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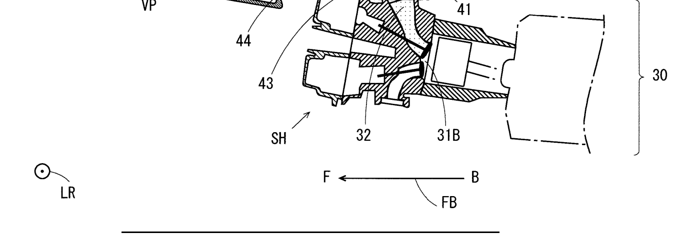
(54) **STRADDLED VEHICLE**

(57) There is disclosed a motorcycle (100) with an engine (30), an air cleaner (10) and an intake pipe (50); the intake pipe (50) being configured to be one portion of an intake path guiding air that has been cleaned by the air cleaner (10) to the engine (30); intake pipe (50) further having an upstream portion (51) disposed in a clean section of an inner space of air cleaner (10), a downstream portion (52) disposed outside of air cleaner (10), and an attached portion (53) that is located between the upstream portion (51) and the downstream portion (52) of intake pipe (50) and attached to an outer wall of air cleaner (10); the upstream portion (52) of the intake pipe (50) including a funnel portion (511) that opens to the inner space of air cleaner (10) and a pipe portion (512) that connects a funnel portion (511) and the attached portion (53) to each other; one or a plurality of through holes (59) being formed in a portion (512), that is closer to the attached portion (53) than the funnel portion (511), in the pipe portion (512).

FIG.3



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Description

Technical Field

[0001] The present disclosure relates to a straddled vehicle having an engine and an air cleaner.

Prior Art

[0002] When a straddled vehicle including an engine travels, air is introduced into the engine, so that an intake sound is generated. The magnitude of the generated intake sound is defined according to an air path that guides air outside of the vehicle to the engine and a working state of the engine.

[0003] A significantly loud intake sound is preferably reduced as much as possible as a noise. Various configurations have been proposed to reduce an intake sound. For example, a motorcycle described in JP 2010-127076 A has a resonator for reducing an intake sound. Specifically, the motorcycle described in JP 2010-127076 A has an engine and an air cleaner. Further, the motorcycle includes a duct portion, in a front portion of the vehicle, that guides air flowing from a position farther forward than the vehicle to the air cleaner. The resonator is attached to the duct portion. The inner space of the duct portion and the inner space of the resonator communicate with each other via a coupling pipe. An intake sound is reduced by resonation of a sound generated when air flows into the resonator from the duct portion and a sound generated when air flows into the air cleaner from the duct portion.

[0004] Due to the above-mentioned mechanism, the resonator is required to have an inner space with a predetermined capacity corresponding to an intake sound to be reduced. Therefore, the resonator has a constant size. As such, the resonator described in Patent Document 1 is formed to have an inner space with a predetermined capacity and to have a shape corresponding to the positional relationship with other members (headlights and the like) provided around the duct portion. However, the configuration of the resonator fabricated in this manner is likely to be complicated. On the other hand, in a case in which the resonator has a predetermined shape, the size of the constituent elements in the peripheral portion of the intake path is likely to be increased in order to suppress the interference between the resonator, and the intake path of the engine and the peripheral members thereof.

Description of the invention

[0005] An object of the present disclosure is to provide a straddled vehicle in which a configuration of a peripheral portion of an intake path is simplified and made compact and which can reduce an intake sound.

[0006] A straddled vehicle according to one aspect of the present disclosure includes an engine, an air cleaner that cleans air to be supplied to the engine, and an intake pipe that is configured to be one portion of an intake path guiding air that has been cleaned by the air cleaner to the engine, wherein the intake pipe has an upstream portion disposed in a clean section of an inner space of the air cleaner, a downstream portion disposed outside of the air cleaner, and an attached portion that is located between the upstream portion and the downstream portion in the intake pipe and is attached to an outer wall of the air cleaner, the upstream portion includes a funnel portion that opens to the inner space of the air cleaner, and a pipe portion that connects the funnel portion and the attached portion to each other, and one or a plurality of through holes are formed in a portion, that is closer to the attached portion than the funnel portion, in the pipe portion.

[0007] With the present disclosure, the configuration of the peripheral portion of the intake path can be simplified and made compact, and an intake sound can be reduced.

[0008] Other features, elements, characteristics, and advantages of the present disclosure will become more apparent from the following description of preferred embodiments of the present disclosure with reference to the attached drawings.

Brief description of the drawings

[0009]

Fig. 1 is a one-side view of a motorcycle according to one embodiment of the present disclosure;

Fig. 2 is an enlarged plan view of a front half portion of the motorcycle of Fig. 1;

Fig. 3 is a cross-sectional view of the motorcycle of Fig. 2 taken along the line A-A;

Fig. 4 is a diagram of an air cleaner of Fig. 2 as viewed from a position rearward of the vehicle;

Fig. 5 is a schematic side view of a left intake pipe of Fig. 2 as viewed from a position leftward of the motorcycle;

Fig. 6 is a schematic side view of a right intake pipe of Fig. 2 as viewed from a position rightward of the motorcycle;

Fig. 7 is a graph showing the test results of an intake sound level measurement experiment;

Fig. 8 is a schematic diagram showing a list of configurations of first to ninth intake pipes according to an intake pipe characteristic evaluation experiment;

Fig. 9 is a schematic diagram showing the list of configurations of the first to ninth intake pipes according to the intake pipe characteristic evaluation experiment;

Fig. 10 is a graph representing a frequency response function of a sound output from each of the first to ninth intake pipes according to the intake pipe characteristic evaluation experiment;

Fig. 11 is a graph representing the relationship between the peak frequencies of the first to ninth intake pipes according to the intake pipe characteristic evaluation experiment and the total opening area of the one or plurality of through holes in the first to ninth intake pipes;

Fig. 12 is a graph representing the relationship between the output of a crankshaft and an engine rotation speed measured in an engine intake performance confirmation experiment; and

Fig. 13 is a graph representing the relationship between a torque of the crankshaft and the engine rotation speed measured in the engine intake performance confirmation experiment.

Embodiments of the invention

[0010] A straddled vehicle according to one embodiment of the present disclosure will be described below with reference to the drawings. A motorcycle will be described as one example of the straddled vehicle.

1. Schematic Configuration of Motorcycle

[0011] Fig. 1 is a one-side view of a motorcycle according to one embodiment of the present disclosure. In Fig. 1, the motorcycle 100 standing up to be perpendicular to the road surface is shown. In each of Fig. 1 and subsequent given diagrams, a forward-and-rearward direction FB, a leftward-and-rightward direction LR and an upward-and-downward direction UD of the motorcycle 100 are suitably indicated by the arrows. The direction in which the arrow is directed in the forward-and-rearward direction FB is referred to as forward, and its opposite direction is referred to as rearward. Further, the direction in which the arrow is directed in the leftward-and-rightward direction LR is referred to as leftward, and its opposite direction is referred to as rightward. Further, the direction in which the arrow is directed in the upward-and-downward direction UD is referred to as upward, and its opposite direction is referred to as downward. Further, in each of Fig. 1 and subsequent given diagrams, reference characters F, B, L, R, U and D shown together with the arrows indicating directions indicate forward, rearward, leftward, rightward, upward and downward, respectively.

[0012] The motorcycle 100 of Fig. 1 includes a metallic body frame 1 and a rear frame 5. The front end portion of the main frame 1 is configured to be a head pipe 1H. The main frame 1 is formed to extend obliquely downwardly while branching to the left and the right from the head pipe 1H. In the following description, a portion of the main frame 1 extending leftwardly from the head pipe 1H is referred to as a left frame 1A, and a portion of the main frame 1 extending rightwardly from the head pipe 1H is referred to as a right frame 1B (Fig. 2), as necessary. The rear frame 5 is attached to the main frame 1 so as to extend rearwardly and slightly upwardly from the rear end portion of the main frame 1.

[0013] A front fork 2 is provided at the head pipe 1H to be rotatable about the center axis of the head pipe 1H. A front wheel 3 is rotatably supported at the lower end portion of the front fork 2. A handle 4 is provided at the upper end portion of the front fork 2.

[0014] The main frame 1 supports an engine 30 at a position farther downward than the head pipe 1H. The engine 30 according to the present embodiment is a parallel-twin engine, and has two combustion chambers 31A, 31B (Fig. 4) arranged in the leftward-and rightward direction LR. An air cleaner 10 and a fuel tank 20 are provided to be located upwardly of the engine 30 and rearwardly of the head pipe 1H. The air cleaner 10 and the fuel tank 20 are arranged in this order from the front to the rear with a space therebetween. The air cleaner 10 is supported by the main frame 1, and the fuel tank 20 is supported by the main frame 1 and the rear frame 5. A seat 6 is provided above the fuel tank 20. The seat 6 extends in the forward-and-rearward direction FB from a position above the fuel tank 20 to a position above a rear half portion of the rear frame 5.

[0015] A throttle body 40 and two intake pipes 50 are disposed between the air cleaner 10 and the fuel tank 20 in the forward-and-rearward direction FB. The throttle body 40 is attached to a portion of the engine 30 where an intake port is formed.

[0016] The two intake pipes 50 connect the air cleaner 10 and the throttle body 40 to each other, and are configured to be portions of two intake paths VP (Fig. 4) extending from the air cleaner 10 to the two combustion chambers 31A, 31B (Fig. 4) of the engine 30. Further, the two intake pipes 50 are formed of resin or rubber having certain flexibility, and are disposed side by side in the leftward-and-rightward direction LR. In Fig. 1, only one of the intake pipes 50 (the left intake pipe 50) is shown.

[0017] When the motorcycle 100 is seen in side view, large portions of the two intake pipes 50 overlap with the main frame 1. In each intake pipe 50, a through hole 59 for reducing an intake sound generated during work of the engine 30 is formed. Details of the through hole 59 will be described below. In the following description, the left intake pipe of the two intake pipes 50 is referred to as a left intake pipe 50A, and the right intake pipe of the two intake pipes 50 is referred to as a right intake pipe 50B (Fig. 2), as necessary.

[0018] Fig. 2 is an enlarged plan view of the front half portion of the motorcycle 100 of Fig. 1. In Fig. 2, the outer shape of the motorcycle 100 of Fig. 1 is indicated by the one-dot and dash lines. Further, in Fig. 2, the constituent elements other than the main frame 1, the air cleaner 10, the fuel tank 20, the throttle body 40 and the two intake pipes 50 are not shown to facilitate understanding of the positional relationship between the two intake paths VP (Fig. 4) and their peripheral members.

[0019] As shown in Fig. 2, when the motorcycle 100 is seen in plan view, the air cleaner 10, the two intake pipes 50 and the throttle body 40 are disposed between the left frame 1A and the right frame 1B in the leftward-and-rightward direction LR. Further, when the motorcycle 100 is seen in plan view, the fuel tank 20 is disposed at a position farther rearward than the air cleaner 10 such that the left and right side portions of the fuel tank 20 overlap with a rear portion of the left frame 1A and a rear portion of the right frame 1B.

[0020] With such a configuration, the two intake pipes 50 connect the air cleaner 10 and the throttle body 40 to each other through the space surrounded by the air cleaner 10, the fuel tank 20, the left frame 1A and the right frame 1B. In other words, the two intake pipes 50 are provided so as to pass through the space limited by a predetermined layout of the air cleaner 10, the fuel tank 20, the left frame 1A and the right frame 1B.

[0021] As shown in Fig. 1, at a position below the rear frame 5, a rear arm 7 is provided so as to extend rearwardly from the rear end portion of the engine 30. A rear wheel 8 is rotatably supported at the rear end portion of the rear arm 7. The rear wheel 8 is rotated as a drive wheel by motive power generated by the engine 30.

2. Details of Intake Path and its Peripheral Members

[0022] Fig. 3 is a cross-sectional view of the motorcycle 100 of Fig. 2 taken along the line A-A, and Fig. 4 is a diagram of the air cleaner 10 of Fig. 2 as viewed from a position rearward of the vehicle. In Fig. 3, the main frame 1 is not shown. On the other hand, Fig. 4 shows the air cleaner 10 and the two intake pipes 50 (50A, 50B) connected to the air cleaner 10. Further, in Fig. 4, the block diagram of the engine 30 is shown, and a portion of the intake path VP extending from the left intake pipe 50A to the combustion chamber 31A and a portion of the intake path VP extending from the right intake pipe 50B to the combustion chamber 31B are schematically shown by the one-dot and dash lines.

[0023] As shown in Fig. 3, the air cleaner 10 includes an air cleaner case 11 and a filter element 12. The air cleaner case 11 has an inner space, and the filter element 12 is accommodated in the inner space. The filter element 12 sections the inner space of the air cleaner case 11 into two spaces which are a contamination section (dirty-side space) DS and a clean section (clean-side space) CS.

[0024] Two air lead-in portions 13 (Fig. 4) for leading air outside of the air cleaner 10 into the contamination section DS are formed in the upper portion of the air cleaner case 11. Further, in the rear portion of the air cleaner case 11, two air lead-out portions 14 (Fig. 4) for causing the clean section CS to communicate with the space outside of the air cleaner 10 are formed. The two air lead-out portions 14 are circular openings formed in a portion of the air cleaner case 11 (the outer wall of the air cleaner 10).

[0025] As shown in Fig. 4, the two air lead-out portions 14 are arranged in the leftward-and-rightward direction LR with a space there between. One portion of the left intake pipe 50A is inserted into the left air lead-out portion 14 to be fixed. One portion of the right intake pipe 50B is inserted into the right air lead-out portion 14 to be fixed. The other portion of the left intake pipe 50A and the other portion of the right intake pipe 50B extend obliquely downwardly while being curved outside of the air cleaner 10.

[0026] As shown in Fig. 3, the engine 30 according to the present embodiment has a cylinder head SH. The cylinder head SH is located in a front end portion of the engine 30 with the engine 30 being supported by the main frame 1. Two intake ports 32 are formed in the cylinder head SH so as to open upwardly. The two intake ports 32 respectively correspond to the two combustion chambers 31A, 31B (Fig. 4), and are arranged in the leftward-and-rightward direction LR.

[0027] The throttle body 40 is attached to a portion of the cylinder head SH where the two intake ports 32 are formed. The throttle body 40 includes two flow-path forming pipes 41 respectively corresponding to the two intake ports 32 of the engine 30. The two flow-path forming pipes 41 are arranged in the leftward-and-rightward direction LR, similarly to the two intake ports 32.

[0028] Further, the throttle body 40 includes two throttle valves 42, two injectors 43 and two valve actuators 44 that are respectively attached to the two flow-path forming pipes 41. In the throttle body 40, the valve actuator 44 works in response to an operation of an accelerator grip (not shown), and an opening of the throttle valve 42 is adjusted. Further, a fuel injection state of the injector 43 is adjusted by the control of an Engine Control Unit (ECU) (not shown).

