinder head of an internal combustion engine that desirably includes a poppet-type intake valve and exhaust valve each having an umbrella portion formed on a shaft end side and configured to respectively open and close an intake port and an exhaust port that are open to a combustion chamber, the cylinder head uses a decarbonized fuel including hydrogen, the exhaust valve includes a refrigerant-containing hollow valve in which water is enclosed as a refrigerant in a hollow portion extending from the umbrella portion to the shaft end side, and the intake valve includes a solid valve in which longitudinal sectional wave-shaped projecting strip portions that are continuous concentrically are provided on an entire bottom surface of the umbrella portion.

[0016] (Action) The action on the exhaust valve is the same as the “action on the exhaust valve” in the cylinder of the internal combustion engine according to one aspect of the present invention described above, and redundant description thereof will be omitted. On the other hand, since the entire bottom surface (umbrella surface) of the umbrella portion of the intake valve has the longitudinal sectional wave-shaped projecting stripe portions that are continuous concentrically, the surface area (a heat receiving area facing the combustion chamber) of the bottom surface of the umbrella portion is enlarged compared with the conventional intake valve in which the bottom surface (umbrella surface) of the umbrella portion is formed of a flat surface, and thus the umbrella portion is easily heated. As a result, while the temperature of the umbrella surface vicinity region of the intake valve in the combustion chamber increases, the temperature of the umbrella surface vicinity region of the exhaust valve is sufficiently reduced, and the temperature difference between the umbrella surface vicinity regions of both the intake and exhaust valves is reliably reduced.

[0017] Further, in a third aspect of the present invention of a cylinder head of an internal combustion engine that desirably includes a poppet-type intake valve and exhaust valve each having an umbrella portion formed on a shaft end side and configured to respectively open and close an intake port and an exhaust port that are open to a combustion chamber, the cylinder head uses a decarbonized fuel including hydrogen, the exhaust valve includes a refrigerant-containing hollow valve in which water is enclosed as a refrigerant in a hollow portion extending from the umbrella portion to the shaft end side, and the intake valve includes a solid valve of which an umbrella portion is formed to be thinner than the umbrella portion of the exhaust valve.

[0018] (Action) The action on the exhaust valve is the same as the “action on the exhaust valve” in the cylinder of the internal combustion engine according to one aspect of the present invention described above, and redundant description thereof will be omitted. On the other hand, unlike the conventional structure in which the umbrella portion of the intake valve is formed to have the same thickness as the thickness of the umbrella portion of the exhaust valve, the umbrella portion of the intake valve is thinned compared with the umbrella portions of the intake valve and the exhaust valve of the related art. As a result, since the umbrella portion of the intake valve has a smaller heat capacity than that of the umbrella portion of the conventional intake valve formed to have the same thickness as the umbrella portion of the exhaust valve, a temperature increase of the umbrella surface is promoted, so that the umbrella portion of the intake valve is more easily heated than the umbrella portion of the conventional intake valve. As a result, while the temperature of the umbrella surface vicinity region of the intake valve in the combustion chamber increases, the temperature of the umbrella surface vicinity region of the exhaust valve is sufficiently reduced, and the temperature difference between the umbrella surface vicinity regions of both the intake and exhaust valves is reduced.

[0019] Further, according to a fourth aspect of the invention of the cylinder head of the internal combustion engine, in the third aspect of the invention, the entire bottom surface of the umbrella portion of the intake valve is desirably provided with protrusions having a grid shape in a plan view defined by a large number of intersecting grooves or projecting strip portions having a longitudinal sectional wave shape and continuing concentrically.

[0020] (Action) Since the protrusions having a grid shape in a plan view defined by a large number of intersecting grooves or the projecting strip portions having a longitudinal sectional wave shape and continuing concentrically are provided on the entire bottom surface of the umbrella portion of the intake valve, the umbrella portion is further easily heated due to the increase in the surface area (a heat receiving area facing the combustion chamber) of the bottom surface of the umbrella portion of the intake valve in addition to the decrease in the heat capacity of the umbrella portion due to the thinning. As a result, while the temperature of the umbrella surface vicinity region of the intake valve in the combustion chamber increases, the temperature of the umbrella surface vicinity region of the exhaust valve is sufficiently reduced, and the temperature difference between the umbrella surface vicinity regions of both the intake and exhaust valves is further reliably reduced.

[0021] In addition, according to a fifth aspect of the invention of the cylinder head of the internal combustion engine, in the first aspect to the fourth aspect of the invention of the cylinder head of the internal combustion engine, the bottom surface of the umbrella portion of the exhaust valve is desirably configured by a mirror surface.

[0022] (Action) The umbrella portion bottom surface of the exhaust valve configured by the mirror surface reflects infrared rays, and the temperature increase is suppressed due to the decrease in radiant heat transmitted from the combustion chamber to the umbrella portion bottom surface, the umbrella portion of the exhaust valve is more easily cooled, and thus the temperature of the umbrella surface vicinity region of the exhaust valve in the combustion chamber decreases. The temperature of the umbrella portion of the exhaust valve is brought closer to the temperature of the umbrella portion of the intake valve cooled by an intercooler or the like, so that the temperature difference between the umbrella surface vicinity regions of both the intake and exhaust valves is reduced.

[0023] In addition, according to a sixth aspect of the invention of the cylinder head of the internal combustion engine, in the first aspect to the fifth aspect of the invention, the internal combustion engine is desirably a marine engine.

[0024] (Action) Even in a marine engine having a low rotation speed during driving, the umbrella portion of the exhaust valve is sufficiently cooled, and the temperature difference between the umbrella surface vicinity regions of both the intake and exhaust valves in the combustion chamber is reduced.

[0025] In addition, an internal combustion engine desirably includes a cylinder block having, inside, a piston reciprocally held in a cylinder, a crankshaft rotatably held, and a connecting rod rotatably connected to both the piston and the crankshaft to convert reciprocating motion of the piston into rotational motion; and the first to sixth aspects of the invention of the cylinder head of the internal combustion engine, which is fixed to the cylinder block and forms a combustion chamber with an inner side of the cylinder.

[0026] (Action) In the internal combustion engine having the cylinder head according to each claim of the present application, while the temperature in the umbrella surface vicinity region of the intake valve increases in the combustion chamber, the temperature in the umbrella surface vicinity region of the exhaust valve is sufficiently reduced, and the temperature difference between the umbrella surface vicinity regions of both the intake and exhaust valves in the combustion chamber is reduced.

Advantageous Effects of Invention

[0027] According to the cylinder head, the surface area of the umbrella portion bottom surface of the intake valve is larger than that of the exhaust valve by the protrusions having a grid shape, a wave shape, or the like, or the umbrella portion of the intake valve is formed to be thinner than the umbrella portion of the exhaust valve, and the umbrella portion of the intake valve is more likely to be heated than the umbrella portion of the conventional intake valve due to a decrease in heat capacity, so that the temperature difference between the umbrella surface vicinity regions of both the intake and exhaust valves in the combustion chamber is reduced, and a hot spot is less likely to occur in the combustion chamber. Therefore, knocking due to preignition is reduced even when a decarbonized fuel including hydrogen is used. Furthermore, the water loaded in the hollow portion of the exhaust valve is a safe cooling medium compared with metallic sodium, and the fact that the fuel of the internal combustion engine is a decarbonized fuel including hydrogen is also meaningful as a global warming countermeasure.

