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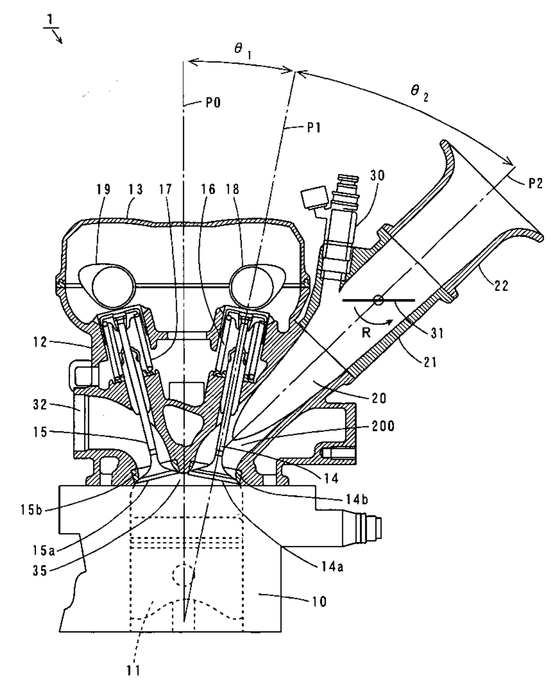
(54) ## HIGH-OUTPUT ENGINE AND VEHICLE

(57) A length of a partition of an intake port is set such that the ratio between the length of the partition and the distance between the centers of adjacent intake valves is not less than 0.45 nor more than 0.72. An injector is attached on the upper side of a throttle body. The angle Φ at which the injector is attached is set to be not less than 42 degrees nor more than 55 degrees. The injection starting timing of the injector is set within the periods in which the intake valves are closed.

FIG. 1



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Description

[Technical Field]

[0001] The present invention relates to a high-power engine having an intake port with a plurality of branch passages, and to a vehicle equipped with the same.

[Background Art]

[0002] In an engine having a plurality of intake valves, the intake port (intake hole) branches into a plurality of branch passages so as to smoothly guide air to the plurality of intake valves. The wall portion between a plurality of branch passages of the intake port is referred to as a partition. An intake port having such a partition is disclosed in Patent Document 1, for example.

[0003] In general, high-power engines have longer-sized partitions than low-power engines in order to reduce intake resistance.

[0004] High-power engines are engines which have a maximum revolution speed of 10000 rpm or more, or engines in which the center axis of the cylinder forms an angle of from 10 degrees to 20 degrees with the center axis of an intake valve, or engines in which the center axis of the intake port forms an angle of from 30 degrees to 45 degrees with the center axis of the intake valve.

[Patent Document 1] JP 6-272640 A

[Disclosure of the Invention]

[Problems to be Solved by the Invention]

[0005] Recently, there are demands for engines used in two-wheeled motorcycles with enhanced transient output response and enhanced exhaust gas characteristics, as well as for engines used in four-wheeled automobiles.

[0006] In a high-power engine, further enhancing the transient output response and exhaust gas characteristics, while maintaining high steady-state output, requires sufficient optimization of the structure of the intake port.

[Means for Solving the Problems]

[0007] An object of the present invention is to provide a high-power engine that offers an enhanced transient output response and enhanced exhaust gas characteristics while maintaining high steady-state output, and a vehicle equipped with the same.

[0008] The inventors of the present invention conducted experiments and examinations to find that a high-power engine having a longer-sized partition in the intake port suffers adhesion of fuel to the partition, and then the transient output response and exhaust gas characteristics are deteriorated, and the inventors devised the invention described below on the basis of the findings.

[0009] According to an aspect of the present invention, a high-power engine includes: a cylinder; a cylinder head provided to forma combustion chamber together with the cylinder, and having an intake port that guides air into the combustion chamber; a plurality of intake valves disposed to open and close at downstream opening ends of the intake port; and a fuel injection device disposed to inject fuel toward an inner wall of the intake port in a position that is further upstream than the intake valves, wherein the intake port has a plurality of branch passages separated by a partition to guide air respectively to the plurality of intake valves, and a ratio of a length of the partition with respect to a distance between the centers of adjacent ones of the intake valves is set to be not less than 0.45 nor more than 0.72.

[0010] In the high-power engine, the intake port has a plurality of branch passages separated by a partition, so as to guide air respectively to the plurality of intake valves. The ratio of a length of the partition with respect to the distance between the centers of adjacent intake valves is set to be not less than 0.45 nor more than 0.72, and the fuel injection device is disposed to inject the fuel toward the inner wall of the intake port in a position further upstream than the intake valves. In this case, the partition has a shorter length, and the fuel injection device injects fuel toward a position further upstream than the partition.

[0011] This prevents the adhesion of fuel to the partition and allows the fuel to be more efficiently guided into the combustion chamber. As a result, it is possible to enhance the transient output response and exhaust gas characteristics while maintaining high steady-state output.