[0029] As described above, the two intake pipes 50 connect the air cleaner 10 and the throttle body 40 to each other. Thus, in the present embodiment, as indicated by the light dotted pattern in Fig. 3, the right intake path VP is configured to be the right intake pipe 50B, the right flow-path forming pipe 41 of the throttle body 40 and the inner space of the right intake port 32 of the engine 30. Further, the left intake path VP is configured to be the left intake pipe 50A, the left flow-path forming pipe 41 of the throttle body 40 and the inner space of the left intake port 32 of the engine 30.

[0030] During work of the engine 30, air outside the motorcycle 100 is introduced into the contamination section DS of the air cleaner 10. The introduced air flows into the clean section CS while being purified by the filter element 12. In the clean section CS, the purified air flows into the two intake pipes 50 through a funnel portion 511 and a through hole 59, described below, and is supplied to the combustion chambers 31A, 31B of the engine 30.

[0031] The length of each intake path VP (the length of each intake path VP in the axial direction) and the cross-sectional area (flow-path cross-sectional area) of an opening orthogonal to the axial direction of the intake path VP are highly relevant to the air supply performance to the engine 30 (hereinafter referred to as engine intake performance). When the engine intake performance is high, an output of the engine 30 is high. When the engine intake performance is low, an output of the engine 30 is low. Therefore, an output of the engine 30 in a case in which the rotation speed of the engine 30 is within a predetermined rotation-speed range depends on the length of each intake path VP. As such, in the present embodiment, the length of each intake path VP is set such that an output of the engine 30 in the predetermined rotation-speed range is maintained high to some extent.

[0032] On the other hand, the length of each intake path VP is highly relevant to a natural frequency of the intake path VP. Therefore, when a natural frequency of the intake path VP corresponding to a length set in consideration of an output of the engine 30 overlaps with the frequency band of a specific intake sound generated by the intake path VP, the level (sound pressure level) of an intake sound becomes significantly high. As such, in the motorcycle 100 according to the present embodiment, the through hole 59 is formed in the intake pipe 50 such that the natural frequency of each intake path VP deviates from the frequency band of a specific intake sound.

[0033] Details of the left intake pipe 50A will be described below. Fig. 5 is a schematic side view of the left intake pipe 50A of Fig. 2 as viewed from a position leftward of the motorcycle 100. In Fig. 5, a pattern and irregularities formed on the outer surface of the left intake pipe 50A are not shown. Further, in Fig. 5, a portion of the air cleaner case 11 (the outer wall of the air cleaner 10) is indicated by the one-dot and dash lines.

[0034] As shown in Fig. 5, the left intake pipe 50A is a cylindrical member formed to be curved from one end portion to the other end portion, and includes an upstream portion 51, a downstream portion 52 and an attached portion 53. The upstream portion 51 is a portion disposed in the clean section CS of the air cleaner 10 with the left intake pipe 50A being connected to the air cleaner 10. The downstream portion 52 is a portion disposed in the outer space ES of the air cleaner 10 with the left intake pipe 50A being connected to the air cleaner 10. In the axial direction of the left intake pipe 50A according to the present embodiment, the length of the upstream portion 51 of the left intake pipe 50A is larger than 1/3 of the length of the entire left intake pipe 50A and is smaller than 1/2 of the length of the entire left intake pipe 50A.

[0035] The attached portion 53 is located between the upstream portion 51 and the downstream portion 52, and has a first annular convex portion 53a and a second annular convex portion 53b. Each of the first annular convex portion 53a and the second annular convex portion 53b is formed in an annular shape so as to surround the outer peripheral surface of the left intake pipe 50A. The first annular convex portion 53a and the second annular convex portion 53b are disposed with a minute space therebetween in a direction in which a center axis ca of the left intake pipe 50A extends (the axial direction). The distance between the first annular convex portion 53a and the second annular convex portion 53b is set equal to or substantially equal to the thickness of the air cleaner case 11. Further, the outer diameter of the portion between the first annular convex portion 53a and the second annular convex portion 53b in the left intake pipe 50A is set equal to or substantially equal to the inner diameter of each air lead-out portion 14 of the air cleaner case 11.

[0036] Thus, when the motorcycle 100 is assembled, the upstream portion 51 of the left intake pipe 50A is inserted into the left air lead-out portion 14 (opening) of the air cleaner case 11. Further, a portion of the air cleaner case 11 where the left air lead-out portion 14 is formed (the inner edge of the opening) is fitted between the first annular convex portion 53a and the second annular convex portion 53b of the left intake pipe 50A. Thus, the left intake pipe 50A is attached to the air cleaner case 11. In this state, the downstream portion 52 is further connected to the left flow-path forming pipe 41 of the throttle body 40.

[0037] Here, the upstream portion 51 of the left intake pipe 50A includes the funnel portion 511 and a pipe portion 512. In the left intake pipe 50A, the funnel portion 511 is an upstream end portion of the left intake pipe 50A that opens to the clean section CS of the air cleaner 10. The funnel portion 511 is formed such that its inner diameter continuously increases from the inside of the left intake pipe 50A toward the clean section CS. On the other hand, the pipe portion 512 is formed such that the inner diameter is constant or substantially constant in the axial direction of the left intake pipe 50A.

[0038] One through hole 59 is formed in a portion of the pipe portion 512 closer to the attached portion 53 than the funnel portion 511. In the left intake pipe 50A, the one through hole 59 is formed in a leftward portion of the pipe portion 512 so as to open leftwardly of the motorcycle 100.

[0039] Details of the right intake pipe 50B will be described. Fig. 6 is a schematic side view of the right intake pipe 50B of Fig. 2 as viewed from a position rightward of the motorcycle 100. In Fig. 6, similarly to the example of Fig. 5, a pattern and irregularities formed on the outer surface of the right intake pipe 50B are not shown. Further, in Fig. 6, a portion of the air cleaner case 11 is indicated by the one-dot and dash line.

[0040] The right intake pipe 50B is basically formed so as to be symmetrical to the left intake pipe 50A with respect to a vertical plane extending in the forward-and-rearward direction FB through the space between the left intake pipe 50A and the right intake pipe 50B. Therefore, similarly to the left intake pipe 50A, the right intake pipe 50B is a cylindrical member formed to be curved from one end portion to the other end portion, and includes an upstream portion 51, a downstream portion 52 and an attached portion 53. Further, in the axial direction of the right intake pipe 50B, the length of the upstream portion 51 of the right intake pipe 50B is larger than 1/3 of the entire right intake pipe 50B and is smaller than 1/2 of the entire right intake pipe 50B.

[0041] Therefore, when the motorcycle 100 is assembled, the upstream portion 51 of the right intake pipe 50B is inserted into the right air lead-out portion 14 (opening) of the air cleaner case 11. Further, a portion of the air cleaner case 11 where the right air lead-out portion 14 is formed (the inner edge of the opening) is fitted between a first annular convex portion 53a and a second annular convex portion 53b of the right intake pipe 50B. Thus, the right intake pipe 50B is attached to the air cleaner case 11. In this state, the downstream portion 52 is further connected to the right flow-path forming pipe 41 of the throttle body 40.

[0042] Also in the right intake pipe 50B, the upstream portion 51 includes a funnel portion 511 and a pipe portion 512, similarly to the left intake pipe 50A. Further, one through hole 59 is formed in a portion of the pipe portion 512 closer to the attached portion 53 than the funnel portion 511. However, one through hole 59 formed in the right intake pipe 50B is formed in a rightward portion of the pipe portion 512 so as to open rightwardly of the motorcycle 100, differently from the one through hole 59 in the left intake pipe 50A.

[0043] Therefore, in the present embodiment, as indicated by the black dots in Fig. 2, the through hole 59 of the left intake pipe 50A and the through hole 59 of the right intake pipe 50B are oriented in directions not oriented toward each other in the leftward-and-rightward direction LR. More specifically, the through hole 59 of the left intake pipe 50A and the through hole 59 of the right intake pipe 50B are oriented in opposite directions in the leftward-and-rightward direction LR.

3. Intake Sound Level Measurement Experiment and Intake Sound Audibility Experiment

<1> Intake Sound Level Measurement Experiment

[0044] In regard to the above-mentioned motorcycle 100, the inventors of the present disclosure conducted an experiment (intake sound level measurement experiment) for confirming the level of an intake sound generated when the engine 30 worked in a specific vehicle velocity range.

[0045] Specifically, the inventors of the present disclosure prepared the motorcycle 100 including the two intake pipes 50 shown in Figs. 5 and 6 as the motorcycle 100 of an inventive example. The length of each intake pipe 50 in the axial direction was about 180 mm, and the length of the upstream portion 51 in the axial direction was about 90 mm. Further, the through hole 59 was formed at a position spaced apart from the funnel portion 511 by about 80mm. Further, the cross-sectional area of the opening (the flow-path cross-sectional area) orthogonal to the axial direction of the intake pipe 50 was about 962 mm^2, and the opening area of the through hole 59 was about 79 mm^2. In the present embodiment, the flow-path cross-sectional area of the intake pipe 50 is the area of the region surrounded by the inner peripheral surface of the portion of the intake pipe 50 having the smallest inner diameter, for example.

[0046] Further, the inventors of the present disclosure prepared a motorcycle including two intake pipes having the same configuration as the two intake pipes 50 of the inventive example except that the through-hole 59 was not formed, as a motorcycle of a comparative example.

[0047] In regard to the motorcycle 100 of the inventive embodiment, the sound pressure level of an intake sound generated by the motorcycle 100 in a period during which a vehicle velocity reached a "second velocity v2 higher than a first velocity v1 " from the "first velocity v1" with the throttle valve 42 at a maximum opening was measured. Further, also in regard to the motorcycle of the comparative embodiment, similarly to the motorcycle 100 of the inventive example, the sound pressure level of an intake sound generated by the motorcycle in a period during which a vehicle velocity reached the "second velocity v2" from the "first velocity v1" with the throttle valve 42 at a maximum opening was measured.

[0048] Fig. 7 is a graph representing the test results of the intake sound level measurement experiment. In the graph of Fig. 7, the ordinate indicates a sound pressure level, and the abscissa indicates a vehicle velocity. Further, in the graph of Fig. 7, the measurement result of an intake sound during acceleration of the motorcycle 100 of the inventive example is indicated by the thick solid line, and the measurement result of an intake sound during acceleration of the motorcycle of the comparative example is indicated by the dotted line.

[0049] As shown in the graph of Fig. 7, both of the sound pressure levels of the intake sounds generated by the motorcycle 100 of the inventive embodiment and the motorcycle of the comparative example increase in a period during which the vehicle velocities increase from the "first velocity v1" to the "second velocity v2." However, a change amount of the sound pressure level of the motorcycle 100 of the inventive example due to an increase in vehicle velocity is different from a change amount of the sound pressure level of the motorcycle of the comparative example due to an increase in vehicle velocity.

[0050] In a large range of the vehicle velocity from the "first velocity v1" to the "second velocity v2" except for the vicinity of the "first velocity v1," the sound pressure level of the intake sound generated by the motorcycle 100 of the inventive example is lower than the sound pressure level of the intake sound generated by the motorcycle of the comparative example. Further, a difference in sound pressure level between the inventive example and the comparative example basically increases as the vehicle velocity increases. Thus, the sound pressure level of the intake sound generated by the motorcycle 100 of the inventive example is lower than the sound pressure level of the intake sound generated by the motorcycle of the comparative example by about 2 dB(A) at a maximum.

[0051] Thus, it was confirmed that, with the motorcycle 100 of the inventive example, it was possible to reduce an intake sound generated when the vehicle velocity was in a relatively wide range from a velocity slightly higher than the "first velocity v1" (a velocity higher than the first velocity v1 by about 5 km/h) to the "second velocity v2," as compared with the motorcycle of the comparative example including the intake pipe in which the through hole 59 is not formed. It is considered that this is due to the fact that the natural frequency of each intake path VP in the motorcycle 100 of the inventive embodiment largely deviates from the frequency of a specific intake sound because of the through holes 59 formed in the two intake pipes 50.

<2> Intake Sound Audibility Experiment

[0052] The inventors of the present disclosure conducted an experiment (intake sound audibility experiment) to confirm how a person felt when the person heard an intake sound generated when the engine 30 worked in a specific vehicle velocity range in regard to the motorcycle 100 of the above-mentioned inventive embodiment and the motorcycle of the comparative example.

[0053] Specifically, the inventors of the present disclosure caused the motorcycle 100 of the inventive embodiment to travel at a vehicle velocity of about 40 km/h while maintaining the throttle valve 42 at 1/2 of the maximum opening. Further, the inventors of the present disclosure caused the motorcycle of the comparative embodiment to travel at a vehicle velocity of about 40 km/h while maintaining the throttle valve 42 at 1/2 of the maximum opening. Then, it was determined whether an intake sound generated by the motorcycle 100 of the inventive example and an intake sound generated by the motorcycle of the comparative example were heard differently. As a result, it was determined that the level of an intake sound generated by the motorcycle 100 of the inventive example was lower than the level of the intake sound generated by the motorcycle of the comparative example.

[0054] Further, the inventors of the present disclosure caused the motorcycle 100 of the inventive embodiment to travel at a vehicle velocity of about 80 km/h while maintaining the throttle valve 42 at the maximum opening. Further, the inventors of the present disclosure caused the motorcycle 100 of the comparative embodiment to travel at a vehicle velocity of about 80 km/h while maintaining the throttle valve 42 at the maximum opening. Then, it was determined whether an intake sound generated by the motorcycle 100 of the inventive example and an intake sound generated by the motorcycle of the comparative example were heard differently. As a result, it was determined that the level of an intake sound generated by the motorcycle 100 of the inventive example was lower than the level of the intake sound generated by the motorcycle of the comparative example.

[0055] Thus, it was confirmed that, with the motorcycle 100 of the inventive example, the level of an intake sound audible to a person was lowered as compared to the motorcycle of the comparative example, regardless of an opening of the throttle valve 42 and a vehicle velocity. That is, it was confirmed that the motorcycle 100 of the inventive example can reduce a noise caused by an intake sound as compared with the motorcycle of the comparative example.

4. Effects of Embodiments

[0056]

(a) In the motorcycle 100 according to the present embodiment, the upstream portions 51 of the two intake pipes 50 are inserted into the two air lead-out portions 14 of the air cleaner case 11. Further, the attached portion 53 of each intake pipe 50 is attached to the air lead-out portion 14 corresponding to the air cleaner case 11. The upstream portion 51 of the intake pipe 50 is located in the clean section CS of the air cleaner 10. On the other hand, the downstream portion 52 is located in the outer space ES of the air cleaner 10.