[0028] In addition, according to the cylinder head, the temperature of the umbrella portion of the exhaust valve is brought closer to the temperature of the umbrella portion of the intake valve cooled by an intercooler or the like, so that the temperature difference between the umbrella surface vicinity regions of both the intake and exhaust valves is further reduced, and a hot spot is less likely to occur in the combustion chamber. Therefore, knocking due to preignition is reduced even when a decarbonized fuel including hydrogen is used.

[0029] In addition, according to the cylinder head, knocking due to preignition is sufficiently reduced even when a decarbonized fuel including hydrogen is used in a marine engine.

[0030] In addition, according to the present internal combustion engine, the temperature difference between the umbrella surface vicinity regions of both the intake and exhaust valves in the combustion chamber is reduced, and a hot spot is less likely to occur in the combustion chamber, so that knocking due to preignition is reduced even when a decarbonized fuel including hydrogen is used. According to the present internal combustion engine, by reducing knocking when a decarbonized fuel including hydrogen is used, torque is improved on the basis of an ignition advance (an ignition timing is slightly advanced from the time of reaching the top dead center of the piston), and fuel efficiency is improved.

Brief Description of Drawings

[0031]

FIG. 1 is a longitudinal sectional view illustrating an embodiment of an internal combustion engine having a cylinder head of the present application.

FIG. 1A is an explanatory view of a valve mechanism including an exhaust valve of a marine internal combustion engine having a cylinder head of the present application.

FIG. 2A is a longitudinal sectional view of an intake valve used in the cylinder head. FIG. 2B is a longitudinal sectional view of an exhaust valve used in the cylinder head.

FIGS. 2AA to 2AC are graphs in which the temperature of a refrigerant-containing hollow valve used in an automobile engine is measured through a dynamic heater ring test for each rotation speed of the engine, in which FIG. 2AA is a graph at 750 rpm, FIG. 2AB is a graph at 1800 rpm, and FIG. 2AC is a graph at 5200 rpm.

FIG. 3 is an enlarged view of a bottom surface of an umbrella portion of an intake valve provided with a protrusion having a grid shape in a plan view when viewed in a direction of an arrow A in FIG. 2.

FIG. 4 is an explanatory view illustrating a modification of the bottom surface of the umbrella portion of the intake valve provided with a protrusion having a grid shape in a plan view.

FIG. 5A is an enlarged longitudinal sectional view illustrating a modification of a bottom surface of an umbrella portion of an intake valve having a longitudinal sectional wave-shaped projecting strip portion. FIG. 5B is a view illustrating a bottom surface of the umbrella portion of the intake valve provided with a wave-shaped protrusion when viewed in an arrow B in FIG. 5A.

Description of Embodiments

[0032] A preferred embodiment of an internal combustion engine having a cylinder head of the present application will be described with reference to FIG. 1. As illustrated in FIG. 1, an internal combustion engine 1 is configured by mounting a cylinder head 2 on a cylinder block 3. The cylinder block 3 has a cylindrical cylinder 3a in an upper portion and a crankshaft 3b in a lower portion. A piston 3c is provided inside the cylinder 3a to be reciprocally slidable. A connecting rod 3e is rotatably attached to both the cylinder 3a and the crankshaft 3b via a first connecting shaft 3f and a second connecting shaft 3g. As a result, the reciprocating motion of the cylinder 3a is converted into the rotational motion of the crankshaft 3b by the connecting rod 3e.

[0033] The cylinder head 2 in FIG. 1 is connected and fixed to the cylinder block 3 at a position facing the cylinder 3a and the piston 3c. In an inner region of both the cylinder head 2 and the cylinder 3a, a combustion chamber 4 is provided in an upper region of an upper surface of the cylinder 3a. In the cylinder head 2, an intake port 2a and an exhaust port 2b open toward the combustion chamber 4, and an ignition plug 2g that emits a spark to the combustion chamber is provided. The ignition plug 2g is provided in a gasoline automobile internal combustion engine or the like, but in a case where the internal combustion engine 1 is a marine diesel internal combustion engine, the ignition plug 2g is not provided.

[0034] In the cylinder head 2 in FIG. 1, the intake port 2a communicates with an intake passage 2c, and the exhaust port 2b communicates with an exhaust passage 2d. The cylinder head 2 includes an intake valve 5 and an exhaust valve 6. The intake valve 5 and the exhaust valve 6 are reciprocally held by valve guides 2e and 2f attached to the cylinder head 2, respectively. The intake valve 5 and the exhaust valve 6 have a shape in which umbrella portions 5b and 6b of which diameters gradually increase are provided at one ends of shaft portions 5a and 6a, respectively. Hereinafter, the description will be made assuming that the shaft portions 5a and 6a of the intake valve 5 and the exhaust valve 6 are on the upper side, and the umbrella portions 5b and 6b are on the lower side. The intake port 2a and the exhaust port 2b are opened and closed by the umbrella portions 5b and 6b, respectively.

[0035] In the intake valve 5 and the exhaust valve 6 illustrated in FIG. 1, upper seats 5c and 6c are attached to the basal ends of the shaft portions 5a and 6a. In the cylinder head 2, lower seats 5d and 6d are provided at positions facing the upper seats 5c and 6c, and valve springs 5e and 6e that are compression springs are provided between the upper seats 5c and 6c and the lower seats 5d and 6d, respectively. When the intake valve 5 and the exhaust valve 6 are pushed by cams 7b and 8b rotated by cam shafts 7a and 8a, respectively, the umbrella portions 5b and 6b are lowered to open the intake port 2a and the exhaust port 2b, respectively. When the pressing by the cams 7b and 8b is released on the basis of the rotational positions, the umbrella portions 5b and 6b are lifted by the biasing force of the valve springs 5e and 6e, respectively, and close the intake port 2a and the exhaust port 2b. As a result, operations of “intake” in which only the intake port 2a is opened, “compression” and “combustion” in which both the intake port 2a and the exhaust port 2b are closed, and “exhaust” in which only the exhaust port 2b is opened are executed.

[0036] A fuel injection device (not illustrated) is provided in the cylinder head 2, and the fuel injection device injects an air-fuel mixture in which a fuel is turned into a fine mist from the intake passage 2c to the combustion chamber 4 at a timing of “suction”. In the “compression” step, the air-fuel mixture in the combustion chamber 4 is compressed, and the air-fuel mixture is exploded by fire with the ignition plug 301 (in a marine diesel internal combustion engine, by spontaneous ignition due to a high temperature in the combustion chamber 4), and the “combustion” step is executed, and in the exhaust stroke, the exhaust gas is discharged from the exhaust passage 2d.

[0037] Next, a valve mechanism of a marine internal combustion engine including an exhaust valve, which is a characteristic part of the present application, in a cylinder block will be described with reference to FIG. 1A. In FIG. 1A, description will be made by assuming that upper: lower: left: right =Up: Lo: Le: Ri indicated by the reference signs. FIG. 1A illustrates an exhaust valve mechanism 21 of a marine internal combustion engine. The exhaust valve mechanism 21 includes a cam shaft 22 having a cam 22a, a push rod 23, a rocker arm 24, a bridge arm 25, a pair of exhaust valves (26a, 26b), and a pair of compression coil springs (27a, 27b). An intake valve mechanism (not illustrated) is provided in a depth direction of the paper surface in FIG. 1A. The intake valve mechanism (not illustrated) includes a pair of intake valves instead of the pair of exhaust valves (26a, 26b), and has a configuration common to the exhaust valve mechanism 21 in addition to a configuration in which an installation angle of a cam in the cam shaft 22 is different from that of the cam 22a.