[0012] The high-power engine may further include a throttle valve that opens and closes in a position further upstream than the intake port, and the fuel injection device may be disposed on a side where a stronger flow of air is produced than on another side when the throttle valve opens.

[0013] In this case, the fuel injection device is disposed on the side where a stronger flow of incoming air is produced when the throttle valve is opened, which promotes aerification of the fuel injected from the fuel injection device. This enhances combustion efficiency and further improves exhaust gas characteristics.

[0014] The high-power engine may further include an intake pipe having an inner space that communicates with the intake port, wherein the intake port and the inner space of the intake pipe may form an approximately linear-shaped air intake passage, the throttle valve may be provided such that its upper end opens to a downstream side and its lower end opens to an upstream side in the intake pipe, and the fuel injection device may be provided on an upper side of the intake pipe such that the fuel injection device injects the fuel toward a lower side of the inner wall of the intake port.

[0015] In the intake pipe, the upper end of the throttle valve opens to the downstream side and the lower end of the throttle valve opens to the upstream side. This produces a stronger flow of incoming air in the upper part, than in the lower part, in the linear-shaped air intake passage. In this case, the fuel injection device is provided on the upper side of the intake pipe such that the fuel injection device injects fuel toward the lower side of the inner wall of the intake port, and therefore the aerification of the fuel injected from the fuel injection device is promoted. This enhances combustion efficiency and further improves exhaust gas characteristics.

[0016] The angle between a direction in which the fuel injection device injects the fuel and a center axis of the intake port may be set to be not less than 42 degrees nor more than 55 degrees.

[0017] In this case, suitable mixed gas is formed in the cylinder. This further enhances the transient output response and exhaust gas characteristics.

[0018] The fuel injection by the fuel injection device may be started in a period in which the plurality of intake valves are closed.

[0019] When the fuel is injected in a period when the intake valves are closed, the amount of uncombusted fuel in the exhaust gas is reduced. Thus, the exhaust gas characteristics are further enhanced by starting the fuel injection while the plurality of intake valves are closed.

[0020] In this case, the fuel injected from the fuel injection device is more likely to adhere to the partition when the plurality of intake valves are closed, but the adhesion of fuel to the partition can be prevented by setting the partition shorter and disposing the fuel injection device such that the fuel is injected to a position further upstream than the partition. Accordingly, the improvements of the transient output response and exhaust gas characteristics are achieved remarkably.

[0021] According to another aspect of the present invention, a vehicle includes: a high-power engine; a wheel; and a transmission mechanism that transmits power generated by the high-power engine to the wheel, and the high-power engine includes: a cylinder; a cylinder head provided to form a combustion chamber together with the cylinder, and having an intake port that guides air into the combustion chamber; a plurality of intake valves disposed to open and close at downstream opening ends of the intake port; and a fuel injection device disposed to inject fuel toward an inner wall of the intake port in a position that is further upstream than the intake valves, wherein the intake port has a plurality of branch passages separated by a partition to guide air respectively to the plurality of intake valves, and a ratio of a length of the partition with respect to a distance between the centers of adjacent ones of the intake valves is set to be not less than 0.45 nor more than 0.72.

[0022] In the vehicle, the power generated by the high-power engine is transmitted to the wheel by the transmission mechanism. In the high-power engine, the intake port has a plurality of branch passages separated by a partition, so as to guide air respectively to the plurality of intake valves. The ratio of a length of the partition with respect to the distance between the centers of adjacent intake valves is set to be not less than 0.45 nor more than 0.72, and the fuel injection device is disposed to inject the fuel toward the inner wall of the intake port in a position further upstream than the intake valves. In this case, the partition has a shorter length, and the fuel injection device injects fuel toward a position further upstream than the partition.

[0023] This prevents the adhesion of fuel to the partition and allows the fuel to be more efficiently guided into the combustion chamber. As a result, it is possible to enhance the transient output response and exhaust gas characteristics while maintaining high steady-state output.

[0024] The high-power engine may further include a throttle valve that opens and closes in a position further upstream than the intake port, and the fuel injection device may be disposed on a side where a stronger flow of air is produced than on another side when the throttle valve opens.

[0025] In this case, the fuel injection device is disposed on the side where a stronger flow of incoming air is produced when the throttle valve is opened, which promotes aerification of the fuel injected from the fuel injection device. This enhances combustion efficiency and further improves exhaust gas characteristics.

[0026] The high-power engine may further include an intake pipe having an inner space that communicates with the intake port, wherein the intake port and the inner space of the intake pipe may form an approximately linear-shaped air intake passage, the throttle valve may be provided such that its upper end opens to a downstream side and its lower end opens to an upstream side in the intake pipe, and the fuel injection device may be provided on an upper side of the intake pipe such that the fuel injection device injects the fuel toward a lower side of the inner wall of the intake port.

