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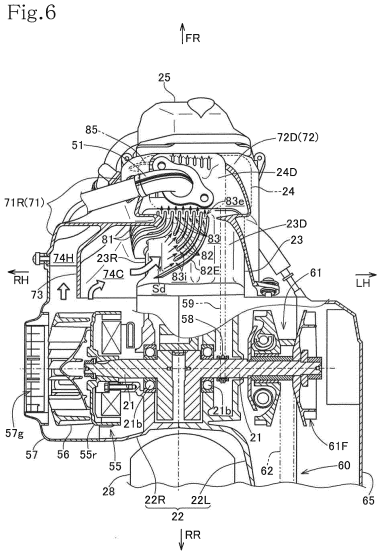
(54) AIR-COOLED INTERNAL COMBUSTION ENGINE

(57) Provided is an air-cooled internal combustion engine capable of thoroughly cooling a cylinder block and a cylinder head and capable of particularly efficiently cooling an extension portion of an exhaust pipe extending from the cylinder head where heat generation is intense. In the air-cooled internal combustion engine, a centrifugal cooling fan 56 is secured to one end of a crankshaft 21, and a cylinder block 23 and a cylinder head 24 are surrounded by a shroud 70. In the internal combustion engine, an exhaust-side cylinder side surface 23D of the cylinder block 23 is formed with a plurality of air-guiding cooling fins 82 arranged in parallel, with air-guiding grooves 83 formed between adjacent ones of the air-guiding cooling fins 82, the air-guiding grooves 83 each have a structure in which an inlet port 83i is opened in the direction toward a fan-side side edge 23Dr of the exhaust-side cylinder side surface 23D, while an outlet port 83e is opened in the direction toward the exhaust-side head side surface 24D, and each of the air-guiding grooves 83 communicates from the inlet port 83i to the outlet port 83e.

Fig.6



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Description

[Technical Field]

[0001] The present invention relates to an air-cooled internal combustion engine in which a cooling airflow is fed into a shroud by a cooling fan connected directly to a crankshaft, to cool a cylinder block and a cylinder head.

[Background Art]

[0002] An air-cooled internal combustion engine having a cylinder block and a cylinder head surrounded by a shroud, wherein a cooling airflow is fed into the shroud by the rotation of a cooling fan secured to an end of a crankshaft, to forcibly cool the cylinder block and the cylinder head, has been well known, as described in PATENT DOCUMENT 1, for example.

[Prior Art Document]

[Patent Document]

[0003] [Patent Document 1] JP H7-253019 A

[0004] The air-cooled internal combustion engine disclosed in PATENT DOCUMENT 1 is mounted on a two-wheeled motor vehicle, with the crankshaft oriented in the left-right or vehicle width direction, and the cylinder block and the cylinder head extend forward from a crankcase in the state of being sequentially stacked.

[0005] An intake pipe extends upward from an upper side surface of the cylinder head, and an exhaust pipe extends downward from a lower side surface of the cylinder head.

[0006] A centrifugal cooling fan is secured to a right end of the crankshaft.

[0007] The cylinder block and the cylinder head are surrounded by the shroud, a fan cover covering the centrifugal cooling fan from a lateral side is connected to the shroud, and a cooling airflow is fed into the shroud by the centrifugal cooling fan, to cool the cylinder block and the cylinder head.

[0008] A left side surface and a lower side surface of the cylinder block are formed with cooling fins oriented in a circumferential direction, a right side surface where the centrifugal cooling fan is provided is formed with cooling fins curved forward and downward, and an upper side surface is formed with cooling fins inclined such as to form V-shapes together with the curved cooling fins.

[0009] Therefore, most part of the cooling airflow generated by the rotation of the centrifugal cooling fan is guided from the fan cover by the shroud to be sent to the upper region of the right side surface of the cylinder block, and is divided into a flow along the upper side surface and a flow along the right side surface of the cylinder block.

[0010] The cooling airflow on one side which is divided toward the upper side surface of the cylinder block is guided by the inclined cooling fins, to go around from the upper side surface to the left side surface of the cylinder head and further go around to the lower side surface.

[0011] The cooling airflow on the other side which is divided toward the right side surface of the cylinder block is sent to the lower side surface of the cylinder block by the inclined cooling fins, and is caused to flow near the lower side surface toward the left side surface of the cylinder block by the cooling fins oriented in the circumferential direction, to go around to the left side surface.

[Summary of the Invention]

[Underlying Problem to be solved by the Invention]

[0012] In the air-cooled internal combustion engine disclosed in PATENT DOCUMENT 1, the cooling airflow generated by the rotation of the centrifugal cooling fan passes as described above to cool the cylinder block and the cylinder head. However, an extension portion of the exhaust pipe extending from the cylinder head where heat generation is intense is located at the lower side surface of the cylinder head, and is cooled through a process in which the cooling airflow sent to the upper side surface of the cylinder block goes around from the upper side surface to the left side surface and, further, to the lower side surface of the cylinder head. Therefore, the distance of travel until the cooling airflow reaches the extension portion of the exhaust pipe is long, and the extension portion is cooled by the cooling airflow raised in temperature due to the heating during the traveling. Accordingly, there is a need for a structure for cooling the extension portion of the exhaust pipe more effectively.

[0013] The present invention has been made in consideration of such a point. It is therefore an object of the present invention to provide an air-cooled internal combustion engine which is capable of thoroughly cooling a cylinder block and a cylinder head and is capable of efficiently cooling particularly an extension portion of an exhaust pipe extending from the cylinder head where heat generation is intense.

[Means to solve the Underlying Problem]

[0014] In order to achieve the above object, according to the present invention, there is provided an air-cooled internal combustion engine in which: a cylinder block provided with cooling fins and a cylinder head extend in a sequentially stacked manner from a crankcase rotatably supporting a crankshaft, in a direction perpendicular to an axis of the crankshaft; a centrifugal cooling fan is secured to one end of the crankshaft; an intake pipe and an exhaust pipe extend from side surfaces of the cylinder head on opposite upper and lower sides; the cylinder block and the cylinder head are surrounded by a shroud; and a fan cover covering the centrifugal cooling fan from a lateral side is connected to the shroud, in such manner

that a cooling airflow is fed into the shroud by the centrifugal cooling fan to cool the cylinder block and the cylinder head; characterized in that:

the cylinder block has an exhaust-side cylinder side surface continuous with an exhaust-side head side surface, which is a lower side surface of the cylinder head from which the exhaust pipe extends, the exhaust-side cylinder side surface being provided with a plurality of air-guiding cooling fins arranged in parallel, with air-guiding grooves formed between adjacent ones of the air-guiding cooling fins; and
the plurality of the air-guiding grooves formed by the air-guiding cooling fins each have a structure in which an inlet port is opened in a direction toward a fan-side side edge of the exhaust-side cylinder side surface on the same side as the end of the crankshaft to which the centrifugal cooling fan is secured, while the air-guiding grooves each have an outlet port opened in a direction toward the exhaust-side head side surface, each of the air-guiding grooves communicating from the inlet port to the outlet port.

[0015] According to this configuration, the cooling airflow generated by the rotation of the centrifugal cooling fan is sent to the fan-side cylinder side surface of the cylinder block and, further, to the side surface (fan-side head side surface) of the cylinder head that is continuous with the fan-side cylinder side surface, and most part of the cooling airflow sent to the fan-side cylinder side surface is caused by the shroud to go around the fan-side side edge from the fan-side cylinder side surface to the exhaust-side cylinder side surface, to be guided into the inlet ports of the air-guiding grooves formed by the air-guiding cooling fins on the exhaust-side cylinder side surface, to be guided into the air-guiding grooves and to flow out through the outlet ports to the exhaust-side head side surface. Therefore, the cooling airflow is blown toward the extension portion of the exhaust pipe extending from the exhaust-side head side surface, whereby the extension portion of the exhaust pipe where heat generation is intense can particularly be cooled positively and efficiently.

[0016] In addition, part of the cooling airflow sent to the fan-side cylinder side surface and the fan-side head side surface of the cylinder head flows to side surfaces on the side of the intake pipe of the cylinder block and the cylinder head and, further, goes around to the side surface on the side opposite to the fan side. For this reason, the cylinder block and the cylinder head are cooled thoroughly.

[0017] In the above-mentioned configuration, the air-guiding cooling fins may be curved in an arcuate shape, and the air-guiding grooves may be curved in an arcuate shape from the inlet port to the outlet port.

[0018] Since the air-guiding grooves of the exhaust-side cylinder side surface are curved in an arcuate shape from the inlet ports to the outlet ports, the resistance to the cooling airflows introduced into the inlet ports is restrained, and the cooling airflows can flow out smoothly through the outlet ports by being changed in flow direction, whereby the extension portion of the exhaust pipe can be cooled with an increased efficiency.

[0019] In the above-mentioned configuration, air-guiding cooling fins with upstream end portions may include an outermost-side air-guiding cooling fin with an upstream end portion which is farthest from the cylinder head and located at an end edge of the exhaust-side cylinder side surface on the side of the crankcase, and the outermost-side air-guiding cooling fin may have a downstream end portion located at an end edge of the exhaust-side cylinder side surface on the side of the cylinder head.

[0020] According to this configuration, the outermost-side air-guiding cooling fin whose upstream end portion is farthest from the cylinder head, of the plurality of air-guiding cooling fins, has its upstream end portion located on the end edge of the exhaust-side cylinder side surface on the crankcase side, and has its downstream end portion located on the end edge of the exhaust-side cylinder side surface on the side of the cylinder head. Therefore, the cooling airflow going around from the fan-side cylinder side surface to the exhaust-side cylinder side surface can be efficiently taken in by the outermost-side air-guiding cooling fin, while reducing leakage, and the cooling airflow can be made to flow out to the exhaust-side head side surface by the air-guiding grooves of the plurality of air-guiding cooling fins. Accordingly, the extension portion of the exhaust pipe extending from the exhaust-side head side surface can be cooled with increased efficiency.

[0021] In the above-mentioned configuration, the air-guiding cooling fins except the outermost-side air-guiding cooling fin may have upstream end portions spaced from the fan-side side edge of the exhaust-side cylinder side surface by predetermined distances, respectively.

[0022] According to this configuration, the air-guiding cooling fins except the outermost-side air-guiding cooling fin have their upstream end portions spaced from the fan-side side edge of the exhaust-side cylinder side surface by the predetermined distances, respectively. Therefore, the exhaust-side cylinder side surface is formed on the side of the fan-side side edge with a space where no cooling fin is present, the space being surrounded by the outermost-side air-guiding cooling fin. For this reason, the cooling airflow going around the side of the fan-side side edge from the fan-side cylinder side surface to the exhaust-side cylinder side surface can be efficiently taken into this space, and can be made to flow into the curved air-guiding grooves. Consequently, the extension portion of the exhaust pipe can be cooled with increased efficiency.

[0023] In the above-mentioned configuration, the fan-side cylinder side surface, which is a side surface of the cylinder block on the same side as the end of the crankshaft to which the centrifugal cooling fan is secured, may

not be formed with the cooling fins, except in a region on the side of the cylinder head.

[0024] According to this arrangement, on the fan-side cylinder side surface of the cylinder block, the cooling fins are not formed, except the side of the region on the cylinder head. Therefore, the cooling airflow sent to the fan-side cylinder side surface by the rotation of the centrifugal cooling fan can be effectively taken into that space on the fan-side cylinder side surface in which the cooling fins are not formed. The airflow can be caused to flow along the part of the fan-side cylinder side surface in which the cooling fins are not formed, and to go around the fan-side side edge to the exhaust-side cylinder side surface, so that a sufficient quantity of the cooling airflow can be introduced into the air-guiding grooves and can be blown to the extension portion of the exhaust pipe, whereby the extension portion of the exhaust pipe can be cooled with increased effectiveness.