[0038] The exhaust valve mechanism 21 illustrated in FIG. 1A and the intake valve mechanism (not illustrated) are provided in a cylinder head 35, and the cylinder head 35 is mounted on a cylinder block (not illustrated) similarly to the internal combustion engine in FIG. 1, and configures a marine diesel internal combustion engine. Similarly to the internal combustion engine in FIG. 1, a cylinder block (not illustrated) is provided with a piston that is connected to a connecting rod and reciprocally slides due to the rotation of a crankshaft in a cylindrical cylinder. In the cylinder head 35, exhaust ports (28a, 28b) and intake ports (not illustrated) are open toward a combustion chamber 36. The exhaust ports (28a, 28b) include seat portions (29a, 29b) at an opening circumferential edge portion and communicate with an exhaust passage 30, and the intake ports (not illustrated) communicate with an intake passage (not illustrated).

[0039] As illustrated in FIG. 1A, the rocker arm 24 is swingably attached around a rocker shaft 24a provided in the cylinder head 35. The rocker arm 24 swings around the rocker shaft 24a by connecting a pivot portion 24c of a basal end 24b to the push rod 23 that moves up and down on the basis of the rotation of the cam 22a of the cam shaft 22. A distal end 24d of the rocker arm 24 abuts on the bridge arm 25 provided in the cylinder head 35 in a vertically movable state. The bridge arm 25 is connected to basal ends (26a1 and 26b1) of the exhaust valves (26a, 26b) on the left and right, and is biased to the distal end 24d of the upper rocker arm 24 by the compression coil springs (27a, 27b). The exhaust valves (26a, 26b) are held in a slidable state in valve insertion pipes (31a, 31b) of the cylinder head 35. The exhaust valves (26a, 26b) open the exhaust ports (28a, 28b) when the distal end 24d of the rocker arm 24 is lowered on the basis of a rotation aspect of the cam 22a.

[0040] In addition, the exhaust valves (26a, 26b) close the exhaust ports (28a, 28b) in a state in which face portions (26a2,26b2) come into contact with the seat portions (29a, 29b) of the cylinder head 35 when the distal end 24d of the rocker arm 24 receives an upward biasing force of the compression coil springs (27a, 27b) from the bridge arm 25 on the basis of a rotation aspect of the cam 22a. The intake valves (not illustrated) open and close intake ports (not illustrated) at a timing different from that of the exhaust valves (26a, 26b) on the basis of a rotation aspect of an intake cam (not illustrated) having an installation angle different from that of the exhaust cam 22a of the cam shaft

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[0041] Next, the intake valve 5 and the exhaust valve 6 used in the cylinder head 2 in FIG. 1 and the cylinder head 35 in FIG. 1A will be described with reference to FIGS. 2A and 2B. In the description, the shaft portions 5a and 6a sides will be referred to as basal end sides, and the umbrella portions 5b and 6b sides will be referred to as distal end sides. The exhaust valves (26a, 26b) in FIG. 1A and the intake valves not illustrated in FIG. 1A have substantially the same shape as that of the intake valve 5.

[0042] FIG. 2A illustrates the intake valve 5 used in the cylinder head 2. The intake valve 5 is a solid internal combustion engine valve made of metal, and is formed by the shaft portion 5a having a constant outer diameter and the umbrella portion 5b integrally formed on the distal end side of the shaft portion 5a. The umbrella portion 5b is configured to have a poppet shape formed by a neck portion 5b1 having a recessed curved shape of which a diameter increases toward the distal end, a face portion 5b2 having a notch shape that is integrally formed at the distal end of the neck portion and comes into contact with the opening circumferential edge portion of the intake port 2a illustrated in FIG. 1 to close the intake port 2a when the valve is closed, and an umbrella outer portion 5b3 having a constant outer diameter and is integrally formed at the distal end of the face portion 5b2.

[0043] FIG. 2B illustrates the exhaust valve 6 used in the cylinder head 2. The exhaust valve 6 is a hollow internal combustion engine valve made of metal having high heat resistance, and is formed by the shaft portion 6a having a constant outer diameter and the umbrella portion 6b integrally formed on the distal end side of the shaft portion 6a. The shaft portion 6a includes a shaft distal end 6a1 having a hollow portion 9 extending in the axial direction at the center, and a shaft basal end 6a2 joined to a basal end of the shaft distal end 6a1. The umbrella portion 6b is configured to have a poppet shape formed by a neck portion 6b1 integrally formed at the distal end of the shaft distal end 6a1 and having a recessed curved shape of which a diameter increases toward the distal end, a face portion 6b2 integrally formed at the distal end of the neck portion and having a notch shape that comes into contact with the opening circumferential edge portion of the exhaust port 2b illustrated in FIG. 1 to close the exhaust port 2b when the valve is closed, and an umbrella outer portion 6b3 integrally formed at the distal end of the face portion 6b2 and having a constant outer diameter.

[0044] As illustrated in FIG. 2B, the hollow portion 9 is formed to extend from the inside of the central portion of the shaft distal end 6a1 of the shaft portion 6a to the vicinity of the basal ends of the neck portion 6b1 and the face portion 6b2. The shaft distal end 6a1 is joined to the shaft basal end 6a2 through friction welding or the like in a state in which water (purified water 10) serving as a refrigerant is charged in a partial region of the hollow portion 9. The exhaust valve 6 is a heat pipe cooling type hollow valve, and when the valve 6 reciprocates in the axial direction in conjunction with driving of the engine, the cooling medium (water) in the hollow portion changes between a liquid phase and a gas phase, so that heat on the umbrella portion 6b side is transmitted to the shaft portion 6a side, that is, high heat due to the exhaust gas applied to the umbrella portion 6b can be released to the shaft portion 6a having a low temperature.

[0045] The inventors verified the heat dissipation effect of the exhaust valve through the dynamic heater ring test (see FIGS. 2AA to 2AC) in a case where a rotation speed of the automobile engine was set to 750 rpm, 1800 rpm, and 5200 rpm by using, as exhaust valves, a hollow valve (conventional technique) in which metallic sodium is loaded in the hollow portion and a heat pipe cooling type hollow valve in which water is loaded as a cooling medium in the hollow portion. As a result, it was confirmed that the latter (heat pipe cooling type hollow valve loaded with water) was superior in heat dissipation effect to the former (hollow valve loaded with metallic sodium) at any rotation speed. Specifically, the dynamic heater ring test was performed on three types of valves: a solid valve, a hollow valve loaded with metallic sodium (60% of the volume of the hollow portion is occupied by Na), and a heat pipe cooling type hollow valve loaded with water (24% of the volume of the hollow portion is occupied by purified water).