[0027] In the intake pipe, the upper end of the throttle valve opens to the downstream side and the lower end of the throttle valve opens to the upstream side. This produces a stronger flow of air in the upper part, than in the lower part, in the linear-shaped air intake passage. In this case, the fuel injection device is provided on the upper side of the intake pipe such that the fuel injection device injects fuel toward the lower side of the inner wall of the intake port, and therefore the aerification of the fuel injected from the fuel injection device is promoted. This enhances combustion efficiency and further improves exhaust gas characteristics.
[0028] The angle between a direction in which the fuel injection device injects the fuel and a center axis of the intake port may be set to be not less than 42 degrees nor more than 55 degrees.
[0029] In this case, suitable mixed gas is formed in the cylinder. This further enhances the transient output response and exhaust gas characteristics.
[0030] The fuel injection by the fuel injection device may be started in a period in which the plurality of intake valves are closed.
[0031] When the fuel is injected in a period when the intake valves are closed, the amount of uncombusted fuel in the exhaust gas is reduced. Thus, the exhaust gas characteristics are further enhanced by starting the fuel injection while the plurality of intake valves are closed.
[0032] In this case, the fuel injected from the fuel injection device is more likely to adhere to the partition when the plurality of intake valves are closed, but the adhesion of fuel to the partition can be prevented by setting the partition shorter and disposing the fuel injection device such that the fuel is injected to a position further upstream than the partition. Accordingly, the improvements of the transient output response and exhaust gas characteristics are achieved remarkably.

[Effects of the Invention]

[0033] According to the present invention, it is possible to prevent the adhesion of fuel to the partition and hence to more efficiently guide the fuel into the combustion chamber. As a result, it is possible to enhance the transient output response and exhaust gas characteristics while maintaining high steady-state output.

[Brief Description of the Drawings]

[0034]

[FIG. 1] FIG. 1 is a diagram showing the cylinder head, seen from below, of a high-power engine according to an embodiment of the present invention.
[FIG. 2] FIG. 2 is a transverse sectional view of the high-power engine of FIG. 1.
[FIG. 3] FIG. 3(a), (b), (c) shows perspective views illustrating the inverted shapes of three kinds of intake ports, and FIG. 3(d), (e), (f) shows longitudinal sectional views respectively of the intake ports of FIG. 3(a), (b), (c) taken along the axial direction.
[FIG. 4] FIG. 4 is a diagram showing a torque characteristic of engines exhibited when the throttle valve is rapidly opened.
[FIG. 5] FIG. 5 is a graph showing the measurements of steady output value and output reduction in a transient state of high-power engines.
[FIG. 6] FIG. 6 is a diagram used to describe the position in which, and the angle at which, the injector is attached.
[FIG. 7] FIG. 7 is a diagram used to describe the position in which, and the angle at which, the injector is attached.
[FIG. 8] FIG. 8 is a diagram used to describe the position in which, and the angle at which, the injector is attached.
[FIG. 9] FIG. 9 is a diagram used to describe the position in which, and the angle at which, the injector is attached.
[FIG. 10] FIG. 10 is a diagram showing the measurements of differential area between transient IMEP and steady IMEP of high-power engines in which the injectors are attached in different positions and at different angles and the intake ports have different partition lengths.
[FIG. 11] FIG. 11 is a diagram showing measurements illustrating a relation between injection starting timing of the injector and discharge from fuel.
[FIG. 12] FIG. 12 is a schematic diagram of a two-wheeled motorcycle equipped with the high-power engine of FIG. 1.

[Best Mode for Carrying out the Invention]

[0035] FIG. 1 is a longitudinal sectional view of a high-power engine according to an embodiment of the present invention. FIG. 2 is a diagram showing the cylinder head, seen from below, of the high-power engine of FIG. 1.
[0036] The high-power engine 1 of FIG. 1 has a cylinder 10. A piston 11 is provided in the cylinder 10 and forced to reciprocate up and down. A cylinder head 12 is provided on top of the cylinder 10. The cylinder 10 and the cylinder head

12 form a combustion chamber 35. The top of the cylinder head 12 is covered by a cylinder head cover 13.

[0037] An intake port 20 extends obliquely downward from one side of the cylinder head 12 toward its center. A throttle body 21 and a funnel 22 are connected to the intake port 20 of the cylinder head 12. The throttle body 21 and the funnel 22 form an intake pipe. The intake port 20, the inner space in the throttle body 21, and the inner space in the funnel 22 form an approximately linear-shaped air intake passage.

[0038] A fuel injection device (hereinafter referred to as an injector) 30 for injecting fuel is provided on the upper side of the throttle body 21. Also, a throttle valve 31 is provided in the throttle body 21 and turned around a horizontal axis that crosses the center axis P2 of the intake port 20.

[0039] The axial center of the injector 30 (the direction in which fuel is injected) is set toward the lower side of the inner wall of the intake port 20 on the downstream side of the throttle valve 31. The throttle valve 31 turns in the direction shown by the arrow R such that its upper end opens to the downstream side and its lower end opens to the upstream side. The intake of air that flows in through the funnel 22 increases as the throttle valve 31 is opened. In this case, the throttle valve 31 guides the incoming air such that a strong flow of air is produced in the vicinity of the end of the injector 30, which promotes aerification of the fuel injected from the injector 30.