[0025] In the above-mentioned configuration, an exhaust-side inner surface of the shroud, facing the exhaust-side cylinder side surface of the cylinder block, may be formed with air-guiding ribs extending along the air-guiding grooves formed by the air-guiding cooling fins.

[0026] According to this configuration, the exhaust-side inner surface of the shroud is also formed with the air-guiding ribs extending along the air-guiding grooves formed by the air-guiding cooling fins. Therefore, by the cooperation of the air-guiding cooling fins of the cylinder block and the air-guiding ribs of the shroud, the cooling airflow having gone around to the exhaust-side cylinder side surface can be guided by the shroud, can be caused to flow out to the exhaust-side head side surface, and can be blown toward the extension portion of the exhaust pipe. For this reason, it is possible to eliminate a plurality of the air-guiding cooling fins of the cylinder block, so that forming of the cylinder block is facilitated, and heat cracking at the time of forming can be prevented.

[0027] In the above-mentioned configuration, the air-guiding ribs and the air-guiding cooling fins may be arranged alternately with each other.

[0028] According to this configuration, the air-guiding ribs and the air-guiding cooling fins are arranged alternately with each other, whereby the air-guiding ribs can be efficiently arranged in relation to the air-guiding cooling fins.

[0029] In the above-mentioned configuration, an air-guiding partition wall for guiding the cooling airflow respectively to the cylinder head and the cylinder block may be formed inside a side portion of the shroud to which the fan cover is connected.

[0030] According to this configuration, the cooling airflow fed by the rotation of the centrifugal cooling fan is divided by the air-guiding partition wall and generally guided respectively to the cylinder block and the cylinder head. Therefore, a cooling airflow is sufficiently secured which is sent only to the fan-side cylinder side surface of the cylinder block without flowing to the side of the cylinder head. This sufficient quantity of cooling airflow goes around to the exhaust-side cylinder side surface and is blown to the extension portion of the exhaust pipe by the air-guiding grooves, whereby a cooling effect can be enhanced.

[Advantageous Effects of Invention]

[0031] According to the present invention, the exhaust-side cylinder side surface of the cylinder block is formed with the plurality of air-guiding cooling fins arranged in parallel, and the air-guiding grooves formed between adjacent ones of the air-guiding cooling fins each have a structure in which the inlet port is opened in the direction toward the fan-side side edge of the exhaust-side cylinder side surface, while the outlet port is opened in the direction toward the exhaust-side head side surface, and the air-guiding groove communicates from the inlet port to the outlet port.

[0032] Therefore, the cooling airflow generated by the rotation of the centrifugal cooling fan is sent to the fan-side cylinder side surface of the cylinder block and, further, to the side surface (fan-side head side surface) of the cylinder head that is continuous with the fan-side cylinder side surface, and most part of the cooling airflow sent to the fan-side cylinder side surface is caused by the shroud to go around the fan-side side edge from the fan-side cylinder side surface to the exhaust-side cylinder side surface, to be guided into the inlet ports of the air-guiding grooves formed by the air-guiding cooling fins on the exhaust-side cylinder surface, to be guided into the air-guiding grooves and to flow out through the outlet ports to the exhaust-side head side surface. For this reason, the cooling airflow is blown toward the extension portion of the exhaust pipe extending from the exhaust-side head side surface, whereby the extension portion of the exhaust pipe where heat generation is intense can particularly be cooled positively and effectively.

[0033] In addition, part of the cooling airflow sent to the fan-side cylinder side surface and the fan-side head side surface of the cylinder head flows to the side surfaces on the side of the intake pipe of the cylinder block and the cylinder head, and is further guided by the shroud to go around to the side surface on the side opposite to the fan side. Therefore, the cylinder block and the cylinder head are cooled thoroughly.

[Brief Description of Drawings]

[0034]

FIG. 1 is a general right side view of a two-wheeled motor vehicle on which is mounted an air-cooled internal combustion engine according to an embodiment of the present invention;

FIG. 2 is a left side view of a power unit mounted on the two-wheeled motor vehicle;

FIG. 3 is a right side view of the power unit;

FIG. 4 is a front view of the power unit;

FIG. 5 is a bottom view of a lower portion of the internal combustion engine of the power unit;
FIG. 6 is a bottom view in which part of the internal combustion engine is depicted in section and a shroud is cut away;
FIG. 7 is a right side view of the internal combustion engine in which a fan cover and the shroud are cut away;
FIG. 8 is a perspective view of a cylinder block;
FIG. 9 is a bottom view of the cylinder block; and
FIG. 10 is a sectional view of the cylinder block and the shroud, taken along arrows X-X of FIG. 5.

[Mode for carrying out the Invention]

[0035] An embodiment of the present invention will be described below with reference to FIGS. 1 to 9.

[0036] A scooter-type two-wheeled motor vehicle 1 on which an air-cooled internal combustion engine according to the present embodiment is mounted is depicted in FIG. 1.

[0037] Note that herein the forward, rearward, leftward, rightward, upward and downward directions conform to an ordinary standard in which the straight forward running direction of the two-wheeled motor vehicle 1 relating to the present embodiment is the forward direction; thus, in the drawings, FR indicates the front side, RR the rear side, LH the left-hand side, RH the right-hand side, UP the upper side, and DW indicates the lower side.

[0038] A vehicle body front portion 1F and a vehicle body rear portion 1R are interconnected through a low floor portion 1C, and a body frame constituting a skeleton of a vehicle body is composed generally of a down tube 3 and main pipes 4.

[0039] Specifically, the down tube 3 extends downward from a head pipe 2 of the vehicle body front portion 1F, the down tube 3 is bent at its lower end to be horizontal and extends rearward under the floor portion 1C, the pair of left and right pipes 4 are connected to a rear end of the down tube 3, the main pipes 4 form slant portions 4a extending obliquely rearwardly upward from the connection part, and upper portions of the slant portions 4a are further bent to form horizontal portions 4b extending substantially horizontally toward the rear side.

[0040] Between the pair of main pipes 4, an accommodation box 5 and a fuel tank 6 are supported on the front and rear sides, and a seat 7 is disposed to cover the upper side of the accommodation box 5 and the fuel tank 6.

[0041] On the other hand, at the vehicle body front portion 1F, a handlebar 8 is provided on the upper side while being turnably supported by the head pipe 2, a front fork 9 extends downward, and a front wheel 10 is rotatably supported on a lower end of the front fork 9.

[0042] Support brackets 11 are provided at front end portions of the main pipes 4 in a manner to project rearward, and a power unit P is oscillatably connected to and supported by the support bracket 11 through link members 12.

[0043] Referring to FIGS. 2 and 3, the power unit P is provided at a front portion thereof with a single-cylinder four-stroke air-cooled internal combustion engine 20. The internal combustion engine 20 is provided in such a manner that a cylinder block 23, a cylinder head 24 and a cylinder head cover 25 sequentially stacked from a crankcase 22, which supports a crankshaft 21 in an orientation in the vehicle width direction, are forwardly projected in the posture of being largely inclined forward to such a state as to be nearly horizonal. End portions of a pair of left and right engine hangers 22h projecting forward from a lower portion of the crankcase 22 are connected to the link members 12 through a pivot shaft 13.

[0044] Referring to FIG. 6, which is a bottom view in which part of the internal combustion engine 20 is depicted in section and the shroud is cut away, the crankcase 22 is composed of a left crankcase portion 22L and a right crankcase portion 22R split to the left and right sides. The crankshaft 21 oriented in the vehicle width direction is rotatably supported on the left crankcase portion 22L and the right crankcase portion 22R through main bearings 21b, respectively.

[0045] An alternate current (AC) generator 55 is provided at a right-side shaft portion of the crankshaft 21, and a centrifugal cooling fan 56 is integrally mounted to an outer rotor 55r of the AC generator 55.

[0046] A fan cover 57 covering the right crankcase portion 22R from the right side accommodates the centrifugal cooling fan 56 therein.

[0047] The fan cover 57 is formed with a grille 57g, which is an outside air inlet port, in the manner of facing the centrifugal cooling fan 56.

[0048] Referring to FIG. 6, the left crankcase portion 22L extends rearward to serve also as a transmission case portion, a transmission case cover 65 covers the transmission case portion (left crankcase portion) 22L from the left side, and a belt-type continuously variable transmission 60 is disposed inside thereof.

[0049] At a left-side shaft portion of the crankshaft 21, a driving chain sprocket 58 is provided adjacently to the main bearing 21b, and, at a left-side shaft end portion, a driving pulley 61 of the belt-type continuously variable transmission 60 is provided.

[0050] By a cam chain 59 wrapped around the driving chain sprocket 58, power is transmitted to a valve drive mechanism on the side of the cylinder head 24.

[0051] Referring to FIG. 2, a speed reduction gear output shaft of a speed reduction mechanism 64 provided at a rear side of the belt-type continuously variable transmission 60 is a rear axle 28a, and a rear wheel 28 is provided on the rear axle 28a (see FIG. 2).

[0052] A rear cushion 19 is interposed between an upper end of a rear portion of the transmission case portion 22L that accommodates the speed reduction mechanism 64 and upper bent portions of the main pipes 4.

[0053] A driven pulley 63 of the belt-type continuously variable transmission 60 is rotatably supported on a

speed reduction gear input shaft 64a of the speed reduction mechanism 64, and a belt 62 is wrapped around the driving pulley 61 provided on the crankshaft 21 and the driven pulley 63 provided on the speed reduction gear input shaft 64a, whereby power of the internal combustion engine 20 is transmitted through the belt to the driven pulley 63. Rotation of the driven pulley 63 is transmitted to the speed reduction gear input shaft 64a of the speed reduction mechanism 64 through a centrifugal clutch 68, and power transmission to the rear wheel 28 is performed with speed reduction by the speed reduction mechanism 64.

[0054] An outside air intake fan 61F is formed on a left-side pulley half of the driving pulley 61.

[0055] In the vehicle body front portion 1F, vertically oriented portions of the head pipe 2 and the down tube 3 are covered from the front and rear sides by a front cover 1a and a leg shield 1b. At the floor portion 1C, a forward-rearward oriented portion of the down tube 3 is covered by a floor cover 1c. In the vehicle body rear portion 1R, the main pipes 4 are covered on the left and right sides and the rear side by a body cover 1d.

[0056] Referring to FIGS. 2 and 3, the internal combustion engine 20 at a front portion of the power unit P has a configuration in which an intake pipe 31 extends upward from an upper surface of the cylinder head 24, which is stacked on the cylinder block 23 projecting forward from the crankcase 22 and which projects further forward, and an exhaust pipe 51 extends downward from a lower surface of the cylinder head 24.

[0057] In addition, as illustrated in FIG. 3, to a right side surface of the cylinder head 24, an ignition plug 26 is fitted to a part near the central cylinder head cover 25, and an oxygen concentration sensor 27 is fitted to a part to which the exhaust pipe 51 extends.

[0058] The intake pipe 31, which communicates with an intake port 30 of the cylinder head 24 and extends from an upper surface of the cylinder head 24, is bent rearward, to be connected to a throttle body 33, and is provided at an intermediate portion thereof with a fuel injection valve 32.

[0059] The throttle body 33 is connected to a connecting tube 34 extending from an air cleaner device 40 disposed on the crankcase 22, and an intake system extending from the air cleaner device 40 through the connecting tube 34 and communicating through the throttle body 33 with the intake pipe 31 and the intake port 30 is configured.

