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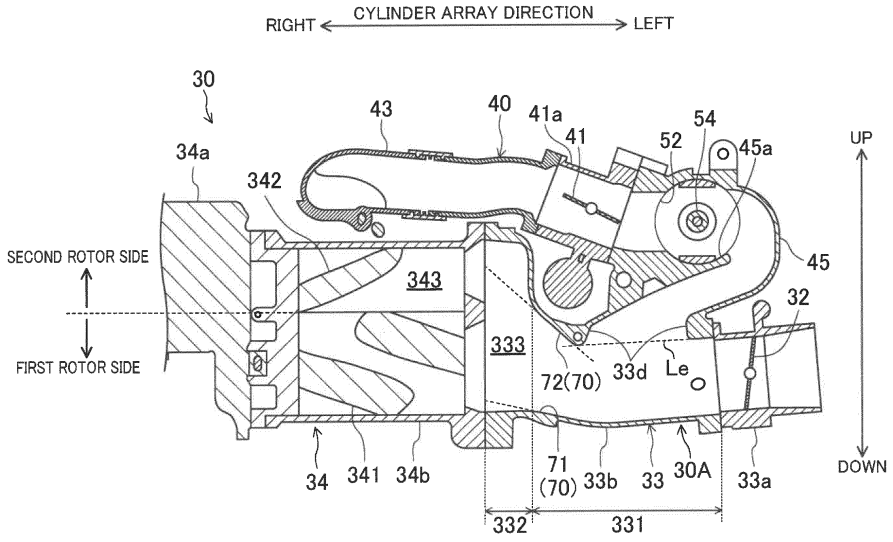
(54) ENGINE PROVIDED WITH MECHANICAL SUPERCHARGER

(57) An intake passage (30) of an engine (1) has a first passage body (33b) supplying gas to a mechanical supercharger (34). The first passage body (33b) is connected to a rotor chamber (343) of the supercharger (34) from one side in a cylinder array direction and is offset toward a first rotor (341) in an arrangement direction of first and second rotors (341, 342). An inner wall of the first passage body (33b) is provided with a guide portion (70) directing a gas flow flowing along the inner wall toward the second rotor (342) in the arrangement direction.

FIG.8



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Description

TECHNICAL FIELD

[0001] The disclosed technique relates to an engine provided with a mechanical supercharger.

BACKGROUND ART

[0002] Patent Document 1 discloses an exemplary engine provided with a mechanical supercharger. Specifically, the engine disclosed in Patent Document 1 includes an intake passage (an intake system) connected to a combustion chamber and a mechanical supercharger provided in the intake passage and operating through externally transmitted power (a mechanical supercharger).

[0003] The supercharge according to Patent Document 1 includes a Lysholm pump with two-axis rotors. Specifically, this supercharger has two rotors extending in a predetermined central axial direction and provided adjacent to each other in a direction orthogonal to the central axial direction. An introduction passage portion (an intake introduction pipe) supplying gas to this supercharger is connected to a rotor chamber from one side in the central axial direction.

CITATION LIST

PATENT DOCUMENT

[0004] [Patent Document 1] Japanese Unexamined Patent Publication No. H09-228846

SUMMARY OF THE INVENTION

TECHNICAL PROBLEM

[0005] In such an engine provided with a mechanical supercharger as described in Patent Document 1, assume that the two rotors are called a first rotor and a second rotor, gas is required to be supplied evenly to both the first and second rotors to increase supercharging efficiency as much as possible.

[0006] As a measure therefor, for example, the introduction passage portion may be connected to a center in an arrangement direction of the first and second rotors. That is to say, if the first rotor and the second rotor are arranged in an up-and-down direction, the introduction passage portion is connected to a center in the up-and-down direction. This connection structure causes the gas supplied from the introduction passage portion to be distributed to the first rotor and the second rotor in a balanced manner.

[0007] However, in view of making the engine compact, the introduction passage portion (specifically, at least part of the introduction passage portion) may be offset toward the first rotor in the arrangement direction. In this case, the gas supplied from the introduction passage portion may be distributed toward the first rotor in an unbalanced manner. Given these circumstances, there is still room for improvement in increasing supercharging efficiency.

[0008] The inventors of the present invention have conducted earnest studies to find a configuration that can maximize supercharging efficiency even when the introduction passage portion is provided close to the first rotor.

[0009] The disclosed technique has been made in view of the point, and an object thereof is to increase the supercharging efficiency of an engine provided with a mechanical supercharger while making the engine compact.

SOLUTION TO THE PROBLEM

[0010] A disclosed technique relates to an engine provided with a mechanical supercharger including: an intake passage connected to a combustion chamber; and a mechanical supercharger provided in the intake passage and operating on externally transmitted power, the supercharger having a first rotor extending in a predetermined central axial direction, a second rotor extending parallel to the first rotor and provided adjacent to the first rotor in an arrangement direction orthogonal to the central axial direction, and a rotor chamber housing the first and second rotors.

[0011] The supercharger includes an introduction passage portion connected to the rotor chamber from one side in the central axial direction, and at least an upstream portion of the introduction passage portion is offset toward the first rotor in the arrangement direction.

[0012] The introduction passage portion includes an inner wall provided with a guide portion directing a gas flow flowing along the inner wall toward the second rotor in the arrangement direction.

[0013] With this configuration, in the arrangement direction of the first and second rotors, the upstream side of the introduction passage portion is offset toward the first rotor. Although such provision is advantageous in making the engine compact, the gas supplied from the introduction passage portion may be distributed toward the first rotor in an unbalanced manner as described above.

[0014] However, with the configuration, the inner wall of the introduction passage portion is provided with the guide portion, and at least part of the gas supplied from the introduction passage portion can be directed toward the second rotor by the guide portion. Accordingly, the gas can be distributed to the first rotor and the second rotor in a balanced manner, hence the supercharging efficiency of the engine can be increased.

[0015] Intake system components in the intake passage may be provided closer to the second rotor in the arrangement direction than the introduction passage portion is.

[0016] As described above, the introduction passage portion is offset toward the first rotor in the arrangement

direction of the first and second rotors. Since the introduction passage portion is offset toward the first rotor, a space is provided on the second rotor side of the introduction passage portion accordingly. The intake system components are arranged in such a space, whereby the engine can be made compact in the arrangement direction.

[0017] The introduction passage portion may have a first passage portion offset toward the first rotor in the arrangement direction and a second passage portion provided between the first passage portion and the rotor chamber, and is formed to be larger in a flow passage cross section larger than the first passage portion, and the second passage portion may form a gas relay chamber.

[0018] With this configuration, the second passage portion can form the gas relay chamber. Hence, the gas flow can be expanded, for example, across the arrangement direction, and the gas can be distributed to the first rotor and the second rotor in a balanced manner. This is advantageous in increasing the supercharging efficiency of the engine.

[0019] The guide portion may have either one of or both of a first inclined portion formed on an inner wall close to the first rotor in the arrangement direction and a second inclined portion formed on an inner wall close to the second rotor in the direction out of the inner wall of the introduction passage portion, and both the first and second inclined portions may be inclined to head toward the second rotor from the first rotor in the arrangement direction from an upstream side toward a downstream side in a gas flow direction.

[0020] With this configuration, the gas flow flowing along either one of or both of the inner wall close to the first rotor and the inner wall close to the second rotor can be directed toward the second rotor using the so-called Coanda effect. Hence, this is advantageous in increasing the supercharging efficiency of the engine.

[0021] The arrangement direction may substantially correspond to an up-and-down direction, the first rotor may be provided substantially below the second rotor, a bypass passage branching off from the introduction passage portion to bypass the supercharger and to guide gas to the combustion chamber may be provided, the bypass passage may be connected to an upper side in the up-and-down direction of the introduction passage portion, and an EGR passage may be connected to the bypass passage, the guide portion may have at least the first inclined portion, and a branching portion at which the introduction passage portion and the bypass passage branch off may be provided upstream of the first inclined portion in the gas flow direction.

[0022] With this configuration, the first inclined portion is formed by a lower inner wall of the introduction passage portion.

[0023] With the configuration, the first inclined portion is interposed between the branching portion and the supercharger in the gas flow direction.

[0024] By the way, water contained in a combusted gas flowed backward through the EGR passage may become condensed water in the EGR passage and the bypass passage, to flow into the introduction passage portion through the branching portion, and by extension, to flow into the supercharger.

[0025] However, with the above-mentioned configuration, the first inclined portion is interposed between the branching portion and the supercharger, and if the condensed water flows into the introduction passage portion, the first inclined portion dams up the condensed water, thereby reducing the risk of flow of the condensed water into the supercharger. Accordingly, corrosion of the supercharger caused by components contained in the condensed water can be prevented.

[0026] The guide portion may have both the first and second inclined portions, and the first and second inclined portions may be provided to overlap with each other in the gas flow direction in the upstream passage portion.

[0027] Both the first and second inclined portions are configured to direct the gas flow toward the second rotor. Considering that the second inclined portion is provided close to the second rotor with respect to the first inclined portion, the gas flow is directed toward the second inclined portion by the first inclined portion. Consequently, the configuration is advantageous in exhibiting the Coanda effect in the second inclined portion by the gas flow directed toward the second inclined portion.

[0028] A throttle passage portion provided with a throttle valve may be arranged upstream of the introduction passage potion of the intake passage, and an upstream end of either one of or both of the first and second inclined portions may be provided on an extension line extending in the gas flow direction from an inner wall of the throttle passage portion.

[0029] This configuration is advantageous in guiding the gas flow flowing along the inner wall of the throttle passage portion to the first and second inclined portions. This is further advantageous in increasing the supercharging efficiency of the engine.

[0030] The engine provided with a mechanical supercharger may include: an engine body including a cylinder block, a cylinder head and the combustion chamber; auxiliary machines mounted on an outer surface of the engine body; and an intercooler provided downstream of the supercharger in the intake passage, in which the arrangement direction may substantially correspond to an up-and-down direction, the supercharger may be provided above the auxiliary machines, and the intercooler may be adjacent to the auxiliary machines in the central axial direction and may be provided below the supercharger in the arrangement direction.

[0031] With this configuration, the supercharger and the intercooler can be provided on one side of the engine without interfering with the auxiliary machines. Hence, an intake system can be made compact, resulting in an advantage of increasing supercharging response.

[0032] Another technique disclosed herein relates to an engine provided with a mechanical supercharger including: an intake passage connected to a combustion chamber; and a mechanical supercharger provided in the intake passage and operating on externally transmitted power, the supercharger having a first rotor extending in a predetermined central axial direction, a second rotor extending parallel to the first rotor and provided adjacent to the first rotor in an arrangement direction orthogonal to the central axial direction, and a rotor chamber housing the first and second rotors.

[0033] The intake passage has an introduction passage portion supplying gas to the supercharger.

[0034] The introduction passage portion is connected to the rotor chamber from one side in the central axial direction and is offset toward the first rotor in the arrangement direction.

[0035] An inner wall of the introduction passage portion is provided with a guide portion inclined to head toward the second rotor from the first rotor in the arrangement direction from an upstream side toward a downstream side in a gas flow direction.

[0036] With this configuration, in the arrangement direction of the first and second rotors, the introduction passage portion is provided close to the first rotor. Although such provision is advantageous in making the engine compact, the gas supplied from the introduction passage portion may be distributed toward the first rotor in an unbalanced manner as described above.

[0037] However, with the configuration, the inner wall of the introduction passage portion is provided with the guide portion, and at least part of the gas supplied from the introduction passage portion can be directed toward the second rotor by the guide portion. With this effect, the gas can be distributed to the first rotor and the second rotor in a balanced manner, hence supercharging efficiency can be increased.

ADVANTAGES OF THE INVENTION

[0038] As described above, the engine provided with a mechanical supercharger can increase its supercharging efficiency while making the engine compact.

BRIEF DESCRIPTION OF THE DRAWINGS

[0039]

[FIG.1] FIG. 1 is a schematic view illustrating an example of a configuration of an engine.

[FIG.2] FIG. 2 is a view illustrating the engine viewed from the front.

[FIG.3] FIG. 3 is a view illustrating the engine viewed from the upper side.

[FIG.4] FIG. 4 is a view illustrating gas flows in an intake passage respectively in supercharging and in natural aspiration in comparison manner.

[FIG.5] FIG. 5 is a view illustrating the intake passage viewed from the front.

[FIG.6] FIG. 6 is a longitudinal sectional view of the intake passage.

[FIG.7] FIG. 7 is a view illustrating the intake passage viewed from the left side.

[FIG.8] FIG. 8 is a longitudinal sectional view of the intake passage.

[FIG.9] FIG. 9 is a longitudinal sectional view of the intake passage.

[FIG.10] FIG. 10 is a transverse sectional view of the intake passage.

[FIG. 11] FIG. 11 is a view illustrating the intake passage viewed from the rear side.

[FIG.12] FIG. 12 is a view illustrating the intake passage viewed from the upper side.

[FIG.13] FIG. 13 is a diagram illustrating an EGR gas flow in the intake passage in a comparison manner between in supercharging and in natural aspiration.

[FIG.14] FIG. 14 is a view illustrating a fresh air flow sucked into a supercharger in comparison to that in a conventional configuration.

DESCRIPTION OF EMBODIMENTS

[0040] Hereinafter, an embodiment of an engine provided with a mechanical supercharger will be described in detail referring to the accompanying drawings. The following description is merely exemplary in nature. FIG. 1 is a schematic view illustrating an example of a configuration of an engine 1 provided with a mechanical supercharger disclosed herein (hereinafter simply referred to as "engine"). FIG. 2 is a view illustrating the engine 1 viewed from the front, whereas FIG. 3 is a view illustrating the engine 1 viewed from the upper side.

[0041] The engine 1 is a four-stroke combustion engine mounted in an automobile and includes a mechanical supercharger 34 operating through externally transmitted power as illustrated in FIG. 1 to FIG. 3. Fuel of the engine 1 is gasoline in this exemplary configuration.

[0042] Although not shown in detail, the engine 1 is a so-called in-line four-cylinder transverse engine including four cylinders 11 arranged in line, the four cylinders 11 being arranged in a vehicle width direction. With this configuration, in this exemplary configuration, an engine front-rear direction, which is an arrangement direction of the four cylinders 11 (a cylinder array direction), substantially corresponds to the vehicle width direction, while an engine width direction substantially corresponds to a vehicle front-rear direction.

[0043] In an inline multi-cylinder engine, the cylinder array direction and a central axial direction of a crankshaft 15 as an engine output shaft (an engine output shaft direction) coincide with each other. Hereinafter, the directions may be collectively referred to as the cylinder array direction (or the vehicle width direction).

[0044] Hereinafter, unless otherwise specified, the term "front side" means the front side in the vehicle front-rear direction, the term "rear side" means the rear side

in the vehicle front-rear direction, the term "left side" means one side in the vehicle width direction (one side in the cylinder array direction, which is an engine rear side), and the term "right side" means the other side in the vehicle width direction (the other side in the cylinder array direction, which is an engine front side).

[0045] In the following description, the term "upper side" means the upper side in a vehicle height direction, with the engine 1 mounted in the vehicle (hereinafter also referred to as an "in-vehicle mounted state), and the term "lower side" means the lower side in the vehicle height direction in the in-vehicle mounted state.

(Outline Configuration of Engine)

[0046] In this exemplary configuration, the engine 1 is of a front-intake and rear-exhaust type. Specifically, the engine 1 includes: an engine body 10 having the four cylinders 11; an intake passage 30 provided at the front side of the engine body 10 and communicating with the cylinders 11 via an intake port 18; and an exhaust passage 50 provided at the rear side of the engine body 10 and communicating with the cylinders 11 via an exhaust port 19.

[0047] In this exemplary configuration, the intake passage 30 constitutes an intake device including: multiple passages introducing gas; devices such as a supercharger 34 and an intercooler 36; and an air bypass passage (hereinafter simply referred to as "bypass passage") 40 bypassing these devices to communicate with a combustion chamber 16, all of which are combined as a unit.