[0040] As will be described later, the intake port 20 has two branch passages. An intake valve 14 is positioned in the opening at the lower end of one branch passage of the intake port 20. Also, as shown in FIG. 2, an intake valve 24 is positioned in the opening at the lower end of the other branch passage of the intake port 20.

[0041] As shown in FIG. 1, the intake valve 14 has a valve head 14a. The intake valve 14 is energized by a spring 16 in such a direction that the valve head 14a closes the opening of the valve seat 14b at the lower end of the intake port 20 (in an obliquely upward direction). An intake cam 18 is rotatably provided at the upper end of the intake valve 14. The intake cam 18 rotates to open/close the intake valve 14.

[0042] As shown in FIG. 2, the intake valve 14 and the intake valve 24 are located adj acent to each other. The distance between the centers of the adjacent intake valves 14 is expressed as "D". The intake valve 24 is structured in the same way as the intake valve 14 shown in FIG. 1.

[0043] As shown in FIG. 1, an exhaust port 32 extends downward from the other side of the cylinder head 12 toward its center. An exhaust valve 15 is positioned in the opening at the lower end of the exhaust port 32. The exhaust valve 15 has a valve head 15a. The exhaust valve 15 is energized by a spring 17 in such a direction that the valve head 15a closes the opening of the valve seat 15b at the lower end of the exhaust port 32 (in an obliquely upward direction). An exhaust cam 19 is rotatably provided at the upper end of the exhaust valve 15. The exhaust cam 19 rotates to open/close the exhaust valve 15.

[0044] As shown in FIG. 2, another exhaust valve 25 is provided adjacent to the exhaust valve 15. The exhaust valve 25 is structured in the same way as the exhaust valve 15 shown in FIG. 1.

[0045] In the high-power engine 1 of this embodiment, the angle θ_1 between the center axis P0 of the cylinder 10 and the center axis P1 of the intake valve 14 is from 10 degrees to 20 degrees, and the angle θ_2 between the center axis P1 of the intake valve 14 and the center axis P2 of the intake port 20 is from 30 degrees to 45 degrees.

[0046] Generally, the axial center of injecting direction of an injector is set toward the back of the valve head of the intake valve. This is for the purpose of reducing the adhesion of fuel to the inner wall of the intake port, so as to obtain an improved transient output response and improved exhaust gas characteristics of the engine.

[0047] However, as mentioned above, the axial center of the injector 30 of this embodiment is set toward the lower side of the inner wall surface of the intake port 20 in a position further upstream than the valve head 15a of the intake valve 15. As will be described later, this further improves the transient output response and exhaust gas characteristics.

[0048] FIG. 3(a), (b), (c) shows perspective views illustrating the inverted shapes of three kinds of intake ports. That is, FIG. 3 (a), (b), (c) shows the shapes of the inner wall surfaces of three kinds of intake ports. FIG. 3(d), (e), (f) shows longitudinal sectional views of the intake ports of FIG. 3(a), (b), (c) that are taken along the axial direction.

[0049] As shown in FIG. 3, each intake port 20 is formed of an approximately cylindrical common passage 201 and two approximately cylindrical branch passages 202 and 203 that branch out from the common passage 201.

[0050] The wall portion between the branch passages 202 and 203 is herein referred to as a partition 200. The upstream part of the partition 200 is formed in the shape of "V". The partition 200 separates the branch passages 202 and 203. A length L of the partition 200 along the axial direction is hereinafter referred to as a partition length. The partition length L is defined as a distance on the center line of the intake port 20 from the top surface of the valve seat 14b to the most downstream position of the V-shape of the partition 200 in the intake passage.

[0051] The intake port 20 of FIG. 3(b) has a standard partition length L (e.g., 30 mm). The intake port 20 of FIG. 3(a) has a shorter partition length L (e.g., 15 mm) than the intake port 20 of FIG. 3(b). The intake port 20 of FIG. 3(c) has a longer partition length L (e.g., 50 mm) than the intake port 20 of FIG. 3(b).

[0052] As will be described later, this embodiment enhances the transient output response and exhaust gas characteristics of the engine 1 by using an intake port 20 having a partition length L that is shorter than the standard length.

[0053] Now, in order to optimize the partition length L of the intake port 20, the steady output value and output reduction in the transient state were measured with high-power engines 1 having intake ports 20 with different partition lengths L.

[0054] The steady output value is a maximum output that the high-power engine 1 provides in the steady state (the output provided when the throttle valve 31 is full opened). The output reduction in the transient state is the amount by which the steady output value falls when the throttle valve 31 is rapidly opened, and it corresponds to the required amount of fuel correction described below.