[0057] The through hole 59 is formed in the upstream portion 51 of the intake pipe 50. The through hole 59 is located in the clean section CS of the inner space of the air cleaner 10. Therefore, an unpurified air, droplets of rainwater or the like does not flow into the intake pipe 50 from the through hole 59.

[0058] The natural frequency of each of the intake paths VP, extending from the air cleaner 10 to the combustion chambers 31A, 31B of the engine 30, is defined depending on the length of the intake path VP and the flow-path cross-sectional area of the intake path VP. Further, the natural frequency of each intake path VP is defined depending on a position of the through hole 59 formed in the intake pipe 50 and an opening area of the through hole 59. In regard to the relationship between the natural frequency of the intake path VP and the position of the through hole 59, the more largely the position of the through hole 59 deviates from the funnel portion 511 and the closer the through hole 59 is to the air cleaner case 11 (the outer wall of the air cleaner 10), the more largely the natural frequency of the intake path VP changes. Therefore, with the above-mentioned configuration, the natural frequency of the intake path VP can be changed largely. Therefore, it is possible to reduce a specific intake sound by causing the natural frequency of the intake path VP to deviate from the frequency band of the specific intake sound.

[0059] Further, with the above-mentioned configuration, it is not necessary to provide an additional configuration such as a resonator around the air cleaner 10 and the two intake pipes 50 in order to reduce an intake sound. Therefore, the configuration of the air cleaner 10 and the peripheral portions of the two intake pipes 50 can be simplified and made compact.

[0060] As a result, the configuration of the peripheral portions of the intake paths VP can be simplified and made compact, and an intake sound can be reduced.

[0061] (b) As described above, in the motorcycle 100, it is not necessary to provide an additional configuration for reducing an intake sound, such as a resonator, in the two intake pipes 50. Therefore, in the throttle body 40, a valve actuator can be provided in the vicinity of the flow-path forming pipe 41 without consideration of interference with an additional configuration for reducing an intake sound. Therefore, the configurations of the air cleaner 10, the two intake pipes 50, the throttle body 40 and the peripheral members can be made compact. Further, the flexibility of layout of the air cleaner 10, the two intake pipes 50, the throttle body 40, and its peripheral members is improved.

[0062] (c) As described above, the natural frequency of each intake path VP is defined depending on a position of the through hole 59 formed in the intake pipe 50 and an opening area of the through hole 59. In the above-mentioned example, the one through hole 59 is formed in the one intake pipe 50. In a case in which the number of the through holes 59 is one, the opening area of the through hole 59 can be easily calculated. This facilitates design of the one through hole 59 to be formed in the intake pipe 50. Further, in a case in which the number of the through holes 59 formed in the intake pipe 50 is one, a reduction in strength of the intake pipe 50 is suppressed as compared with a case in which the large number of the through holes 59 are formed in the intake pipe 50. Further, an increase in number of processes required for formation of the through hole 59 is suppressed at the time of fabrication of the intake pipe 50.

[0063] (d) The length of the upstream portion 51 in the axial direction of each intake pipe 50 is larger than ⅓ of the entire length of the intake pipe 50. In this case, because the upstream portion 51 is disposed in the inner space of the air cleaner 10, a space occupied by the intake pipe 50 around the air cleaner 10 can be significantly reduced as compared to a case in which the entire intake pipe 50 is provided in the outer space ES of the air cleaner 10. Further, because the length of the upstream portion 51 is larger than ⅓ of the entire length of the intake pipe 50, the through hole 59 can be formed at a position further away from the funnel portion 511. That is, the through hole 59 can be formed at a position where the natural frequency of the intake path VP is likely to deviate more largely. As a result, it is possible to form the through hole 59 at a position suitable for reduction of an intake sound while setting the length of the intake pipe 50 in consideration of the engine intake performance.

[0064] (e) The length of the upstream portion 51 in the axial direction of each intake pipe 50 is smaller than 1/2 of the entire length of the intake pipe 50. In this case, it is not necessary to excessively increase the size of the air cleaner 10 in order to dispose a portion of the intake pipe 50 (the upstream portion 51) in the inner space of the air cleaner 10.

[0065] (f) With the two intake pipes 50 attached to the air cleaner 10, the through hole 59 of the left intake pipe 50A and the through hole 59 of the right intake pipe 50B are oriented in opposite directions in the leftward-and-rightward direction LR. In this case, the state of air flow into the through hole 59 in one of the left intake pipe 50A and the right intake pipe 50B is unlikely to be affected by an airflow generated in the vicinity of the through hole 59 in the other intake pipe. Therefore, the natural frequencies of the two intake paths VP respectively formed of the left intake pipe 50A and the right intake pipe 50B can be appropriately adjusted. Further, degradation of the engine intake performance caused by an unstable state of air flow into the two intake pipes 50 is suppressed.

5. Preferrable Forming Conditions of Through Hole 59 in Intake Pipe 50

<1> In Regard to Opening Area of Through Hole 59 Formed in One Intake Pipe 50

[0066] The number, positions and shapes of the through holes 59 formed in each of the two intake pipes 50 are not limited to the above-mentioned example as long as the natural frequency of a corresponding intake path VP can deviate from a specific frequency range (adjusted to a desired natural frequency). Two or more through holes 59 may be formed in one intake pipe 50.

[0067] In a case in which a plurality of through holes 59 are formed in one intake pipe 50, the natural frequency of a corresponding intake path VP is defined depending on the positions of the plurality of through holes 59 formed in the intake pipe 50 and the total opening area of the plurality of through holes 59. Here, the total opening area of the one or plurality of through holes 59 formed in the one intake pipe 50 is preferably not less than 8% and not more than 16% with respect to a flow-path cross- sectional area of the one intake pipe 50. This range was derived based on the experiments conducted by the inventors of the present disclosure. A plurality of experiments for deriving a preferable range of the total opening area of the one or more through holes 59 and the results of the experiments will be described below.

<2> Intake Pipe Characteristic Evaluation Experiment

[0068]

(a) The inventors of the present disclosure conducted an experiment (intake pipe characteristic evaluation experiment) for confirming the relationship between the positions and the total opening area of one or a plurality of through holes formed in one intake pipe 50, and the natural frequency of an intake path VP corresponding to the one intake pipe 50.

[0069] Specifically, the inventors of the present disclosure first prepared nine intake pipes having the same configuration as that of the intake pipe 50 of Fig. 5 except that the through hole 59 is not formed. The length of each of the nine intake pipes in an axial direction is about 180 mm. Further, the inner diameter of each intake pipe except for the funnel portion 511 is 35 mm.

[0070] Next, the inventors of the present disclosure took out one of the nine intake pipes and determined that the intake pipe is a first intake pipe. The first intake pipe is an intake pipe in which the through hole 59 is not formed. Here, an annular portion considered to be appropriate for formation of the through hole 59 for reducing an intake sound in the axial direction of the intake pipe is referred to as a hole formation subject portion. The hole formation subject portion is a portion of the intake pipe that is disposed in the clean section CS and is close to the inner surface of the air cleaner case 11. In this intake pipe characteristic evaluation experiment, the hole formation subject portion was a portion spaced apart from the funnel portion 511 by about 80 mm in the axial direction.

[0071] Next, the inventors of the present disclosure took out one of the remaining eight intake pipes, and formed two circular through holes 59 having an inner diameter of 5 mm in a portion directed downwardly in the hole formation subject portion, with the intake pipe being maintained in a predetermined attitude for an experiment. The intake pipe that was fabricated in this manner was determined as a second intake pipe.

[0072] Next, the inventors of the present disclosure took out one of the remaining seven intake pipes, and formed two rectangular through holes 59 of 8mm x 6mm in a portion directed downwardly in the hole formation subject portion, with the intake pipe being maintained in a predetermined attitude for an experiment. The intake pipe that was fabricated in this manner was determined as a third intake pipe.

[0073] Next, the inventors of the present disclosure took out one of the remaining six intake pipes, and formed two circular through holes 59 having an inner diameter of 5 mm in a portion directed upwardly in the hole formation subject portion, with the intake pipe being maintained in a predetermined attitude for an experiment. The intake pipe that has been fabricated in this manner was determined as a fourth intake pipe.

[0074] Next, the inventors of the present disclosure took out one of the remaining five intake pipes, and formed two circular through holes 59 having an inner diameter of 5 mm in a portion directed toward one side and a portion directed toward the other side in the hole formation subject portion, with the intake pipe being maintained in a predetermined attitude for an experiment. The intake pipe that has been fabricated in this manner was determined as a fifth intake pipe.

[0075] Next, the inventors of the present disclosure took out one of the remaining four intake pipes, and formed two circular through holes 59 having an inner diameter of 10 mm in a portion directed toward one side in a horizontal direction and a portion directed toward the other side in the horizontal direction in the hole formation subject portion, with the intake pipe being maintained in a predetermined attitude for an experiment. The intake pipe that has been fabricated in this manner was determined as a sixth intake pipe.

[0076] Next, the inventors of the present disclosure took out one of the remaining three intake pipes, and formed one circular through hole 59 having an inner diameter of 10 mm in a portion directed toward one side in the horizontal direction in the hole formation subject portion, with the intake pipe being maintained in a predetermined attitude for an experiment. The intake pipe that has been fabricated in this manner was determined as a seventh intake pipe.

[0077] Next, the inventors of the present disclosure took out one of the remaining two intake pipes, and formed one circular through hole 59 having an inner diameter of 10 mm in a portion directed toward the other side in the horizontal direction in the hole formation subject portion, with the intake pipe being maintained in a predetermined attitude for an experiment. The intake pipe that has been fabricated in this manner was determined as an eighth intake pipe.

[0078] Next, the inventors of the present disclosure took out the remaining one intake pipe, and formed one circular through hole 59 having an inner diameter of 12 mm in a portion directed toward the other side in the hole formation subject portion, with the intake pipe being maintained in a predetermined attitude for an experiment. The intake pipe that has been fabricated in this manner was determined as a ninth intake pipe.

[0079] Figs. 8 and 9 are schematic diagrams showing a list of the configurations of the first to ninth intake pipes according to the intake pipe characteristic evaluation experiment. In Figs. 8 and 9, in regard to each of the first to ninth intake pipes, the side view of the intake pipe maintained in the predetermined attitude for an experiment and the cross-sectional view of the hole formation subject portion are shown. In each of the side views of Figs. 8 and 9, the portion the frame formed of the dotted lines indicates the hole formation subject portion 54 in the intake pipe. Further, in each of the side views of Figs. 8 and 9, the section corresponding to the cross-sectional view of the hole formation subject portion 54 shown at the right of the side view is indicated by the line Q-Q.

[0080] After the first to ninth intake pipes were fabricated, the inventors of the present disclosure input a sound to the end portion of the downstream portion 52 of each of the first to ninth intake pipes and continuously changed the frequency of the input sound (sweep). Further, the inventors of the present disclosure, when a sound is input to each intake pipe, also measured a frequency response function in regard to a sound output from the funnel portion 511 of each intake pipe.

[0081] Fig. 10 is a graph representing the frequency response function of a sound output from each of the first to ninth intake pipes according to the intake pipe characteristic evaluation experiment. In the graph of Fig. 10, the ordinate indicates the frequency response function, and the abscissa indicates the frequency of a sound. Further, in the graph of Fig. 10, the solid line indicates the frequency response function corresponding to the first intake pipe, the dotted line indicates the frequency response function corresponding to the second intake pipe, and the one-dot and dash line indicates the frequency response function corresponding to the third intake pipe. Further, the thick one-dot and dash line indicates the frequency response function corresponding to the fourth intake pipe, the thick dotted line indicates the frequency response function corresponding to the fifth intake pipe, and the two-dot and dash line indicates the frequency response function corresponding to the six intake pipe. Further, the thick two-dot and dash line indicates the frequency response function corresponding to the seventh intake pipe, the thick solid line indicates the frequency response function corresponding to the eighth intake pipe, and the broken line indicates the frequency response function corresponding to the ninth intake pipe.

[0082] In the graph of Fig. 10, the frequency corresponding to the peak of the frequency response function (peak frequency) of each of the first to ninth intake pipes represents the natural frequency (resonance frequency) of the intake pipe. In the frequency band from a "first frequency f1" to a "second frequency f2 higher than the first frequency f1" of an intake sound estimated to be generated as a noise from the above-mentioned plurality of intake pipes, the peak frequencies of the second to ninth intake pipes deviate from a peak frequency fp1 of the first intake sound. The peak frequencies of the second to ninth intake pipes are higher than the peak frequency fp1 of the first intake pipe by about 10 Hz to 30 Hz. Based on this result, it is found that, in a case in which the through hole 59 is formed in the intake pipe 50, the natural frequency of the intake pipe 50 can deviate from (be higher than) the natural frequency of the intake pipe having no through hole 59.

[0083] Fig. 11 is a graph representing the relationship between the peak frequencies of the first to ninth intake pipes according to the intake pipe characteristic evaluation experiment and the total opening area of the one or plurality of through holes 59 in the first to ninth intake pipes. In the graph of Fig. 11, the ordinate indicates the peak frequency, and the abscissa indicates the total opening area of the one or plurality of through holes 59 of each intake pipe. Further, in regard to the indices in the graph of Fig. 11, the outlined inverted triangle indicates the peak frequency of the first intake pipe, the outlined circle indicates the peak frequency of the second intake pipe, and the outlined square indicates the peak frequency of the third intake pipe. Further, the mark X indicates the peak frequency of the fourth intake pipe, the double circle indicates the peak frequency of the fifth intake pipe, and the outlined triangle indicates the peak frequency of the sixth intake pipe. Further, the black circle indicates the peak frequency of the seventh intake pipe, the black square indicates the peak frequency of the eighth intake pipe, and the black triangle indicates the peak frequency of the ninth intake pipe.

[0084] As shown in Fig. 11, since the through hole 59 is not formed in the first intake pipe, the total opening area is 0 mm^2. On the other hand, the total opening area of each of the second intake pipe, the fourth intake pipe and the fifth intake pipe is about 39 mm^2, and the total opening area of each of the seventh intake pipe and the eighth intake pipe is about 79 mm^2. On the other hand, the total opening area of the third intake pipe is 96 mm^2, the total opening area of the ninth intake pipe is about 113 mm^2, and the total opening area of the sixth intake pipe is about 157 mm^2.

[0085] The peak frequencies of a plurality of intake pipes having the same total opening area are similar to each other to the extent that the peak frequencies vary within the range of several Hz. For example, as indicated by the frame formed of the thick one-dot and dash lines in Fig. 11, the peak frequencies of the second intake pipe, the fourth intake pipe and the fifth intake pipe, the total opening area of each of which is about 39 mm^2, are concentrated in the range of about 5 Hz. Further, as indicated by the frame formed of the thick two-dot and dash line in Fig. 11, the peak frequencies of the seventh intake pipe and the eighth intake pipe, the total opening area of each of which is about 79 mm^2, are concentrated in the range of about 5 Hz. Based on the above-mentioned fact, it is found that the peak frequency of the intake pipe is defined mainly by the total opening area, regardless of the number of the through holes 59 and the positions of the through holes 59 in the circumferential direction of the intake pipe.