[0048] In the cylinders 11, the engine body 10 combusts a mixture of fuel and gas supplied from the intake passage 30 in a predetermined combustion order. Specifically, the engine body 10 includes a cylinder block 12, and a cylinder head 13 placed on the cylinder block 12.

[0049] The cylinder block 12 houses therein the four cylinders 11. The four cylinders 11 are arranged in line along the central axis of a crankshaft 15 (i.e., in the cylinder array direction). Note that FIG. 1 shows only one of the cylinders.

[0050] A piston 14 is slidably fitted into each of the cylinders 11. The piston 14 is coupled to the crankshaft 15 through a connecting rod 141. The piston 14 defines the combustion chamber 16 together with the cylinder 11 and the cylinder head 13. Note that the "combustion chamber" here is not limited to a space formed when the piston 14 reaches a compression top dead center. The term "combustion chamber" is used in a broad sense.

[0051] The cylinder head 13 has two intake ports 18 for each cylinder 11. FIG. 1 shows only one of the intake ports 18. The two intake ports 18 are arranged side by side in the cylinder array direction and communicate with the corresponding one of the cylinders 11.

[0052] Each of the two intake ports 18 is provided with an intake valve 21. The intake valve 21 opens and closes the path between the combustion chamber 16 and each of the intake ports 18. The intake valve 21 is opened and closed by an intake valve train mechanism at predetermined timing.

[0053] In this exemplary configuration, the intake valve train mechanism includes, as illustrated in FIG. 1, an electric intake sequential-valve timing (S-VT) 23 acting as a variable valve train mechanism. The electric intake S-VT 23 continuously changes a rotational phase of an intake camshaft within a predetermined angle range. Accordingly, an opening time point and a closing time point of the intake valve 21 change continuously. Note that the intake valve train mechanism may include a hydraulic S-VT instead of the electric intake S-VT 23.

[0054] Further, the cylinder head 13 has two exhaust ports 19 for each of the cylinders 11. FIG. 1 shows only one of the exhaust ports 19. The two exhaust ports 19 are arranged side by side in the cylinder array direction and communicate with the corresponding one of the cylinders 11.

[0055] Each of the two exhaust ports 19 is provided with an exhaust valve 22. The exhaust valve 22 opens and closes the path between the combustion chamber 16 and each of the exhaust ports 19. The exhaust valve 22 is opened and closed by an exhaust valve train mechanism at predetermined timing.

[0056] In this exemplary configuration, the exhaust valve train mechanism includes, as illustrated in FIG. 1, an electric exhaust sequential-valve timing (S-VT) 24 acting as a variable valve train mechanism. The electric exhaust S-VT 24 continuously changes a rotational phase of an exhaust camshaft within a predetermined angle range. Accordingly, an opening time point and a closing time point of the exhaust valve 22 change continuously. Note that the exhaust valve train may include a hydraulic S-VT instead of the electric S-VT 24.

[0057] The cylinder head 13 has an injector 6 for each of the cylinders 11. In this exemplary configuration, the injector 6 is a multi-nozzle fuel injection valve which directly injects fuel into the combustion chamber 16.

[0058] The injector 6 is connected to a fuel supply system 61. The fuel supply system 61 includes a fuel tank (not shown) which stores fuel and a fuel supply passage 62 connecting the fuel tank and the injector 6 together. The fuel supply passage 62 is interposed between a fuel pump 65 and a common rail 64.

[0059] The cylinder head 13 has a spark plug 25 provided for each of the cylinders 11. The spark plug 25 has a tip protruding into the combustion chamber 16, so that the tip forcibly ignites the air-fuel mixture inside the combustion chamber 16.

[0060] Referring back to the description of the intake passage 30, the intake passage 30 in this exemplary configuration is connected to one side face (specifically, a side face on the front side) of the engine body 10 to communicate with the intake ports 18 of each of the cylinders 11. Specifically, the intake passage 30 conducts gas to be introduced into the combustion chamber 16, and is connected through the intake ports 18 to the combustion

chamber 16.

[0061] An air cleaner 31 filtering fresh air is provided to an upstream end of the intake passage 30. Whereas, a surge tank 38 is provided near a downstream end of the intake passage 30. The intake passage 30 located downstream of the surge tank 38 forms two branching independent passages 39 for each of the cylinders 11. A downstream end of each of the independent passages 39 is connected to the intake ports 18 of each of the cylinders 11.

[0062] A throttle valve 32 is provided to the intake passage 30 between the air cleaner 31 and the surge tank 38. An opening of the throttle valve 32 is adjusted to regulate the amount of fresh air to be introduced into the combustion chamber 16.

[0063] In the intake passage 30, the supercharger 34 is provided downstream of the throttle valve 32. The supercharger 34 supercharges the gas to be introduced into the combustion chamber 16. In this exemplary configuration, the supercharger 34 is mechanically driven by the engine 1 (specifically, power transmitted from the crankshaft 15). This supercharger 34 is configured as a two-axis rotor Roots blower.

[0064] An electromagnetic clutch 34a is interposed between the supercharger 34 and the crankshaft 15. The electromagnetic clutch 34a transmits and blocks driving force between the supercharger 34 and the crankshaft 15. As described later, a control unit (not shown) such as an engine control unit (ECU) selectively engages and disengages the electromagnetic clutch 34a to turn on and off the supercharger 34. Specifically, the operation of this engine 1 is switched between a mode of supercharging the gas to be introduced into the combustion chamber 16 and a mode of not supercharging the gas to be introduced into the combustion chamber 16 by turning on and off the supercharger 34.

[0065] In the intake passage 30, the intercooler 36 is provided downstream of the supercharger 34. The intercooler 36 houses a core 36a (see also FIG. 10) performing heat exchange with the gas passing through the supercharger 34 and cools the gas compressed by the supercharger 34. The intercooler 36 of this exemplary configuration is of a water-cooling type.

[0066] As a passage connecting various kinds of devices incorporated in the intake passage 30, the intake passage 30 includes: a first passage 33 provided downstream of the air cleaner 31 and guiding the gas filtered through the air cleaner 31; a second passage 35 guiding the gas compressed by the supercharger 34 to the intercooler 36; and a third passage 37 guiding the gas cooled by the intercooler 36 to the surge tank 38.

[0067] In the intake passage 30, the first passage 33, the second passage 35, the third passage 37, and the surge tank 38 constitute a "main intake passage" in which the supercharger 34 and the intercooler 36 are interposed in the stated order from upstream in the air flow direction. Hereinafter, a reference character "30A" will be assigned to the main intake passage.

[0068] The intake passage 30 is provided with a bypass passage 40 apart from the main intake passage 30A. The bypass passage bypasses the supercharger 34 and the intercooler 36. Specifically, the bypass passage 40 branches off from the upstream side of the supercharger 34 and is connected to the downstream side of the intercooler 36 (specifically, the surge tank 38) in the main intake passage 30A.

[0069] The bypass passage 40 is also provided with an air bypass valve (hereinafter simply referred to as "a bypass valve") 41 changing a cross-sectional flow area of the bypass passage 40. The bypass valve 41 changes the cross-sectional flow area of the bypass passage 40 to adjust the flow rate of the gas flowing through the bypass passage 40.

[0070] FIG. 4 is a view illustrating gas flows in an intake passage respectively in supercharging and in natural aspiration in comparison manner.

[0071] When the supercharger 34 is turned off (i.e., when the electromagnetic clutch 34a is disengaged), the bypass valve 41 fully opens. With this operation, as shown in a lower illustration of FIG. 4, the gas passing through the intake passage 30 bypasses the supercharger 34 to flow into the surge tank 38 and is introduced into the combustion chamber 16 via the independent passage 39. The engine 1 is operated without supercharging, that is, by natural aspiration.

[0072] When the supercharger 34 is turned on (i.e., when the electromagnetic clutch 34a is engaged), the opening of the bypass valve 41 is adjusted as appropriate. With this operation, as shown in an upper illustration in FIG. 4, part of the gas passing through the supercharger 34 in the intake passage 30 flows back to the upstream of the supercharger 34 through the bypass passage 40. A rate of the backflow gas can be adjusted through adjustment of the opening of the bypass valve 41. Through the backflow rate, a supercharging pressure of the gas to be introduced into the combustion chamber 16 can be adjusted. In this exemplary configuration, the supercharger 34, the bypass passage 40, and the bypass valve 41 constitute a supercharging system.

[0073] The exhaust passage 50 is connected to the other side surface (specifically, a rear side surface) of the engine body 10 and communicates with the exhaust ports 19 of each of the cylinders 11. The exhaust passage 50 is a passage through which exhaust gas discharged from the combustion chamber 16 flows. Although not shown in detail, an upstream part of the exhaust passage 50 forms independent passages, each of which branches off for one of the cylinders 11. An upstream end of each of the independent passages is connected to the exhaust ports 19 of each of the cylinders 11.

[0074] An exhaust gas purification system with one or more catalyst converters 51 is arranged on the exhaust passage 50. Each of the catalyst converters 51 includes a three-way catalyst. Note that the exhaust gas purification system may include any given catalyst other than the three-way catalyst.

[0075] An EGR passage 52 acting as an external EGR system is connected between the intake passage 30 and the exhaust passage 50. The EGR passage 52 allows the burned gas, guided through the exhaust passage, to flow back to the intake passage 30. Specifically, an upstream end of the EGR passage 52 is connected to the exhaust passage 50 downstream of the catalyst converter 51. Meanwhile, a downstream end of the EGR passage 52 is connected to the intake passage 30 upstream of the supercharger 34 and downstream of the throttle valve 32.

[0076] The EGR passage 52 is provided with a water-cooled EGR cooler 53. The EGR cooler 53 cools the combusted gas. An EGR valve 54 adjusts a flow rate of the combusted gas flowing through the EGR passage 52. On the drawing plane of FIG. 1, the EGR valve 54 is illustrated to be provided to the EGR passage. Actually, however, the EGR valve 54 is provided to the bypass passage 40 as described later. Through adjustment of the opening of the EGR valve 54, the backflow rate of the cooled combusted gas; that is, the external EGR gas, can be adjusted.

[0077] In this exemplary configuration, an EGR system 55 includes the external EGR system including the EGR passage 52 and the EGR valve 54, and the internal EGR system including the electric intake S-VT 23 and the electric exhaust S-VT 24 described above.

[0078] The engine 1 is also provided with various kinds of auxiliary machines other than the fuel pump 65. This engine 1 includes, as such the auxiliary machines, an alternator 91 that generates AC current for use in an electric system, an air conditioner 92 for air conditioning, and a water pump (not shown) for circulating cooling water.

[0079] As illustrated in FIG. 2, the fuel pump 65 is mounted on a left front surface (outer surface) of the engine body 10. Meanwhile, the alternator 91 and the air conditioner 92 are mounted on a right front portion of the engine body 10. The alternator 91 and the air conditioner 92 are arranged in this order from above. A drive pulley 34d of the supercharger 34 is arranged above the alternator 91. Although not shown in detail, a timing belt for driving the supercharger 34 is looped around this drive pulley 34d.

(Configuration of Intake Passage)

[0080] Next, a configuration of the essential portion of the intake passage 30 will be described in detail.

[0081] FIG. 5 is a view illustrating the intake passage 30 viewed from the front. FIG. 6 is a longitudinal sectional view of the intake passage 30. FIG. 7 is a view illustrating the intake passage 30 viewed from the left side. FIG. 8 is a longitudinal sectional view of the intake passage 30. FIG. 9 is a longitudinal sectional view of the intake passage 30. FIG. 10 is a transverse sectional view of the intake passage 30. FIG. 11 is a view illustrating the intake passage 30 viewed from the rear side. FIG. 12 is a view illustrating the intake passage 30 viewed from the upper side.

[0082] The portions constituting the intake passage 30 are all provided on the front side of the engine body 10, specifically, along front surfaces of the cylinder head 13 and the cylinder block 12.

[0083] Furthermore, as described above, the intake passage 30 includes: multiple passages (specifically, the first passage 33, the second passage 35, the third passage 37, the surge tank 38, and the independent passage 39) to introduce gas; devices such as the supercharger 34 and the intercooler 36; and the bypass passage 40 bypassing these devices, all of which are combined. As illustrated in drawings such as FIG. 5, the main intake passage 30A included in the intake passage 30 is provided below the bypass passage 40.

[0084] As described above, the supercharger 34 is configured as a two-axis rotor Roots blower. Specifically, as illustrated in drawings such as FIG. 8, the supercharger 34 includes a first rotor 341 extending in a predetermined central axial direction, a second rotor 342 extending parallel to the first rotor 341 and provided adjacent to the first rotor 341 in an arrangement direction orthogonal to the central axial direction, and a rotor chamber 343 housing the first and the second rotors 341 and 342.

[0085] In this exemplary configuration, the central axial direction coincides with the cylinder array direction (refer to FIG. 8). Hence, in the following description, the central axial direction will be simply referred to as the cylinder array direction. Though the arrangement direction almost corresponds to the up-and-down direction, the arrangement direction is slightly inclined relative to the up-and-down direction. Specifically, as indicated by a straight line La in FIG. 10, although the first rotor 341 and the second rotor 342 are arranged in this order from below, the second rotor 342 positioned substantially above the first rotor 341 slightly protrudes closer to the front than the first rotor 341. The second rotor 342 thus protrudes closer to the front, so the arrangement direction is slightly inclined to the front from below to above.

[0086] In this engine 1, for the purpose of increasing supercharging response, the supercharger 34 and the intercooler 36 are collectively provided near an upstream end of the intake port 18.

[0087] Next, a schematic layout of these components will be described; as illustrated in figures such as FIG. 10, the supercharger 34 is located opposite to the engine body 10, with the surge tank 38 interposed therebetween. A gap corresponding to the dimension of the surge tank 38 is formed between a rear surface of the supercharger 34 and a front surface of the engine body 10. The first passage 33 extends in the cylinder array direction on the left of the supercharger 34, and is connected to the left end of the supercharger 34. The supercharger 34 and the intercooler 36 are arranged side by side in the up-and-down direction in this order and are adjacent to each other in the direction. The second passage 35 extends substantially in the up-and-down direction to connect a front portion of the supercharger 34 and a front portion

of the intercooler 36 together. The surge tank 38 is provided between the supercharger 34 and the engine body 10 and is provided to face the upstream end of the intake port 18 with the independent passages 39 interposed therebetween. The third passage 37 is provided to extend through the clearance between (i) the intercooler 36 and the supercharger 34 and (ii) the engine body 10. The third passage 37 connects the rear of the intercooler 36 to the bottom of the surge tank 38 so that the intercooler 36 is located below the surge tank 38. The bypass passage 40 branches off from a middle of the first passage 33 to extend upward and then extends inside the engine body 10 (to the right). The bypass passage 40 branches off downstream into two, and the two branching passages 40 are connected to the upper part of the surge tank 38.

[0088] As can be seen from FIG. 5, the EGR valve 54 and the bypass valve 41 are provided between the supercharger 34 and the throttle valve 32 in the cylinder array direction. Specifically, the EGR valve 54 is provided at the upper right of the throttle valve 32, whereas the bypass valve 41 is provided substantially on the right of the EGR valve 54 and at the upper left of an intake portion of the supercharger 34 (in this exemplary configuration, the left end of the supercharger 34). Thus, both the EGR valve 54 and the bypass valve 41 are laid out to be positioned between the throttle valve 32 and the left end of the supercharger 34 in the cylinder array direction. The EGR valve 54 and the bypass valve 41, and the bypass passage 40 provided with the bypass valve 41 are respectively an example of "intake system components".