[0046] As a result, in a case where the rotation speed was 5200 rpm, the temperature of the umbrella surface of the latter (heat pipe cooling type hollow valve loaded with water) was reduced by 98°C from the temperature of the umbrella surface of the solid valve, but it was not much different from the reduction of the temperature of the umbrella surface of the former (hollow valve loaded with metallic sodium) (relative to the solid valve). On the other hand, in a case where the rotation speed was 750 rpm (1800 rpm), the temperature of the umbrella surface of the latter (heat pipe cooling type hollow valve loaded with water) was significantly lower than the temperature of the umbrella surface of the solid valve by 219°C (227°C). This reduction amount is much larger than about 50°C that is the temperature reduction on the umbrella surface (relative to the solid valve) of the former (hollow valve loaded with metallic sodium).

[0047] That is, it has been confirmed that there is no large difference in the temperature of the umbrella surface between the former and the latter as illustrated in FIG. 2AC at a high rotation speed (rotation speed of 5200 rpm) assumed to be used in an automobile engine, but there is a difference of slightly less than 200°C in the temperature of the umbrella surface between the former and the latter as illustrated in FIGS. 2AA and 2AB at a low rotation speed (750 rpm, 1800 rpm) assumed to be used in an automobile engine during low speed traveling or a marine engine (the latter valve has a better heat dissipation effect). As described above, the heat pipe cooling type exhaust valve exhibits a particularly excellent heat dissipation effect in an internal combustion engine operated at a low rotation speed, such as an automobile engine when traveling at a low speed in an urban area or a marine engine.

[0048] In the present embodiment, the hollow portion 9 is formed inside the shaft distal end 6a1 integrally formed with the neck portion 6b1, and after water 10 serving as a refrigerant is charged into the hollow portion 9, the hollow portion 9 is enclosed by joining the shaft basal end 6a2. However, in the exhaust valve, the shaft distal end 6a1, the shaft basal end 6a2, and the umbrella portion may be integrally formed, a hole (hollow portion) extending from the umbrella surface 6b4 side to the shaft end side may be bored, and after water 10 serving as a refrigerant is charged into the hole, a cap may be welded to an opening of the hole (hollow portion) to seal the hole (hollow portion). Further, the distal end of the hollow portion 9 illustrated in FIG. 2B may be an umbrella hollow portion having a shape of which the inner diameter gradually increases toward the distal end side inside the umbrella portion 6b.

[0049] On the other hand, as illustrated in FIGS. 2A and 2B, the axial lengths (dimensions from back surfaces Jr1 and jr2 of the respective end portions to umbrella surfaces 5b4 and 6b4 which are bottom surfaces of the umbrella portions (5, 6)) of the intake valve 5 and the exhaust valve 6 are L1 and L1+Δ. The respective outer diameters of the shaft portion 5a, the neck portion 5b1, and the face portion 5b2 of the intake valve 5 are formed to be the same as those of the shaft portion 6a, the neck portion 6b1, and the face portion 6b2 of the exhaust valve 6, and the outer diameters of the umbrella outer portions 5b3 and 6b3 are formed to have the same dimension d1.

[0050] In addition, in the cylinder head of the internal combustion engine of the present embodiment, by employing the heat pipe cooling type hollow exhaust valve using water as a refrigerant, the temperature of the umbrella surface of the exhaust valve can be significantly reduced, but there is a limit to the cooling (improvement of the heat dissipation effect) of the umbrella surface of the exhaust valve. Therefore, by using a structure that suppresses a decrease in the temperature of (the umbrella surface of) the intake valve formed of a solid body together, it is possible to effectively reduce a temperature difference (prevent the occurrence of knocking) between the regions of the region near the umbrella portions of both the intake and exhaust valves in the combustion chamber.

[0051] The respective umbrella outer portions (5b3, 6b3) of the intake valves (5, 6) illustrated in FIGS. 2A and 2B are portions exposed to the combustion chamber 4 when the valves are closed. In the intake valve 5 in FIG. 2A, the thickness of the umbrella outer portion 5b3 in the axial direction is smaller than that of the conventional intake valve, and the thickness is also smaller than that of the umbrella outer portion 6b3 of the exhaust valve 6 in FIG. 2B by the axial length Δ. However, the shapes (areas) of the face portions 5b2 and 6b2 do not change. As a result, the total length L1 of the intake valve 5 and the axial length J1 from the upper end of the face portion 5b2 to the umbrella surface 5b4 are configured to be shorter than the total length L1+Δ of the exhaust valve 6 and the axial length J2 from the upper end of the face portion 6b2 to the umbrella surface 6b4. As described above, since the umbrella portion 5b of the intake valve 5 has a smaller heat capacity than that of the conventional intake valve by making the umbrella outer portion 5b3 thinner than the umbrella portion 6b of the exhaust valve 6, the temperature increase of the umbrella surface 5b4 is promoted. That is, the umbrella portion 5b of the intake valve 5 is more easily heated than the umbrella portion of the conventional intake valve, so that the temperature of the region near the umbrella surface 5b4 of the intake valve 5 increases in the combustion chamber 4, and the temperature of the region near the umbrella surface 6b4 of the exhaust valve 6 is sufficiently reduced. Thus, a temperature difference between the umbrella surface vicinity regions of both the intake valve 5 and the exhaust valve 6 is reduced. As a result, according to the cylinder head 2 of the present embodiment, even when the cylinder head 2 is employed in an automobile engine or a marine engine using a decarbonized fuel including hydrogen, a region having a large temperature difference is less likely to occur in the combustion chamber 4 when the cylinder head 2 is operated at a low rotation speed, so that knocking due to preignition can be prevented. By reducing knocking when a decarbonized fuel including hydrogen is used, according to an automobile engine or a marine engine employing the cylinder head 2, torque is improved on the basis of ignition advance (an ignition timing is slightly advanced from the time at which a piston reaches the top dead center), and fuel efficiency is improved.

[0052] While the umbrella surface 6b4 of the exhaust valve 6 illustrated in FIG. 2B is subjected to the mirror surface processing, the umbrella surface 5b4 that is the bottom surface of the intake valve 5 illustrated in FIG. 2A is provided with a large number of minute protrusions 11 having a grid shape in a plan view, which are defined by a large number of intersecting grooves 12 illustrated in FIG. 3, over the entire umbrella surface 5b4. The grid-shaped protrusion 11 (outlined portion) in FIG. 3 is formed in a portion surrounded by four intersecting grooves by a large number of orthogonal intersecting grooves (black portions) 12 formed in a recessed shape on the umbrella surface 5b4. The umbrella surface 6b4 of the exhaust valve 6 configured as a mirror surface reflects infrared rays, so that a temperature increase is suppressed due to a decrease in radiant heat transmitted from the combustion chamber 4 in FIG. 1 to the umbrella surface 6b4. In addition, it is desirable to form as many protrusions 11 as possible by providing as many intersecting grooves 12 as possible.

[0053] Since the bottom surface of the umbrella portion 5b in the intake valve 5 illustrated in FIG. 3, that is, the umbrella surface 5b4 has more grid-shaped protrusions 11 formed of the plurality of intersecting grooves 12, the surface area of the umbrella surface 5b4 is enlarged, and the umbrella portion in the intake valve 5 easily receives heat from a high-temperature exhaust gas in the combustion chamber 4. As a result, the umbrella portion 5b of the intake valve 5 is more easily heated, so that the temperature difference between the regions near the umbrella surface 5b4 and 6b4 of both the intake valve 5 and the exhaust valve is reduced in the combustion chamber 4, and a hot spot is less likely to occur in the combustion chamber 4. Therefore, knocking due to preignition is reduced even when a decarbonized fuel including hydrogen is used.