[0086] Further, according to the relationship shown in Fig. 11, it is recognized that the higher the total opening area of the one or plurality of through holes 59 formed in the intake pipe, the higher the peak frequency of the intake pipe tends to be. Specifically, in Fig. 11, the straight line LL that connects the peak frequency fp1 of the first intake pipe, which has the smallest total opening area of 0 mm^2, among the nine intake pipes, and the peak frequency fp6 of the sixth intake pipe, which has the largest total opening area of 157 mm^2, among the nine intake pipes, is drawn (see the thick dotted line of Fig. 11). In this case, the peak frequencies of the second intake pipe, the third intake pipe, the fourth intake pipe, the fifth intake pipe, the seventh intake pipe, the eighth intake pipe and the ninth intake pipe, which have the total opening areas of between 0 mm^2 and 157 mm^2, indicate values that correspond to the total opening areas and close to the straight line LL.

[0087] As a result, it was found that, in a case in which the through hole 59 is formed in the intake pipe 50, regardless of the number of the through holes 59 and the positions of the through holes 59 in the circumferential direction of the intake pipe, the larger the total opening area, the more largely the natural frequency of the intake pipe 50 can be changed. That is, it was found that, it is possible to largely change the natural frequencies of the two intake paths VP and largely reduce a specific intake sound by increasing the total opening area of the one or plurality of through holes 59 formed in the intake pipe 50.

<3> Engine Intake Performance Confirmation Experiment

[0088] In consideration of the results of the intake pipe characteristic evaluation experiment, it is considered that it is preferable to form one or a plurality of through holes 59 in order to have a larger total opening area. However, when the total opening area of the through holes 59 is excessively large, air may not be appropriately supplied to each of the combustion chambers 31A, 31B during work of the engine 30. That is, the engine intake performance may be degraded.

[0089] The inventors of the present disclosure conducted an experiment (engine intake performance determination experiment) for understanding the relationship between the total opening area of the one or plurality of through holes 59 formed in the intake pipe 50 and the engine intake performance.

[0090] Specifically, the inventors of the present disclosure first prepared the first intake pipe, the sixth intake pipe and the seventh intake pipe fabricated in the intake pipe characteristic evaluation experiment. The first intake pipe is the intake pipe in which the through hole 59 is not formed. The sixth intake pipe is the intake pipe in which the two circular through holes 59 having an inner diameter of 10 mm are formed. The seventh intake pipe is an intake pipe in which the one circular through hole 59 having an inner diameter of 10 mm is formed.

[0091] Next, the inventors of the present disclosure causes the engine to work with the first intake pipe being incorporated in the intake path of the predetermined engine. Further, the inventors of the present disclosure measured an output and a torque of the crankshaft when the engine rotation speed is within a predetermined range (hereinafter referred to as an experimental speed range), using a dynamometer. Further, the inventors of the present disclosure conducted the measurement for the sixth intake pipe and the seventh intake pipe similar to the measurement conducted for the first intake pipe.

[0092] Fig. 12 is a graph representing the relationship between the output of the crankshaft and the engine rotation speed measured in the engine intake performance confirmation experiment. In the graph of Fig. 12, the ordinate indicates the engine output (output of the crankshaft), and the abscissa indicates the engine rotation speed. Further, in regard to the indices in the graph of Fig. 12, the outlined inverted triangles indicate the engine output corresponding to the first intake pipe, the outlined triangles indicate the engine output corresponding to the sixth intake pipe, and the black circles indicate the engine output corresponding to the seventh intake pipe. Further, in the graph of Fig. 12, the measurement results of the plurality of engine outputs corresponding to the first intake pipe are connected by the solid line, the measurement results of the plurality of engine outputs corresponding to the sixth intake pipe are connected by the one-dot and dash line, and the measurement results of the plurality of engine outputs corresponding to the seventh intake pipe are connected by the dotted line.

[0093] As shown in Fig. 12, according to the result of the engine intake performance confirmation experiment, the relationship between the engine output and the engine rotation speed varies slightly when the engine rotation speed is in part of the experimental speed range. Specifically, as indicated by the frame formed of the two-dot and dash lines in Fig. 12, when the engine rotation speed is partially in the experimental speed range, the engine outputs corresponding to the sixth intake pipe and the seventh intake pipe are lower than the engine output corresponding to the first intake pipe.

[0094] Fig. 13 is a graph showing the relationship between the torque of the crankshaft measured in the engine intake performance confirmation experiment and the engine rotation speed. In the graph of Fig. 12, the ordinate indicates the engine torque (torque of the crankshaft), and the abscissa indicates the engine rotation speed. Further, in regard to the indices in the graph of Fig. 13, the outlined inverted triangles indicate the engine torques corresponding to the first intake pipe, the outlined triangles indicate the engine torques corresponding to the sixth intake pipe, and the black circles indicate the engine output corresponding to the seventh intake pipe. Further, in the graph of Fig. 13, the measurement results of the plurality of engine torques corresponding to the first intake pipe are connected by the solid line, the measurement results of the plurality of engine torques corresponding to the sixth intake pipe are connected by the one-dot and dash line, and the measurement results of the plurality of engine torques corresponding to the seventh intake pipe are connected by the dotted line.

[0095] As shown in Fig. 13, according to the results of the engine intake performance confirmation experiment, the relationship between the engine torque and the engine rotation speed varies over a relatively wide range of the engine rotation speed. Specifically, as indicated by the frame formed of the two-dots and dash lines in Fig. 13, the engine torques corresponding to the sixth intake pipe and the seventh intake pipe are lower than the engine torque corresponding to the first intake pipe, over

[0096] As a result, it was found that the total opening area of the one or plurality of through holes 59 formed in the intake pipe 50 is to be determined in consideration of the engine intake performance in addition to the reduction of an intake sound.

<4> Optimum Condition Determination Experiment

[0097] The inventors of the present disclosure conducted an experiment (optimum condition determination experiment) for determining a preferable range of the total opening area of the one or plurality of through holes 59 based on the results of the intake pipe characteristic evaluation experiment and the engine intake performance confirmation experiment.

[0098] Specifically, the inventors of the present disclosure first prepared the first intake pipe, the second intake pipe, the sixth intake pipe and the seventh intake pipe fabricated in the intake pipe characteristic evaluation experiment. The first intake pipe is an intake pipe in which the through hole 59 is not formed. The second intake pipe is an intake pipe in which the two circular through holes 59 having an inner diameter of 5 mm are formed. The sixth intake pipe is an intake pipe in which the two circular through holes 59 having an inner diameter of 10 mm are formed. The seventh intake pipe is an intake pipe in which the one circular through hole 59 having an inner diameter of 10 mm is formed.

[0099] Next, the inventors of the present disclosure incorporated the first intake pipe into a motorcycle corresponding to the motorcycle 100 of Fig. 1. Further, the inventors of the present disclosure caused the motorcycle in which the first intake pipe was incorporated to travel under a predetermined condition and determined a degree of discomfort felt by a rider when the rider heard an intake sound generated by the motorcycle. The determined degree of discomfort in regard to an intake sound at this time is referred to as a reference discomfort. Further, the inventors of the present disclosure caused the motorcycle in which the first intake pipe was incorporated to travel under a predetermined condition and confirmed a power feeling of a rider. The confirmed power feeling at this time is referred to as a reference power feeling.

[0100] Next, the inventors of the present disclosure incorporated the second intake pipe into a motorcycle corresponding to the motorcycle 100 of Fig. 2. Further, the inventors of the present disclosure caused the motorcycle in which the second intake pipe was incorporated to travel under a predetermined condition and determined whether a degree of discomfort felt by a rider when the rider heard an intake sound generated by the motorcycle was lower than the reference discomfort. Further, the inventors of the present disclosure caused the motorcycle in which the second intake pipe was incorporated to travel under a predetermined condition and determined whether the power feeling of a rider has changed largely from the reference power feeling. Further, the inventors of the present disclosure conducted the measurement in regard to the sixth intake pipe and the seventh intake pipe similar to the measurement in regard to the second intake pipe.

[0101] As a result, in regard to the second intake pipe, the degree of discomfort in regard to an intake sound hardly changed from the reference discomfort. That is, in regard to the second intake pipe, the effect of reduction of an intake sound was hardly recognized. Further, in regard to the second intake pipe, the power feeling of the rider did not change greatly from the reference power feeling. That is, in a case in which the second intake pipe was used, the engine intake performance did not change largely (did not decrease).

[0102] On the other hand, in regard to the sixth intake pipe, the degree of discomfort in regard to an intake sound was lower than the reference discomfort. That is, with the sixth intake pipe, the effect of reduction of an intake sound was recognized. Further, in regard to the sixth intake pipe, although the power feeling of the rider changed from the reference power feeling, the rider could tolerate the extent of change. That is, in a case in which the sixth intake pipe was used, it was not recognized that the engine intake performance changed largely (decreased).

[0103] On the other hand, in regard to the seventh intake pipe, the degree of discomfort in regard to an intake sound was lower than the reference discomfort. That is, with use of the seventh intake pipe, the effect of reduction of an intake sound was recognized. Further, in regard to the seventh intake pipe, although the power feeling of the rider has changed from the reference power feeling, the rider could tolerate the extent of change. That is, in a case in which the seventh intake pipe was used, it was not recognized that the engine intake performance changed (decreased) largely.

<5> Summary of Preferable Forming Condition of Intake Pipe 50

[0104] Based on the above-mentioned results, it was found that, in order to obtain the effect of the reduction of an intake sound in regard to an intake pipe having the length and the inner diameter corresponding to the first intake pipe, it was desirable to ensure an opening area equal to or larger than at least the opening area of the through hole 59 formed in the seventh intake pipe. Further, it was found that, in order to prevent the engine intake performance from being largely degraded in regard to an intake pipe having the length and the inner diameter corresponding to the first intake pipe, it was desirable to ensure an opening area equal to or smaller than at least the total opening area of the two through holes 59 formed in the sixth intake pipe.

[0105] It is considered that the relationship between the total opening area of the one or plurality of through holes 59 formed in one intake pipe and the effect of reduction of an intake sound can be defined based on the relationship between a value of the total opening area and the flow-path cross-sectional area of the intake pipe.

[0106] Specifically, according to the above-mentioned experiment result, the intake pipe having the minimum total opening area for obtaining the effect of reduction of an intake sound is the seventh intake pipe. As such, the inventors of the present disclosure calculated the ratio of the opening area of the one through hole 59 formed in the seventh intake pipe with respect to the flow-path cross-sectional area of the seventh intake pipe. The calculation result was 8%.

[0107] Further, according to the above-mentioned experiment result, the intake pipe that having the maximum total opening area for preventing degradation of the engine intake performance is the sixth intake pipe. As such, the inventors of the present disclosure calculated the ratio of the total opening area of the two through holes 59 formed in the sixth intake pipe with respect to the flow-path cross-sectional area of the sixth intake pipe. The calculation result was 16 %.

[0108] Based on the above-mentioned calculation result, it is preferable to design the intake pipe 50 such that the ratio of the total opening area of the one or plurality of through holes 59 with respect to the flow-path cross-sectional area of the intake pipe 50 is not less than 8 % and not more than 16 %. In this case, the effect of reduction of an intake sound can be sufficiently obtained, and the engine intake performance can be prevented from being largely degraded.

6. Other Embodiments

[0109]

(a) While the engine 30 of the motorcycle 100 according to the above-mentioned embodiment is a parallel-twin engine, the present disclosure is not limited to this. The engine 30 may be a single-cylinder engine or an engine having three or more cylinders. In this case, the intake path VP is formed in accordance with the number of cylinders. Therefore, the number of the intake pipes 50 corresponding to the number of the cylinders are provided in the motorcycle 100.

(b) While the motorcycle 100 according to the above-mentioned embodiment includes the intake pipe 50 in which the one through hole 59 is formed, the present disclosure is not limited to this. The motorcycle 100 may include the intake pipe 50 having two through holes 59, the intake pipe 50 having three through holes 59 or the intake pipe 50 having four through holes 59.

(c) While the above-mentioned embodiment is an example in which the present disclosure is applied to a motorcycle, the present disclosure is not limited to this. The present disclosure may be applied to another straddled vehicle such as a four-wheeled automobile, a motor tricycle or an ATV (All Terrain Vehicle).

7. Correspondences between Constituent Elements in Claims and Parts in Preferred Embodiments

[0110] In the following paragraphs, non-limiting examples of correspondences between various elements recited in the claims below and those described above with respect to various preferred embodiments of the present disclosure are explained. As each of various elements recited in the claims, various other elements having configurations or functions described in the claims can be also used.

[0111] In the above-mentioned embodiment, the engine 30 is an example of an engine, the air cleaner 10 is an example of an air cleaner, the intake pipe 50, the left intake pipe 50A and the right intake pipe 50B are examples of an intake pipe, the intake path VP is an example of an intake path, the upstream portion51 is an example of an upstream portion, the downstream portion 52 is an example of a downstream portion, and the attached portion 53 is an example of an attached portion.

[0112] Further, the funnel portion 511 is an example of a funnel portion, the pipe portion 512 is an example of a pipe portion, the one or plurality of through holes 59 is an example of one or a plurality of through holes, the motorcycle 100 is an example of a straddled vehicle, the air cleaner case 11 is an example of an outer wall and an air cleaner case, the filter element 12 is an example of a filter element, and the air lead-out portion 14 is an example of an opening.

[0113] Further, the intake port 32 is an example of an intake port, the throttle body 40 is an example of a throttle body, the two intake paths VP are examples of a first intake path and a second intake path, the left intake pipe 50A is an example of a first intake pipe, the right intake pipe 50B is an example of a second intake pipe, and the leftward-and-rightward direction LR is an example of one direction.

8. Overview of Embodiments

[0114] (Item 1) A straddled vehicle according to one item includes an engine, an air cleaner that cleans air to be supplied to the engine, and an intake pipe that is configured to be one portion of an intake path guiding air that has been cleaned by the air cleaner to the engine, wherein the intake pipe has an upstream portion disposed in a clean section of an inner space of the air cleaner, a downstream portion disposed outside of the air cleaner, and an attached portion that is located between the upstream portion and the downstream portion in the intake pipe and is attached to an outer wall of the air cleaner, the upstream portion includes a funnel portion that opens to the inner space of the air cleaner, and a pipe portion that connects the funnel portion and the attached portion to each other, and one or a plurality of through holes are formed in a portion, that is closer to the attached portion than the funnel portion, in the pipe portion.