[0089] In this manner, the EGR valve 54 and the bypass valve 41 are provided close to the throttle valve 32, whereby the dimension of the engine 1 in the vehicle height direction can be reduced compared with a configuration in which the EGR valve 54 and the bypass valve 41 are provided immediately above the supercharger 34, for example. Hence, as illustrated in FIG. 5 and FIG. 6, the spacing between the engine 1 and a bonnet B can be ensured more sufficiently without increasing the dimension of the engine 1 in the vehicle front-rear direction (see a spacing H in FIG. 5).

[0090] Thus, the engine 1 not only increases supercharging response, and by extension, supercharging efficiency by collectively providing the supercharger 34 and the intercooler 36 on the intake side, but also makes the engine 1 compact by collectively providing the various kinds of valve members such as the EGR valve 54.

[0091] However, for the purpose of collectively providing the valve members, thoughtful devising is required for a configuration around the supercharger 34. As described above, in the first place, the various kinds of auxiliary machines are mounted on the front side of the engine body 10, and a space for allowing the supercharger 34 to be provided is limited.

[0092] Next, for the purpose of describing a layout related to making the engine 1 compact and improvement in supercharging efficiency in detail, the structures of the portions forming the intake passage 30 will be described one by one.

[0093] The first passage 33 is provided with the throttle valve 32 and extends from the one side toward the other side (specifically, from left to right) in the cylinder array direction. Specifically, as illustrated in drawings such as FIG. 8 and FIG. 9, the first passage 33 is shaped into a tube form extending substantially in the cylinder array direction (the right-left direction). An upper portion (the left) of the first passage 33 includes a throttle body 33a housing the throttle valve 32. The throttle body 33a is made of metal and shaped into a short cylinder form, and located on the left and in front of the engine body 10, with openings on both ends of the throttle body 33a facing laterally. The upstream end (i.e., the left end) of the throttle body 33a is connected to the air cleaner 31 via a passage (not shown), while the downstream end (i.e., the right end) of the throttle body 33a is connected to a first passage body 33b, which is the upstream (left) part of the first passage 33. The throttle body 33a is an example of the "throttle passage portion."

[0094] As illustrated in FIG. 8, the first passage body 33b connects the throttle body 33a to the supercharger 34. Specifically, the first passage body 33b is shaped to be a long cylinder form with openings on its both ends facing laterally. The first passage body 33b is arranged to be substantially coaxial with the throttle body 33a in front of the engine body 10. More specifically, as can be seen from FIG. 8 to FIG. 9, the first passage body 33b is formed such that the diameter of the first passage body 33b gradually increases from the one side toward the other side (specifically, from left to right) in the cylinder array direction. As described above, the upstream end (i.e., the left end) of the first passage body 33b is connected to the downstream end of the throttle body 33a. Whereas, the downstream end (i.e., the right end) of the first passage body 33b is connected to an intake portion of the supercharger 34. The first passage body 33b supplies gas to the supercharger 34 and is an example of the "introduction passage portion" of the supercharger 34.

[0095] The first passage body 33b as the introduction passage portion is connected to the rotor chamber 343 from the one side (the left side) in the cylinder array direction. An upstream portion of the first passage body 33b (an upstream passage portion 331) is offset toward the first rotor 341 (the lower side on the drawing of FIG. 8) in the arrangement direction.

[0096] An inner wall of the first passage body 33b is provided with a guide portion 70 inclined to head toward the second rotor 342 from the first rotor 341 in the arrangement direction from an upstream side toward a downstream side along the gas flow direction in order to direct the gas flow flowing along the inner wall toward the second rotor 342 in the arrangement direction.

[0097] Specifically, the first passage body 33b includes the upstream passage portion 331 offset toward the first rotor 341 in the arrangement direction, and a downstream passage portion 332 provided between the upstream

passage portion 331 and the rotor chamber 343 and formed to be larger in a gas flow passage cross section than the upstream passage portion 331. The guide portion 70 is provided in the upstream passage portion 331. On the other hand, the downstream passage portion 332 forms a gas relay chamber 333. The upstream passage portion 331 is an example of the "first passage portion." Whereas, the downstream passage portion 332 is an example of the "second passage portion."

[0098] As illustrated in drawings such as FIG. 8, and FIG. 9, the upstream passage portion 331 extends from the one side toward the other side (specifically, from left to right) in the cylinder array direction and is substantially coaxial with both the throttle body 33a and the first rotor 341. Since the upstream passage portion 331 is offset toward the first rotor 341, a space for arranging components is provided on the second rotor 342 side of the upstream passage portion 331 accordingly. In this engine 1, as illustrated in FIG. 8, the intake system components such as the bypass passage 40, the bypass valve 41, and the EGR valve 54 are provided closer to the second rotor 342 in the arrangement direction than the upstream passage portion 331 is. In this manner, the various kinds of valve members are collectively provided, resulting in making the engine 1 compact.

[0099] The downstream end of the throttle body 33a is connected to the upstream end (the left end) of the upstream passage portion 331, whereas the upstream end (the left end) of the downstream passage portion 332 is connected to the downstream end (the right end) of the upstream passage portion 331.

[0100] The guide portion 70 is provided on a downstream inner wall of the upstream passage portion 331. Specifically, the guide portion 70 includes a first inclined portion 71 formed on its inner wall close to the first rotor 341 in the arrangement direction and a second inclined portion 72 formed on the inner wall close to the second rotor 342 in the arrangement direction.

[0101] Both the first and second inclined portions 71 and 72 are inclined to head toward the second rotor 342 from the first rotor 341 in the arrangement direction from the upstream side toward the downstream side along the gas flow direction (in this example, from left to right along the cylinder array direction).

[0102] As can be seen from FIG. 8, when viewed in a cross section including the cylinder array direction and the arrangement direction, the second inclined portion 72 is larger in an inclination angle than the first inclined portion 71.

[0103] Specifically, an upstream end (a left end) of the first inclined portion 71 is positioned slightly below a lower edge of the first rotor 341, whereas a downstream end (a right end) of the first inclined portion 71 is provided at substantially the same position as the lower edge of the first rotor 341 in the arrangement direction. An extension line extending in the gas flow direction from the first inclined portion 71 substantially passes through a center of the first rotor 341 in the arrangement direction as indicated by a broken line in FIG. 8.

[0104] On the other hand, in the arrangement direction, an upstream end (a left end) of the second inclined portion 72 is positioned near an upper portion of the first rotor 341, and a downstream end (a right end) of the second inclined portion 72 is positioned near a lower portion of the second rotor 342. An extension line extending in the gas flow direction from the second inclined portion 72 passes through an upper end portion of the second rotor 342 in the arrangement direction as indicated by the broken line in FIG. 8.

[0105] As can be seen from the fact that the first inclined portion 71 and the second inclined portion 72 are arranged within a range of a double-pointed arrow designated by a reference character 331 in FIG. 8, they are provided to overlap with each other in a gas flow direction in the upstream passage portion 331 (the right-and-left direction on the drawing of FIG. 8).

[0106] As described above, the throttle body 33a provided with the throttle valve 32 is provided upstream of the first passage body (specifically, the upstream passage portion 331) 33b of the intake passage 30. The upstream end (the left end) of the second inclined portion 72 is provided on an extension line Le extending in the gas flow direction from an inner wall of the throttle body 33a.

[0107] As described later in detail, the bypass passage 40 is connected to an upper side in the up-and-down direction of the first passage body (specifically, the upstream passage portion 331) 33b, and the EGR passage 52 is connected to the bypass passage 40.

[0108] A branching portion 33d at which the first passage body 33b and the bypass passage 40 branch off from each other is provided upstream of the first inclined portion 71 in the gas flow direction (in this exemplary configuration, on the left of the first inclined portion 71).

[0109] Moreover, the first passage body 33b also includes the branching portion 33d opening thereon and connected to the bypass passage 40. This branching portion 33d is formed on an upper surface of the first passage body 33b, and connected to the upstream portion (a curving pipe 45 to be described later) of the bypass passage 40. Specifically, as can be seen from FIG. 8, this branching portion 33d is provided on the other side (i.e., the right side) in the cylinder array direction, with respect to the throttle valve 32 in the first passage 33 (by extension, the main intake passage 30A).

[0110] As illustrated in FIG. 9, a part of the guide portion 70 corresponding to the first inclined portion 71 gradually increases in its diameter from the upstream side toward the downstream side in the gas flow direction when viewed in a cross section perpendicular to the arrangement direction.

[0111] As illustrated in FIG. 8 and FIG. 9, the downstream passage portion 332 extends like a short cylinder shape from the one side toward the other side (specifically, from left to right) in the cylinder array direction, and is substantially coaxial with a casing 34b of the super-

charger 34. As illustrated in FIG. 8 and FIG. 9, both the dimension of the downstream passage portion 332 in the arrangement direction and the dimension thereof in a direction perpendicular to both the cylinder array direction and the arrangement direction are longer than those of the upstream passage portion 331. Consequently, a flow passage cross section of the downstream passage portion 332 is larger than that of the upstream passage portion 331.

[0112] The gas relay chamber 333 is formed by this downstream passage portion 332. The relay chamber 333 temporarily stores therein the gas flowing from the upstream passage portion 331 like a so-called surge tank.

[0113] The downstream end of the upstream passage portion 331 is connected to the upstream end (the left end) of the downstream passage portion 332, whereas the downstream end (the right end) of the downstream passage portion 332 is connected to the rotor chamber 343 formed by the casing 34b and communicates with the casing 34b.

[0114] The fresh air purified by the air cleaner 31 and flowing into the first passage 33 passes through the throttle valve 32 to reach the first passage body 33b. In natural aspiration, this fresh air flows through the branching portion 33d into the bypass passage 40. On the other hand, in supercharging, the fresh air joins the gas flowing back through the bypass passage 40, and is sucked into the supercharger 34 from the downstream end of the first passage body 33b (see also FIG. 4).

[0115] Next, a passage structure close to the supercharger 34 and a structure of the bypass passage 40 will be described in order.

- Passage Structure Close to Supercharger -

[0116] First, the passage structure close to the supercharger 34 will be described in detail.

[0117] The supercharger 34 as a Roots blower includes the first and second rotors 341 and 342 each having a rotational shaft extending in the cylinder array direction and the rotor chamber 343 housing the rotors 341 and 342. The first and second rotors 341 and 342 are arranged side by side in the arrangement direction orthogonal to the central axial direction. The supercharger 34 further includes the casing 34b constituting the rotor chamber 343 and a drive pulley 34d that rotates to drive the rotors 341 and 342, and is coupled to the crankshaft 15 via a drive belt 81 looped around the drive pulley 34d. The electromagnetic clutch 34a is interposed between the drive pulley 34d and the rotors 341 and 342. Selectively, the electromagnetic clutch 34a is engaged to transmit the driving force through the crankshaft 15 to the supercharger 34, and disengaged to block the driving force.

[0118] The casing 34b is shaped into a tube extending in the cylinder array direction, and separates from each other the rotor chamber 343 for housing the rotors 341 and 342 and the flow passage of the gas passing through the supercharger 34. Specifically, the casing 34b is formed into a substantial cylinder shape extending in the cylinder array direction, and has an opening left end and an opening front end. As illustrated in drawings such as FIG. 8, the casing 34b is provided at a predetermined distance from a substantially central portion of the front surface of the engine body 10 in the cylinder array direction, and is coaxial with the first passage 33 with a slight offset.

[0119] An introduction part through which the gas compressed by the rotors 341 and 342 is sucked is open at a longitudinal left end of the casing 34b, to which the downstream end of the first passage 33 (specifically, the downstream end of the downstream passage portion 332 of the first passage body 33b) is connected. On the other hand, as illustrated in FIG. 10, a discharge port 34c is open to the front of the casing 34b to discharge the gas compressed by the rotors 341 and 342. The discharge port 34c is connected to the upstream end (i.e., the upper end) of the second passage 35.

[0120] The drive pulley 34d rotates to drive the rotors housed in the casing 34b. Specifically, the drive pulley 34d is shaped into a shaft projecting from the right end of the casing 34b, and extending to be substantially axially aligned with both the first passage 33 and the casing 34b. The drive belt is looped around the tip of the drive pulley 34d, and drives the crankshaft 15 and couples the crankshaft 15 to the supercharger 34, depending on engagement or disengagement of the electromagnetic clutch 34a as described above.

[0121] The supercharger 34 is provided above the auxiliary machines. Specifically, as illustrated in FIG. 5 and FIG. 6, the drive pulley 34d of the supercharger 34 is provided immediately above the alternator 91.

[0122] As illustrated in FIG. 5 and FIG. 10, the second passage 35 connects the supercharger 34 to the intercooler 36. In order for the supercharger 34 and the intercooler 36 to be adjacent to each other in the up-and-down direction, the second passage 35 is formed to extend substantially in the up-and-down direction. As illustrated in FIG. 10, both upper and lower ends of the second passage 35 are open substantially toward the rear. The upper opening of the second passage 35 is connected to the front (specifically, the discharge port 34c) of the casing 34b, while the lower opening of the second passage 35 is connected to the front (specifically, an introduction part 36d to be described later) of the intercooler 36.

[0123] As described above, the intercooler 36 according to this embodiment is of a water-cooling type. As illustrated in FIG. 10, the intercooler 36 includes a core 36a capable of cooling gas, and a cooler housing 36c housing the core 36a.

[0124] The core 36a is shaped into a cuboid and is supported with an attitude with its one side surface (rear surface) facing the front surface of the engine body 10. The front surface of the core 36a forms a surface through which gas flows in, while the rear surface of the core 36a

forms a surface through which gas flows out. The front and rear surfaces are wider than any other surfaces of the core 36a. Although not shown, water tubes made of thin plates shaped into flat tubes are arranged in the core 36a. An exterior wall of each of the water tubes is provided with corrugated fins through brazing.

[0125] The cooler housing 36c is provided below the casing 34b included in the supercharger 34. The cooler housing 36c defines the space for housing the core 36a, and forms a passage included in the intake passage 30 and interposed between the second passage 35 and the third passage 37.

[0126] Specifically, the cooler housing 36c is shaped into a thin rectangular box having a front surface and a rear surface both opening. Below the casing 34b, the rear surface and the front surface of the engine body 10 are supported to face each other. Similarly to the casing 34b, this rear surface is provided at a predetermined distance from the front surface of the engine body 10.

[0127] The opening on the front side of the cooler housing 36c is a gas introduction part 36d of the intercooler 36, to which the downstream end of the second passage 35 is connected. The upstream end of the third passage 37 is connected to an opening 36e on the rear side of the cooler housing 36c.

[0128] The intercooler 36 is adjacent to the auxiliary machines in the cylinder array direction D1 and is provided below the supercharger 34 in the arrangement direction D2. Specifically, as illustrated in FIG. 6, the core 36a of the intercooler 36 is provided on the left of the alternator 91 and below the supercharger 34.

[0129] The third passage 37 is formed integrally with the surge tank 38 and the independent passages 39, and connects the intercooler 36 to the surge tank 38 as shown in FIG. 11.

[0130] The surge tank 38 is shaped into a substantial cylinder form extending along the cylinder bank, and having closed ends along the cylinder bank. As described above, this surge tank 38 is located opposite to the upstream end of the intake port 18 with the independent passages 39 interposed therebetween. Thanks to this provision, the surge tank 38 is to be positioned near the inlet (the upstream end) of the intake port 18 when the independent passages 39 are shaped into a short cylinder as described later. This is advantageous in reducing the length of the passage from the surge tank 38 to the intake port 18.

[0131] As shown in FIG. 11, the bottom of the surge tank 38 is connected to the downstream end of the third passage 37. Specifically, an inlet having a substantially circular cross section is open at a center of an inner bottom face of the surge tank 38 (specifically, a center in the cylinder array direction). The downstream end of the third passage 37 is connected to the surge tank 38 through the inlet.