[0055] First, the method of measuring the output reduction in the transient state will be described. FIG. 4 is a diagram showing a torque characteristic of engines exhibited when the throttle valve is rapidly opened. The vertical axis of FIG. 4 shows the torque, and the horizontal axis shows time, which corresponds to the opening ratio of the throttle valve 31.

[0056] In FIG. 4, the straight line "a" indicates a steady-state torque characteristic (an ideal torque characteristic) that is to be originally obtained, the curve "b" indicates an example of the transient torque characteristic, and the curve "c" indicates another example of the transient torque characteristic. The example of the curve "b" has a relatively good transient output response and the example of the curve "c" has a poor transient output response.

[0057] As shown by the straight line "a", the steady-state torque to be originally obtained increases in proportion to the opening ratio of the throttle valve, and remains constant after the throttle valve is full opened.

[0058] In general, as shown by the curve "b" and curve "c", the transient torque exhibits smaller values, due to a delay of fuel delivery, than the steady-state torque that is proportional to the opening ratio of the throttle valve. Accordingly, corrections are usually made to increase the amount of fuel in the transient state, so as to obtain torque values that correspond to the steady-state torque values. The value of time integration of the difference between the straight line "a" and the curve "b", or the difference between the straight line "a" and the curve "c", corresponds to the amount of fuel correction that is required (hereinafter referred to as a required amount of fuel correction) .

[0059] In the high-power engine having the transient output response of the curve "b", the area between the straight line "a" and the curve "b" is smaller and the required amount of fuel correction is smaller. As a result, the consumption of fuel is reduced and so the amount of exhaust gas is also reduced.

[0060] On the other hand, in the high-power engine having the transient output response of the curve "c", the area between the straight line "a" and the curve "c" is larger and the required amount of fuel correction is larger. As a result, the consumption of fuel is larger and the amount of hydrocarbons in the exhaust gas is larger.

[0061] FIG. 5 and Table 1 show the measurements of the steady output value and output reduction in the transient state of high-power engines 1.

[Table 1]

INTAKE-VALVE CENTER DISTANCE D	INTAKE-PORT PARTITION LENGTH L	X:L/D	OUTPUT REDUCTION IN TRANSIENT STATE	SUPERIOR ITY	STEADY OUTPUT VALVE
32	10	0.31	70	30	78
32	15	0.47	68	32	95
32	23	0.72	70	30	98
32	35	1.09	86	14	98
32	45	1.41	98	2	102
32	55	1.72	100	0	100
32	65	2.03	98	2	98

[0062] In Fig. 5, the horizontal axis shows a ratio X between the partition length L of the intake port 20 and the distance D between the centers of the intake valves 14 and 24, and the vertical axis shows the steady output value and output reduction in the transient state. The square marks indicate the measurements of steady output value and the circular marks indicate the measurements of output reduction in the transient state. The output reduction in the transient state corresponds to the required amount of fuel correction described with FIG. 4.

[0063] The ratio X is used for the optimization of the partition length L because the optimum partition length L differs depending on the size of the high-power engine 1. Herein, the distance D between the centers of the intake valves 14 and 24 is used as an index (representative dimension) that expresses the size of the high-power engine 1.

[0064] FIG. 5 and Table 1 show the steady output value and output reduction in the transient state at different ratios X, assuming the steady output value and output reduction in the transient state at a ratio X of 1.72 to be 100.

[0065] "SUPERIORITY" in Table 1 shows the differences between the output reduction value of 100 at the ratio X of 1.72 and the output reduction values at the different ratios X, where a larger value of SUPERIORITY indicates a superior transient output response.

[0066] Higher steady output values are preferred. According to the results shown in FIG. 5 and Table 1, the steady output value rapidly decreases as the ratio X becomes smaller than about 0.45. Therefore, the range of the ratio X of about 0.45 or more is a stable steady output region.

[0067] On the other hand, a smaller output reduction in the transient state indicates a superior transient output response. Also, a smaller output reduction in the transient state indicates a smaller amount of exhaust gas and superior exhaust gas characteristics. Accordingly, a smaller output reduction in the transient state is preferred. According to the results shown in FIG. 5 and Table 1, the output reduction in the transient state rapidly increases as the ratio X becomes larger than 0.72. This means that increasing the partition length L of the intake port 20 deteriorates the transient output response. Accordingly, the range of the ratio X of 0.72 or less is a permissible region of the output reduction in the transient state.

[0068] The results of FIG. 5 and Table 1 show that ratios X of 0.45 or more are preferred in view of the steady output value, and ratios X of 0.72 or less are preferred in view of the output reduction in the transient state. Accordingly, it is preferable to set the partition length L such that the ratio X is not less than 0.45 nor more than 0.72.

[0069] From these results, this embodiment sets the partition length L such that the ratio X is not less than 0.45 nor more than 0.72. In this case, the partition length L is short and the fuel is injected by the injector 30 to a position further upstream than the partition 200. This prevents the adhesion of fuel to the partition 200, and allows the fuel to be more efficiently guided into the combustion chamber 35. This enhances the transient output response and exhaust gas characteristics, while maintaining high steady output value.