[0115] In the straddled vehicle, the attached portion of the intake pipe is attached to the outer wall of the air cleaner. The upstream portion of the intake pipe is located in the clean section of the inner space of the air cleaner. Further, the downstream portion of the intake pipe is located outwardly of the outer wall of the air cleaner.

[0116] The one or plurality of through holes are formed in the upstream portion of the intake pipe. The one or plurality of through holes are located in the clean section in the inner space of the air cleaner. Therefore, an unpurified air, droplets of rainwater or the like does not flow into the intake pipe from the one or plurality of through holes.

[0117] The natural frequency of the intake path is defined depending on the length of the intake path and the flow-path cross-sectional area of the intake path. Further, the natural frequency of the intake path is defined depending on the positions and the total opening area of the one or plurality of through holes formed in the intake pipe. In regard to the relationship between the natural frequency of the intake path and the positions of the one or plurality of through holes, the farther the positions of the one or plurality of through holes from the funnel portion, and the closer the positions of the one or plurality of through holes to the outer wall of the air cleaner, the more largely the natural frequency of the intake path changes. Therefore, with the above-mentioned configuration, the natural frequency of the intake path can be changed largely. Therefore, it is possible to reduce an intake sound by causing the natural frequency of the intake path to deviate from the frequency band of a specific intake sound.

[0118] Further, with the above-mentioned configuration, it is not necessary to provide an additional configuration such as a resonator around the air cleaner and the intake pipe in order to reduce an intake sound. Therefore, the configuration of the air cleaner and the peripheral portions of the intake pipe can be made simple and compact.

[0119] As a result, the configuration of the peripheral portion of the intake path can be simplified and made compact, and an intake sound can be reduced.

[0120] (Item 2) The straddled vehicle according to item 1, wherein the one or plurality of through holes may be one through hole.

[0121] As described above, the natural frequency of the intake path changes depending on the total opening area of the one or plurality of through holes in addition to the positions of the one or plurality of through holes formed in the intake pipe. In a case in which the number of through holes is one, the total opening area of the one or plurality of through holes can be easily adjusted. This facilitates design of one through hole to be formed in the intake pipe. Further, with the above-mentioned configuration, a reduction in strength of the intake pipe due to the formation of the large number of through holes in the intake pipe is suppressed. Further, an increase in number of processes required for formation of the through hole is suppressed.

[0122] (Item 3) The straddled vehicle according to item 1 or 2, wherein in an axial direction of the intake pipe, a length of the upstream portion may be larger than 1/3 of an entire length of the intake pipe.

[0123] In this case, because the upstream portion is disposed in the inner space of the air cleaner, the space occupied by the intake pipe around the air cleaner can be significantly reduced as compared to a case in which the entire intake pipe is provided outside of the air cleaner. Further, because the length of the upstream portion is larger than ⅓ of the entire length of the intake pipe, one or a plurality of through holes can be formed at positions farther away from the funnel portion. As a result, one or a plurality of through holes can be formed at positions suitable for reduction of an intake sound while the length of the intake pipe is set in consideration of the engine intake performance.

[0124] (Item 4) The straddled vehicle according to any one of items 1 to 3, wherein a ratio of a total opening area of the one or plurality of through holes with respect to a flow-path cross-sectional area of the intake pipe may be not less than 8 % and not more than 16 %.

[0125] The flow-path cross-sectional area of the intake pipe is referred to as a pipe area, and the total opening area of the one or plurality of through holes is referred to as a hole opening area. In a case in which the ratio of the hole opening area to the pipe area is smaller than 8%, it is difficult to cause the natural frequency of the intake path to deviate from the frequency band of a specific intake sound. On the other hand, in a case in which the ratio of the hole opening area to the pipe area is larger than 16%, the supply performance of supplying air to the engine in the intake path may be degraded. Therefore, with the above-mentioned configuration, it is possible to change the natural frequency of the intake path to an extent that the natural frequency of the intake path deviates from the frequency band of the intake sound while suppressing degradation of the supply performance of supplying air to the engine.

[0126] (Item 5) The straddled vehicle according to any one of items 1 to 4, wherein the air cleaner may include an air cleaner case that includes the outer wall and forms the inner space of the air cleaner, and a filter element that sections the inner space into a contamination section and the clean section, in the outer wall, an opening that causes the clean section of the inner space to communicate with an outer space of the air cleaner case, and the attached portion of the intake pipe may be attached to the outer wall by being fitted to the opening of the outer wall.

[0127] In this case, in the air cleaner, the air introduced into the contamination section is purified by the filter element and flows to the clean section. In the clean section, the purified air flows into the intake pipe through the funnel portion and the one or plurality of through holes of the intake pipe. Thereafter, the purified air is supplied to the engine through the intake pipe.

[0128] (Item 6) The straddled vehicle according to any one of items 1 to 5, may further include a throttle body to which the downstream portion of the intake pipe is connected and which is connected to an intake port of the engine and is configured to be another portion of the intake path.

[0129] The throttle body includes a flow-path forming pipe, a throttle valve and a valve actuator, for example. The flow-path forming pipe is a member that forms a flow path that guides air purified by the air cleaner to the engine. The throttle valve is a valve configured to be capable of opening and closing the flow path formed of the flow-path forming pipe. The valve actuator is a device that adjusts an opening of the throttle valve. With the above-mentioned configuration, the downstream portion of the intake pipe is connected to the flow-path forming pipe.

[0130] In this case, it is not necessary to provide an additional configuration for reducing an intake sound, such as a resonator, in the intake pipe. Therefore, a valve actuator can be provided in the vicinity of the flow-path forming pipe without consideration of interference with an additional configuration for reducing an intake sound. Therefore, the configurations of the air cleaner, the intake pipes, the throttle body and the peripheral members can be made compact. Further, the flexibility of layout of the air cleaner, the intake pipes, the throttle body and its peripheral members is improved.

[0131] (Item 7) The straddled vehicle according to any one of items 1 to 6, wherein the intake path may include a first intake path and a second intake path that respectively guide air that has been cleaned by the air cleaner to the engine, the intake pipe may include a first intake pipe that is configured to be one portion of the first intake path, and a second intake pipe that is arranged in one direction with respect to the first intake pipe and is configured to be one portion of the second intake path, each of the first intake pipe and the second intake pipe may have the upstream portion, the downstream portion and the attached portion and may have the one or plurality of through holes in a portion, that is closer to the attached portion than to the funnel portion, in the pipe portion of the upstream portion, and the one or plurality of through holes formed in the first intake pipe and the one or plurality of through holes formed in the second intake pipe may be disposed not to be opposite to each other in the one direction.

[0132] In this case, the state of an air flow into the one or plurality of through holes in one of the first intake pipe and the second intake pipe is less likely to be affected by an airflow generated in the vicinity of the one or plurality of through holes in the other intake pipe. Therefore, the natural frequencies of the first intake path and the second intake path can be appropriately adjusted. Further, degradation of the supply performance of supplying air to the engine caused by an unstable state of an airflow into the two intake pipes is suppressed.

[0133] While preferred embodiments of the present disclosure have been described above, it is to be understood that variations and modifications will be apparent to those skilled in the art without departing the scope and spirit of the present disclosure. The scope of the present disclosure, therefore, is to be determined solely by the following claims.

Claims

1. A straddled vehicle (100), comprising:

an engine (30);
an air cleaner (10) that cleans air to be supplied to the engine (30); and
an intake pipe (50) that is configured to be one portion of an intake path (VP) guiding air that has been cleaned by the air cleaner (10) to the engine (30), wherein
the intake pipe (50) has
an upstream portion (51) disposed in a clean section (CS) of an inner space of the air cleaner (10),
a downstream portion (52) disposed outside of the air cleaner (10), and
an attached portion (53) that is located between the upstream portion (51) and the downstream portion (52) in the intake pipe (30) and is attached to an outer wall of the air cleaner (10),
the upstream portion (51) includes
a funnel portion (511) that opens to the inner space of the air cleaner, and
a pipe portion (512) that connects the funnel portion (511) and the attached portion (53) to each other, and
one or a plurality of through holes (59) are formed in a portion (512), that is closer to the attached portion (53) than the funnel portion (511), in the pipe portion (512)..

2. The straddled vehicle according to claim 1, wherein the one or plurality of through holes (59) are one through hole.

3. The straddled vehicle according to claim 1 or 2, wherein
in an axial direction of the intake pipe (30), a length of the upstream portion (51) is larger than 1/3 of an entire length of the intake pipe (30).

4. The straddled vehicle according to any one of claims 1 to 3, wherein
a ratio of a total opening area of the one or plurality of through holes (59) with respect to a flow-path cross-sectional area of the intake pipe (30) is not less than 8 % and not more than 16 %.

5. The straddled vehicle according to any one of claims 1 to 4, wherein

the air cleaner (10) includes
an air cleaner case (11) that includes the outer wall and forms the inner space of the air cleaner (10), and
a filter element (12) that sections the inner space into a contamination section (DS) and the clean section (CS),
in the outer wall, an opening that causes the clean section (CS) of the inner space to communicate with an outer space of the air cleaner case (11), and
the attached portion (53) of the intake pipe (30) is attached to the outer wall by being fitted to the

opening of the outer wall.

6. The straddled vehicle according to any one of claims 1 to 5, further comprising a throttle body (40) to which the downstream portion (52) of the intake pipe (30) is connected and which is connected to an intake port of the engine (30) and is configured to be another portion of the intake path (VS).

7. The straddled vehicle according to any one of claims 1 to 6, wherein

the intake path (VS) includes a first intake path and a second intake path that respectively guide air that has been cleaned by the air cleaner (10) to the engine (30),
the intake pipe (VS) includes:

a first intake pipe that is configured to be one portion of the first intake path, and
a second intake pipe that is arranged in one direction with respect to the first intake pipe and is configured to be one portion of the second intake path,
each of the first intake pipe and the second intake pipe has the upstream portion (51), the downstream portion (52) and the attached portion (52) and has the one or plurality of through holes (59) in a portion, that is closer to the attached portion (53) than to the funnel portion (511), in the pipe portion (512) of the upstream portion (51), and
the one or plurality of through holes (59) formed in the first intake pipe and the one or plurality of through holes (59) formed in the second intake pipe are disposed not to be opposite to each other in the one direction.