[0060] On the other hand, as illustrated in FIGS. 1, 3 and 4, the exhaust pipe 51 communicating with an exhaust port 50 of the cylinder head 24 and extending downward from the lower surface of the cylinder head 24 is obliquely bent rightward and rearward, is further obliquely bent rearward and downward, extends rearward on the right side of a lower portion of the crankcase 22, and is connected to a muffler 52 disposed on the right side of the rear wheel 28.

[0061] Referring to FIGS. 2 to 4, the peripheries of the cylinder block 23 and the cylinder head 24 are surrounded by the shroud 70 which is generally rectangular pipe-shaped, and the shroud 70 is connected to the fan cover 57 on the right side.

[0062] The shroud 70 has a structure in which an upper shroud 71 and a lower shroud 72 split into upper and lower halves are united in the manner of covering the cylinder block 23 and the cylinder head 24 from the upper and lower sides, to surround the cylinder block 23 and the cylinder head 24, and the cylinder head cover 25 projects from an opening which is largely opened on the front side of the upper shroud 71 and the lower shroud 72.

[0063] The intake pipe 31 penetrates, and extends upward from, an upper-side wall 71U of the upper shroud 71, and the exhaust pipe 51 penetrates, and extends downward from, an air exhaust port 72h of a lower-side wall 72D of the lower shroud 72 (see FIGS. 3 and 4).

[0064] As depicted in FIG. 3, the ignition plug 26 projects from an opening at a front-side portion of mating surfaces of right-side walls 71R and 72R of the upper shroud 71 and the lower shroud 72, and the oxygen concentration sensor 27 projects from an opening in the right-side wall 72R of the lower shroud 72.

[0065] As depicted in FIG. 6, the right-side walls 71R and 72R of the upper shroud 71 and the lower shroud 72 are bulged while being curved rightward from the front side (cylinder head 24 side) toward the rear side (cylinder block 23 side), and are connected to the fan cover 57.

[0066] Inside of the right-side walls 71R and 72R bulged while being curved rightward, an air-guiding partition wall 73 is formed in the state of being curved roughly in parallel to the right-side walls 71R and 72R.

[0067] Referring to FIG. 6, the air-guiding partition wall 73 has a rear end fronting on the centrifugal cooling fan 56 and being formed along a plane substantially orthogonal to a rotational axis thereof (crankshaft 21). The air-guiding partition wall 73 has a front or proximal end located in the vicinity of the mating surfaces of the cylinder block 23 and the cylinder head 24.

[0068] The air-guiding partition wall 73 partitions the inside space of the right-side walls 71R and 72R, whereby a head-side duct 74H and a cylinder-side duct 74C are formed.

[0069] A cooling airflow generated by the rotation of the centrifugal cooling fan 56 is sent into the inside space of the right-side walls 71R and 72R of the shroud 70 due to the provision of the fan cover 57, and is divided by the air-guiding partition wall 73. The cooling airflow on one side is guided by the head-side duct 74H to the cylinder head 24 to mainly cool the cylinder head 24, while the cooling airflow on the other side is guided by the cylinder-side duct 74C to the cylinder block 23 to mainly cool the cylinder block 23.

[0070] The cylinder block 23 and the cylinder head 24 are in the posture of projecting forward from the crankcase 22, and have rectangular peripheral surfaces having side walls on the upper, lower, left and right sides, and the peripheral surfaces are formed with pluralities of

cooling fins 81 and 85.

[0071] An exhaust-side cylinder head side surface 24D of the cylinder head 24 where the exhaust pipe 51 extends is the lower cylinder head side surface.

[0072] A lower cylinder side surface of the cylinder block 23 that is continuous with the exhaust-side cylinder head side surface 24D of the cylinder head 24 is an exhaust-side cylinder side surface 23D.

[0073] Referring to FIG. 8, which is a perspective view of the cylinder block 23 as a single part as viewed from an oblique lower side, there are provided a cylinder bore 23b, in which a piston is reciprocated, and a cam chain chamber 23c, which is located on the left side of the cylinder bore 23b and in which the cam chain 59 is turned. The cylinder bore 23b and the cam chain chamber 23c are formed to penetrate the cylinder block 23 in the vehicle longitudinal direction. The cylinder block 23 has side surfaces on the upper, lower, left and right sides.

[0074] The lower side surface of the cylinder block 23 is the exhaust-side cylinder side surface 23D.

[0075] A right cylinder side surface of the cylinder block 23 is a fan-side cylinder side surface 23R located on the same right side as the right side of the crankshaft 21 on which the centrifugal cooling fan 56 is secured.

[0076] Referring to FIGS. 6, 8 and 9, the exhaust-side cylinder side surface 23D of the cylinder block 23 is formed with a plurality of air-guiding cooling fins 82 arranged in parallel, with air-guiding grooves 83 formed between the adjacent air-guiding cooling fins 82.

[0077] The plurality of air-guiding grooves 83 formed by the air-guiding cooling fins 82 each have a structure in which an inlet port 83i is opened substantially toward a fan-side side edge 23Dr of the exhaust-side cylinder side surface 23D. The fan-side side edge 23Dr is a corner connecting edge continuous with the fan-side cylinder side surface 23R. On the other hand, an outlet port 83e is opened in the direction toward the exhaust-side cylinder head side surface 24D, from which the exhaust pipe 51 extends, of the cylinder head 24. Each of the air-guiding groove 83 communicates from the inlet port 83i to the outlet port 83e.

[0078] The air-guiding cooling fins 82 are curved in an arcuate shape, and, therefore, the air-guiding grooves 83 are bent in an arcuate shape to communicate from the inlet ports 83i to the outlet ports 83e.

[0079] Referring to FIG. 9, which is a bottom view of the cylinder block 23, an outermost-side air-guiding cooling fin 82E whose upstream end portion 82i is farthest from the cylinder head 24, of the plurality of air-guiding cooling fins 82, has an upstream end portion 82Ei located at an end edge on the side of the crankcase 22, of the exhaust-side cylinder side surface 23D, and has a downstream end portion 82Ee located at an end edge on the side of the cylinder head 24, of the exhaust-side cylinder side surface 23D.

[0080] Referring to FIG. 9, the air-guiding cooling fins 82 exclusive of the outermost-side air-guiding cooling fin 82E have their upstream end portions 82Ei spaced from the fan-side side edge 23Rd of the exhaust-side cylinder side surface 23D by predetermined distances, respectively.

[0081] Therefore, the exhaust-side cylinder side surface 23D is formed on the side of the fan-side side edge 23Dr with an exhaust-side space Sd where no cooling fins are present, and the exhaust-side space Sd is thus surrounded by the outermost-side air-guiding cooling fin 82E.

[0082] In addition, referring to FIG. 8, the fan-side cylinder side surface 23R of the cylinder block 23, as a side surface on the same side as the side of the crankshaft 21 on which the centrifugal cooling fan 56 is secured, is not formed with any cooling fin 81, except of the part on the side of the cylinder head 24.

[0083] Therefore, on the fan-side cylinder side surface 23R of the cylinder block 23, the cooling fins 81 are present only on the side of the cylinder head 24, while the cooling fins 81 are absent and a fan-side space Sr is formed on the side of the crankcase opposite to the cylinder head 24.

[0084] The shroud 70 surrounds the peripheries of the cylinder block 23 and the cylinder head 24. Referring to FIG. 5, the lower-side wall 72D of the lower shroud 72 of the shroud 70, covering the lower side of the cylinder block 23 and the cylinder head 24, is formed, on its inner surface facing the exhaust-side cylinder side surface 23D of the cylinder block 23, with air-guiding ribs 75 extending while curved along the arcuately curved air-guiding grooves 83 formed in the exhaust-side cylinder side surface 23D. The air-guiding ribs 75 are formed in a projecting manner.

[0085] Note that the air-guiding ribs 75 are formed by bending the lower-side wall 72D of the lower shroud 72 in a wavy shape as shown in FIG. 10.

[0086] Referring to FIG. 10, which is a sectional view of the cylinder block 23 and the shroud 70 taken along arrows X-X of FIG. 5, the air-guiding cooling fins 82 on the exhaust-side cylinder side surface 23D of the cylinder block 23 and the air-guiding ribs 75 on the lower-side wall 72D of the shroud 70 are arranged alternately with each other.

[0087] Therefore, the air-guiding ribs 75 of the shroud 70 are located opposite to the air-guiding grooves 83 between the air-guiding cooling fins 82 of the cylinder block 23, respectively.

[0088] When the centrifugal cooling fan 56 provided on the right shaft end of the crankshaft 21 is rotated together with the crankshaft 21, outside air is sucked in through the grille 57g of the fan cover 57. The sucked air is dispersed in the centrifugal direction while rotating, and, as shown in FIG. 7, is guided by an inner peripheral surface of a spirally shaped peripheral wall 57s of the fan cover 57 covering the periphery of the centrifugal cooling fan 56 rotating clockwise in the right side view, to become a swirl indicated by void arrows in FIG. 7. Then, the air is sent from a space on the upper side of a fan cover 100, where the diameter of a peripheral wall 100a is the larg-

est, toward a front-side opening and into a right-side bulged portion of the shroud 70 (see void arrows in FIGS. 6 and 7).

[0089] As depicted in FIG. 6, the cooling airflow fed into the right-side bulged portion of the shroud 70 is divided by the air-guiding partition wall 73. The cooling airflow entering the head-side duct 74H on one side is guided to the cylinder head 24, while the cooling airflow entering the cylinder-side duct 74C on the other side is guided to the cylinder block 23 (see void arrows in FIG. 6).

[0090] As depicted in FIG. 7, the cooling airflow guided by the cylinder-side duct 74C is divided into a cooling airflow flowing toward an upper side surface of the cylinder block 23 and a cooling airflow flowing toward the fan-side cylinder side surface 23R, which is a right side surface of the cylinder block 23 (see void arrows in FIG. 7).

[0091] The cooling airflow going to the upper-side side surface of the cylinder block 23 is further guided by the shroud 70 to go around to a left side surface of the cylinder block 23, to cool the upper side surface and the left side surface of the cylinder block 23.

[0092] Referring to FIG. 7, on the fan-side cylinder side surface 23R of the cylinder block 23, the cooling fins 81 are partly present in a region on the side of the cylinder head 24, and, except of this region, the fan-side space Sr is formed where no cooling fin 81 is present. Therefore, the cooling airflow going toward the fan-side cylinder side surface 23R is efficiently taken into the fan-side space Sr (see void arrow in FIG. 7).

[0093] Then, the cooling airflow taken into the fan-side space Sr of the fan-side cylinder side surface 23R is guided by the shroud 70, to go around a fan-side side edge 23Rd to the exhaust-side cylinder side surface (lower-side side surface) 23D.

[0094] Referring to FIGS. 8 and 9, the cooling airflow flowing past the fan-side side edge 23Rd of the cylinder block 23 to the exhaust-side cylinder side surface 23D (see void arrow in FIGS. 8 and 9) is taken into the exhaust-side space Sd formed by being surrounded by the outermost-side air-guiding cooling fin 82E on the side of the fan-side side edge 23Rd of the exhaust-side cylinder side surface 23D.

[0095] The cooling airflow taken into the exhaust-side space Sd is introduced into the inlet ports 83i of the plurality of air-guiding grooves 83 formed by the air-guiding cooling fins 82 (see arrows → in FIGS. 6, 8 and 9) .

[0096] The cooling airflow introduced into each inlet port 83i is changed in flow direction by being guided by the air-guiding groove 83 curved in an arcuate shape, to be guided through the outlet port 83e toward the side of the cylinder head 24, specifically in the direction of the exhaust-side head side surface 24D of the cylinder head 24 from which the exhaust pipe 51 extend (see arrows → in FIGS. 6 and 9).