[0070] Next, in order to optimize the position in which, and the angle at which, the injector 30 is attached to the throttle body 21, the transient output response was measured with high-power engines 1 having injectors 30 attached in different positions and at different angles and intake ports 20 with different partition lengths L.

[0071] FIGS. 6 to 9 are diagrams illustrating positions and angles of the injectors 30.

[0072] The angle at which the injector 30 is attached is defined as an angle Φ between the axial center P3 of the injector 30 and the center axis P2 of the intake port 20.

[0073] In the example of FIG. 6, the injector 30 is positioned on the upper side of the throttle body 21 at a smaller angle Φ. In the example of FIG. 7, the injector 30 is positioned on the upper side of the throttle body 21 at a larger angle Φ than in the example of FIG. 6. Accordingly, in the example of FIG. 7, the fuel is injected to a further upstream position on the lower side of the inner wall of the intake port 20.

[0074] In the example of FIG. 8, the injector 30 is positioned on the lower side of the throttle body 21 at a smaller angle Φ. In the example of FIG. 9, the injector 30 is positioned on the lower side of the throttle body 21 at a larger angle Φ than in the example of FIG. 8. Accordingly, in the example of FIG. 9, the fuel is injected to a further upstream position on the upper side of the inner wall of the intake port 20.

[0075] Table 2 and FIG. 10 show the measurements of differential area between transient IMEP (Indicated Mean Effective Pressure) and steady IMEP of high-power engines 1 having injectors 30 attached in different positions and at different angles and having intake ports 20 with different partition lengths L. The differential area between transient IMEP and steady IMEP corresponds to the output reduction in the transient state.

[Table 2]

TYPE	POSITION	ANGLE Φ [deg]	PARTITION LENGTH [mm]	X:L/D	DIFFERENTIAL AREA BETWEEN TRANSIENT IMEP TRANSIENT IMEP AND STEADY IMEP [kPa·sec]
A	UPPER SIDE	21	15	0.47	147
		31	15	0.47	147
		38	15	0.47	118
		42	15	0.47	82
		51	15	0.47	62
		55	15	0.47	70
B	UPPER SIDE	21	55	1.72	130
		31	55	1.72	111
		38	55	1.72	130
		42	55	1.72	165
		51	55	1.72	198
		55	55	1.72	193
C	LOWER SIDE	21	15	0.47	154
		31	15	0.47	140
		38	15	0.47	118
		42	15	0.47	105
		51	15	0.47	96
		55	15	0.47	103
D	LOWER SIDE	21	55	1.72	120
		31	55	1.72	161
		38	55	1.72	158
		42	55	1.72	180
		51	55	1.72	192
		55	55	1.72	195

[0076] As shown in Table 2, four types, A to D, were used as combinations of the position of the injector 30 and the partition length L of the intake port 20, and the angle Φ of the injector 30 was set at 21 degrees, 31 degrees, 38 degrees, 42 degrees, 51 degrees, and 55 degrees in each of the four types A to D.

[0077] In the type A, the injector 30 was attached to the upper side of the throttle body 21, with a partition length L of 15 mm. In the type B, the injector 30 was attached to the upper side of the throttle body 21, with a partition length L of 55 mm. In the type C, the injector 30 was attached to the lower side of the throttle body 21, with a partition length L of 15 mm. In the type D, the injector 30 was attached to the lower side of the throttle body 21, with a partition length L of 55 mm.

[0078] In FIG. 10, the horizontal axis shows the angle Φ at which the injector 30 was attached, and the vertical axis shows the differential area between transient IMEP and steady IMEP. Triangle marks show the measurements of the type A, square marks show the measurements of the type B, diamond marks show the measurements of the type C, and circular marks show the measurements of the type D.

[0079] A smaller differential area between transient IMEP and steady IMEP indicates a superior transient output response and enhanced exhaust gas characteristics.

[0080] In the types A and C with the shorter partition length L, the differential area between transient IMEP and steady IMEP decreases as the angle Φ of the injector 30 is made larger from 21 degrees, and becomes minimum in the range of angle Φ from 42 degrees to 55 degrees. Comparing the type A and the type C shows that the differential area between transient IMEP and steady IMEP decreases more markedly in the type A in which the injector 30 was attached to the upper side, than in the type C in which the injector 30 was attached to the lower side.

[0081] In contrast, in the type B in which the injector 30 was attached to the upper side and the partition length L was set longer, the differential area between transient IMEP and steady IMEP slightly decreases as the angle Φ of the injector 30 is increased from 21 degrees to 31 degrees, but the differential area between transient IMEP and steady IMEP increases as the angle Φ is increased from 31 degrees to 51 degrees.

[0082] In the type D in which the injector 30 was attached to the lower side and the partition length L was set longer, the differential area between transient IMEP and steady IMEP increases as the angle Φ of the injector 30 is increased from 21 degrees to 55 degrees.