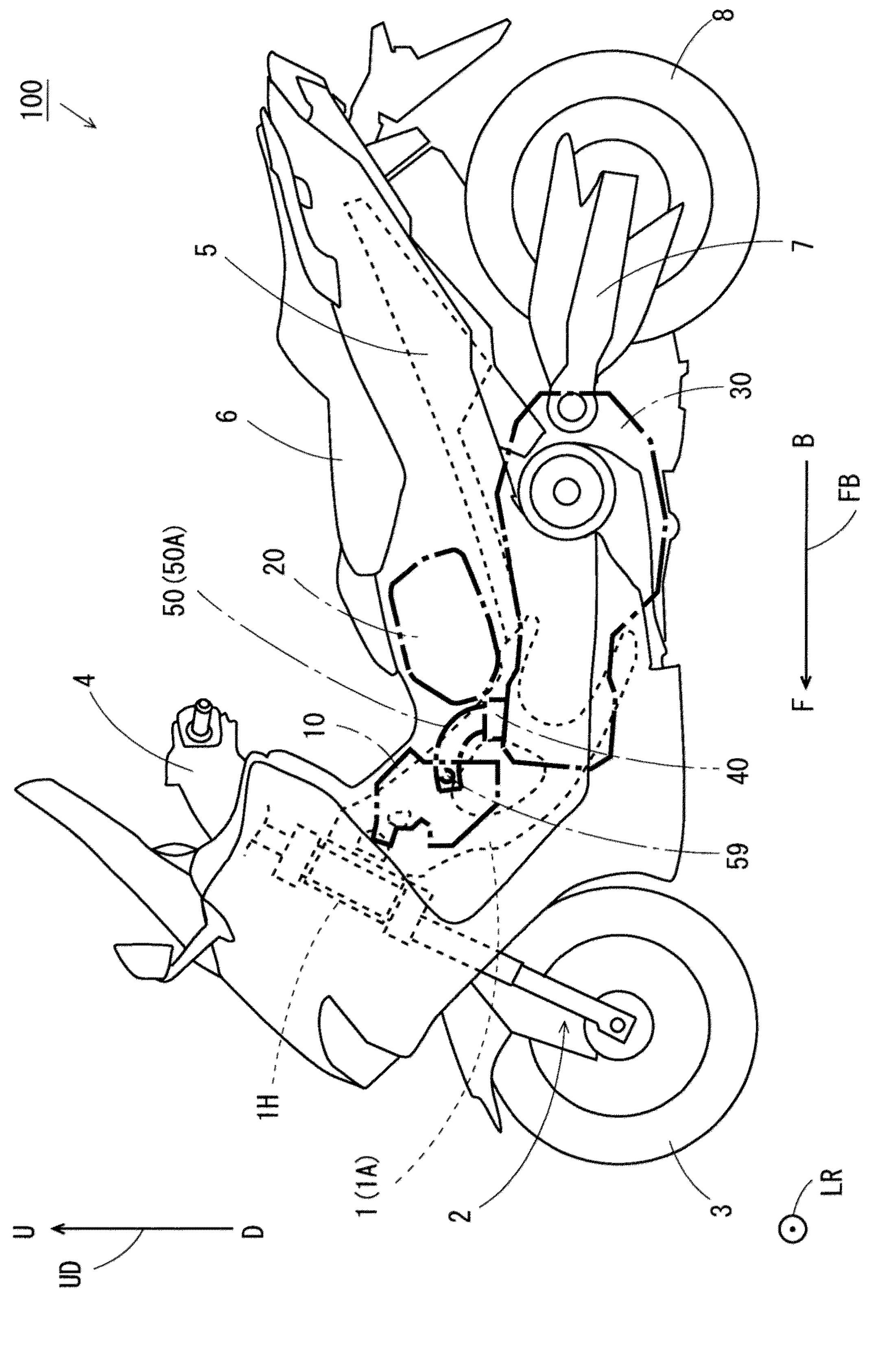


FIG.1

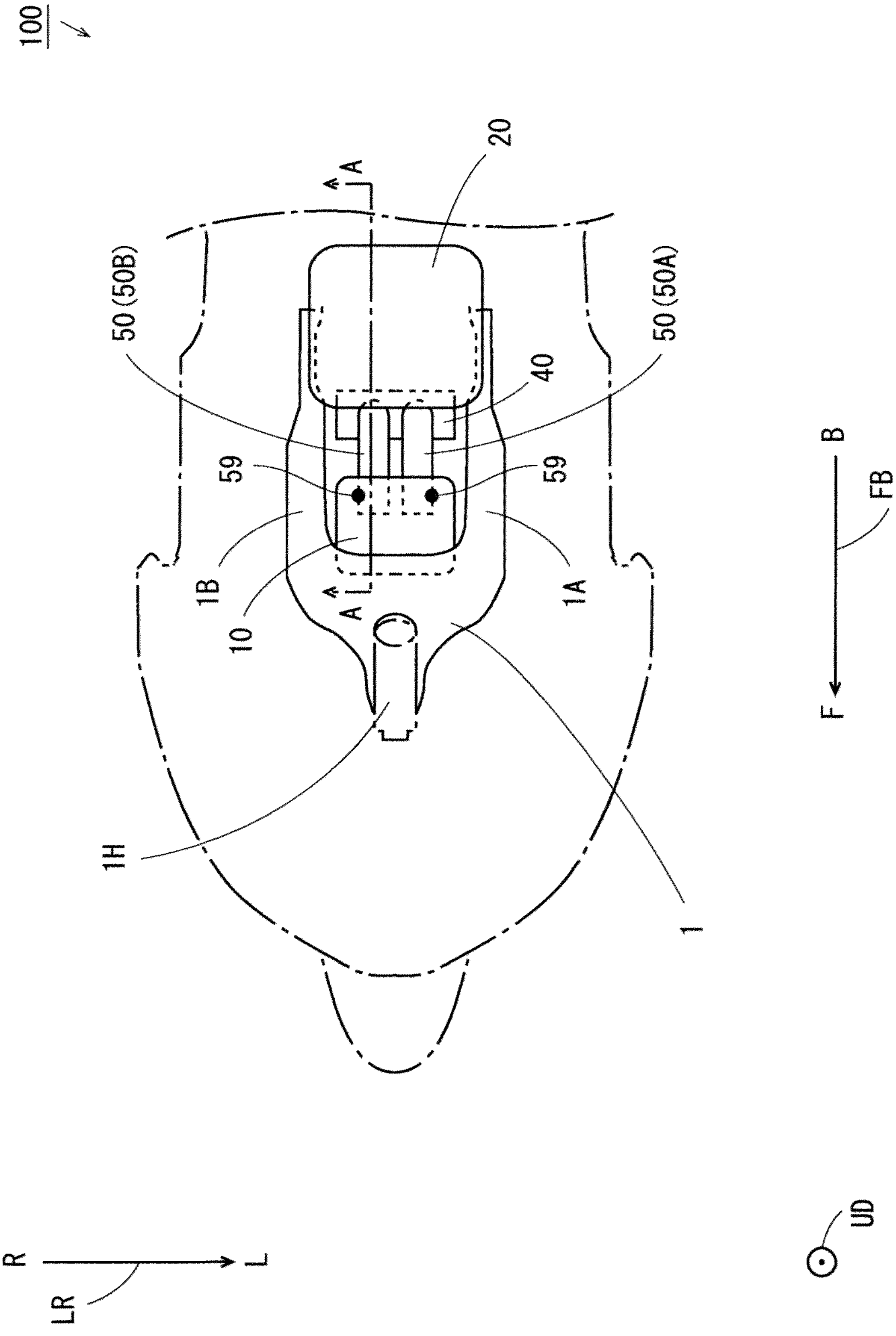
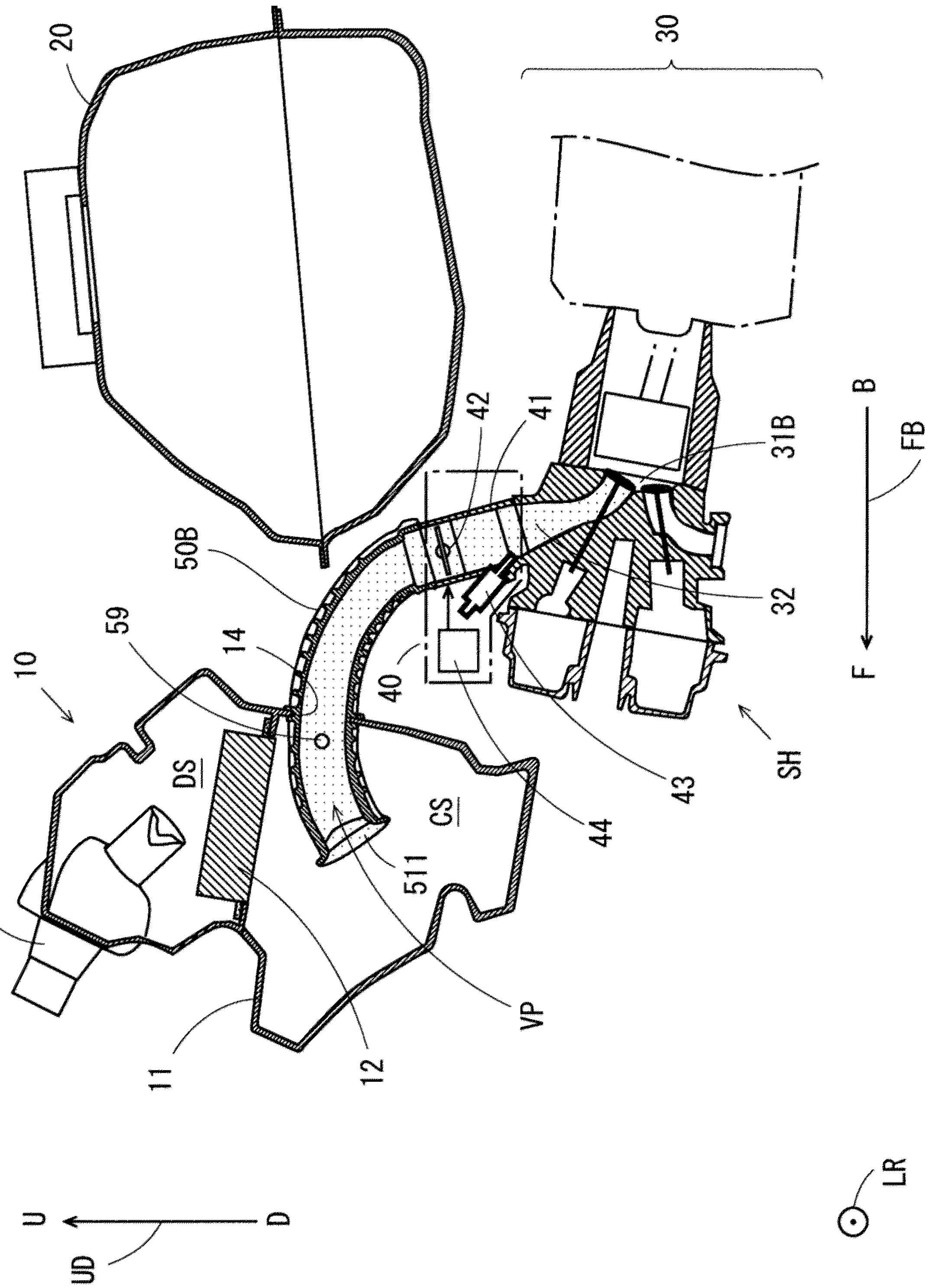


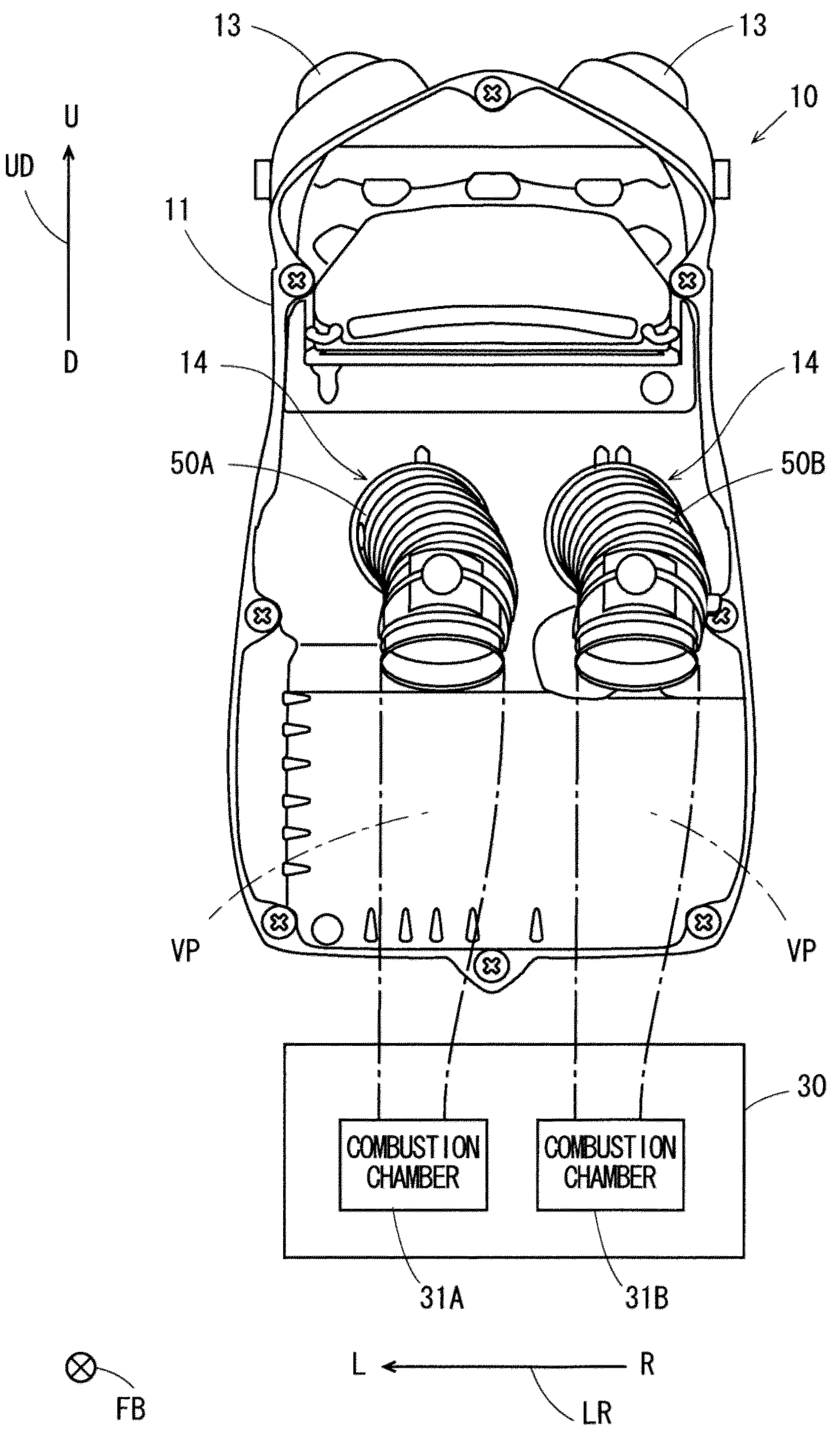
FIG.2



20
30
10
13
11
12
DS
CS
VP
59
14
50B
511
40
41
42
43
44
31B
32
SH
F
B
FB
U
D
UD
LR

FIG.3

FIG.4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UD
D
11
14
14
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50B
VP
VP
30
COMBUSTION CHAMBER
COMBUSTION CHAMBER
31A
31B
FB
L
R
LR