[0054] FIG. 4 illustrates a modification of the umbrella surface (the bottom surface of the umbrella portion) of the intake valve provided with a plurality of grid-shaped minute protrusions 13. In the umbrella surface of the intake valve, a plurality of rhombic grid-shaped protrusions 13 are provided by forming a plurality of recessed intersecting grooves 14 to intersect at an acute angle or an obtuse angle as illustrated in FIG. 4 instead of the plurality of orthogonal recessed intersecting grooves 12 illustrated in FIG. 3. It is also desirable to form as many protrusions 13 as possible by providing as many intersecting grooves 14 as possible. Note that a shape of a plurality of grid-shaped protrusions formed on the umbrella surface of the intake valve is not limited to a rectangular shape or a rhombic shape as long as the plurality of grid-shaped protrusions are formed by a plurality of recessed intersecting grooves that intersect each other.

[0055] Further, in FIGS. 3 and 4, on the umbrella surface (the bottom surface of the umbrella portion 5b) of the intake valve 5, the first grooves formed in parallel at equal intervals and the second grooves formed in parallel at equal intervals extend to intersect each other, the minute protrusions (grid-shaped protrusions) having a rectangular shape in a plan view defined by the first and second grooves are continuous along the grooves, and the minute protrusions are uniformly dispersedly arranged on the entire umbrella surface (the bottom surface of the umbrella portion 5b) of the intake valve 5. However, a depth of the grooves, a width of the grooves, and an interval between the grooves (a pitch of the grooves) are not limited.

[0056] FIGS. 5A and 5B illustrate an intake valve 5’ in which, in the umbrella surface 5b4 of the umbrella portion 5b of the intake valve 5 illustrated in FIG. 2A, projecting strip portions 37 configured as a plurality of longitudinal sectional wave-shaped projecting strip portions are provided on the entire bottom surface instead of the grid-shaped protrusion 11 formed by the plurality of intersecting grooves 12. An axial length from an upper end of a face portion 5b2’ of an umbrella portion 5b′ to a lower end of a projecting strip portion 37 is J1, which is the same as that of the intake valve 5.

[0057] As illustrated in FIG. 5B, the projecting strip portion 37 includes a plurality of annular projections provided concentrically. As illustrated in FIG. 5A, the umbrella surface 5b4′ of the umbrella portion 5b′ has a wave shape in which a curved projecting portion and a curved recessed portion alternately repeat in the longitudinal section. Similar to the umbrella surface 5b4, the umbrella surface 5b4′ also has an increased surface area and easily receives heat from a high-temperature exhaust gas, and thus it is possible to reduce a temperature difference with the region near the umbrella portion of the exhaust valve.

[0058] As illustrated in FIGS. 5A and 5B, the umbrella surface 5b4 of the umbrella portion 5b of the intake valve 5 is formed in a longitudinal sectional wave shape in which annular irregularities are continuous concentrically, a depth (height) of the curved recess (curved projection) and a pitch of the curved recess (curved projection) are set to predetermined values, and the surface area (heat receiving area) of the umbrella surface 5b4′ is enlarged. However, a depth (height) of the curved recess (curved projection) and a pitch of the curved recess (curved projection) are not limited. In the intake valve 5 in the present embodiment, the umbrella portion 5b is thinned as illustrated in FIG. 2A, and the protrusion 11 (or the projecting strip portion 37 in FIG.

4) is provided on the umbrella surface 5b4 as illustrated in FIG. 3. However, in the intake valve 5, the umbrella portion 5b may be thinned without providing the protrusion 11 (or the projecting strip portion 37) on the umbrella surface 5b4, or the protrusion 11 (or the projecting strip portion 37) may be provided on the umbrella surface 5b4 without thinning the umbrella portion 5b.

Reference Signs List

[0059] 1 Internal combustion engine

2 Cylinder head

2a Intake port

2b Exhaust port

3 Cylinder block

3b Crankshaft

3c Piston

3e Connecting rod

4 Combustion chamber

5 Intake valve

5b Umbrella portion

5b1 Neck portion

5b2 Face portion

5b4 Umbrella surface (bottom surface) of umbrella portion 5b

6 Exhaust valve

6b Umbrella portion

6b1 Neck portion

6b2 Face portion

6b4 Umbrella surface (bottom surface) of umbrella portion 6b

9 Hollow portion

10 Purified water which is water

J1 Axial length from upper end of face portion 5b2 to umbrella surface 5b4

J2 Axial length from upper end of face portion 6b2 to umbrella surface 6b4

**CLAIMS**

1. A cylinder head of an internal combustion engine comprising:

a poppet-type intake valve and exhaust valve each having an umbrella portion formed on a shaft end side and configured to respectively open and close an intake port and an exhaust port that are open to a combustion chamber, wherein

the cylinder head uses a decarbonized fuel including hydrogen,

the exhaust valve includes a refrigerant-containing hollow valve in which water is enclosed as a refrigerant in a hollow portion extending from the umbrella portion to the shaft end side, and

the intake valve includes a solid valve in which a large number of protrusions having a grid shape in a plan view defined by a large number of intersecting grooves are provided on an entire bottom surface of the umbrella portion.

2. A cylinder head of an internal combustion engine comprising:

a poppet-type intake valve and exhaust valve each having an umbrella portion formed on a shaft end side and configured to respectively open and close an intake port and an exhaust port that are open to a combustion chamber, wherein the cylinder head uses a decarbonized fuel including hydrogen,

the exhaust valve includes a refrigerant-containing hollow valve in which water is enclosed as a refrigerant in a hollow portion extending from the umbrella portion to the shaft end side, and

the intake valve includes a solid valve in which a plurality of longitudinal sectional wave-shaped projecting strip portions that are continuous concentrically are provided on an entire bottom surface of the umbrella portion.

3. A cylinder head of an internal combustion engine comprising:

a poppet-type intake valve and exhaust valve each having an umbrella portion formed on a shaft end side and configured to respectively open and close an intake port and an exhaust port that are open to a combustion chamber, wherein

the cylinder head uses a decarbonized fuel including hydrogen,

the exhaust valve includes a refrigerant-containing hollow valve in which water is enclosed as a refrigerant in a hollow portion extending from the umbrella portion to the shaft end side, and the intake valve includes a solid valve of which an umbrella portion is formed to be thinner than the umbrella portion of the exhaust valve.

4. The cylinder head of the internal combustion engine according to claim 3, wherein the entire bottom surface of the umbrella portion of the intake valve is provided with protrusions having a grid shape in a plan view defined by a large number of intersecting grooves or projecting strip portions having a longitudinal sectional wave shape and continuing concentrically.

5. The cylinder head of the internal combustion engine according to any one of claims 1 to 4, wherein the bottom surface of the exhaust valve is a mirror surface.

6. The cylinder head of the internal combustion engine according to any one of claims 1 to 5, wherein the internal combustion engine is a marine engine.

7. An internal combustion engine comprising:

a cylinder block having, inside, a piston reciprocally held in a cylinder, a crankshaft rotatably held, and a connecting rod rotatably connected to both the piston and the crankshaft to convert reciprocating motion of the piston into rotational motion; and the cylinder head according to any one of claims 1 to 6, which is fixed to the cylinder block and forms a combustion chamber with an inner side of the cylinder.