[0083] It is thus seen that the transient output response and exhaust gas characteristics are enhanced in the type A and the type C in which the partition length L of the intake port 20 was as short as 15 mm, and the transient output response and exhaust gas characteristics are further enhanced in the type A in which the injector 30 was attached to the upper side.

[0084] These results show that a shorter partition length L is preferred, that attaching the injector 30 on the upper side of the throttle body 21 is preferred, and that positioning the injector 30 at an angle Φ of not less than 42 degrees nor more than 55 degrees is preferred.

[0085] It is thought that attaching the injector 30 to the upper side of the throttle body 21 is preferred because of the following reason. When the throttle valve 31 opens in the direction shown by the arrow R of FIG. 1, a strong flow of air taken in is produced in the upper part in the throttle body 21. Disposing the injector 30 on the side where a strong flow of air is produced in the throttle body 21 promotes aerification of fuel and hence offers enhanced combustion efficiency. This enhances exhaust gas characteristics.

[0086] It is also thought that setting the angle ϕ of the injector 30 to be not less than 42 degrees nor more than 55 degrees enables suitable mixed-gas formation in the cylinder 10. Also, it is thought that setting the partition length L shorter prevents the fuel, injectedfromtheinjector30, from adhering to the partition 200, and so the fuel can be efficiently guided into the combustion chamber 35.

[0087] Thus, in this embodiment, the injector 30 is attached on the upper side of the throttle body 21, the injector 30 is attached at an angle ϕ of not less than 42 degrees nor more than 55 degrees, and the partition length L is set shorter than standard values such that the ratio X is not less than 0.45 nor more than 0.72.

[0088] Next, a relation between the injection starting timing of the injector 30 and an exhaust gas characteristic was examined. FIG. 11 shows the measurements about a relation between the injection starting timing of the injector 30 and fuel discharge.

[0089] In FIG. 11, the horizontal axis shows the injection starting timing of the injector 30 in terms of compressive ATDC (After Top Dead Center) crank rotation angle, and the vertical axis shows the amount of emitted THC (Total HydroCarbons). Square marks and circular marks show the measurements of different kinds of injectors 30.

[0090] A certain time length is required for the fuel injected from the injector 30 to flow into the combustion chamber 35 of the cylinder 10. This time length is determined by the speed of injection and the distance from the tip of the injector 30 to the valve heads of the intake valves 14 and 24. A delay time thus occurs from the time when the injector 30 starts injecting to the time when the fuel flows into the combustion chamber 35 in the cylinder 10.

[0091] Considering this time delay, it is seen from the measurements of FIG. 11 that the HC (Hydrocarbon) discharge is increased when the intake valves 14 and 24 are open, and the HC discharge is decreased when the intake valves 14 and 24 are closed.

[0092] Accordingly, the exhaust gas characteristics can be improved by setting the injection starting timing of the injector 30 within the period in which the intake valves 14 and 24 are closed.

[0093] When the intake valves 14 and 24 are closed, the fuel injected from the injector 30 is more likely to adhere to the partition 200, but, the adhesion of fuel to the partition 200 can be prevented by setting the partition length L shorter and positioning the injector 30 such that the fuel is injected to a position further upstream than the partition 200. Accordingly, the improvements of the transient output response and exhaust gas characteristics are remarkably achieved.

[0094] As described above, this embodiment sets the partition length L such that the ratio X is not less than 0.45 nor more than 0.72. This prevents the adhesion of fuel to the partition 200 and allows the fuel to be more efficiently guided into the combustion chamber 35. This enhances the transient output response and exhaust gas characteristics while maintaining high steady output value.

[0095] Also, the injector 30 is attached on the upper side of the throttle body 21. This promotes aerification of the fuel injected from the injector 30. This enhances combustion efficiency and further improves exhaust gas characteristics.

[0096] Also, the angle Φ at which the injector 30 is attached is set to be not less than 42 degrees nor more than 55 degrees. This allows suitable mixed-gas formation in the cylinder 10. The transient output response and exhaust gas characteristics are further enhanced as a result.

[0097] Also, the injection starting timing of the injector 30 is set within periods in which the intake valves 14 and 24 are closed, which produces remarkable improvements of the transient output response and exhaust gas characteristics.

[0098] FIG. 12 is a schematic diagram of a two-wheeled motorcycle equipped with the high-power engine of FIG. 1.

[0099] In the two-wheeled motorcycle 100 of FIG. 12, a head pipe 52 is provided at the front end of a body frame 51. A front fork 53 is attached to the head pipe 52 such that the front fork 53 can be turned right and left. A front wheel 54 is rotatably supported at the lower end of the front fork 53. A handlebar 55 is attached at the top end of the head pipe 52.

[0100] A seat rail 56 extends rearward from an upper part of the rear end of the body frame 51. A fuel tank 57 is provided on the body frame 51, and a main seat 58a and a tandem seat 58b are provided on the seat rail 56.