[0132] Further, four pairs of the independent passages 39 (i.e., eight independent passages 39 in total) are arranged along the cylinder bank at the rear surface of the surge tank 38. When the engine 1 is mounted in the vehicle, each of the eight independent passages 39 is formed to be a short cylindrical passage extending substantially straight toward the rear. One end (an upstream end) of the independent passage 39 communicates with the space inside the surge tank 38, while the other end (a downstream end) of the independent passage 39 is open toward the engine body 10 (the rear).

[0133] Each of the four pairs of the independent passages 39 is provided to a corresponding one of the four pairs of the intake ports 18. When components of, for example, the third passage 37, the surge tank 38, and the independent passages 39 are mounted on the engine body 10, the independent passages 39 and the corresponding intake ports 18 form a single passage.

[0134] As described above, the downstream portion of the bypass passage 40 branches off into two, and a downstream end of each of the branching passages (hereinafter referred to as "branching passages" 44b and 44c) is connected to the upper surface of the surge tank 38.

[0135] In order to obtain such a connection structure, first and second introduction parts 38c and 38d are provided on the upper surface of the surge tank 38. The first and second introduction parts 38c and 38d are spaced apart from each other along the cylinder array direction, and allow the inside and outside of the surge tank 38 to communicate with each other.

[0136] Of the first and second introduction parts 38c and 38d, the first introduction part 38c located to the other side (to the right) in the cylinder array direction is connected to a downstream end of one of the branching passages (hereinafter also referred to as "the first branching passage") 44b; whereas, the second introduction part 38d located to the one side (to the left) in the cylinder array direction is connected to a downstream end of the other branching passage (hereinafter also referred to as "the second branching passage") 44c (also see FIG. 12).

[0137] In supercharging, an output from the crankshaft 15 is transmitted during the operation of the engine 1 through the drive belt and the drive pulley 34d to rotate the first and second rotors 341 and 342. The rotation of the rotors allows the supercharger 34 to compress the gas sucked through the first passage 33, and discharge the compressed gas through the discharge port 34c. The discharged gas flows into the second passage 35 located in front of the casing 34b.

[0138] As illustrated in FIG. 10, the gas discharged from the supercharger 34 and flowing into the second passage 35 flows downward from the discharge port 34c of the supercharger 34 along the second passage 35.

[0139] Next, the gas passing through the second passage 35 flows from the gas introduction part 36d inside the cooler housing 36c and flows from the front side thereof toward the rear. When passing through the core 36a, the gas flowing inside the cooler housing 36c is cooled with cooling water supplied to the water tubes. The cooled gas flows out of the opening 36e in the rear surface of

the cooler housing 36c, and then flows into the third passage 37.

[0140] As indicated by an arrow A0 of FIG. 11, the gas flowing into the surge tank 38 from the intercooler 36 through the third passage 37 is temporarily stored in the surge tank 38 and then supplied through the independent passage 39 to the intake port 18 of each of the cylinders 11.

- Structure of Bypass Passage -

[0141] Next, a configuration of the bypass passage 40 will be described in detail.

[0142] As described above, the bypass passage 40 branches off from the first passage body 33b and extends to bypass the supercharger 34 and to guide the gas to the combustion chamber 16.

[0143] Specifically, as illustrated in FIG. 8 and FIG. 12, the bypass passage 40 extends obliquely upward to the left from the branching portion 33d opening on the first passage body 33b, and then turns back and extends substantially straight to the right. The portion of the bypass passage 40 extending toward the right changes the direction at the region around the center of the surge tank 38 (specifically, the center in the direction along the cylinder bank) to head obliquely downward and backward, and then branches off into two passages. Each of the passages is connected to the top of the surge tank 38.

[0144] The bypass passage 40 includes the following constitutional elements in the stated order: the curving pipe 45 changing a flow direction of the gas flowing from the branching portion 33d; a valve body 41a containing the bypass valve 41; a straight pipe 43 guiding the gas passing through the valve body 41a toward the right; and a branch pipe 44 guiding the gas passing through the straight pipe 43 obliquely downward and backward and branching into two to be connected to the surge tank 38.

[0145] The curving pipe 45 is shaped into a cylinder form extending obliquely upward to the left from the branching portion 33d and then extending substantially straight to the right, and provided above the first passage 33 so that openings of the curving pipe 45 face downward and to the right.

[0146] A portion of the curving pipe 45 extending obliquely upward to the left from the branching portion 33d gradually increases its diameter obliquely downward to the right, which is opposite to the direction. Such a feature is advantageous in enlarging an opening area of the branching portion 33d.

[0147] Hence, the gas flowing into the curving pipe 45 flows obliquely upward to the left. Then, along a turn of the curving pipe 45, the flow direction of the gas changes. As a result, the gas flowing through the curving pipe 45 flows from outside to inside (left to right) in the cylinder array direction. As already described, the first passage body 33b is connected via the branching portion 33d to the upstream end (lower end) of the curving pipe 45, while the upstream end (left end) of the valve body 41a is connected to the downstream end (right end) of the curving pipe 45.

[0148] The valve body 41a is shaped into a short cylinder form. As illustrated in FIG. 8, the valve body 41a is provided above the first passage 33 and on the left of the supercharger 34, with openings on opposite ends each facing laterally. As described above, the downstream end of the curving pipe 45 is connected to the upstream end of the valve body 41a. Whereas, the upstream end (left end) of the straight pipe 43 is connected to the downstream end (right end) of the valve body 41a.

[0149] The straight pipe 43 is shaped into a long cylinder form extending from the one side toward the other side (specifically, from left to right) in the cylinder array direction. As can be seen in drawings such as FIG. 8, the straight pipe 43 is provided above the first passage 33 and the supercharger 34 to have openings at opposite ends facing laterally. As already described, the downstream end of the valve body 41 a is connected to the upstream end of the straight pipe 43, while the upstream end (left end) of the branch pipe 44 is connected to the downstream end (right end) of the straight pipe 43.

[0150] The branch pipe 44 includes: a bent passage 44a bent like an elbow; and two branch passages 44b and 44c branching off like a tournament chart from the downstream end of the bent passage 44a. Above the supercharger 34 and the surge tank 38, the upstream end of the bent passage 44a faces the left, and both the branch passages 44b and 44c face obliquely downward and backward.

[0151] The two branch passages 44b and 44c are substantially the same in length. One of the branch passages; namely the first branch passage 44b, extends from the branch point to the right along the cylinder array direction, and is then bent obliquely downward and backward. On the other hand, the other branch passage; namely the second branch passage 44c, extends from the branch point to the left along the cylinder array direction, and is then bent obliquely downward and backward. As described above, the respective downstream ends of the two branch passages 44b and 44c are connected to the upper surface of the surge tank 38.

[0152] A downstream end of the EGR passage 52 is connected to the curving pipe 45. Hence, the bypass passage 40 conducts not only the gas flowing from the first passage 33 and the gas flowing backward from the surge tank 38, but also the external EGR gas.

[0153] Moreover, in the curving pipe 45, a lower wall face 45a to which the downstream end of the EGR passage 52 is connected is shaped to be recessed downward. This lower wall face 45a has a structure to receive water.

[0154] In natural aspiration, the gas flowing into the bypass passage 40 passes through the components of the bypass passage 40 to reach the cylinders 11. That is, the gas passing through the throttle valve 32 flows from an intermediate portion of the first passage 33 into the curving pipe 45 of the bypass passage 40, depending

on whether the bypass valve 41 is open or closed. The gas flowing through the curving pipe 45 into the valve body 41a flows to the right as indicated by an arrow of FIG. 12.

[0155] Then, as indicated by an arrow of FIG. 12, the gas passing through the valve body 41a flows to the right along the straight pipe 43, and then flows into the branch pipe 44. As indicated by the other arrows of the figure, the gas, which flowed into the branch pipe 44, passes through the bent passage 44a, and is distributed to the first and second branch passages 44b and 44c. Then, each distributed gas flows into the surge tank 38. The gas flowing into the surge tank 38 is supplied through the independent passage 39 to the intake port 18 of each of the cylinders 11.

[0156] The external EGR gas flowing to the bypass passage 40 in natural aspiration in particular joins the fresh air (refer to an arrow B2 of the lower drawing of FIG. 13) passing through the throttle valve 32 and flowing from the first passage body 33b into the bypass passage 40 and flows through the bypass passage 40 from the upstream side toward the downstream side as indicated by an arrow B1 of the lower drawing. The external EGR gas joining in the fresh air flows into the surge tank 38, passes through the independent passage 39 and the intake port 18 in this order, and reaches the combustion chamber 16.

[0157] On the other hand, in supercharging, the gas flowing back from the surge tank 38 to the bypass passage 40 flows through the components of the bypass passage 40 in the direction opposite to the direction in natural aspiration, and flows into the first passage body 33b.

[0158] In supercharging, as indicated by an arrow A1 of FIG. 13, the external EGR gas flowing into the bypass passage 40 joins the gas flowing back from the surge tank 38 to the bypass passage 40, and flows backward through the bypass passage 40 from downstream to upstream. The gas flowing backward into the first passage body 33b passes through the throttle valve 32, joins the fresh air (see an arrow A3) flowing into the first passage body 33b, and is sucked into the supercharger 34.

(Configuration for Making Engine Compact and Improvement in Supercharging Efficiency)

[0159] For the purpose of increasing the supercharging efficiency of the engine 1 as much as possible, the gas is required to be supplied evenly to both the first and second rotors 341 and 342.

[0160] However, in this engine 1, the first passage body (specifically, the upstream passage portion 331) 33b is offset toward the first rotor 341, whereby the various kinds of valve members are collectively provided, and by extension, the engine 1 is made compact. In this case, the gas supplied from the first passage body 33b may be distributed toward the first rotor 341 in an unbalanced manner.

[0161] However, as illustrated in FIG. 8, the inner wall of the first passage body 33b is provided with the guide portion 70, and at least part of the gas supplied from the first passage body 33b can be directed toward the second rotor 342 by the guide portion 70. In this manner, the gas can be distributed to the first rotor 341 and the second rotor 342 in a balanced manner, hence the supercharging efficiency of the engine 1 can be increased.

[0162] As illustrated in FIG. 8, the upstream passage portion 331 of the first passage body 33b is offset toward the first rotor 341 in the arrangement direction of the first second rotors 341 and 342. Since the upstream passage portion 331 is offset toward the first rotor 341, a space is provided on the second rotor 342 side with respect to the first passage body 33b accordingly. The intake system components are provided in such a space, whereby the engine 1 can be made compact in the arrangement direction.

[0163] As illustrated in FIG. 8, the downstream passage portion 332 of the first passage body 33b can form the gas relay chamber 333. Hence, the gas flow can be expanded, for example, across the arrangement direction and the gas can be distributed to the first rotor 341 and the second rotor 342 in a balanced manner. This is advantageous in increasing the supercharging efficiency of the engine 1.

[0164] The first inclined portion 71 and the second inclined portion 72 illustrated in FIG. 8 are provided, whereby the gas flows flowing along the inner wall close to the first rotor 341 and the inner wall close to the second rotor 342 can each be directed toward the second rotor 342 using the so-called Coanda effect. This is advantageous in increasing the supercharging efficiency of the engine 1.

[0165] As illustrated in drawings such as FIG. 8, the first inclined portion 71 is formed by a lower inner wall of the first passage body 33b and is interposed between the branching portion 33d and the supercharger 34 in the gas flow direction.

[0166] By the way, water contained in the combusted gas flowed backward through the EGR passage 52 may become condensed water in the EGR passage 52 and the bypass passage 40 to flow into the first passage body 33b through the branching portion 33d, and by extension, to flow into the supercharger 34.

[0167] However, as described above, the first inclined portion 71 is interposed between the branching portion 33d and the supercharger 34, and if the condensed water flows into the first passage body 33b, the first inclined portion 71 dams up the condensed water, whereby the condensed water can be prevented from flowing into the supercharger 34. With this effect, corrosion of the supercharger 34 caused by water contained in the condensed water can be prevented.

[0168] As illustrated in FIG. 8, the first and second inclined portions 71 and 72 are provided to overlap with each other in the gas flow direction in the upstream passage portion 331.

[0169] As described above, both the first and second

inclined portions 71 and 72 are configured to direct the gas flow toward the second rotor 342. Considering that the second inclined portion 72 is provided close to the second rotor 342 with respect to the first inclined portion 71, the gas flow is directed toward the second inclined portion 72 by the first inclined portion 71 (in this exemplary configuration, the gas flow is lifted upward). The configuration in which the first inclined portion 71 and the second inclined portion 72 are caused to overlap with each other in the gas flow direction is advantageous in obtaining the Coanda effect in the second inclined portion 72 by the thus directed gas flow.

[0170] As illustrated in FIG. 8, the upstream end of the second inclined portion 72 is provided on the extension line Le extending in the gas flow direction from the inner wall of the throttle body 33a. This configuration is advantageous in guiding the gas flow flowing in the gas flow direction from the inner wall of the throttle body 33a to the first and second inclined portions 71 and 72. This is advantageous in increasing the supercharging efficiency of the engine 1.

[0171] Specifically, as illustrated in FIG. 14, in a conventional configuration, the gas flowing along the inner wall of the throttle body 33a hardly flows along an inclined portion 1072 corresponding to the second inclined portion 72 than in the configuration according to the present invention, which is disadvantageous in distributing the gas toward the second rotor.

[0172] Whereas, in the configuration according to the present invention, the gas flowing along the inner wall of the throttle body 33a flows along the extension line Le to be guided by the second inclined portion 72. Consequently, the gas can be distributed also toward the second rotor 342 in a balanced manner.

[0173] With the layout illustrated in drawings such as FIG. 5, the supercharger 34 and the intercooler 36 can be provided on the front side of the engine 1 without interfering with the alternator 91. Hence, the intake system can be made compact, and by extension, supercharging response can be increased.

<< Other Embodiments >>

[0174] The embodiment is directed to, but not limited to, an example of a configuration including both the first inclined portion 71 and the second inclined portion 72. One of the first inclined portion 71 and the second inclined portion 72 may be provided.

[0175] In the embodiment, both the first inclined portion 71 and the second inclined portion 72 are provided on the inner wall of the upstream passage portion 331. However, this configuration is merely an example. The first inclined portion 71 may be provided on the inner wall of the downstream passage portion 332, for example.

DESCRIPTION OF REFERENCE CHARACTERS

[0176]

1	Engine
10	Engine Body
12	Cylinder Block
13	Cylinder Head
16	Combustion Chamber
30	Intake Passage
32	Throttle Valve
33	First Passage
33a	Throttle Body (Throttle Passage Portion)
33b	First Passage Body (Introduction Passage Portion)
331	Upstream Passage Portion (First Passage Portion)
332	Downstream Passage Portion (Second Passage Portion)
333	Relay Chamber
33d	Branching Portion
34	Supercharger
341	First Rotor
342	Second Rotor
343	Rotor Chamber
36	Intercooler
40	Bypass Passage (Intake System Component)
41	Bypass Valve (Intake System Component)
52	EGR Passage
54	EGR Valve (Intake System Component)
70	Guide Portion
71	First Inclined Portion
72	Second Inclined Portion
91	Alternator (Auxiliary Machine)

Claims

1. An engine provided with a mechanical supercharger, comprising:

   an intake passage connected to a combustion chamber; and

   a mechanical supercharger provided in the intake passage and operating through externally transmitted power, the supercharger having a first rotor extending in a predetermined central axial direction, a second rotor extending parallel to the first rotor and provided adjacent to the first rotor in an arrangement direction orthogonal to the central axial direction, and a rotor chamber housing the first and second rotors,

   an introduction passage portion of the supercharger being connected to the rotor chamber from one side in the central axial direction, and at least an upstream portion of the introduction passage portion being offset toward the first rotor in the arrangement direction,

   an inner wall of the introduction passage portion being provided with a guide portion directing a gas flow flowing along the inner wall toward the second rotor in the arrangement direction.

2. The engine provided with a mechanical supercharger of claim 1, wherein intake system components in the intake passage are provided closer to the second rotor in the arrangement direction than the introduction passage portion is.