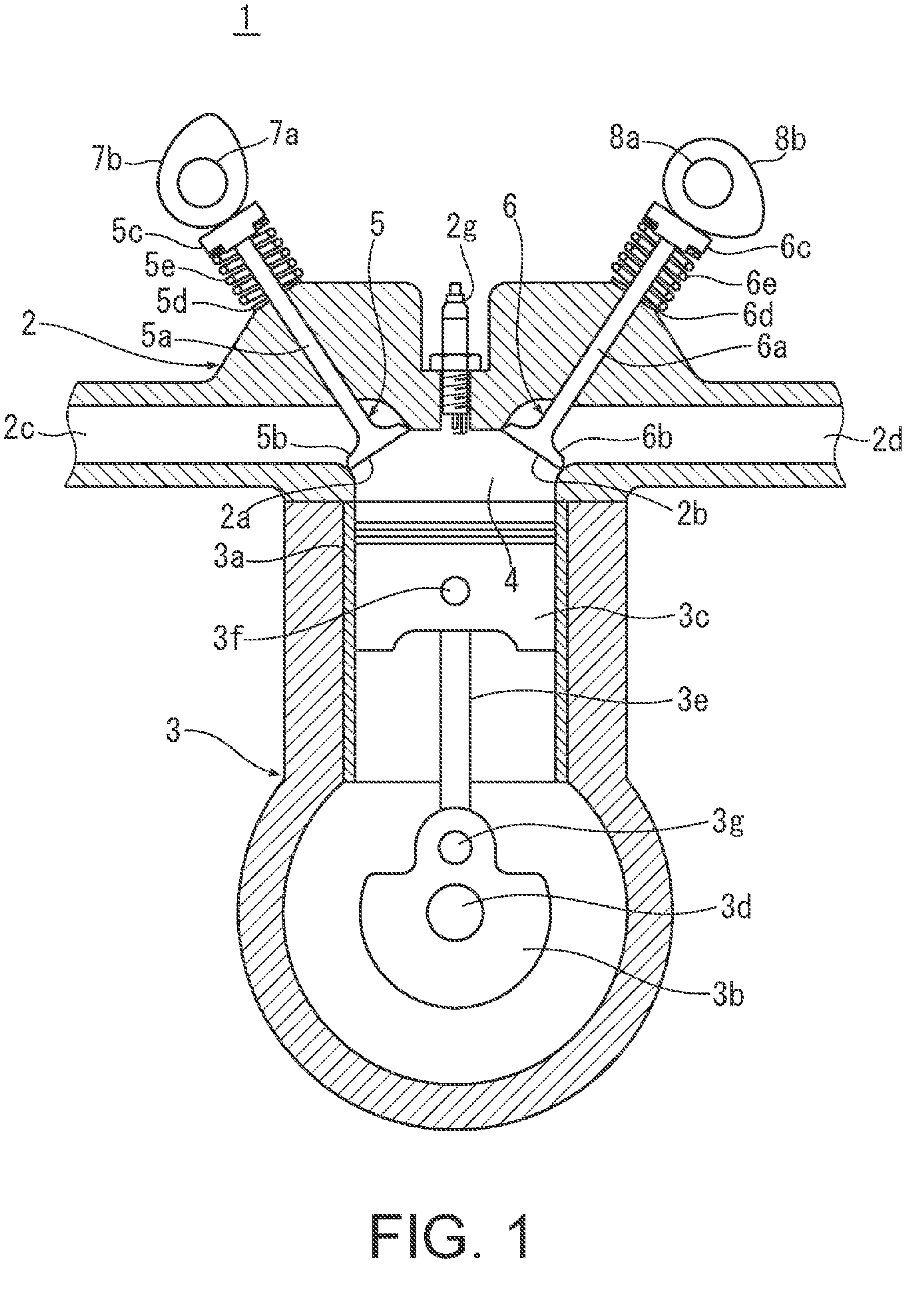
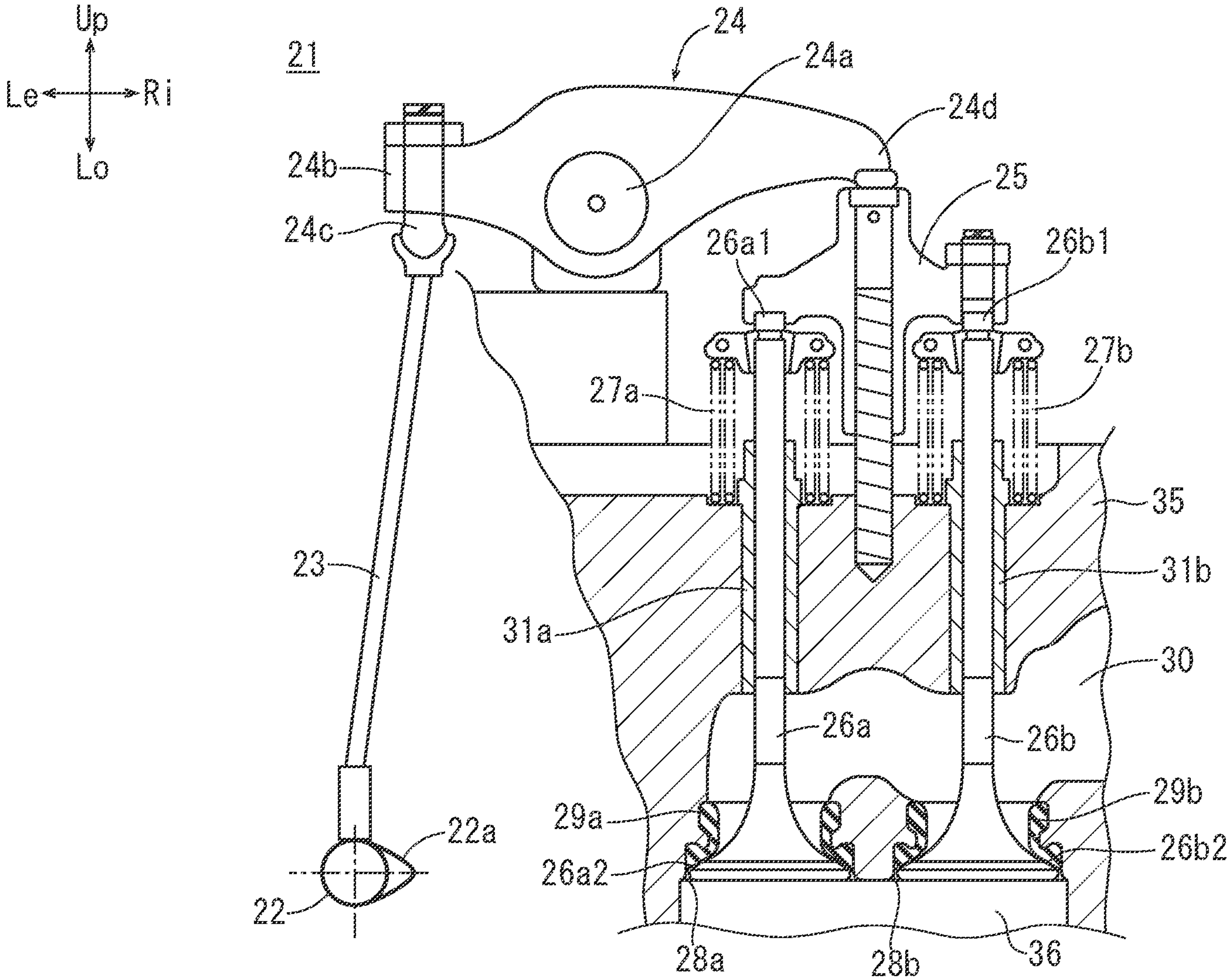