[0097] Therefore, the cooling airflow is blown toward the extension portion of the exhaust pipe 51 extending from the exhaust-side head side surface 24D, and, accordingly, the extension portion of the exhaust pipe 51 where heat generation is intense is particularly efficiently cooled.

[0098] The embodiment of the air-cooled internal combustion engine according to the present invention as described above produces the following effects.

[0099] Referring to FIGS. 7 and 8, the exhaust-side cylinder side surface 23D of the cylinder block 23 is formed with the plurality of air-guiding cooling fins 82 arranged in parallel, and the air-guiding grooves 83 formed between the adjacent air-guiding cooling fins 82 each have a structure in which the inlet port 83i is opened toward the fan-side side edge 23Dr of the exhaust-side cylinder side surface 23D, while the outlet port 83e is opened in the direction toward the exhaust-side head side surface 24D, and each of the air-guiding grooves 83 communicates from the inlet port 83i to the outlet port 83e.

[0100] Therefore, when the cooling airflow generated by the rotation of the centrifugal cooling fan 56 is sent to the fan-side cylinder side surface 23R of the cylinder block 23 and further to the side surface (fan-side head side surface 24R) of the cylinder head 24 that is continuous with the fan-side cylinder side surface 23R, as illustrated in FIG. 6, the cooling airflow taken into the fan-side space Sr, of the cooling airflow sent to the fan-side cylinder side surface 23R, is guided by the shroud 70, to flow around the fan-side side edge 23Rd to the exhaust-side cylinder side surface (lower side surface) 23D and to be taken into the exhaust-side space Sd, thereby being introduced into the inlet ports 83i of the plurality of air-guiding grooves 83 and being guided by the air-guiding grooves 83, to flow out through the outlet ports 83e to the exhaust-side head side surface 24D. Therefore, the cooling airflow is blown toward the extension portion of the exhaust pipe 51 extending from the exhaust-side head side surface 24D, and, accordingly, the extension portion of the exhaust pipe 51 where heat generation is intense can particularly be cooled efficiently.

[0101] Referring to FIG. 8, of the cooling airflow generated by the rotation of the centrifugal cooling fan 56, part of the cooling airflow sent to the fan-side cylinder side surface 23R and the fan-side head side surface 24R of the cylinder head 24 flows to the upper side surface on the side of the intake pipe 31 of the cylinder block 23, and is further guided by the shroud 70, to flow around to the left-side cylinder side surface of the cylinder block 23, thereby cooling the upper side surface and the left side surface of the cylinder block 23. As a result, this part of the cooling airflow cools the cylinder block 23 thoroughly together with the cooling airflow directed to the fan-side cylinder side surface 23R.

[0102] Note that, as depicted in FIG. 6, of the cooling airflow sent into the right-side bulged portion of the shroud 70, the cooling airflow which is divided by the air-guiding partition wall 73 to enter the head-side duct 74H on one side and to be guided to the cylinder head 24 is caused by the shroud 70 to flow along the cooling fins

85 in the periphery of the cylinder head 24, thereby cooling the cylinder head 24 thoroughly.

[0103] The cooling airflow is discharged through the air exhaust port 72h of the lower-side wall 72D of the lower shroud 72 from which the exhaust pipe 51 projects.

[0104] As depicted in FIG. 9, the air-guiding grooves 83 formed in the exhaust-side cylinder side surface 23D are curved in an arcuate shape from the inlet ports 83i to the outlet ports 83e, Therefore, the resistance to the cooling airflows introduced into the inlet ports 83i is restrained, and the cooling airflows can flow out through the outlet ports 83e by being changed in flow direction smoothly, whereby the extending portion of the exhaust pipe 51 can be cooled with improved efficiency.

[0105] As depicted in FIG. 8, of the plurality of air-guiding cooling fins 82, the outermost-side air-guiding cooling fin 82E, whose upstream end portion is farthest from the cylinder head 24, has its upstream end portion 82Ei located on an end edge of the exhaust-side cylinder side surface 23D on the side of the crankcase 22, and has its downstream end portion 82Ee located on an end edge of the exhaust-side cylinder side surface 23D on the side of the cylinder head 24. Therefore, the cooling airflow flowing around from the fan-side cylinder side surface 23R to the exhaust-side cylinder side surface 23D can be efficiently taken in by the outermost-side air-guiding cooling fin 82E, while reducing leakage, and the cooling airflow can be made to flow out to the exhaust-side head side surface 24D by the air-guiding grooves 83 defined by the plurality of the air-guiding cooling fins 82. Accordingly, the portion of the exhaust pipe 51 extending from the exhaust-side head side surface 24D can be cooled with improved efficiency.

[0106] As depicted in FIG. 9, the air-guiding cooling fins 82 excluding the outermost-side air-guiding cooling fin 82E have their upstream end portions 82i spaced from the fan-side side edge 23Rd of the exhaust-side cylinder side surface 23D by predetermined distances, respectively. Therefore, on the exhaust-side cylinder side surface 23D, the exhaust-side space Sd where the cooling fins 81 and 82 are absent is formed on the side of the fan-side side edge 23Dr, in a state of being surrounded by the outermost-side air-guiding cooling fin 82E. For this reason, the cooling airflow flowing over the fan-side side surface 23Dr from the fan-side cylinder side surface 23R to the exhaust-side cylinder side surface 23D can be efficiently taken into the exhaust-side space Sd, and can be made to flow into the curved air-guiding grooves 83. Accordingly, the extension portion of the exhaust pipe 51 can be cooled efficiently.

[0107] As illustrated in FIGS. 7 and 8, the fan-side cylinder side surface 23R of the cylinder block 23 is not formed with the cooling fins 81, except the part on the side of the cylinder head 24. Therefore, the cooling airflow sent to the fan-side cylinder side surface 23R by the rotation of the centrifugal cooling fan 56 can be efficiently taken into the fan-side space Sr on the fan-side cylinder side surface 23R where the cooling fins 81 are not formed. The cooling airflow can be caused to flow along the part of the fan-side cylinder side surface 23R in which the cooling fins 81 are not formed, and to flow around the fan-side side edge 23Rd to the exhaust-side cylinder side surface 23D, so that a sufficient quantity of the cooling airflow can be introduced into the air-guiding grooves 83 and can be blown to the extension portion of the exhaust pipe 51, whereby the extension portion of the exhaust pipe 51 can be cooled with improved effectiveness.

[0108] As shown in FIGS. 5 and 10, the lower-side wall 72D of the lower shroud 72 of the shroud 70, which covers the lower side of the cylinder block 23 and the cylinder head 24, is formed, on its inner surface facing the exhaust-side cylinder side surface 23D of the cylinder block 23, with the projecting air-guiding ribs 75 extending to curve along the arcuately curved air-guiding grooves 83 formed in the exhaust-side cylinder side surface 23D. Therefore, by the cooperation of the air-guiding ribs 75 of the shroud 70 with the air-guiding cooling fins 82 of the cylinder block 23, the cooling airflow flowing around to the exhaust-side cylinder side surface 23D can be guided by the shroud 70, can be caused to flow out to the exhaust-side head side surface 24D, and can be blown toward the extension portion of the exhaust pipe 51. For this reason, it is possible to dispense with some number of the air-guiding cooling fins 82 of the cylinder block 23, so that forming of the cylinder block 23 is facilitated, and heat cracking at the time of forming can be prevented.

[0109] As depicted in FIG. 10, the air-guiding ribs 75 and the air-guiding cooling fins 82 are arranged alternately with each other, whereby the air-guiding ribs 75 can be efficiently arranged in relation to the air-guiding cooling fins 82.

[0110] As illustrated in FIG. 6, the cooling airflow fed by the rotation of the centrifugal cooling fan 56 is divided by the air-guiding partition wall 73 and generally guided respectively to the cylinder block 23 and the cylinder head 24. Therefore, a cooling airflow sent mainly to the fan-side cylinder side surface 23R of the cylinder block 23 is sufficiently secured without much flow to the side of the cylinder head 24. This sufficient quantity of cooling airflow goes around to the exhaust-side cylinder side surface 23D and is blown to the extension portion of the exhaust pipe 51 by the air-guiding grooves 83, whereby a cooling effect can be enhanced.

[0111] While the air-cooled internal combustion engine according to one embodiment of the present invention has been described above, the mode of the present invention is not limited to the above embodiment, and includes a variety of modes carried out within the scope of the gist of the invention.

[0112] For example, the vehicle on which the air-cooled internal combustion engine of the present invention is mounted is not limited to the scooter-type two-wheeled motor vehicle in the embodiment, but may be any of a variety of saddle-type vehicles such as three-wheeled or four-wheeled buggy cars, and need only be

a vehicle having the claimed requirements.

[Reference Signs List]

[0113]

1···Scooter-type two-wheeled motor vehicle, 2···Head pipe, 3···Down tube, 4···Main pipe, 5···Accommodation box, 6···Fuel tank, 7···Seat, 8···Handlebar, 9···Front fork, 10···Front wheel, 11···Support bracket, 12···Link member, 13···Pivot shaft, 19···Rear cushion;
P···Power unit, 20···Internal combustion engine, 21···Crankshaft, 22···Crankcase, 22L···Left crankcase portion (Transmission case portion), 22R···Right crankcase portion, 22h···Engine hanger;
23···Cylinder block, 230···Exhaust-side cylinder side surface, 23Dr···Fan-side side edge, Sd···Exhaust-side space, 23R···Fan-side cylinder side surface, Sr···Fan-side space, 23Dr···Fan-side side edge, 24···Cylinder head, 24D···Exhaust-side head side surface;
25···Cylinder head cover, 26···Ignition plug, 27···Oxygen concentration sensor, 28···Rear wheel;
30···Intake port, 31···Intake pipe, 32···Fuel injection valve, 33···Throttle body, 34···Connecting tube, 40···Air cleaner device;
50···Exhaust port, 51···Exhaust pipe, 52···Muffler, 55···AC generator, 56···Centrifugal cooling fan, 57···Fan cover, 58···Driving chain sprocket, 59···Cam chain;
60···Belt-type continuously variable transmission, 61···Driving pulley, 61F···Outside air intake fan, 62···Belt, 63···Driven pulley, 64···Speed reduction mechanism, 64a···Speed reduction gear input shaft, 65···Transmission case cover;
70···Shroud, 71···Upper shroud, 71U···Upper-side wall, 71R···Right-side wall, 72···Lower shroud, 72D···Lower-side wall, 72h···Air exhaust port, 72R···Right-side wall, 73···Air-guiding partition wall, 74H···Head-side duct, 74C···Cylinder-side duct, 75···Air-guiding rib;
81···Cooling fin, 82···Air-guiding cooling fin, 82i···Upstream end portion, 82e···Downstream end portion, 82E···Outermost-side air-guiding cooling fin, 82Ei···Upstream end portion, 82Ee···Downstream end portion, 83···Air-guiding groove, 83i···Inlet port, 83e···Outlet port, 85···Cooling fin.