3. The engine provided with a mechanical supercharger of claim 1 or 2, wherein
the introduction passage portion has a first passage portion offset toward the first rotor in the arrangement direction and a second passage portion provided between the first passage portion and the rotor chamber, and is formed to be larger in a flow passage cross section larger than the first passage portion, and
the second passage portion forms a gas relay chamber.

4. The engine provided with a mechanical supercharger of any one of claims 1 to 3, wherein
the guide portion has, of the inner wall of the introduction passage portion, either one of or both of a first inclined portion formed on an inner wall close to the first rotor in the arrangement direction and a second inclined portion formed on an inner wall close to the second rotor in the direction, and
both the first and second inclined portions are inclined to head toward the second rotor from the first rotor in the arrangement direction from an upstream side toward a downstream side in a gas flow direction.

5. The engine provided with a mechanical supercharger of claim 4, wherein the arrangement direction substantially corresponds to an up-and-down direction,
the first rotor is provided substantially below the second rotor,
a bypass passage is provided, the bypass passage branching off from the introduction passage portion to bypass the supercharger and to guide gas to the combustion chamber,
the bypass passage is connected to an upper side in the up-and-down direction of the introduction passage portion, an EGR passage is connected to the bypass passage,
the guide portion has at least the first inclined portion, and
a branching portion at which the introduction passage portion and the bypass passage branch off is provided upstream of the first inclined portion in the gas flow direction.

6. The engine provided with a mechanical supercharger of claim 4 or 5, wherein
the guide portion has both the first and second inclined portions, and
the first and second inclined portions are provided to overlap with each other in the gas flow direction in the introduction passage portion.

7. The engine provided with a mechanical supercharger of claim 6, wherein
a throttle passage portion provided with a throttle valve is arranged upstream of the introduction passage potion of the intake passage, and
an upstream end of either one of or both of the first and second inclined portions is provided on an extension line extending in the gas flow direction from an inner wall of the throttle passage portion.

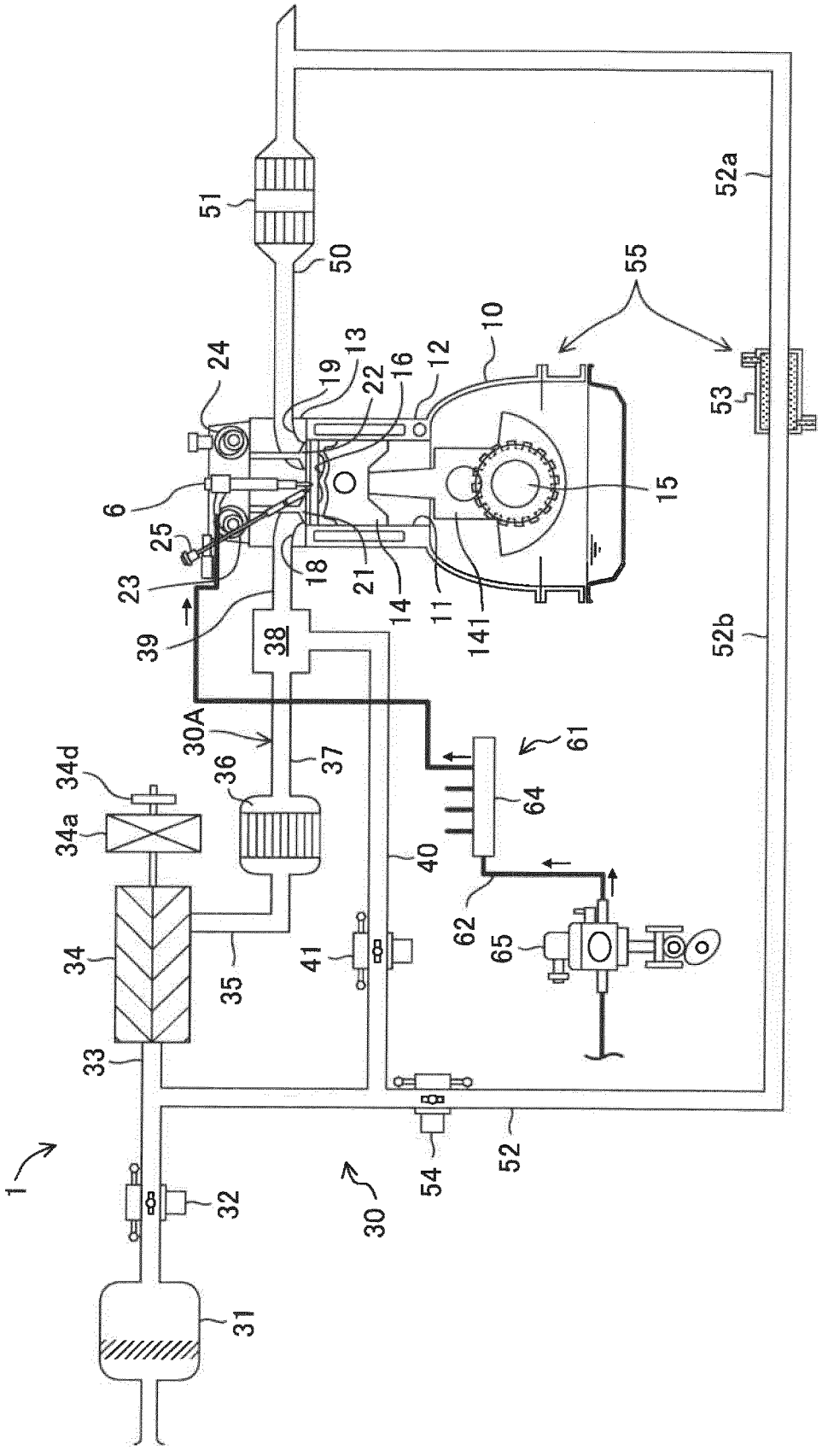
8. The engine provided with a mechanical supercharger of any one of claims 1 to 4, comprising:

an engine body including a cylinder block, a cylinder head, and the combustion chamber;
auxiliary machines mounted on an outer surface of the engine body; and
an intercooler provided downstream of the supercharger in the intake passage, wherein
the arrangement direction substantially corresponds to an up-and-down direction,
the supercharger is provided above the auxiliary machines, and
the intercooler is adjacent to the auxiliary machines in the central axial direction and is provided below the supercharger in the arrangement direction.

9. An engine provided with a mechanical supercharger, comprising:

an intake passage connected to a combustion chamber; and
a mechanical supercharger provided in the intake passage and operating through externally transmitted power, the supercharger having a first rotor extending in a predetermined central axial direction, a second rotor extending parallel to the first rotor and provided adjacent to the first rotor in an arrangement direction orthogonal to the central axial direction, and a rotor chamber housing the first and second rotors,
an introduction passage portion of the supercharger being connected to the rotor chamber from one side in the central axial direction, and at least an upstream portion of the introduction passage portion being offset toward the first rotor in the arrangement direction,
an inner wall of the introduction passage portion being provided with a guide portion inclined to head toward the second rotor from the first rotor in the arrangement direction from an upstream side toward a downstream side in a gas flow direction.

FIG.1


1
30
30A
31
32
33
34
34a
34d
35
36
37
38
39
40
41
50
51
52
52a
52b
53
54
55
6
10
11
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13
14
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18
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22
23
24
25
61
62
64
65
141

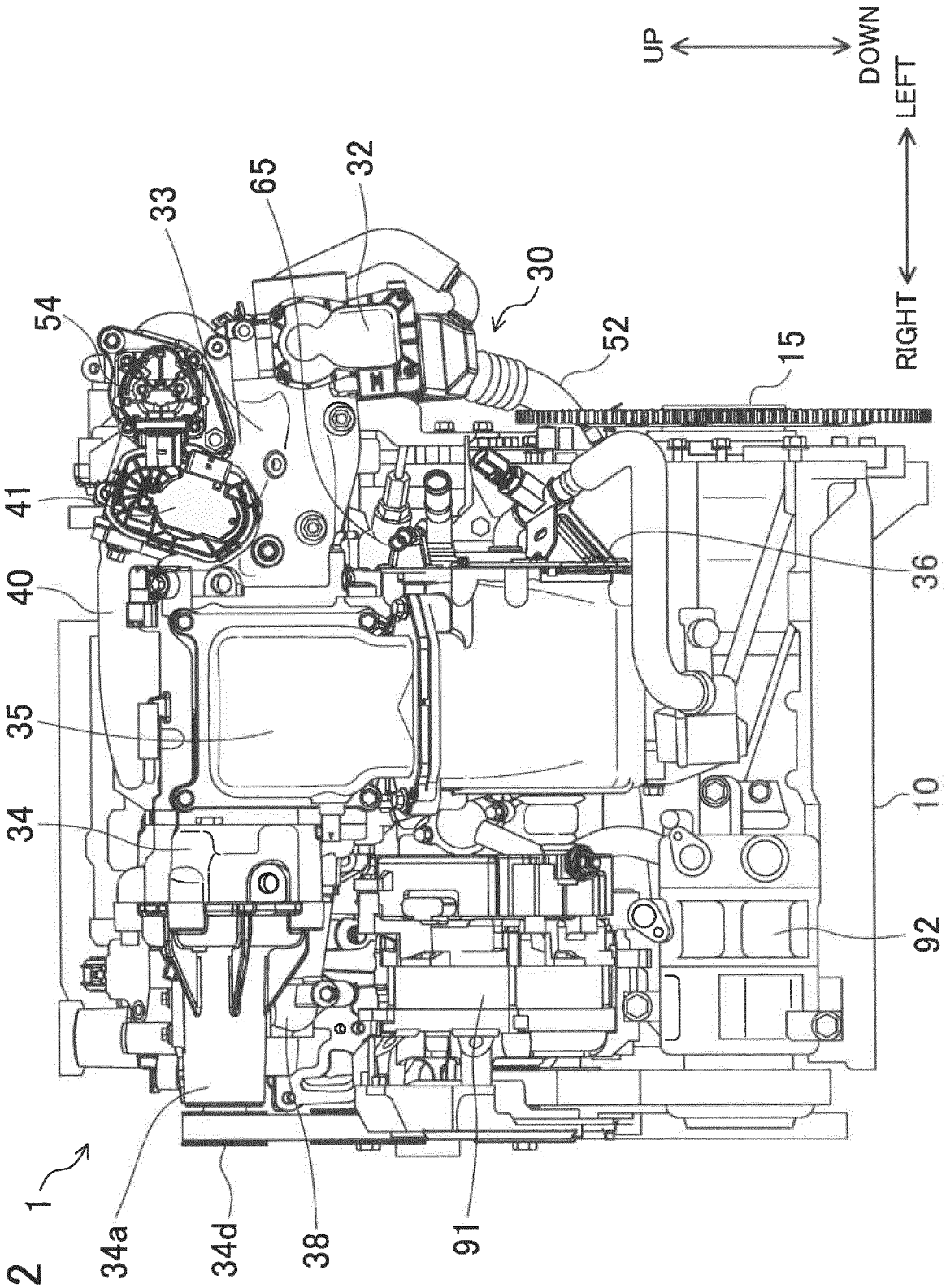
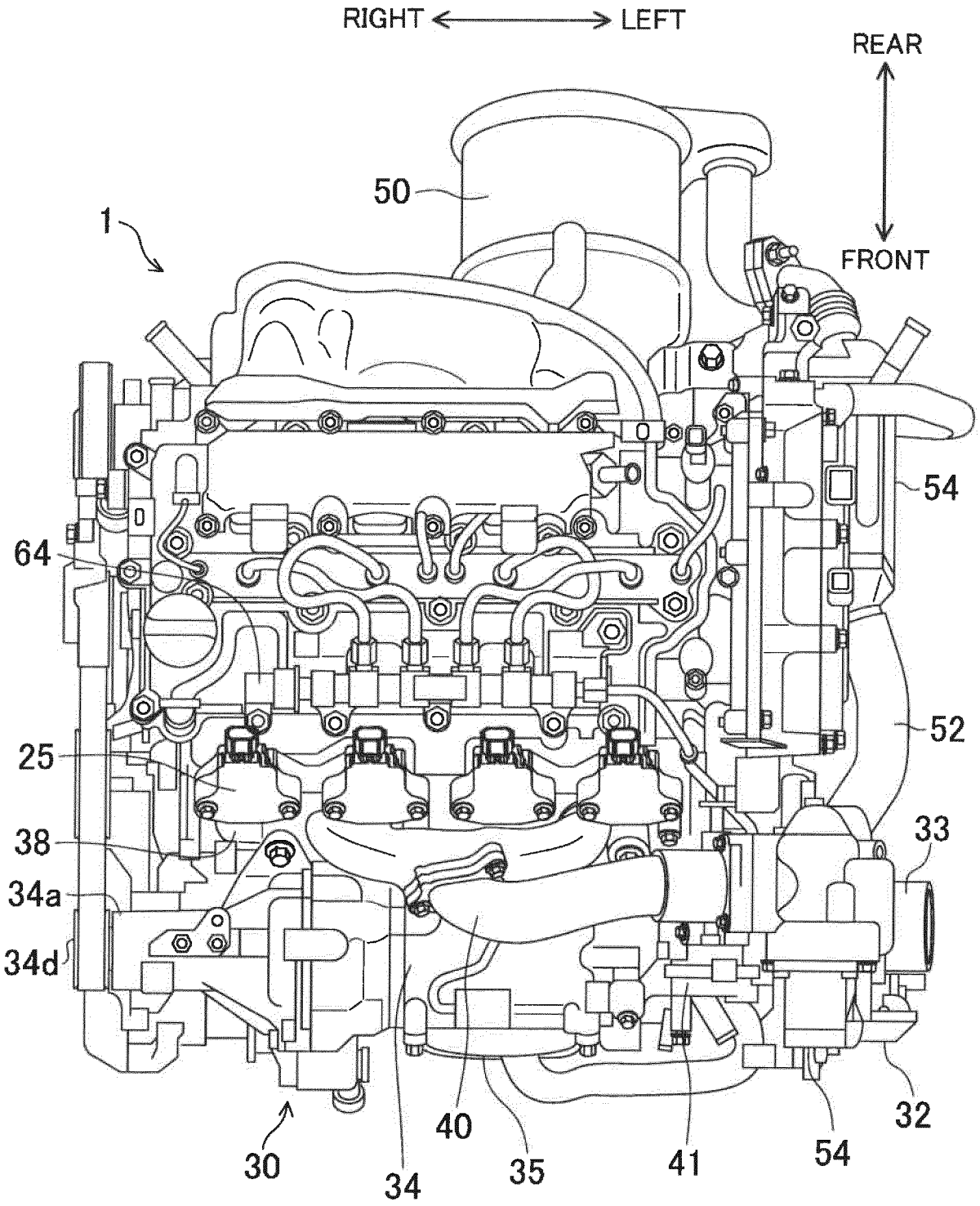