FIG.5

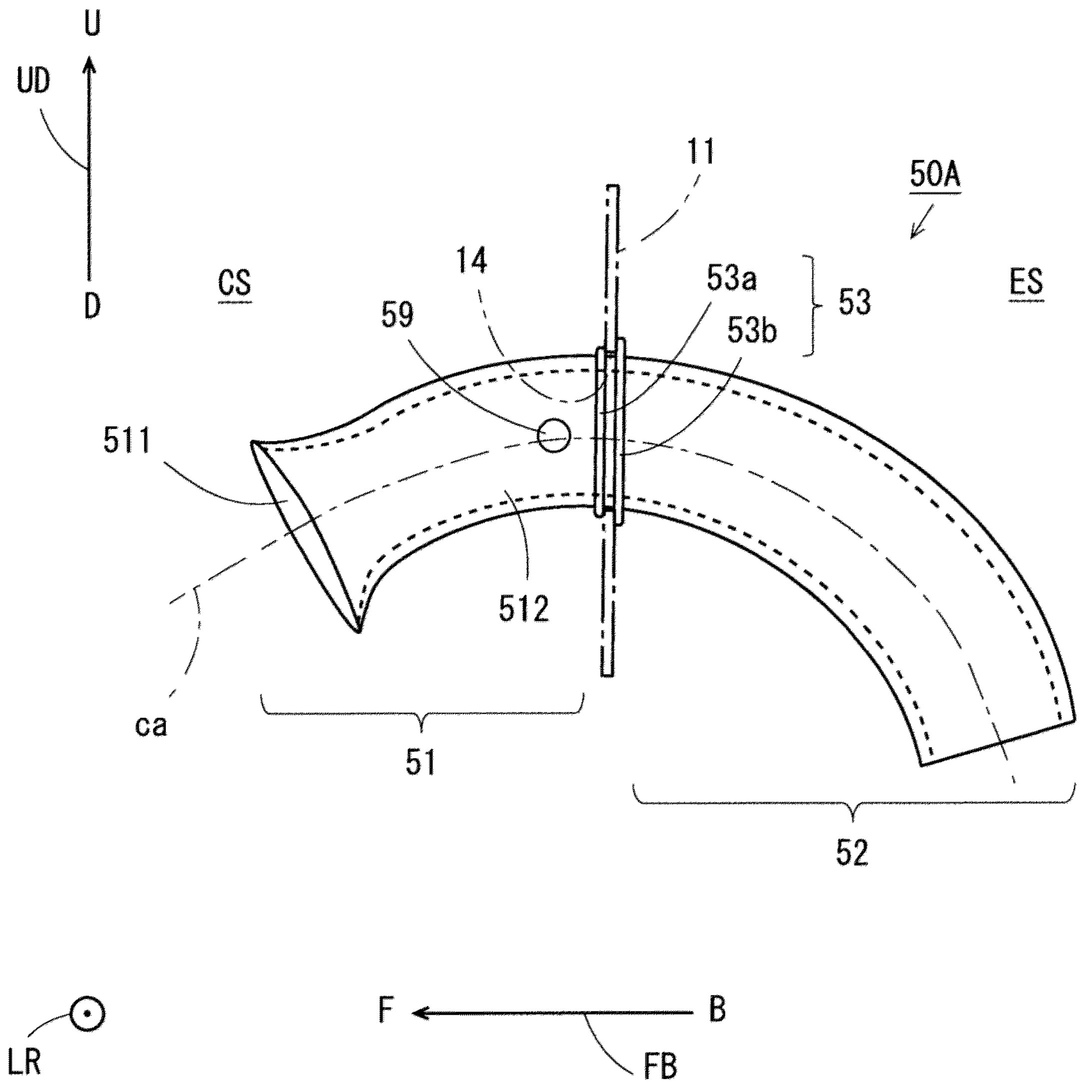


FIG.6

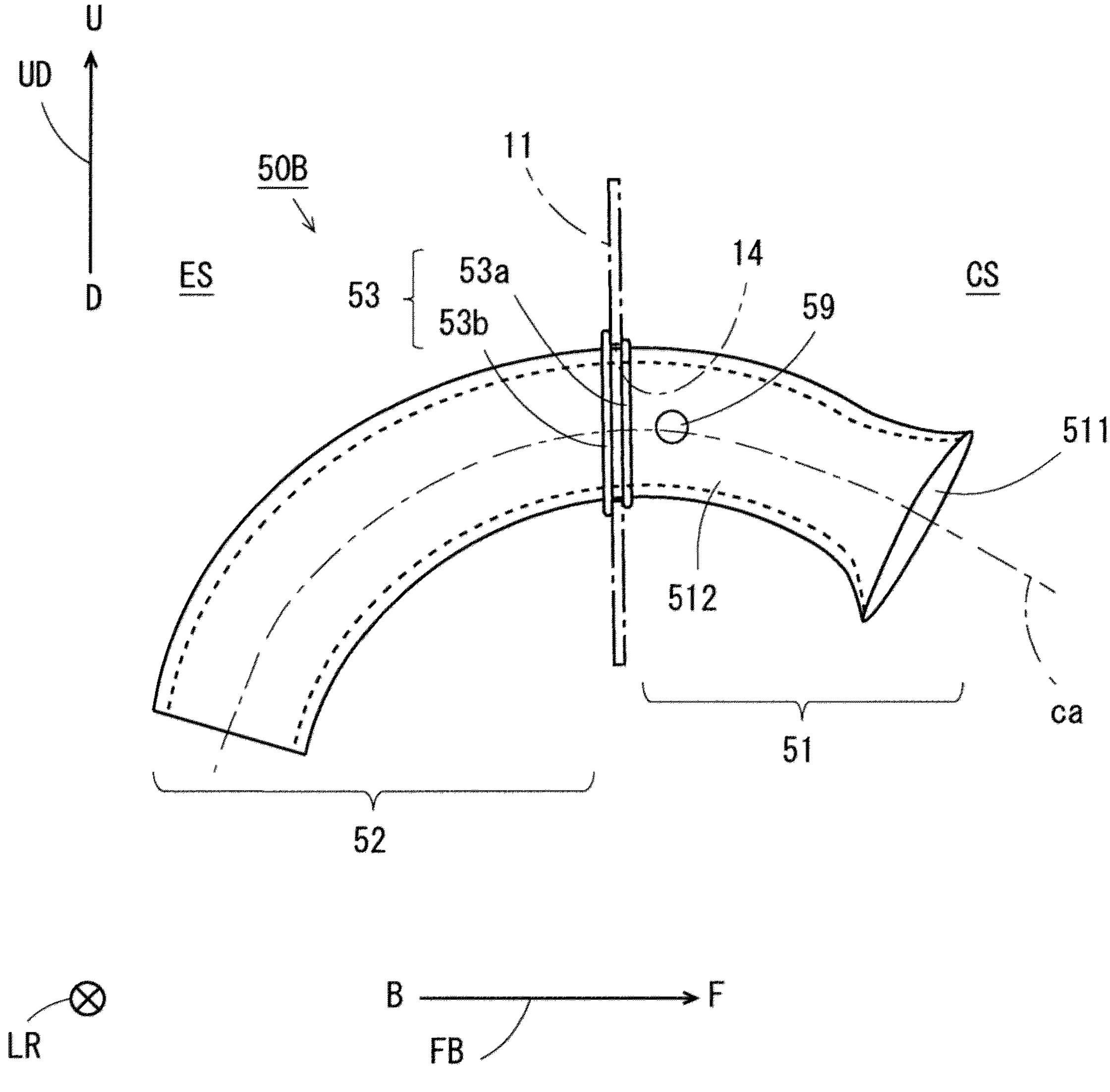


FIG.7

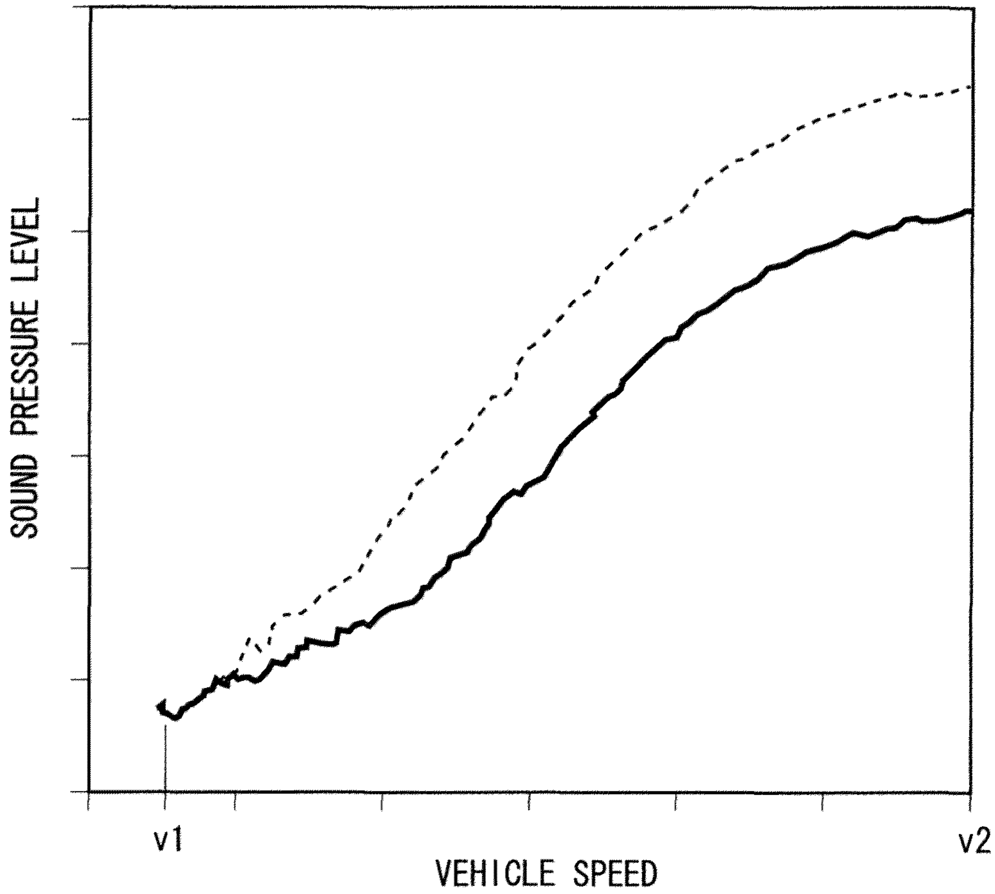


FIG.8

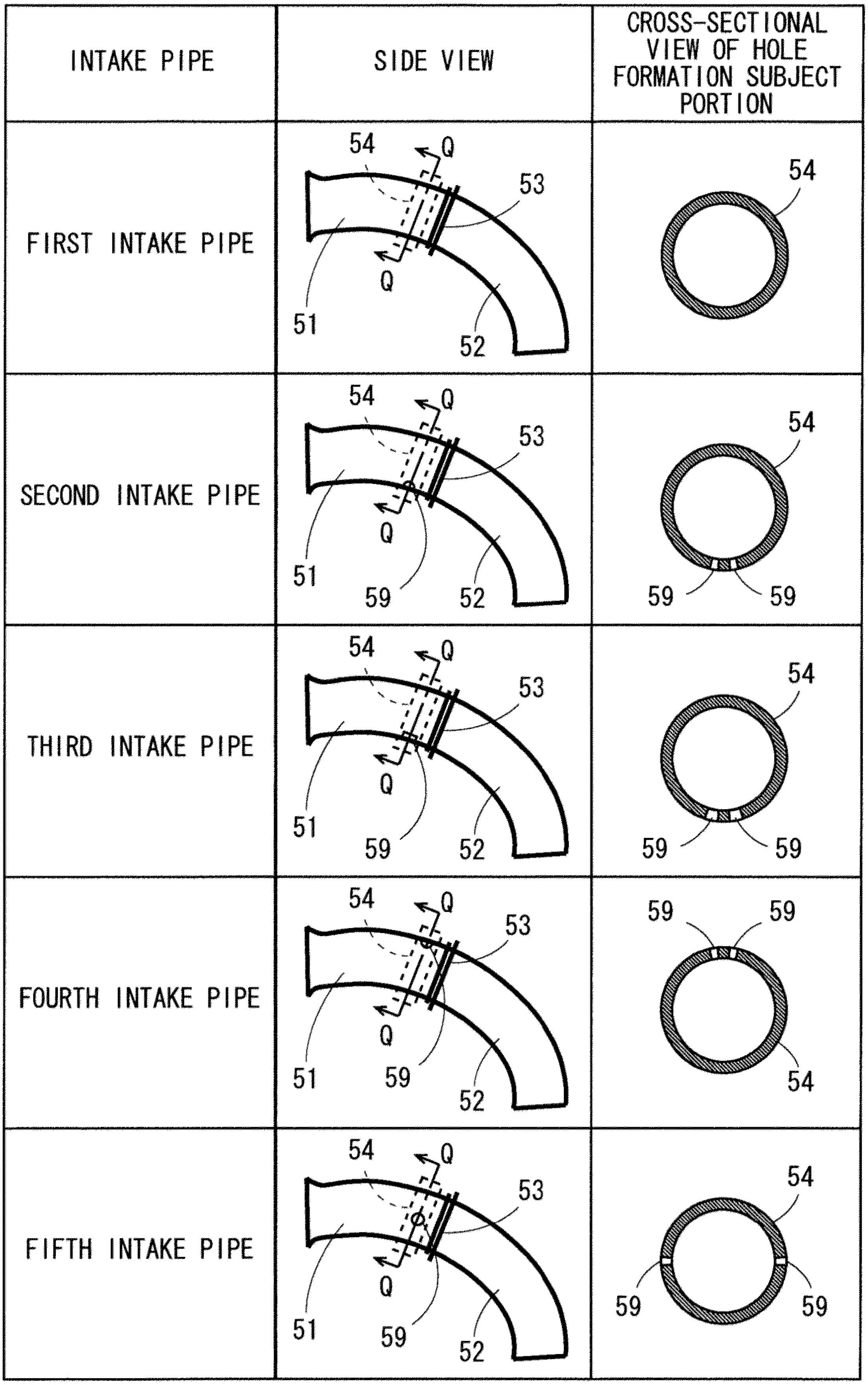

INTAKE PIPE
SIDE VIEW
CROSS-SECTIONAL VIEW OF HOLE FORMATION SUBJECT PORTION
FIRST INTAKE PIPE
54
Q
53
Q
51
52
54
SECOND INTAKE PIPE
54
Q
53
Q
51
59
52
54
59
59
THIRD INTAKE PIPE
54
Q
53
Q
51
59
52
54
59
59
FOURTH INTAKE PIPE
54
Q
53
Q
51
59
52
59
59
54
FIFTH INTAKE PIPE
54
Q
53
Q
51
59
52
54
59
59

FIG.9

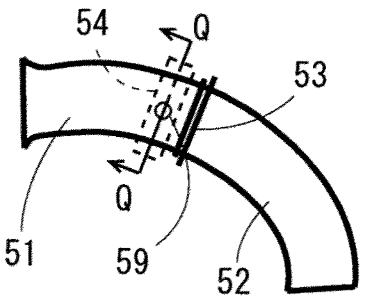
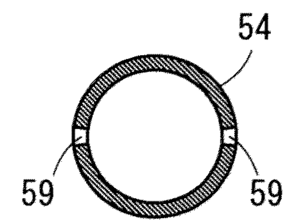
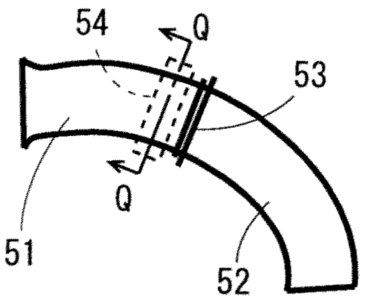
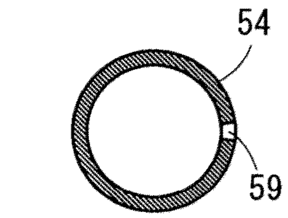
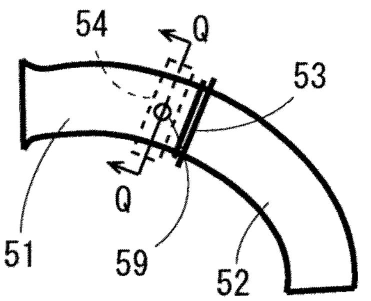
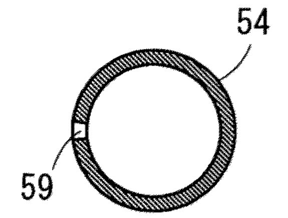
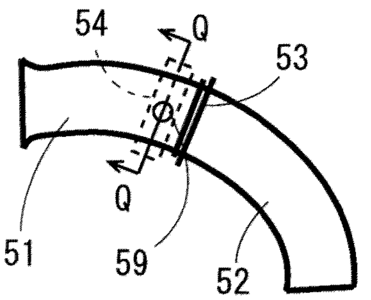
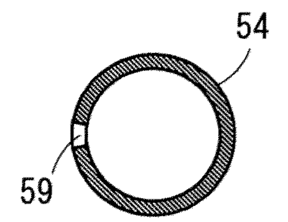
INTAKE PIPE	SIDE VIEW	CROSS-SECTIONAL VIEW OF HOLE FORMATION SUBJECT PORTION
SIXTH INTAKE PIPE		
SEVENTH INTAKE PIPE		
EIGHTH INTAKE PIPE		
NINTH INTAKE PIPE		