Claims

1. An air-cooled internal combustion engine in which:

a cylinder block (23) provided with cooling fins (81) and a cylinder head (24) extend in a sequentially stacked manner from a crankcase (22) rotatably supporting a crankshaft (21), in a direction perpendicular to an axis of the crankshaft (21);
a centrifugal cooling fan (56) is secured to one end of the crankshaft (21);
an intake pipe (31) and an exhaust pipe (51) extend from side surfaces of the cylinder head (24) on opposite upper and lower sides;
the cylinder block (23) and the cylinder head (24) are surrounded by a shroud (70); and
a fan cover (57) covering the centrifugal cooling fan (56) from a lateral side is connected to the shroud (70), in such manner that a cooling airflow is fed into the shroud (70) by the centrifugal cooling fan (56) to cool the cylinder block (23) and the cylinder head (24); **characterized in that**:
the cylinder block (23) has an exhaust-side cylinder side surface (23D) continuous with an exhaust-side head side surface (24D), which is a lower side surface of the cylinder head (24) from which the exhaust pipe (51) extends, the exhaust-side cylinder side surface (23D) being provided with a plurality of air-guiding cooling fins (82) arranged in parallel, with air-guiding grooves (83) formed between adjacent ones of the air-guiding cooling fins (82); and
the plurality of the air-guiding grooves (83) formed by the air-guiding cooling fins (82) each have a structure in which an inlet port (83i) is opened in a direction toward a fan-side side edge (23Dr) of the exhaust-side cylinder side surface (23D) on the same side as the end of the crankshaft (21) to which the centrifugal cooling fan (56) is secured, while the air-guiding grooves (83) each have an outlet port (83e) opened in a direction toward the exhaust-side head side surface (24D), each of the air-guiding grooves (83) communicating from the inlet port (83i) to the outlet port (83e).

2. The air-cooled internal combustion engine according to claim 1, wherein the air-guiding cooling fins (82) are curved in an arcuate shape, and the air-guiding grooves (83) are curved in an arcuate shape from the inlet port (83i) to the outlet port (83e).

3. The air-cooled internal combustion engine according to claim 1 or 2, wherein air-guiding cooling fins (82) with upstream end portions (82i) includes an outermost-side air-guiding cooling fin (82E) with an upstream end portion (82Ei) which is farthest from the cylinder head (24) and located at an end edge of the exhaust-side cylinder side surface (23D) on the side of the crankcase (22), and the outermost-side air-guiding cooling fin (82E) has a downstream end portion (82Ee) located at an end edge of the exhaust-side cylinder side surface (23D) on the side of the cylinder head (24).

4. The air-cooled internal combustion engine according to claim 3, wherein the air-guiding cooling fins (82) except the outermost-side air-guiding cooling fin (82E) have upstream end portions (82i) spaced from the fan-side side edge (23Dr) of the exhaust-side cylinder side surface (23D) by predetermined distances, respectively.

5. The air-cooled internal combustion engine according to any one of claims 1 to 4, wherein the fan-side cylinder side surface (23R), which is a side surface of the cylinder block (23) on the same side as the end of the crankshaft (21) to which the centrifugal cooling fan (56) is secured, is not formed with the cooling fins (81), except in a region on the side of the cylinder head (24) .

6. The air-cooled internal combustion engine according to any one of claims 1 to 5, wherein an exhaust-side inner surface of the shroud (70), facing the exhaust-side cylinder side surface (23D) of the cylinder block (23), is formed with air-guiding ribs (75) extending along the air-guiding grooves (83) formed by the air-guiding cooling fins (82).

7. The air-cooled internal combustion engine according to claim 6, wherein the air-guiding ribs (75) and the air-guiding cooling fins (82) are arranged alternately with each other.

8. The air-cooled internal combustion engine according to any one of claims 1 to 7, wherein an air-guiding partition wall (73) for guiding the cooling airflow respectively to the cylinder head (24) and the cylinder block (23) is formed inside a side portion of the shroud (70) to which the fan cover (57) is connected.

Amended claims under Art. 19.1 PCT

1. (Amended) An air-cooled internal combustion engine in which:

a cylinder block (23) provided with cooling fins (81) and a cylinder head (24) extend in a sequentially stacked manner from a crankcase (22) rotatably supporting a crankshaft (21), in a direction perpendicular to an axis of the crankshaft (21);
a centrifugal cooling fan (56) is secured to one end of the crankshaft (21);
an intake pipe (31) and an exhaust pipe (51) extend from side surfaces of the cylinder head (24) on opposite upper and lower sides;
the cylinder block (23) and the cylinder head (24) are surrounded by a shroud (70); and
a fan cover (57) covering the centrifugal cooling fan (56) from a lateral side is connected to the shroud (70), in such manner that a cooling airflow is fed into the shroud (70) by the centrifugal cooling fan (56) to cool the cylinder block (23) and the cylinder head (24); **characterized in that**:
the cylinder block (23) has an exhaust-side cylinder side surface (23D) continuous with an exhaust-side head side surface (24D), which is a lower side surface of the cylinder head (24) from which the exhaust pipe (51) extends, the exhaust-side cylinder side surface (23D) being provided with a plurality of air-guiding cooling fins (82) arranged in parallel, with air-guiding grooves (83) formed between adjacent ones of the air-guiding cooling fins (82); and
the plurality of the air-guiding grooves (83) formed by the air-guiding cooling fins (82) each have a structure in which an inlet port (83i) is opened in a direction toward a fan-side side edge (23Dr) of the exhaust-side cylinder side surface (23D) on the same side as the end of the crankshaft (21) to which the centrifugal cooling fan (56) is secured, while the air-guiding grooves (83) each have an outlet port (83e) opened in a direction toward the exhaust-side head side surface (24D), each of the air-guiding grooves (83) communicating from the inlet port (83i) to the outlet port (83e); and
the air-guiding cooling fins (82) are curved in an arcuate shape, and the air-guiding grooves (83) are curved in an arcuate shape from the inlet port (83i) to the outlet port (83e).

2. (Deleted)

3. (Amended) The air-cooled internal combustion engine according to claim 1, wherein air-guiding cooling fins (82) with upstream end portions (82i) includes an outermost-side air-guiding cooling fin (82E) with an upstream end portion (82Ei) which is farthest from the cylinder head (24) and located at an end edge of the exhaust-side cylinder side surface (23D) on the side of the crankcase (22), and the outermost-side air-guiding cooling fin (82E) has a downstream end portion (82Ee) located at an end edge of the exhaust-side cylinder side surface (23D) on the side of the cylinder head (24).

4. The air-cooled internal combustion engine according to claim 3, wherein the air-guiding cooling fins (82) except the outermost-side air-guiding cooling fin (82E) have upstream end portions (82i) spaced from the fan-side side edge (23Dr) of the exhaust-side cylinder side surface (23D) by predetermined distances, respectively.

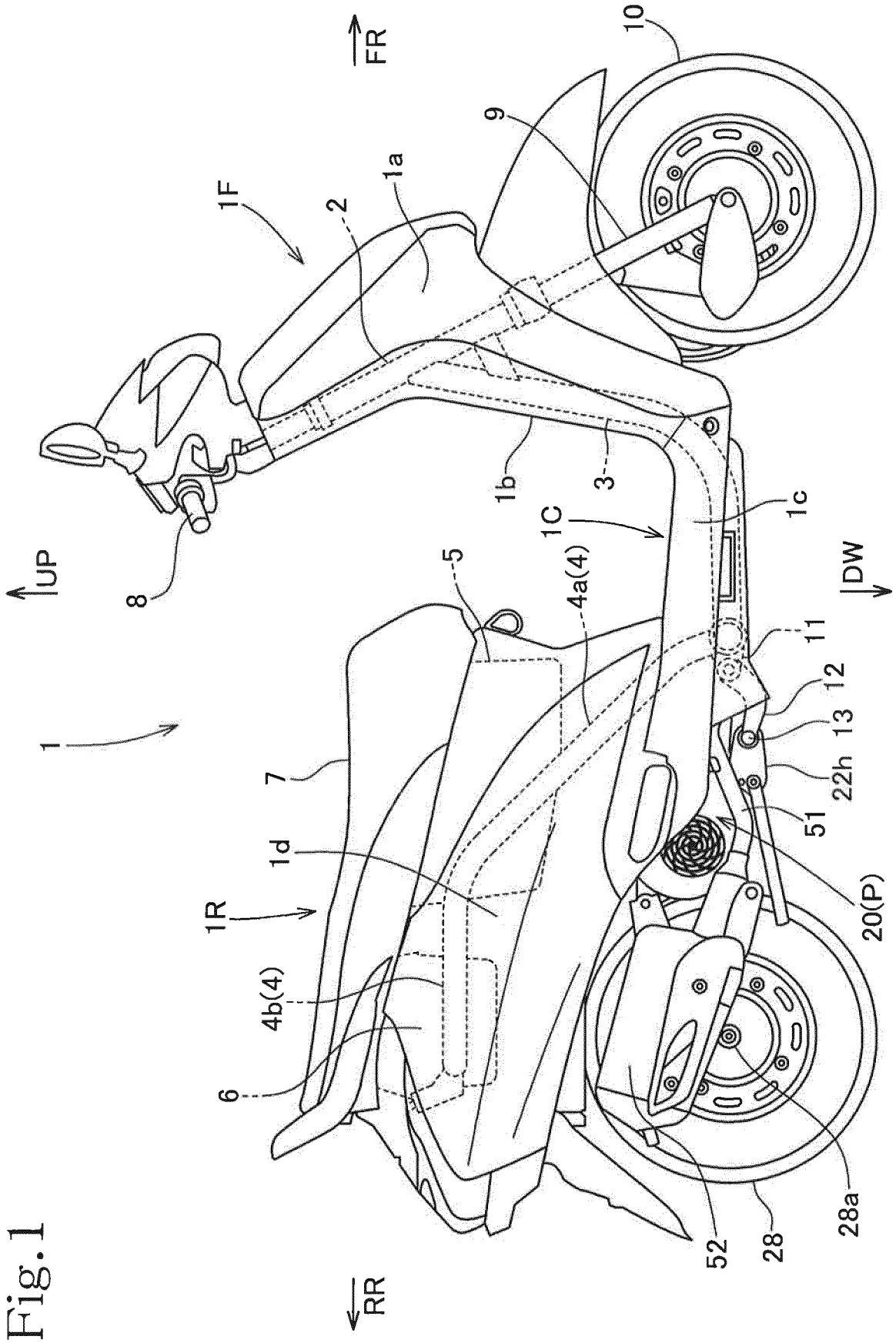
5. (Amended) The air-cooled internal combustion engine according to claims 1, 3 or 4, wherein the fan-

side cylinder side surface (23R), which is a side surface of the cylinder block (23) on the same side as the end of the crankshaft (21) to which the centrifugal cooling fan (56) is secured, is not formed with the cooling fins (81), except in a region on the side of the cylinder head (24).

6. (Amended) The air-cooled internal combustion engine according to any one of claims 1, 3 to 5, wherein an exhaust-side inner surface of the shroud (70), facing the exhaust-side cylinder side surface (23D) of the cylinder block (23), is formed with air-guiding ribs (75) extending along the air-guiding grooves (83) formed by the air-guiding cooling fins (82).

7. The air-cooled internal combustion engine according to claim 6, wherein the air-guiding ribs (75) and the air-guiding cooling fins (82) are arranged alternately with each other.