1
7a
7b
8a
8b
5c
5e
5d
5
2g
6
6c
6e
6d
2
5a
6a
2c
5b
6b
2d
2a
2b
3a
4
3f
3c
3e
3
3g
3d
3b

FIG. 1


Up
Le
Ri
Lo
21
24
24a
24d
25
24b
24c
26a1
26b1
27a
27b
35
23
31a
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26b
29a
29b
26a2
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22a
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28a
28b
36

FIG. 1A

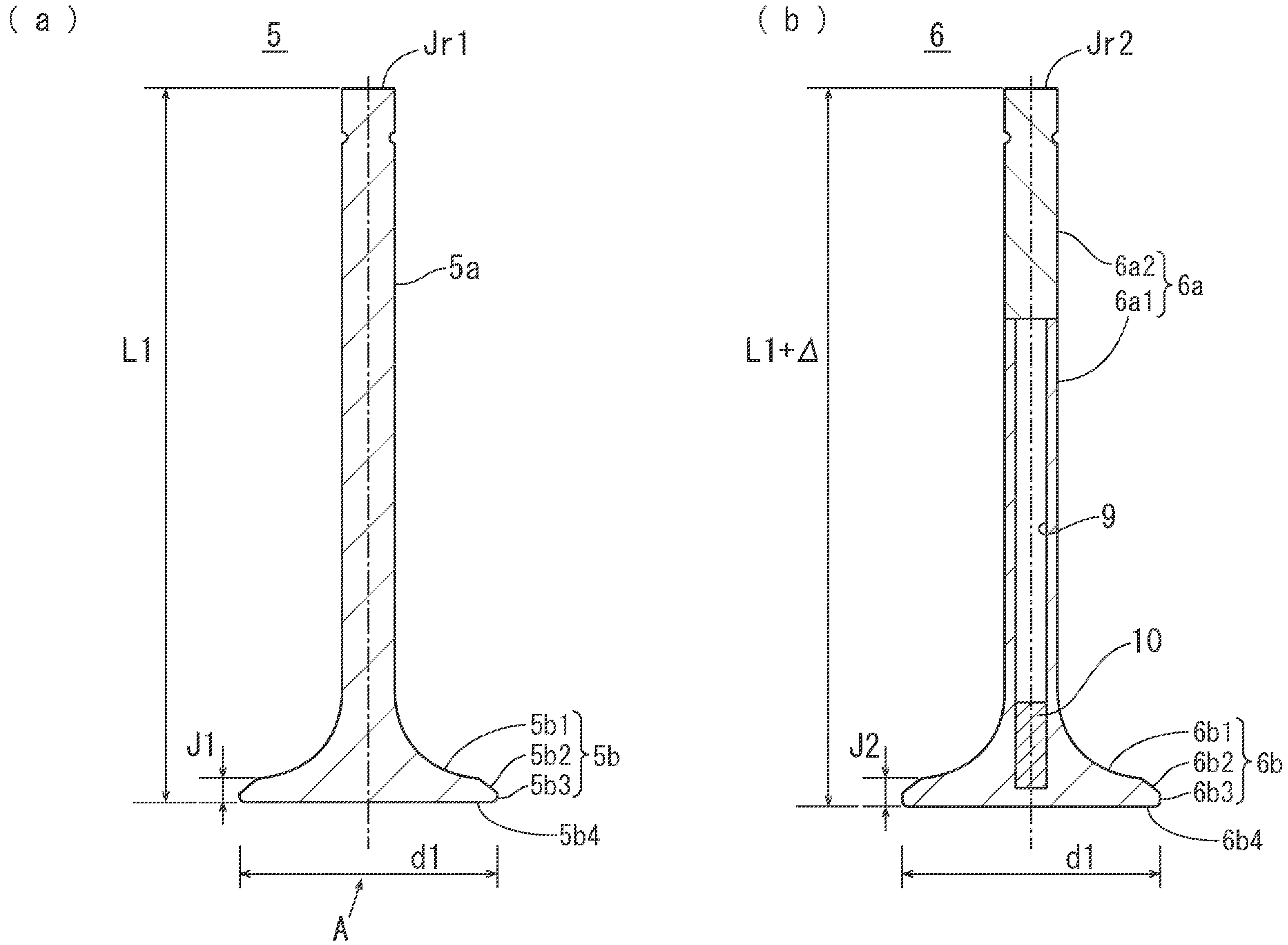
(a)
5
Jr1
5a
L1
5b1
5b2
5b3
5b
J1
5b4
d1
A
(b)
6
Jr2
6a2
6a1
6a
L1+Δ
9
10
6b1
6b2
6b3
6b
J2
6b4
d1