FIG.10

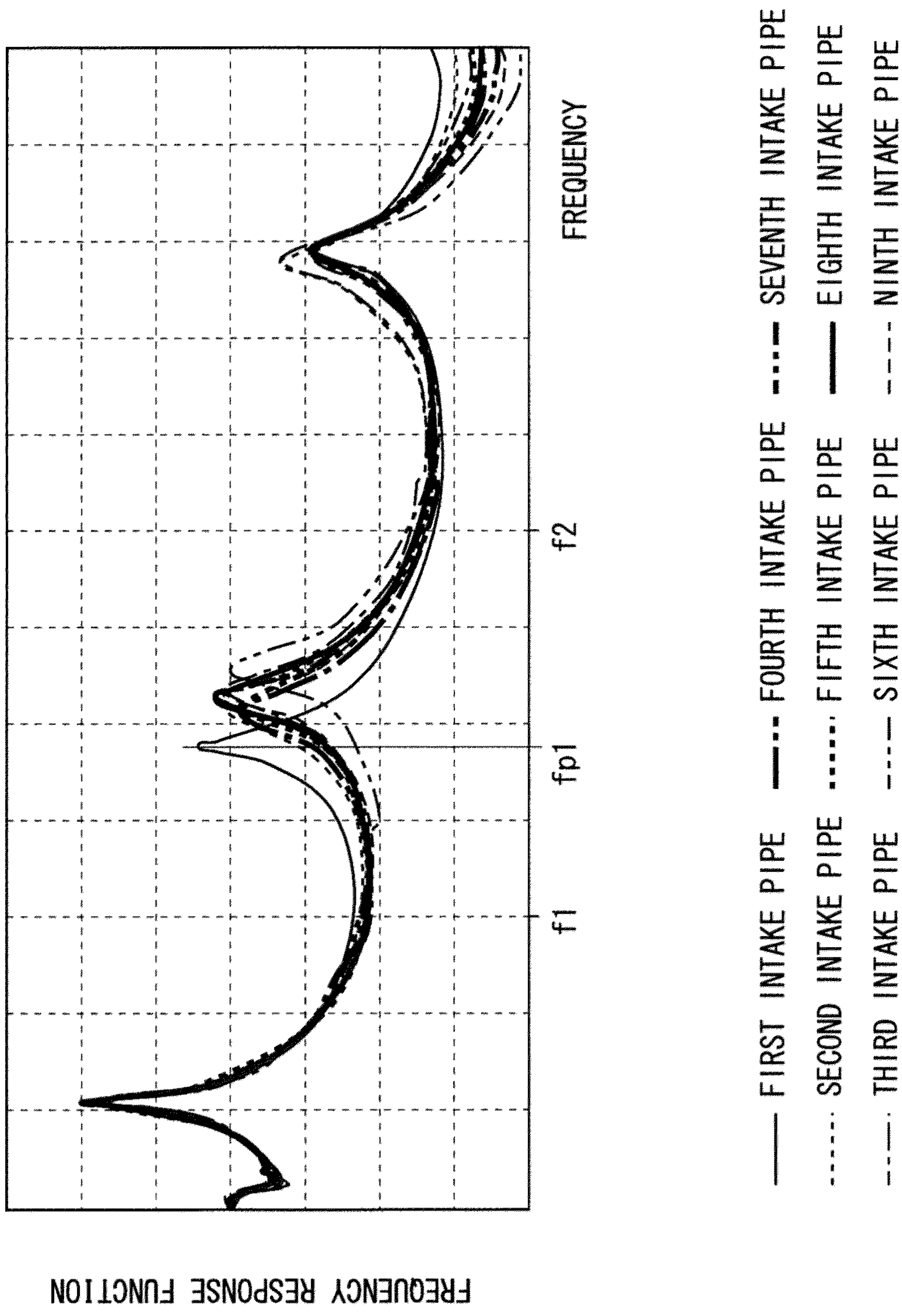

FREQUENCY RESPONSE FUNCTION
FREQUENCY
f1
fp1
f2
FIRST INTAKE PIPE
SECOND INTAKE PIPE
THIRD INTAKE PIPE
FOURTH INTAKE PIPE
FIFTH INTAKE PIPE
SIXTH INTAKE PIPE
SEVENTH INTAKE PIPE
EIGHTH INTAKE PIPE
NINTH INTAKE PIPE

FIG.11

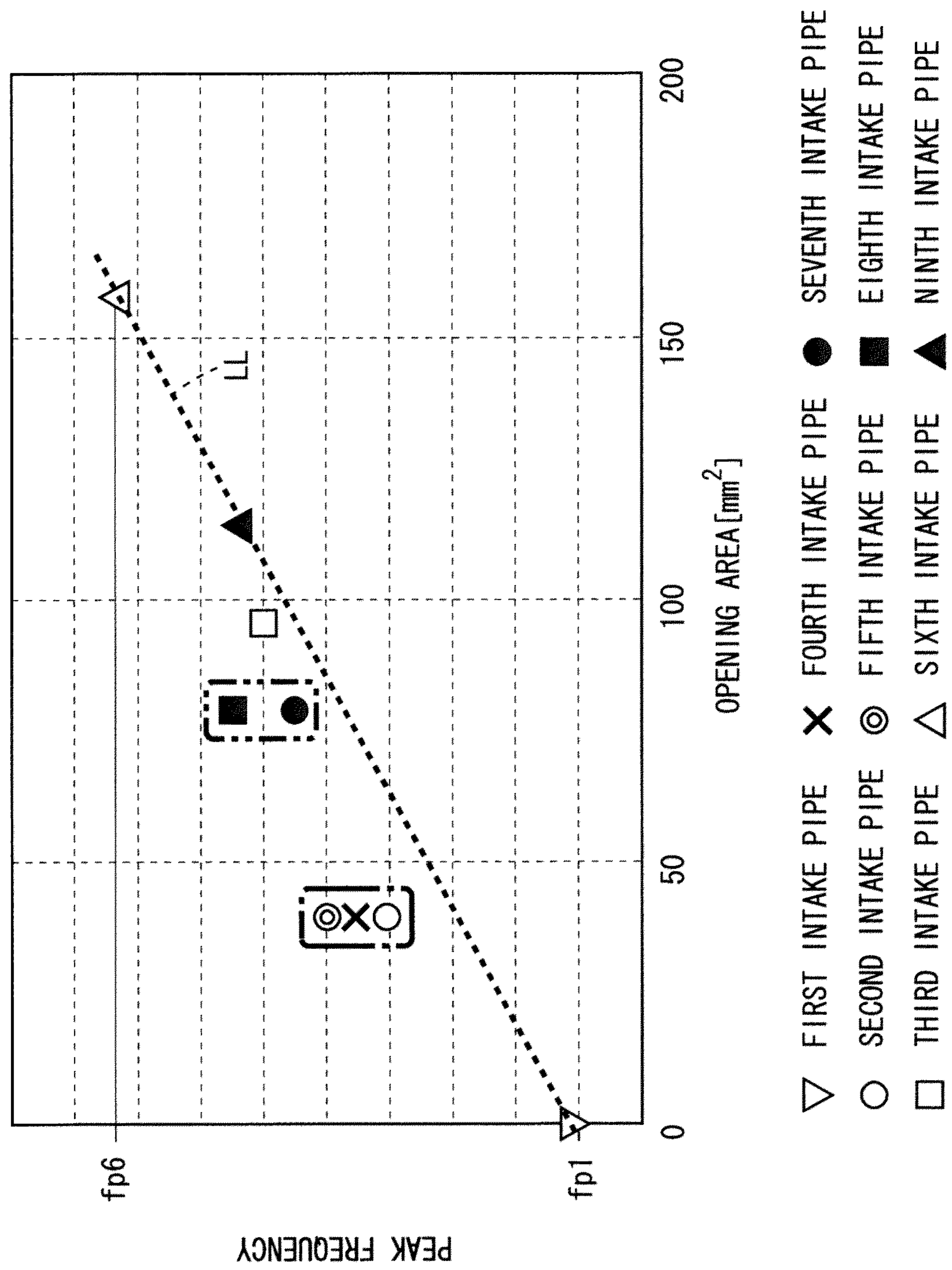

PEAK FREQUENCY
fp6
fp1
0
50
100
150
200
OPENING AREA [mm2]
LL
FIRST INTAKE PIPE
SECOND INTAKE PIPE
THIRD INTAKE PIPE
FOURTH INTAKE PIPE
FIFTH INTAKE PIPE
SIXTH INTAKE PIPE
SEVENTH INTAKE PIPE
EIGHTH INTAKE PIPE
NINTH INTAKE PIPE

FIG.12

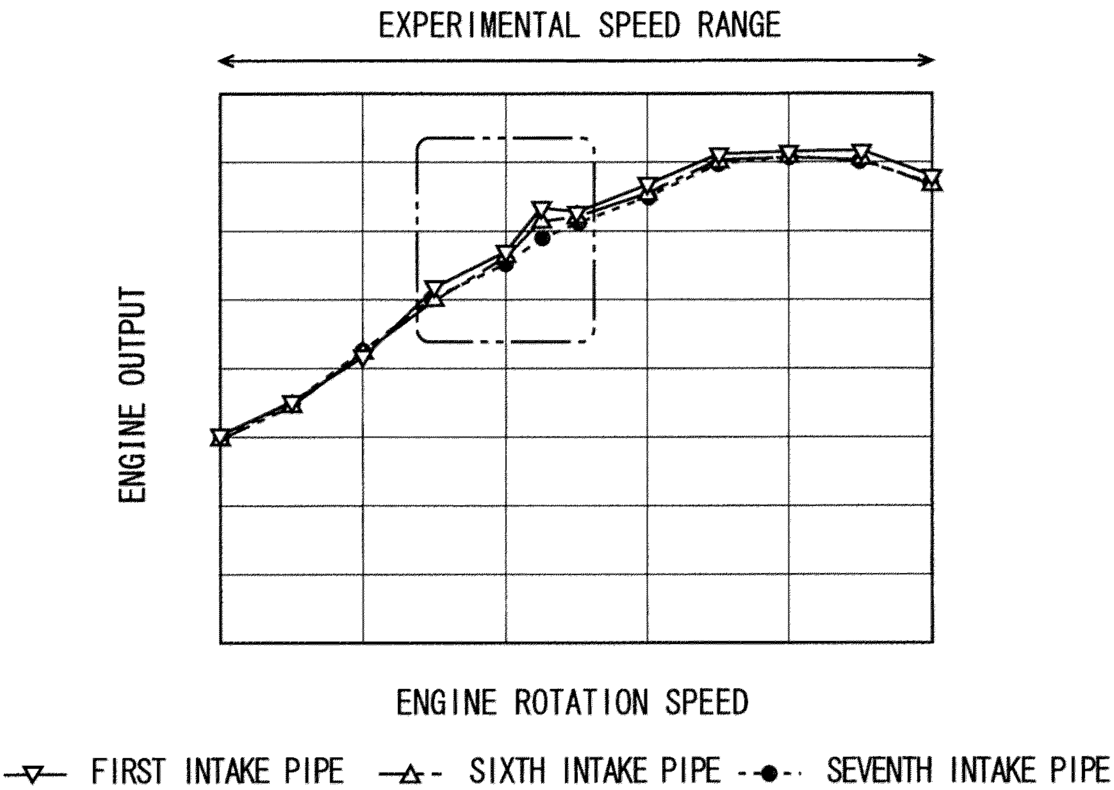
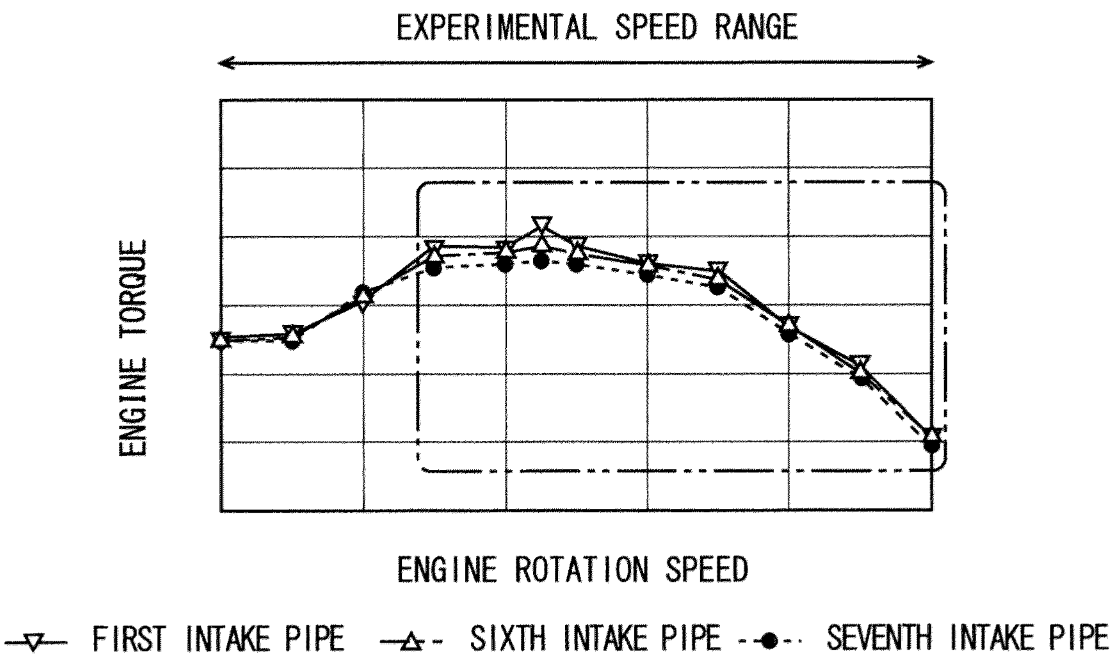

EXPERIMENTAL SPEED RANGE
ENGINE OUTPUT
ENGINE ROTATION SPEED
FIRST INTAKE PIPE
SIXTH INTAKE PIPE
SEVENTH INTAKE PIPE

FIG.13


EXPERIMENTAL SPEED RANGE
ENGINE TORQUE
ENGINE ROTATION SPEED
FIRST INTAKE PIPE
SIXTH INTAKE PIPE
SEVENTH INTAKE PIPE

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EUROPEAN SEARCH REPORT

Application Number
EP 24 19 6942

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2017/167453 A1 (KOYAMA SHINYA [JP] ET AL) 15 June 2017 (2017-06-15) * paragraph [0043] - paragraph [0053]; figures 1, 4-6 * -----	1-7	INV. F02M35/02 F02M35/10 F02M35/12 F02M35/16
X	CN 116 480 502 A (JIANGMEN DACHANGJIANG GROUP CO) 25 July 2023 (2023-07-25) * paragraph [0035] - paragraph [0045]; figures 1-5 * * paragraph [0002] * -----	1-7	
X	CN 116 480 499 A (JIANGMEN DACHANGJIANG GROUP CO) 25 July 2023 (2023-07-25) * paragraph [0034] - paragraph [0042]; figures 4-8 * * paragraph [0002] * -----	1-7	
			TECHNICAL FIELDS SEARCHED (IPC)
			F02M

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	6 December 2024	Rauch, Vincent

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 24 19 6942

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

06-12-2024

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2017167453 A1	15-06-2017	NONE	
CN 116480502 A	25-07-2023	NONE	
CN 116480499 A	25-07-2023	NONE	

EPO FORM P0459

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

REFERENCES CITED IN THE DESCRIPTION

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- JP 2010127076 A **[0003]**