8. (Amended) The air-cooled internal combustion engine according to any one of claims 1, 3 to 7, wherein an air-guiding partition wall (73) for guiding the cooling airflow respectively to the cylinder head (24) and the cylinder block (23) is formed inside a side portion of the shroud (70) to which the fan cover (57) is connected.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11
12
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22h
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1
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1d
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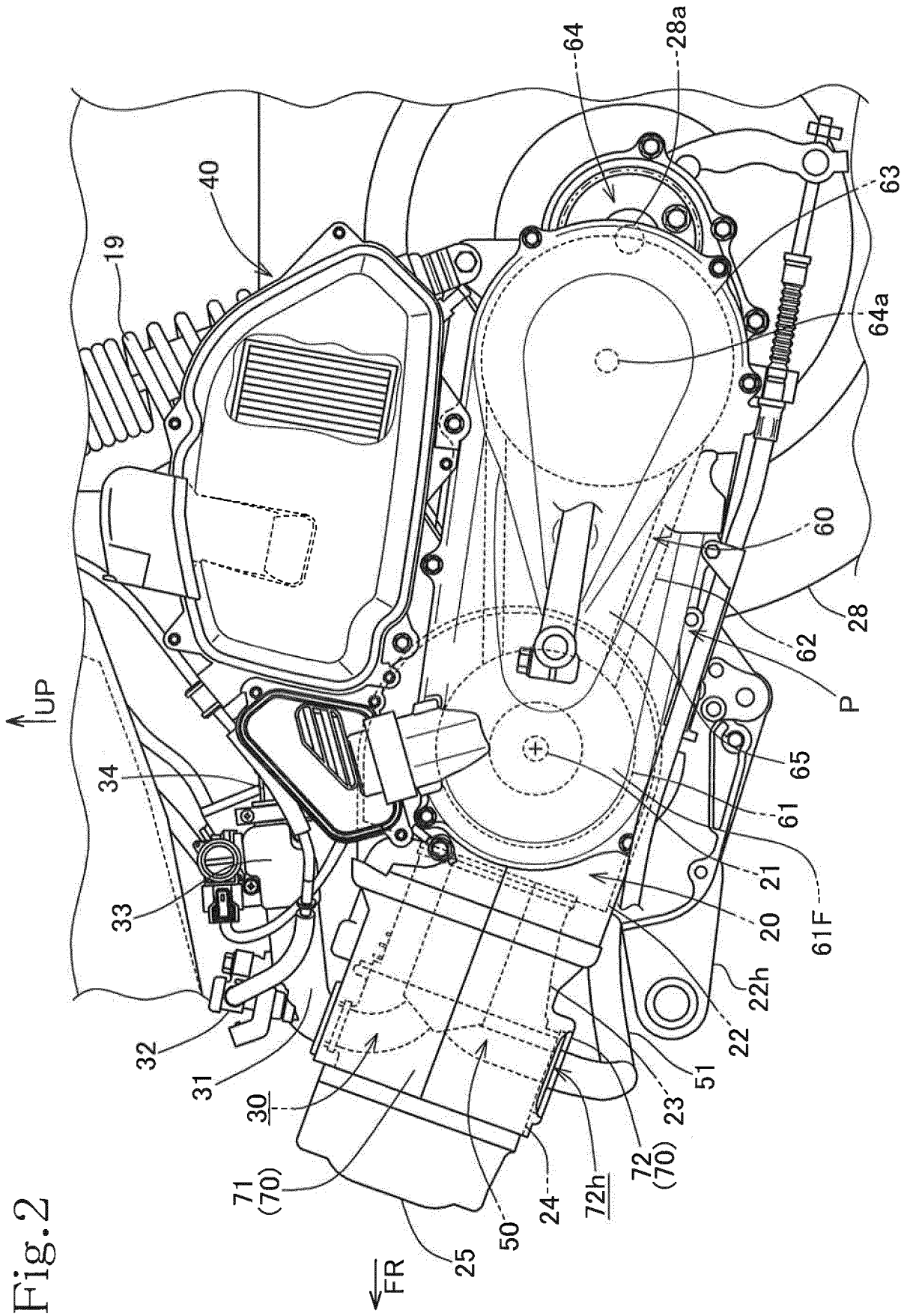
6
52
28
28a
RR

Fig. 1

Fig.2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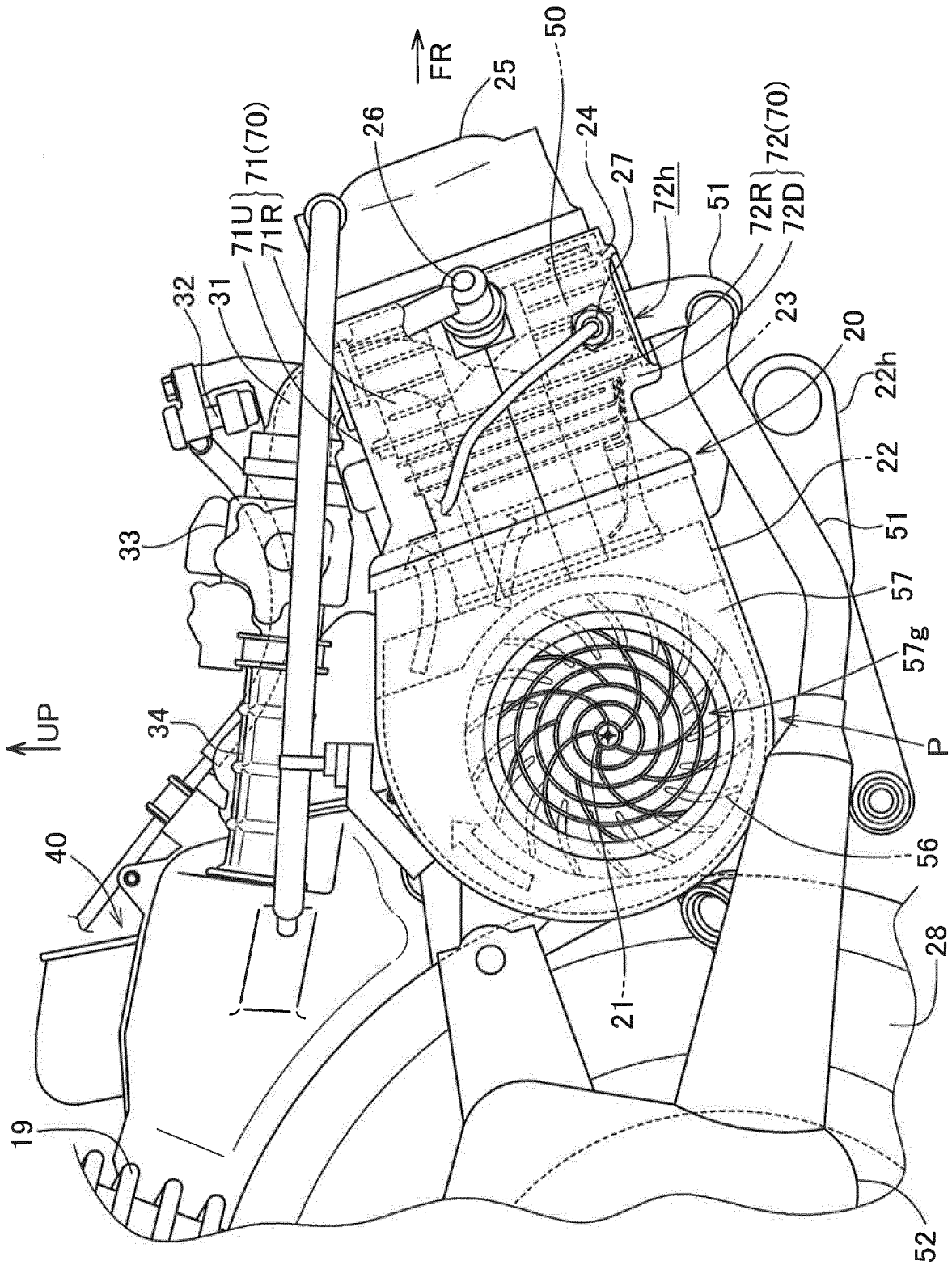
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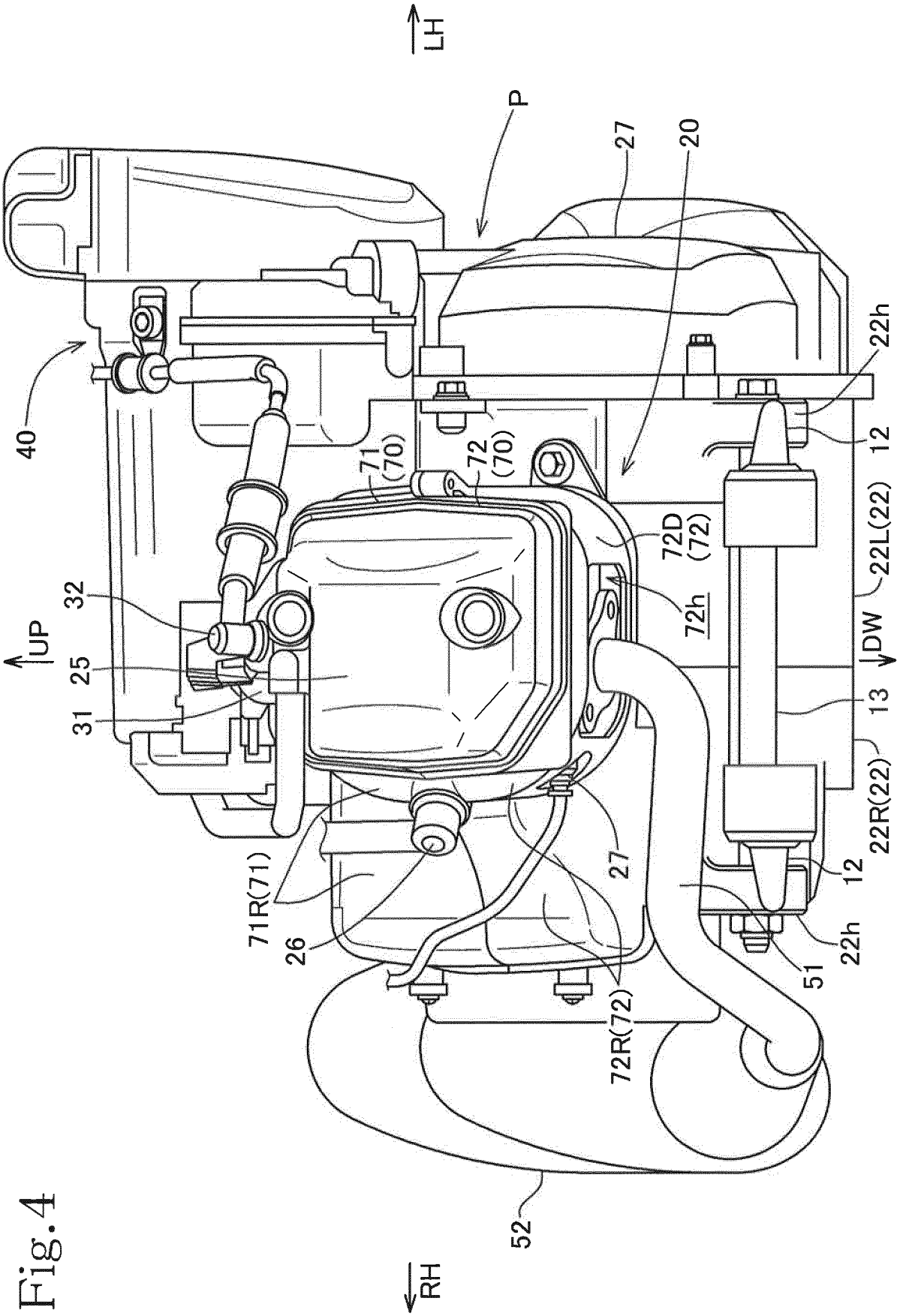
Fig.3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12
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26
22h
51
72R(72)
52
RH