UP
DOWN
LEFT
RIGHT
54
33
65
32
30
52
15
41
40
35
34
36
10
92
1
34a
34d
38
91

FIG.2

FIG.3


RIGHT
LEFT
REAR
FRONT
1
50
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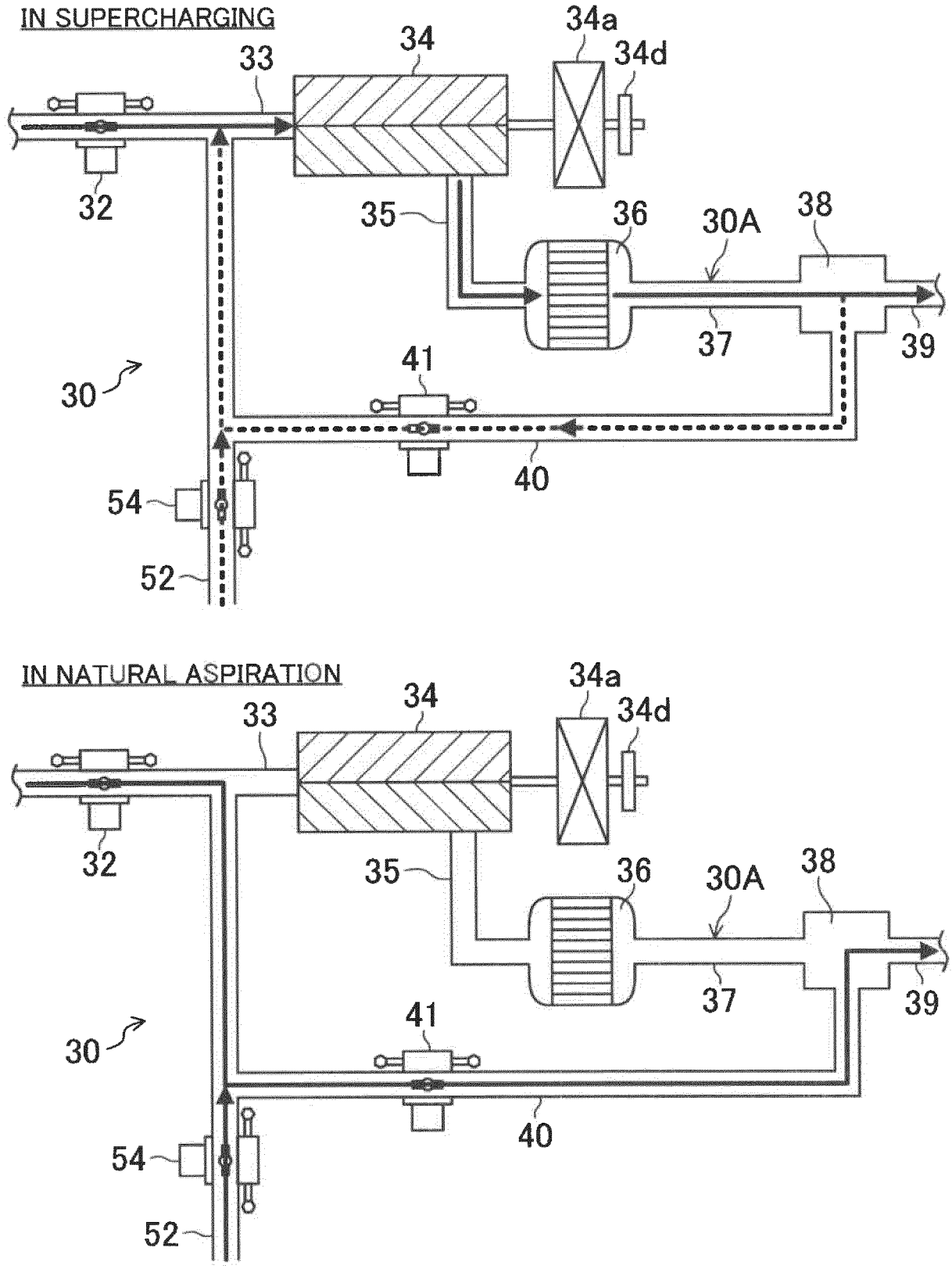
64
52
25
33
38
34a
34d
32
30
40
34
35
41
54

FIG.4


IN SUPERCHARGING
33
34
34a
34d
32
35
36
30A
38
37
39
41
30
40
54
52
IN NATURAL ASPIRATION
33
34
34a
34d
32
35
36
30A
38
37
39
41
30
40
54
52

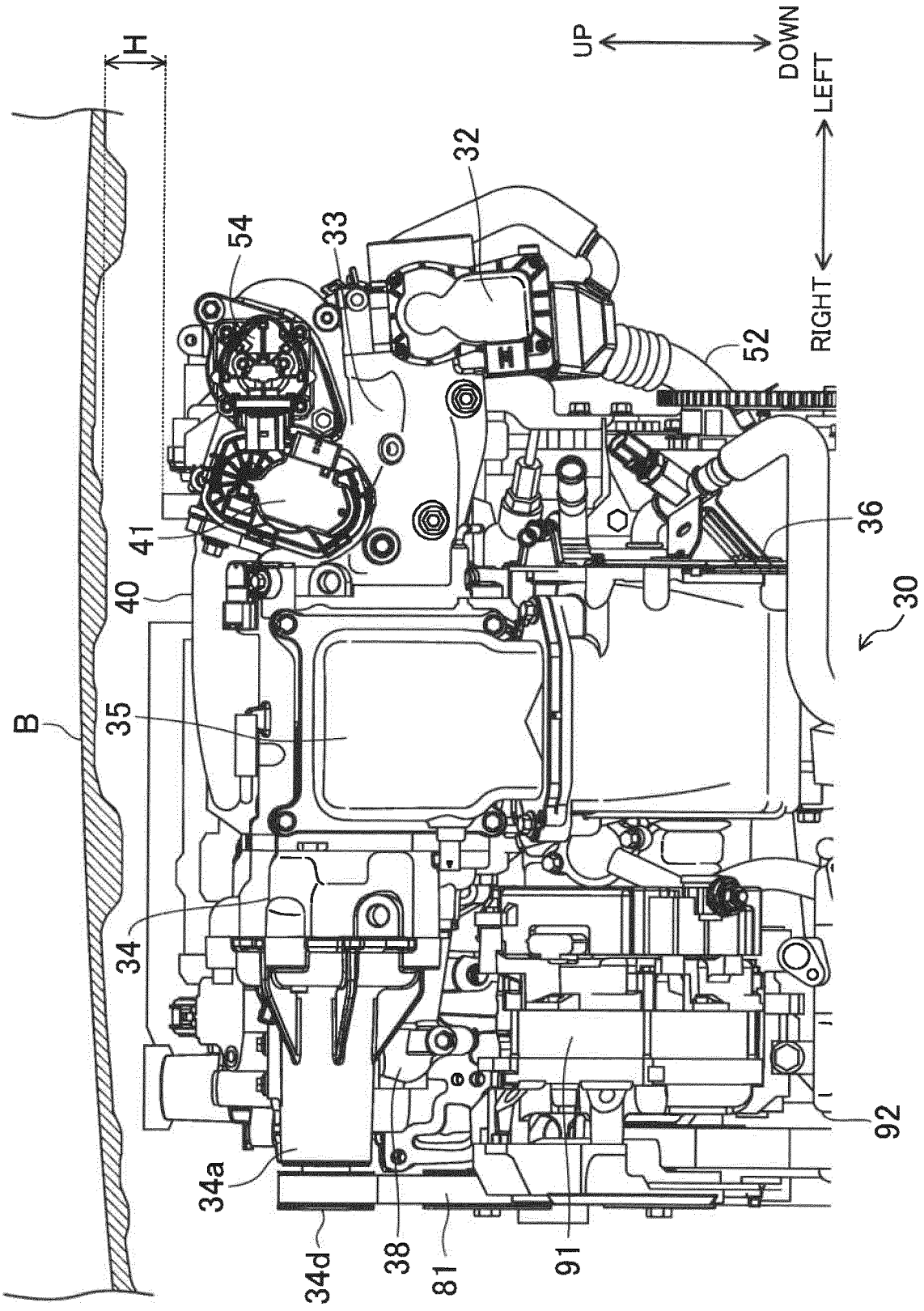
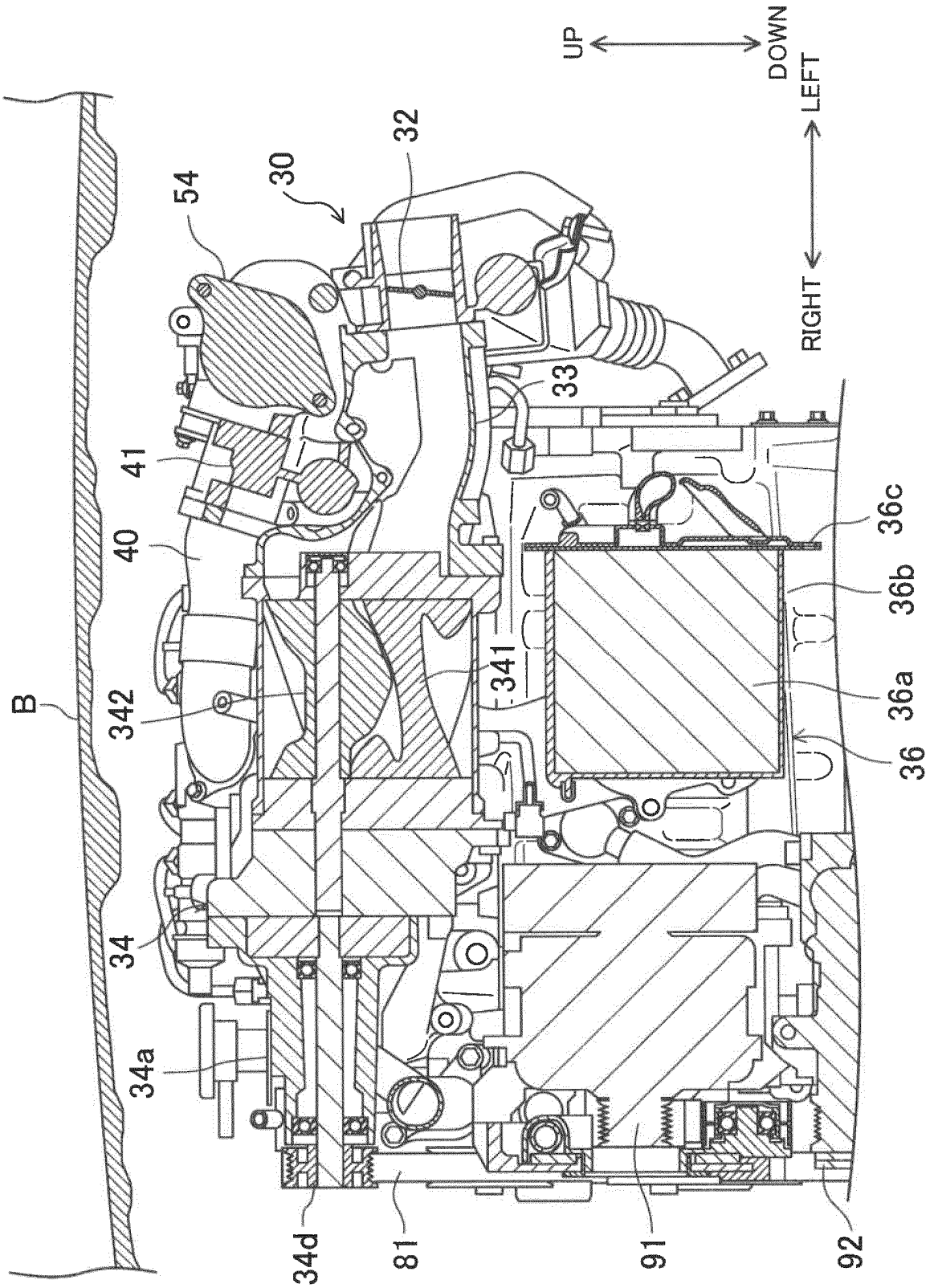

H
UP
DOWN
LEFT
RIGHT
32
54
33
52
41
36
40
30
B
35
34
34a
34d
38
81
91
92

FIG.5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RIGHT
B
54
30
32
33
41
40
342
341
36c
36b
36a
36
34
34a
34d
81
91
92