FIG. 2

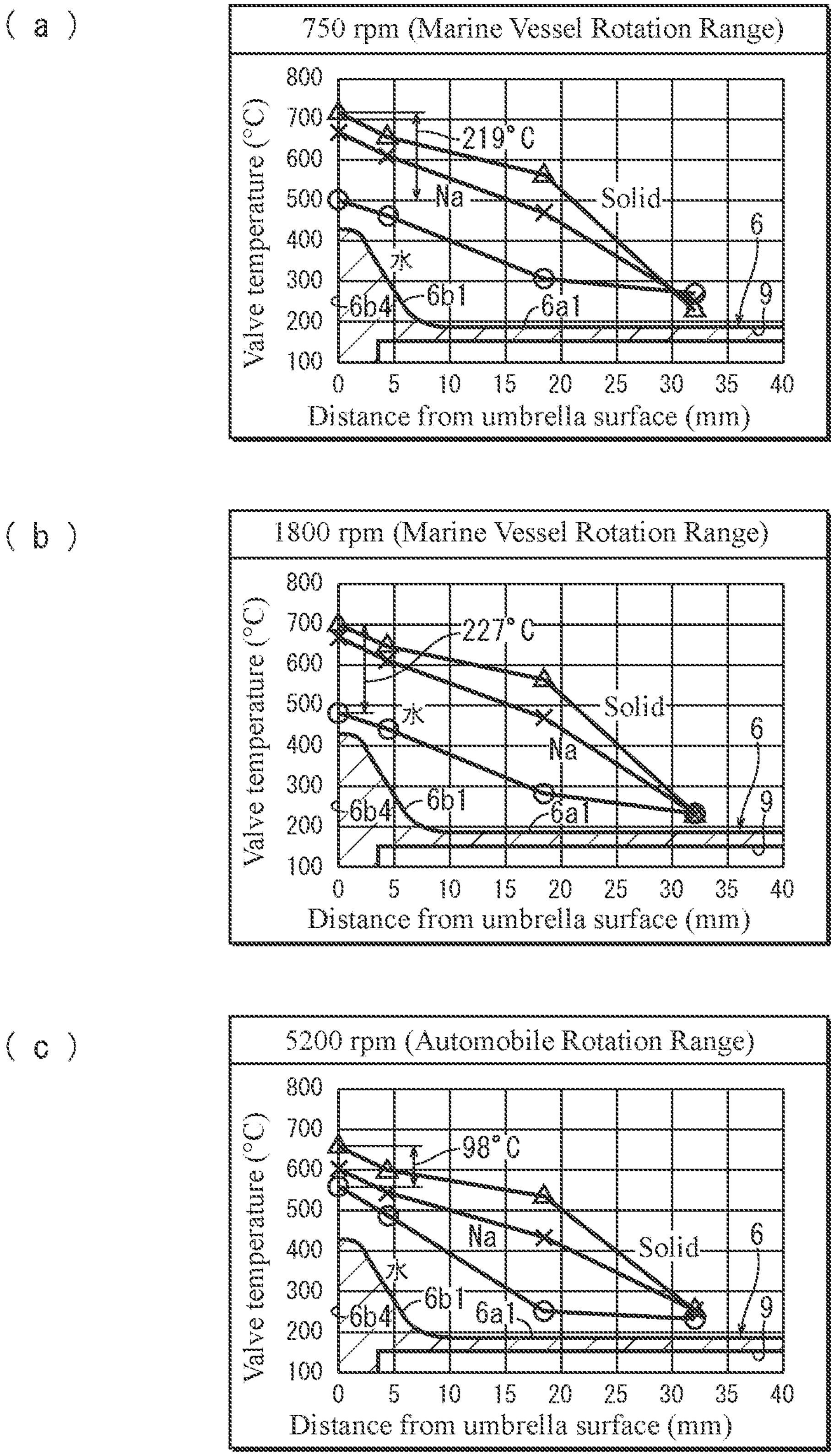


FIG. 2A

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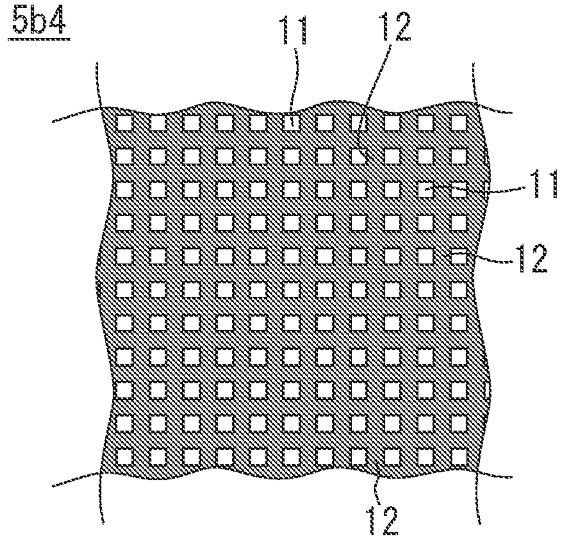


FIG. 3

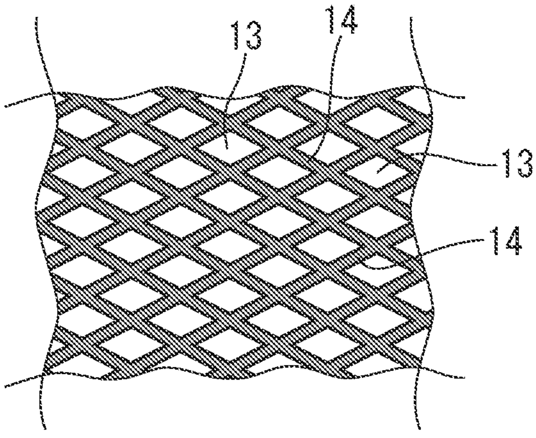


FIG. 4

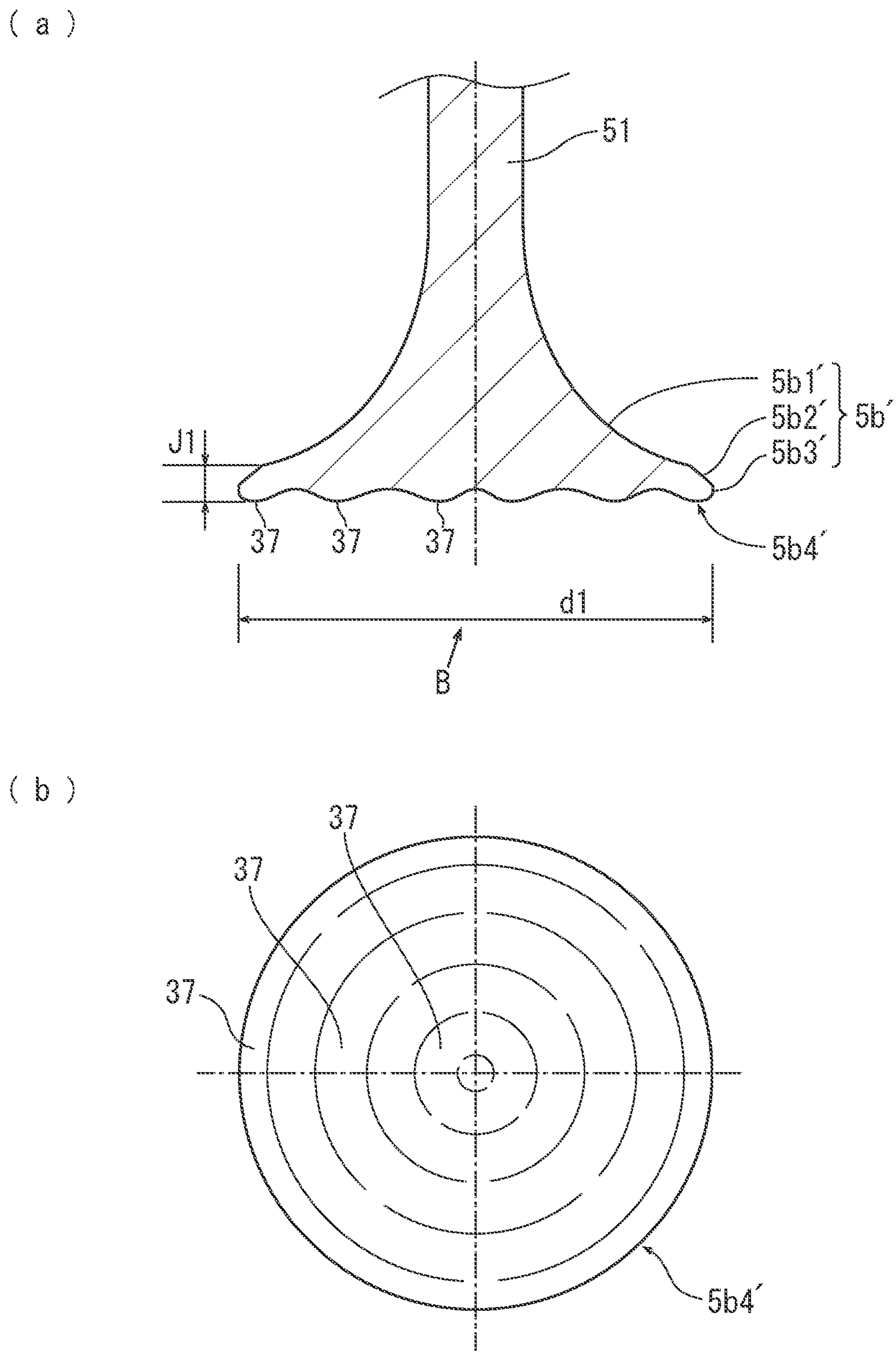


FIG. 5