Fig. 4

Fig.5

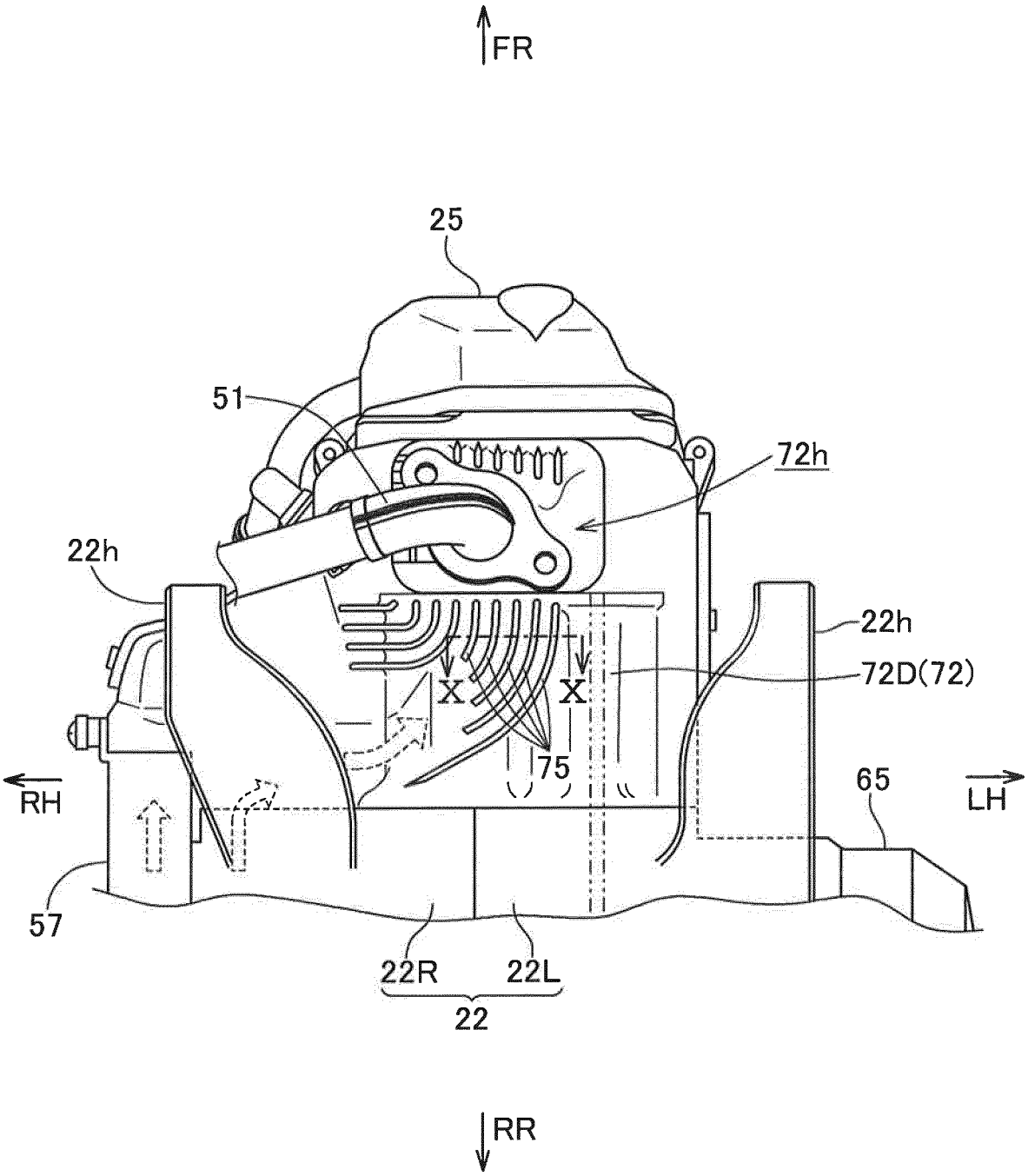
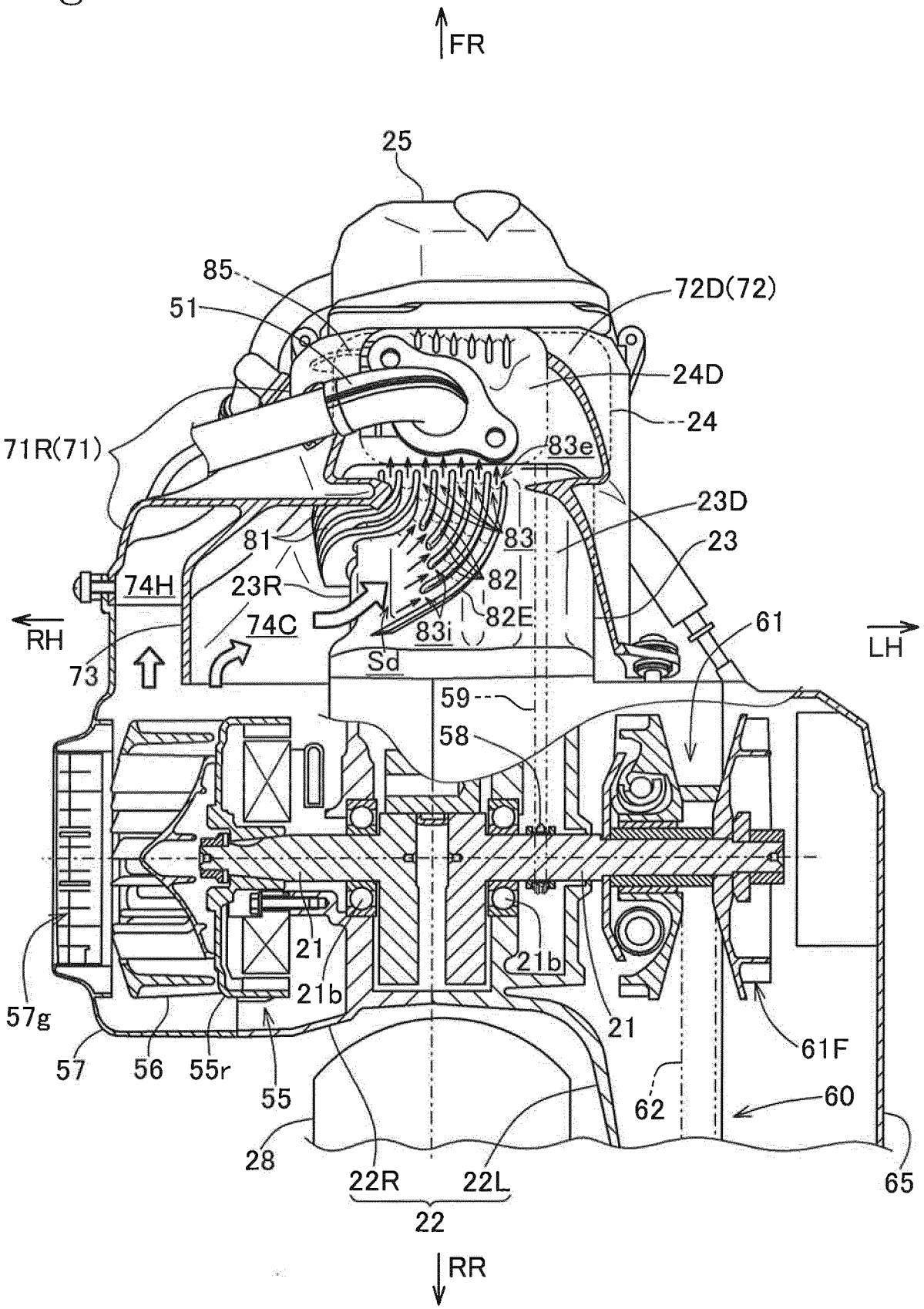


Fig.6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60
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22R
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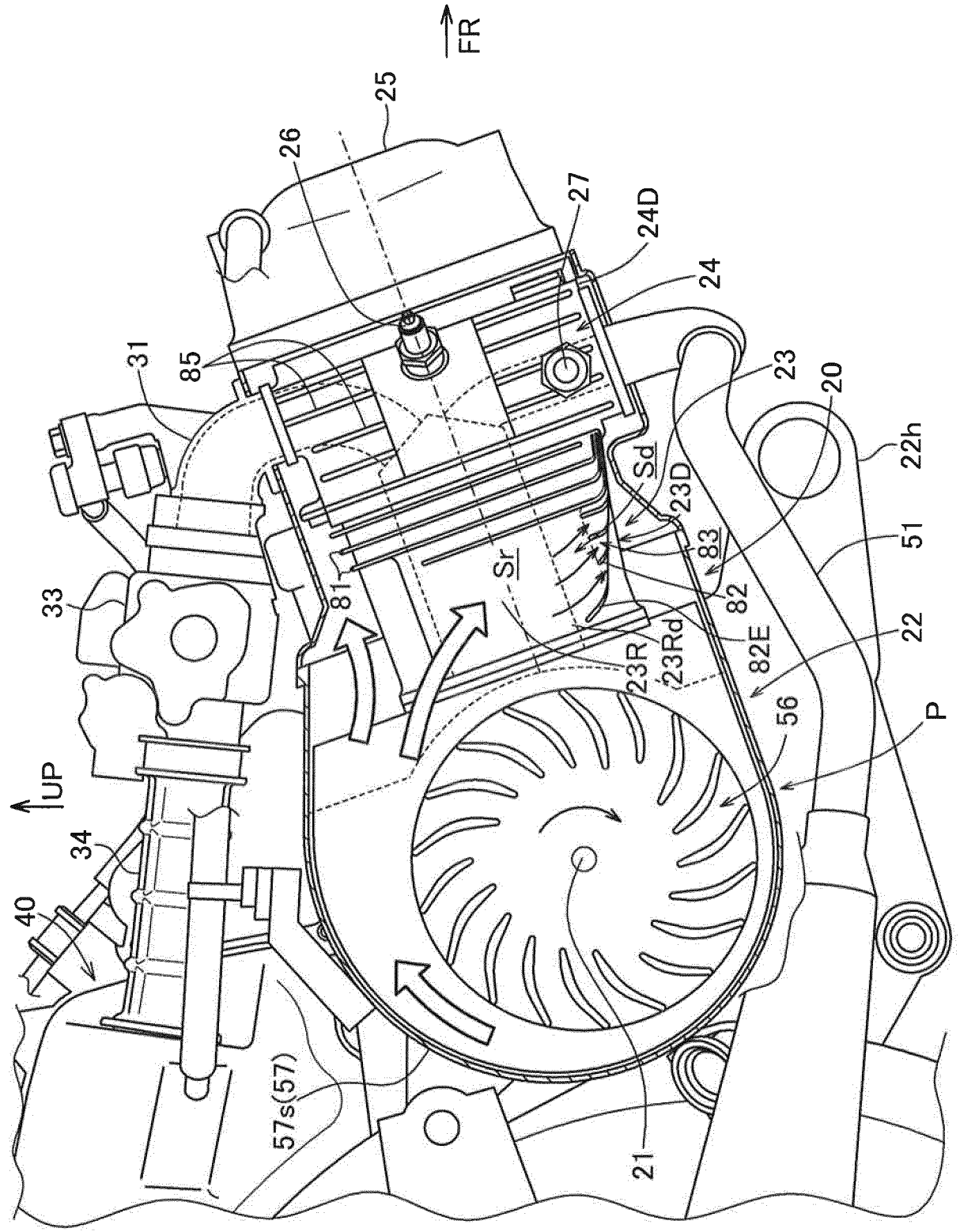
65
22
RR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UP
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Sd
23D
83
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Sr
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23R
23Rd
82E
22
56
P
34
40
57s(57)
21