FIG.6

FIG.7

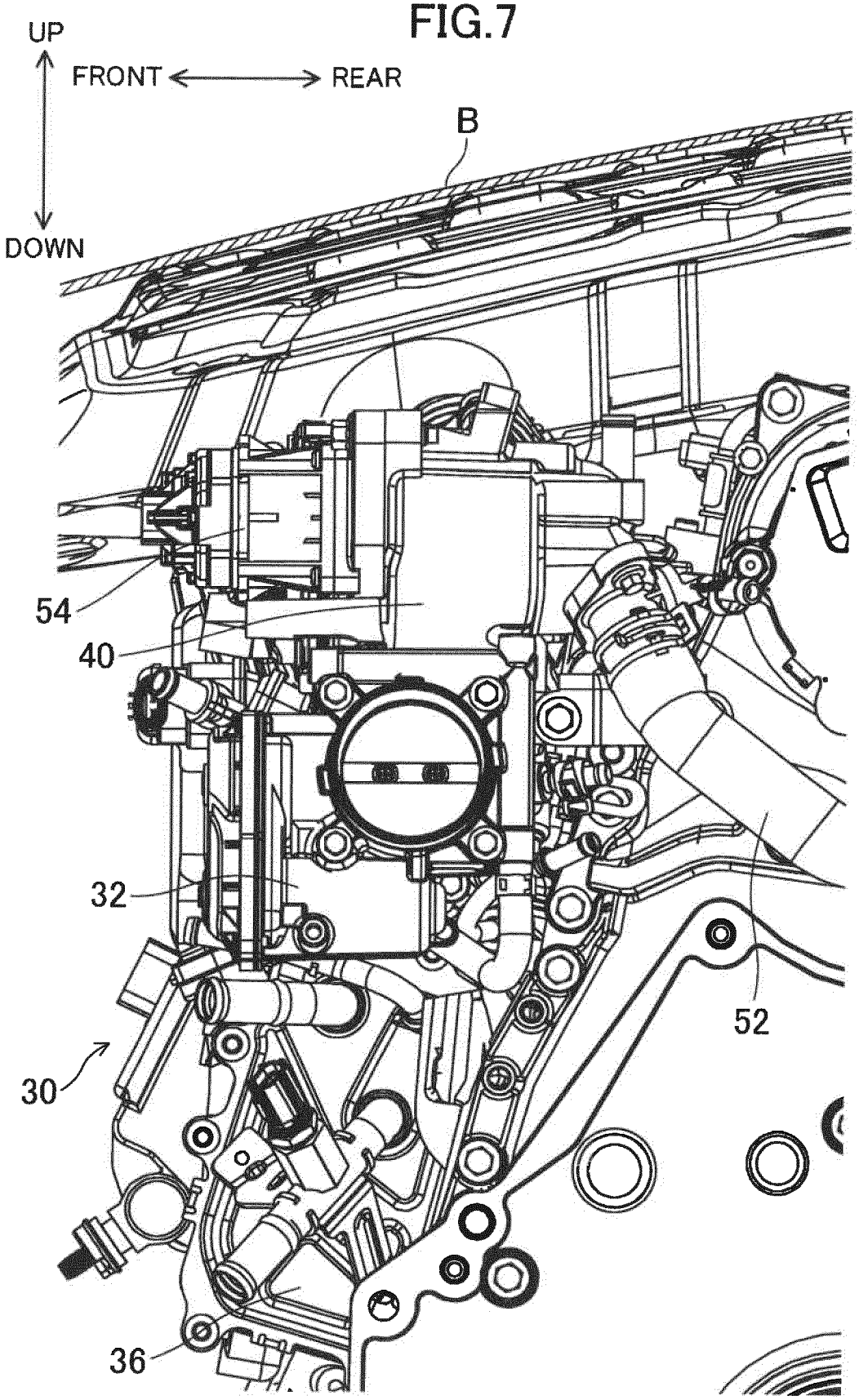


FIG.8

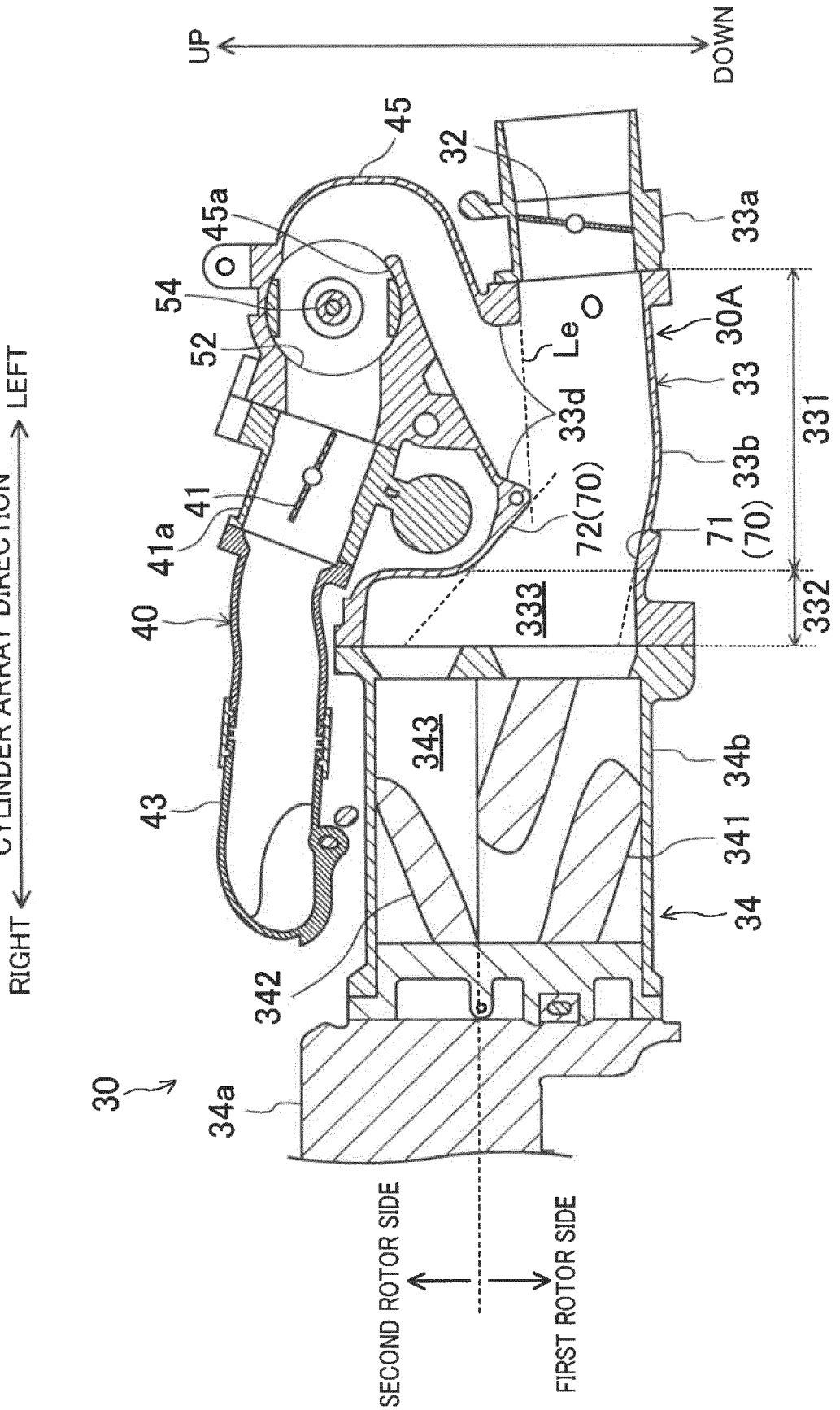
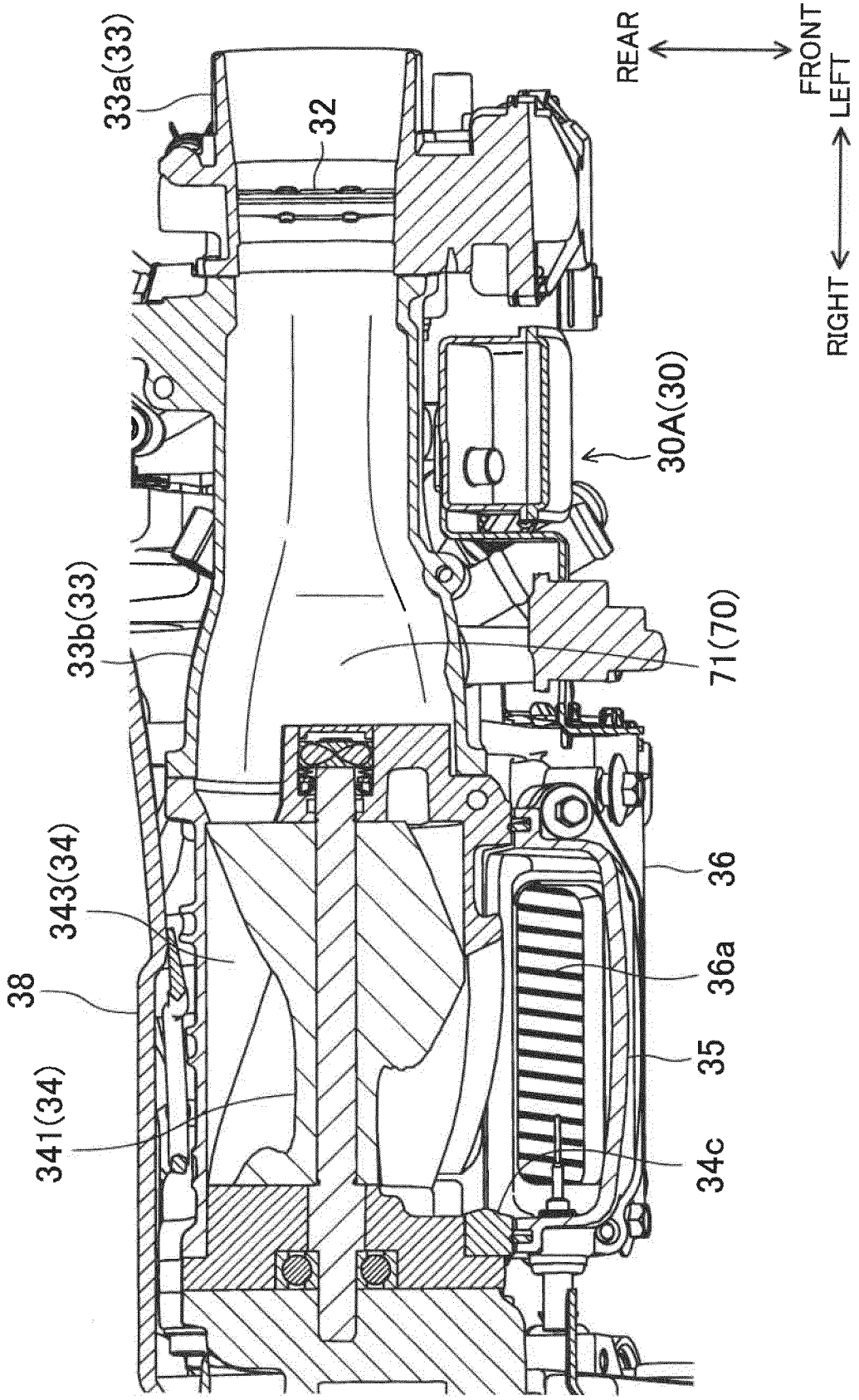

UP
DOWN
LEFT
RIGHT
CYLINDER ARRAY DIRECTION
SECOND ROTOR SIDE
FIRST ROTOR SIDE
45
45a
32
33a
54
52
Le
30A
33
33d
331
41
41a
72(70)
33b
71
(70)
40
333
332
343
34b
43
341
34
342
30
34a

FIG.9


33a(33)
32
REAR
FRONT
LEFT
RIGHT
30A(30)
33b(33)
71(70)
343(34)
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38
36a
35
341(34)
34c

FIG.10

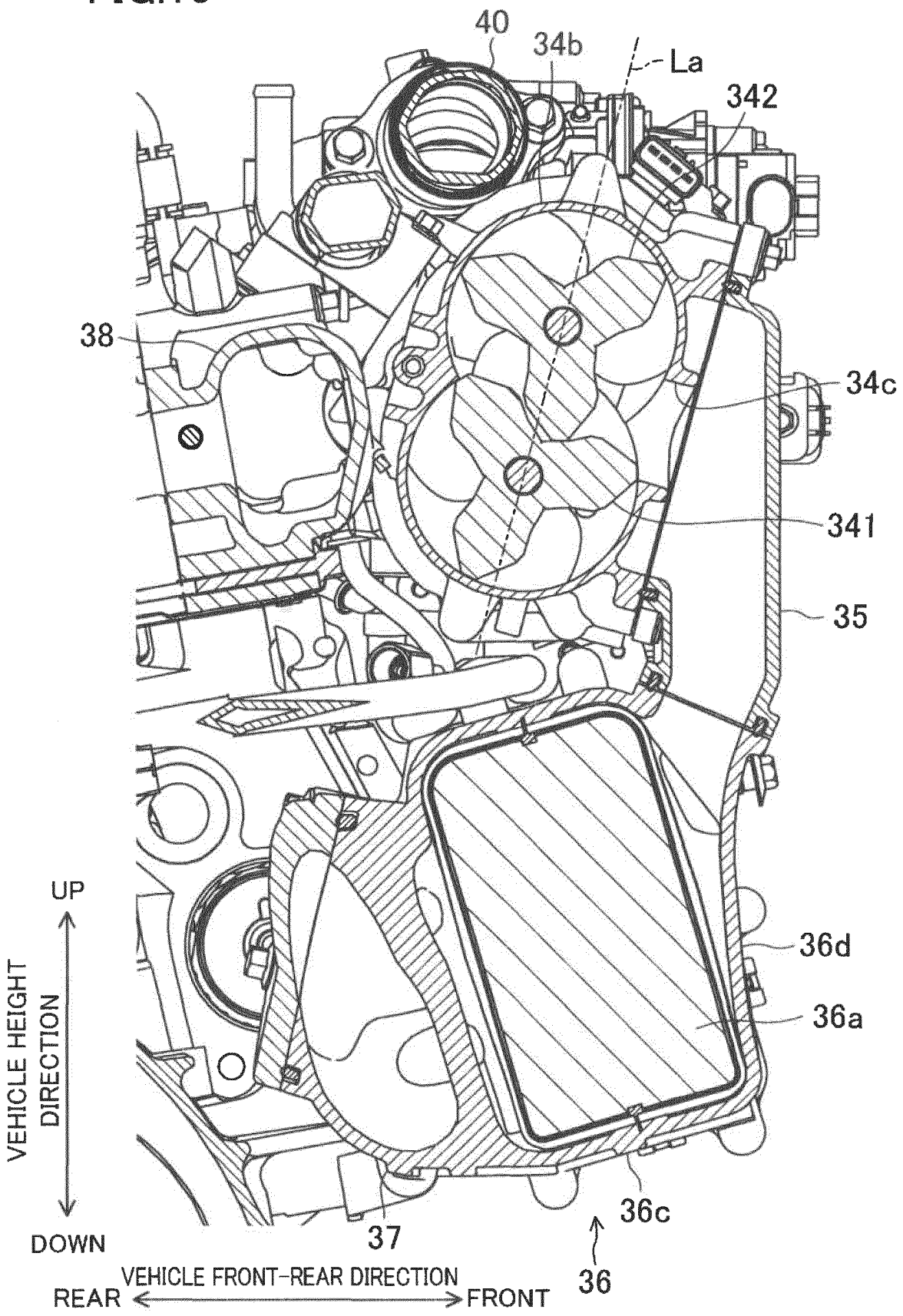

40
34b
La
342
38
34c
341
35
36d
36a
36c
37
36
UP
VEHICLE HEIGHT DIRECTION
DOWN
VEHICLE FRONT-REAR DIRECTION
REAR
FRONT

FIG.11

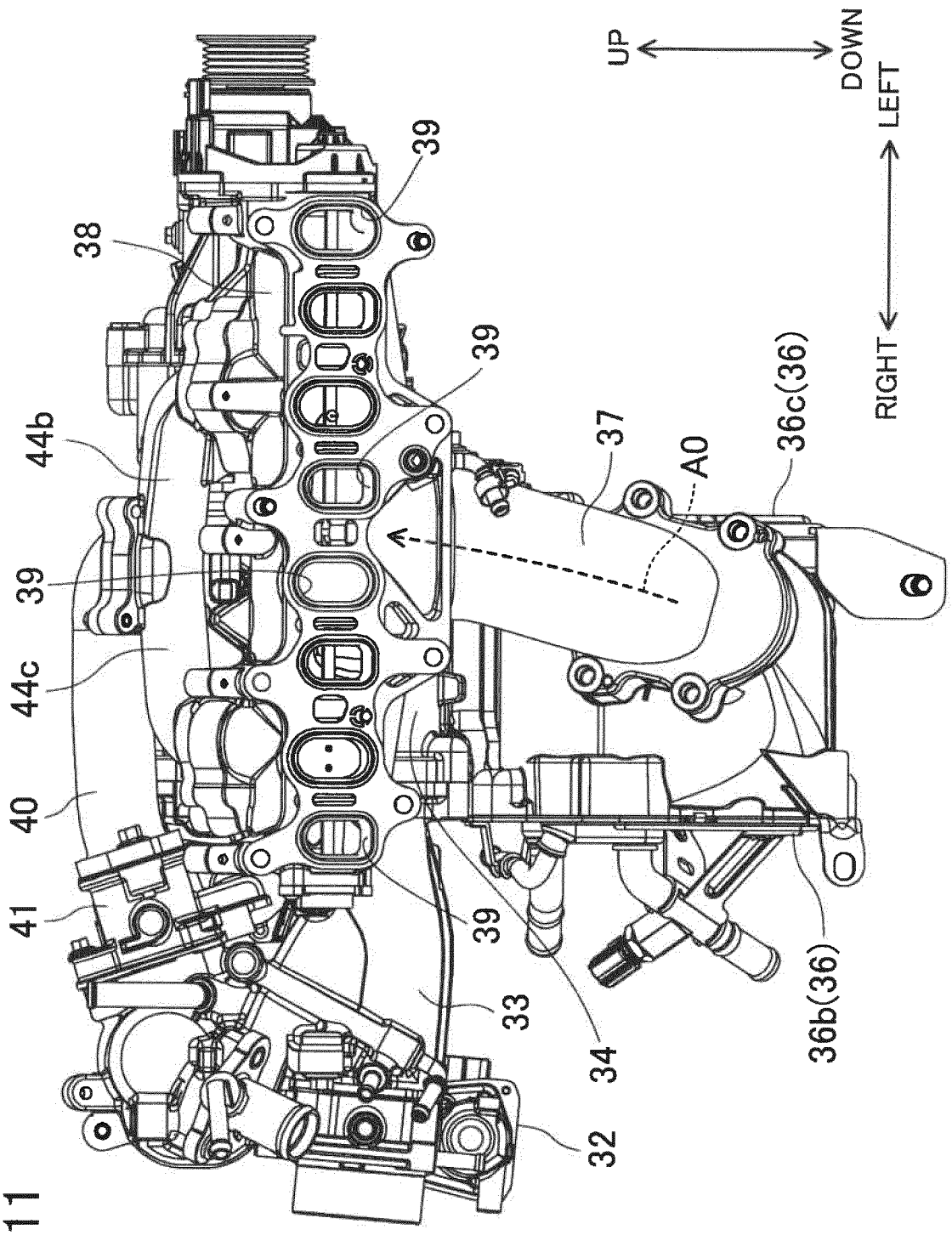

UP
DOWN
LEFT
RIGHT
38
39
39
44b
39
44c
40
41
39
33
34
32
37
A0
36c(36)
36b(36)