Fig. 7

Fig.8

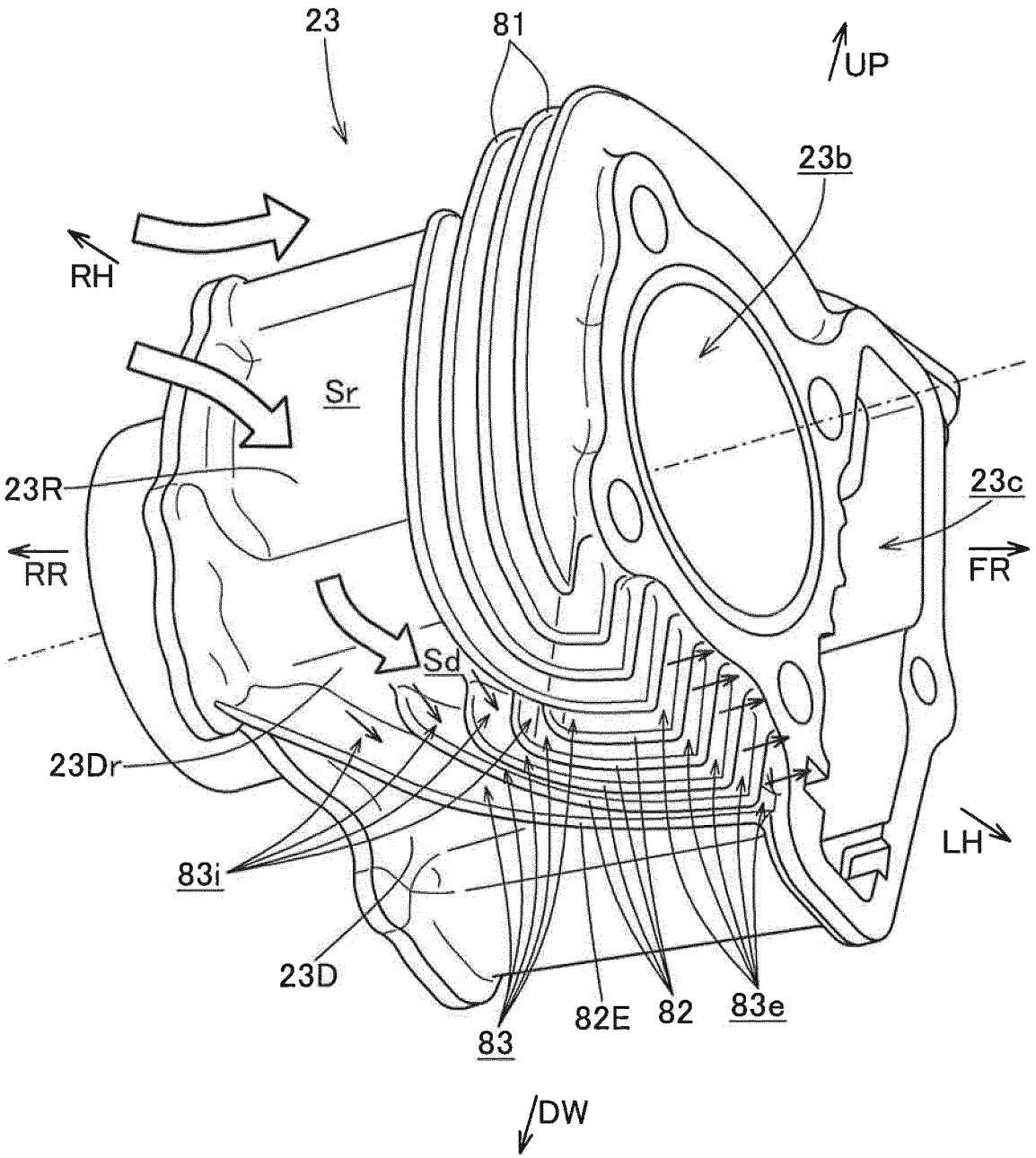
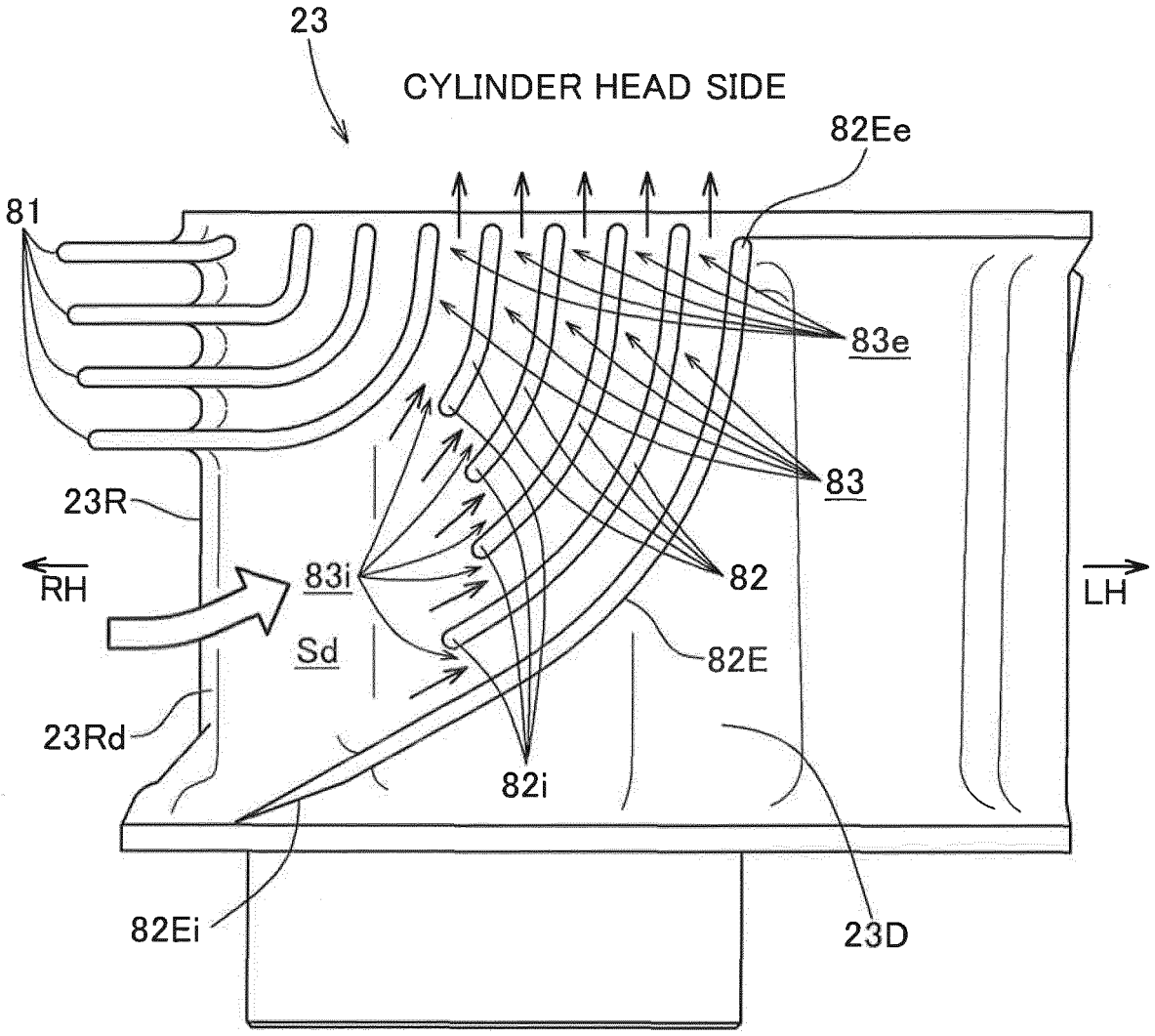


Fig.9


23
CYLINDER HEAD SIDE
82Ee
81
83e
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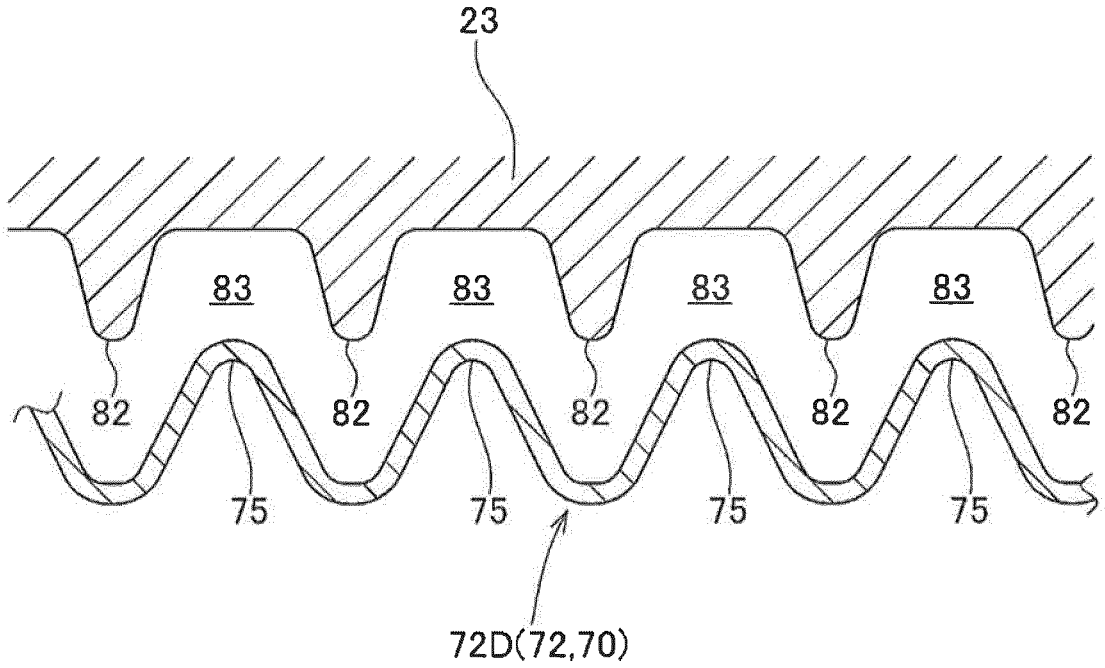
RH
83i
82
LH
Sd
82E
23Rd
82i
82Ei
23D
CRANKCASE SIDE

Fig.10



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2017/028438

A. CLASSIFICATION OF SUBJECT MATTER
F01P1/02(2006.01)i, *F01P5/06*(2006.01)i, *F02F1/00*(2006.01)i, *F02F1/06*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F01P1/02, F01P5/06, F02F1/00, F02F1/04, F02F1/06

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2017
Kokai Jitsuyo Shinan Koho 1971-2017 Toroku Jitsuyo Shinan Koho 1994-2017

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	JP 7-253019 A (Honda Motor Co., Ltd.), 03 October 1995 (03.10.1995), paragraphs [0013] to [0027]; fig. 1 to 8 & IT 95840196 A & ES 2117534 A & CN 1112646 A	1 8 2-7
Y	JP 2013-44231 A (Honda Motor Co., Ltd.), 04 March 2013 (04.03.2013), claim 1; fig. 3 & CN 102953795 A	8
A	JP 2000-314316 A (Honda Motor Co., Ltd.), 14 November 2000 (14.11.2000), entire text; all drawings & TW 513517 B & CN 1271654 A	1-8

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 October 2017 (13.10.17)	24 October 2017 (24.10.17)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2017/028438

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 038099/1973(Laid-open No. 136928/1974) (Kubota Tekko Kabushiki Kaisha), 26 November 1974 (26.11.1974), entire text; all drawings (Family: none)	1-8
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 121048/1976(Laid-open No. 40137/1978) (Zenoa Kabushiki Kaisha), 07 April 1978 (07.04.1978), entire text; all drawings (Family: none)	1-8
A	JP 2014-159763 A (Suzuki Motor Corp.), 04 September 2014 (04.09.2014), entire text; all drawings (Family: none)	1-8
A	JP 2014-5770 A (Honda Motor Co., Ltd.), 16 January 2014 (16.01.2014), entire text; all drawings & CN 103511055 A	1-8
A	JP 2001-241325 A (Yamaha Motor Co., Ltd.), 07 September 2001 (07.09.2001), entire text; all drawings (Family: none)	1-8
A	JP 7-293238 A (Tokyo R & D Co., Ltd.), 07 November 1995 (07.11.1995), entire text; all drawings (Family: none)	1-8

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP H7253019 A **[0003]**