FIG.12

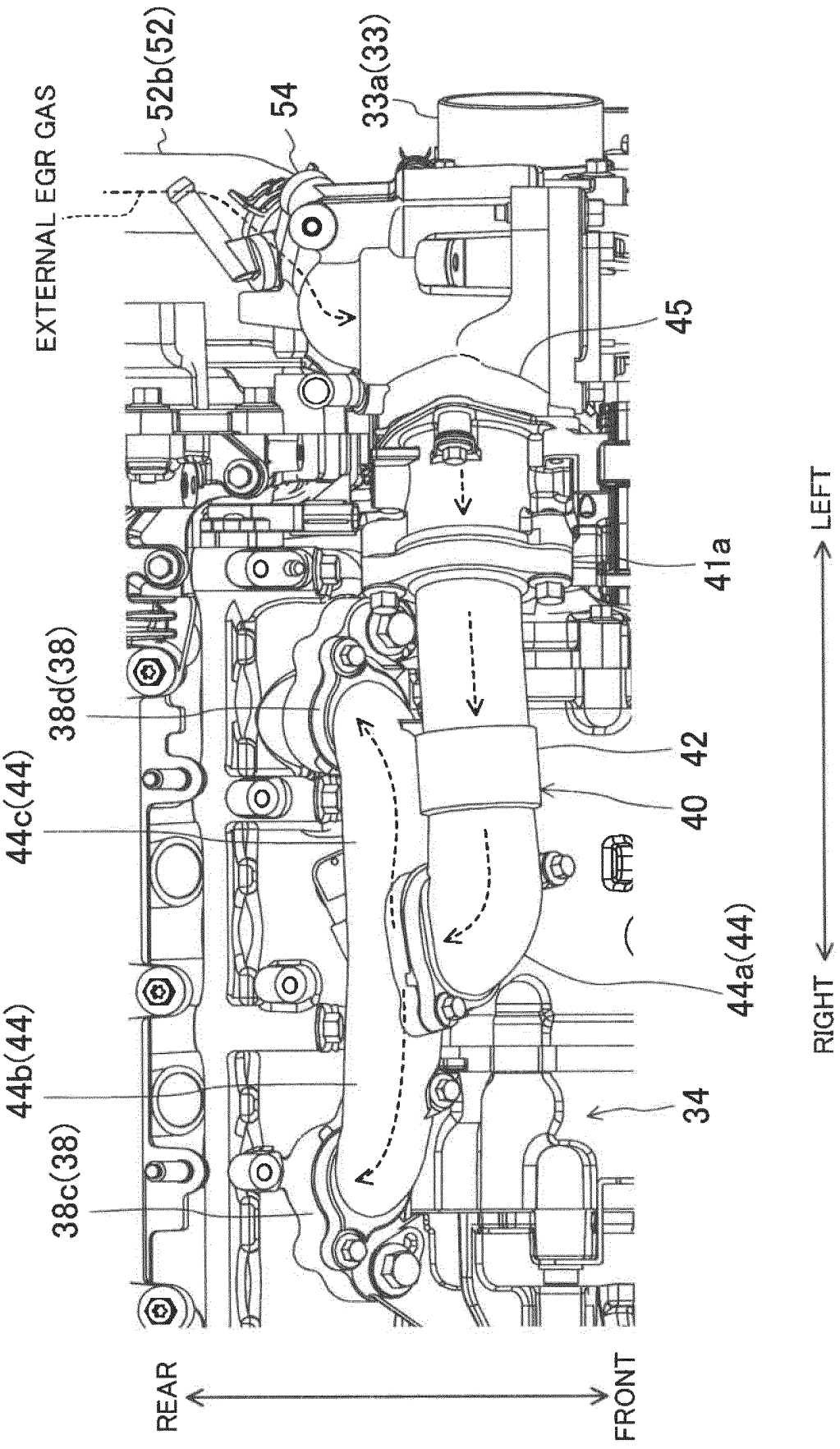
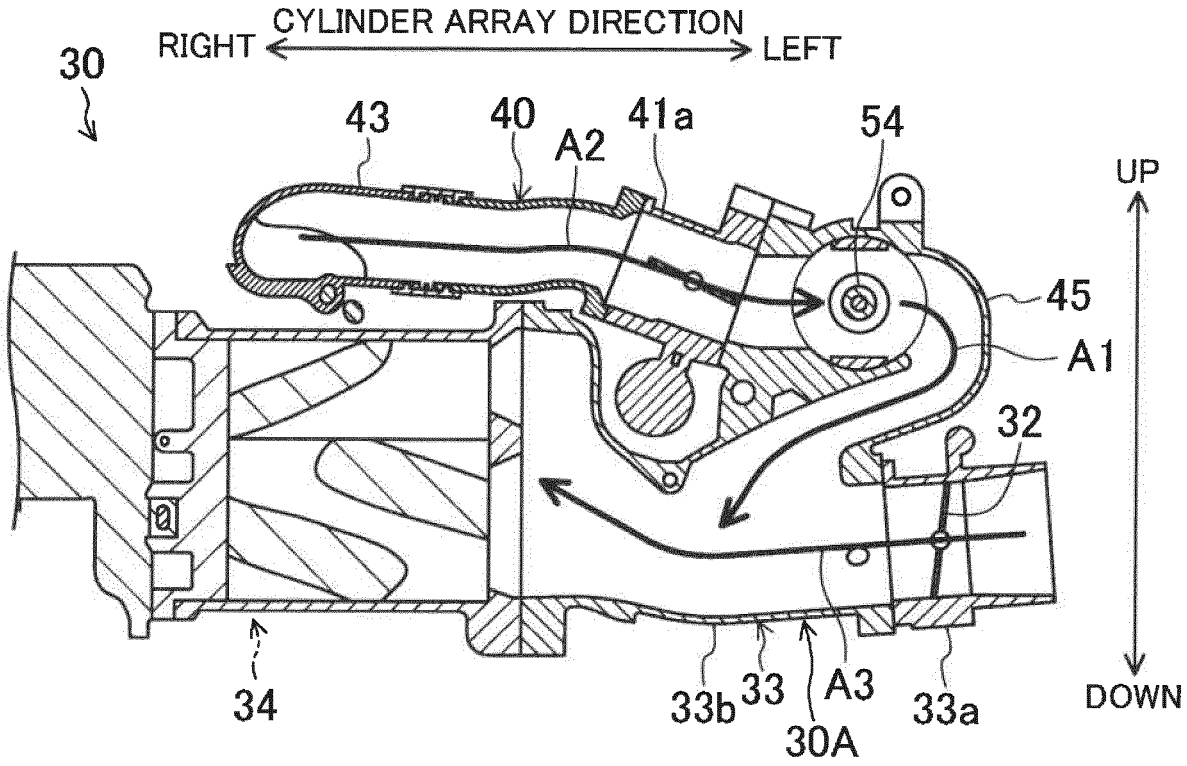

EXTERNAL EGR GAS
52b(52)
54
33a(33)
45
41a
42
40
38d(38)
44c(44)
44b(44)
38c(38)
44a(44)
34
REAR
FRONT
LEFT
RIGHT

FIG.13

IN SUPERCHARGING



IN NATURAL ASPIRATION

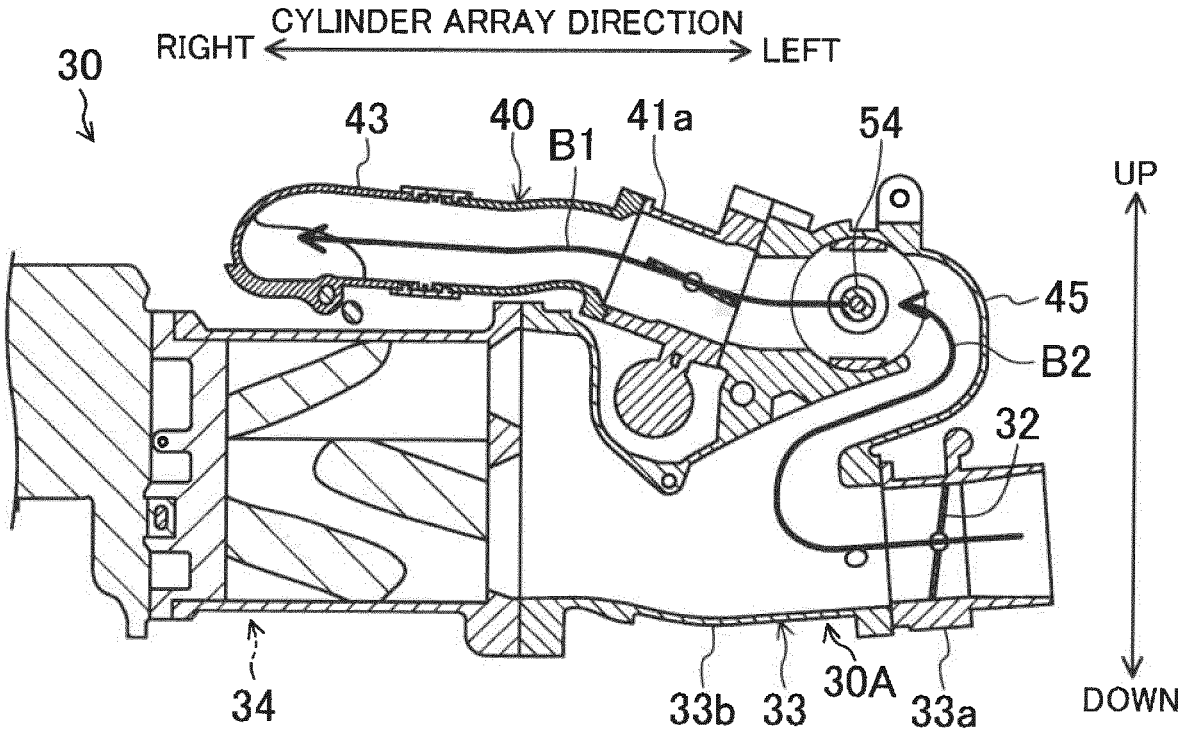
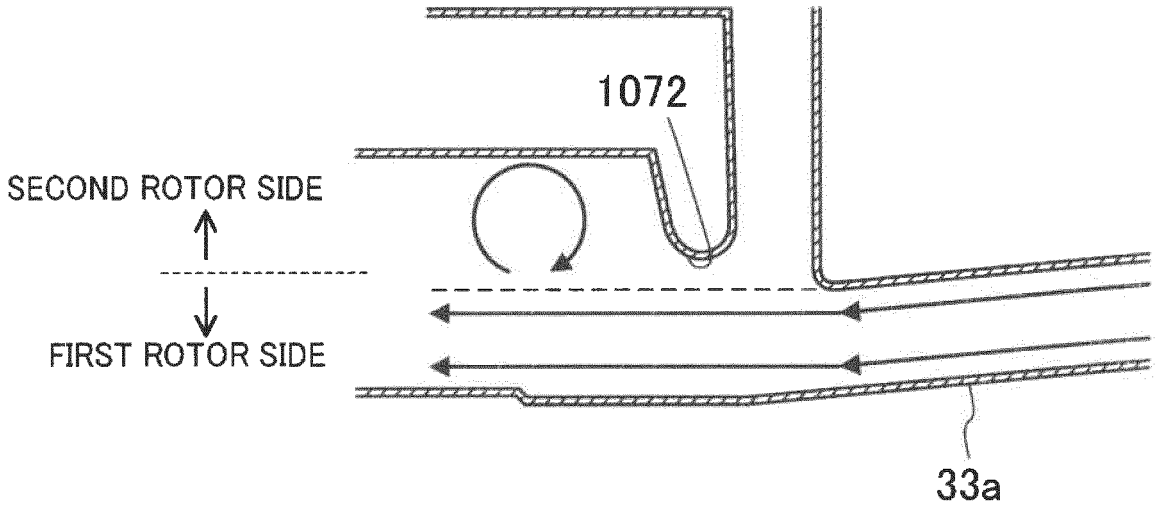
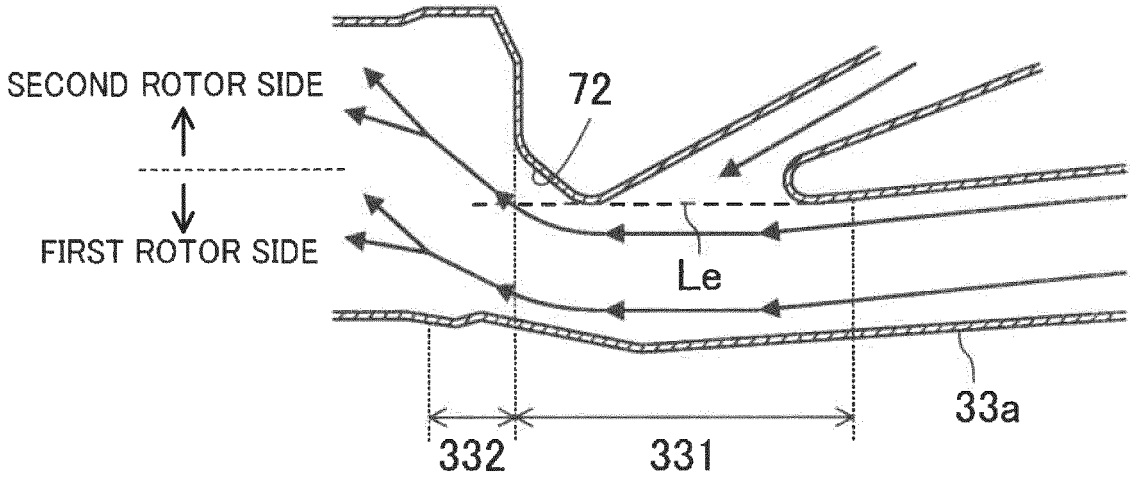


FIG.14

CONVENTIONAL CONFIGURATION



PRESENT INVENTION



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2017/036371

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl. F02B33/36(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)
Int. Cl. F02B33/00-39/16, F04C18/16, F02B67/00-77/14

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2017
Registered utility model specifications of Japan	1996-2017
Published registered utility model applications of Japan	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 3-61616 A (MAZDA MOTOR CORP.) 18 March 1991, page 3, upper right column, line 11 to page 4, lower right column, line 13, fig. 1, 2, 4 & US 5115788 A, column 3, line 29 to column 5, line 62, fig. 1, 2, 4 & EP 412369 A1 & DE 69003773 T2	1, 3, 9 2, 8 5, 7
X Y A	JP 8-21250 A (TOCHIGI FUJI SANGYO KABUSHIKI KAISHA) 23 January 1996, paragraphs [0018]-[0024], fig. 1 (Family: none)	1, 3-4, 6, 9 2, 8 5, 7
Y	JP 2-294520 A (YAMAHA MOTOR CO., LTD.) 05 December 1990, page 3, upper left column, line 11 to page 4, upper right column, line 15, fig. 1 (Family: none)	2

☒ 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
14.12.2017	26.12.2017
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/JP2017/036371

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2003-129856 A (DAIHATSU MOTOR CO., LTD.) 08 May 2003, fig. 1, 2 (Family: none)	8
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 1796/1993 (Laid-open No. 60734/1994) (MAZDA MOTOR CORP.) 23 August 1994, paragraphs [0015], [0018], fig. 1, 2 (Family: none)	8
A	JP 8-334029 A (TOCHIGI FUJI SANGYO KABUSHIKI KAISHA) 17 December 1996, entire text, all drawings (Family: none)	1-9
A	JP 2013-508597 A (HANSEN, Craig N.) 07 March 2013, entire text, all drawings & US 2011/0083432 A1 & WO 2011/046584 A1 & EP 2488724 A1 & CN 102597456 A & KR 10-2012-0098672 A	1-9
A	JP 2007-85174 A (HATAMURA, Koichi) 05 April 2007, entire text, all drawings & WO 2005/066503 A1	1-9
A	US 2016/0222966 A1 (EATON CORPORATION) 04 August 2016, entire text, all drawings & WO 2015/053899 A1 & EP 3055528 A1 & CN 104653281 A	1-9
A	GB 2350406 A (SENECA TECHNOLOGY LIMITED) 29 November 2000, entire text, all drawings & WO 2000/073639 A1 & AU 4131300 A	1-9
A	WO 2017/156236 A1 (EATON CORPORATION) 14 September 2017, entire text, all drawings (Family: none)	1-9

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP H09228846 B **[0004]**