[0101] A rear arm 59 extends rearward from the rear end of the body frame 51. A rear wheel 60 is rotatably supported at the rear end of the rear arm 59.

[0102] The high-power engine 1 of FIG. 1 is held in the center of the body frame 51. A radiator 61 is attached in front of the high-power engine 1. An exhaust pipe 62 is connected to the exhaust ports of the high-power engine 1, and a muffler 63 is attached to the rear end of the exhaust pipe 62.

[0103] A transmission 65 is coupled to the high-power engine 1. A drive sprocket 67 is attached to the output shaft 66 of the transmission 65. The drive sprocket 67 is coupled to a rear-wheel sprocket 69 of the rear wheel 60 through a chain 68. In this embodiment, the transmission 65 and the chain 68 correspond to a transmission mechanism.

[0104] In the two-wheeled motorcycle of FIG. 12, the use of the high-power engine 1 of Fig. 1 offers an enhanced transient output response and enhanced exhaust gas characteristics, while maintaining high steady-state output.

[0105] The embodiment has described the intake port 20 having two branch passages 202 and 203, but the present invention is applicable to intake ports having three or more branch passages. In this case, the intake port has a plurality of partitions.

[0106] Also, in this embodiment, the throttle valve 31 turns in the direction shown by the arrow R and so the upper end opens to the downstream side and the lower end opens to the upstream side, but the throttle valve 31 may turn in the direction opposite to the arrow R such that the upper end opens to the upstream side and the lower end opens to the downstream side. In this case, it is preferable to attach the injector 30 on the lower side of the throttle body 21 such that the injector 30 injects fuel toward the upper side of the inner wall of the intake port 20.

[0107] Also, the embodiment uses the throttle valve 31 that opens/closes by turning, but a sliding-type throttle valve may be used, such as an ISC (Idle SpeedControl) valve that opens/closes by reciprocating in a direction perpendicular to the center axis of the throttle body 21. In this case, it is preferable to attach the injector 30 to the throttle body 21 on the side where the throttle valve opens.

[0108] Furthermore, while the embodiment has described an application of the high-power engine of the invention to a two-wheeled motorcycle, the high-power engine of the invention is applicable to various kinds of vehicles, such as four-wheeled automobiles etc.

[Industrial Applicability]

[0109] The present invention is applicable to various kinds of vehicles and the like, such as two-wheeled motorcycles, four-wheeled automobiles, etc.

Claims

1. A high-power engine comprising:

a cylinder;
a cylinder head provided to form a combustion chamber together with said cylinder, and having an intake port that guides air into said combustion chamber;
a plurality of intake valves disposed to open and close at downstream opening ends of said intake port; and
a fuel injection device disposed to inject fuel toward an inner wall of said intake port in a position that is further upstream than said intake valves,
wherein said intake port has a plurality of branch passages separated by a partition to guide air respectively to said plurality of intake valves, and
a ratio of a length of said partition with respect to a distance between centers of adjacent ones of said intake valves is set to be not less than 0.45 nor more than 0.72.

2. The high-power engine according to claim 1, further comprising a throttle valve that opens and closes in a position further upstream than said intake port, wherein said fuel injection device is disposed on a side where a stronger flow of air is produced than on another side when said throttle valve opens.

3. The high-power engine according to claim 1, further comprising an intake pipe having an inner space that communicates with said intake port,
wherein said intake port and the inner space of said intake pipe form an approximately linear-shaped air intake passage,
said throttle valve is provided such that its upper end opens to a downstream side and its lower end opens to an upstream side in said intake pipe, and
said fuel injection device is provided on an upper side of said intake pipe such that said fuel injection device injects the fuel toward a lower side of the inner wall of said intake port.

4. The high-power engine according to claim 1, wherein an angle between a direction in which said fuel injection device injects the fuel and a center axis of said intake port is set to be not less than 42 degrees nor more than 55 degrees.

5. The high-power engine according to claim 1, wherein the fuel injection by said fuel injection device is started in a period in which said plurality of intake valves are closed.

6. A vehicle comprising:

a high-power engine;
a wheel; and
a transmission mechanism that transmits power generated by said high-power engine to said wheel,
said high-power engine comprising:

a cylinder;
a cylinder head provided to form a combustion chamber together with said cylinder, and having an intake port that guides air into said combustion chamber;
a plurality of intake valves disposed to open and close at downstream opening ends of said intake port; and
a fuel injection device disposed to inject fuel toward an inner wall of said intake port in a position that is further upstream than said intake valves,
wherein said intake port has a plurality of branch passages separated by a partition to guide air respectively to said plurality of intake valves, and
a ratio of a length of said partition with respect to a distance between centers of adjacent ones of said intake valves is set to be not less than 0.45 nor more than 0.72.

7. The vehicle according to claim 6, further comprising a throttle valve that opens and closes in a position further upstream than said intake port, wherein said fuel injection device is disposed on a side where a stronger flow of air is produced than on another side when said throttle valve opens.

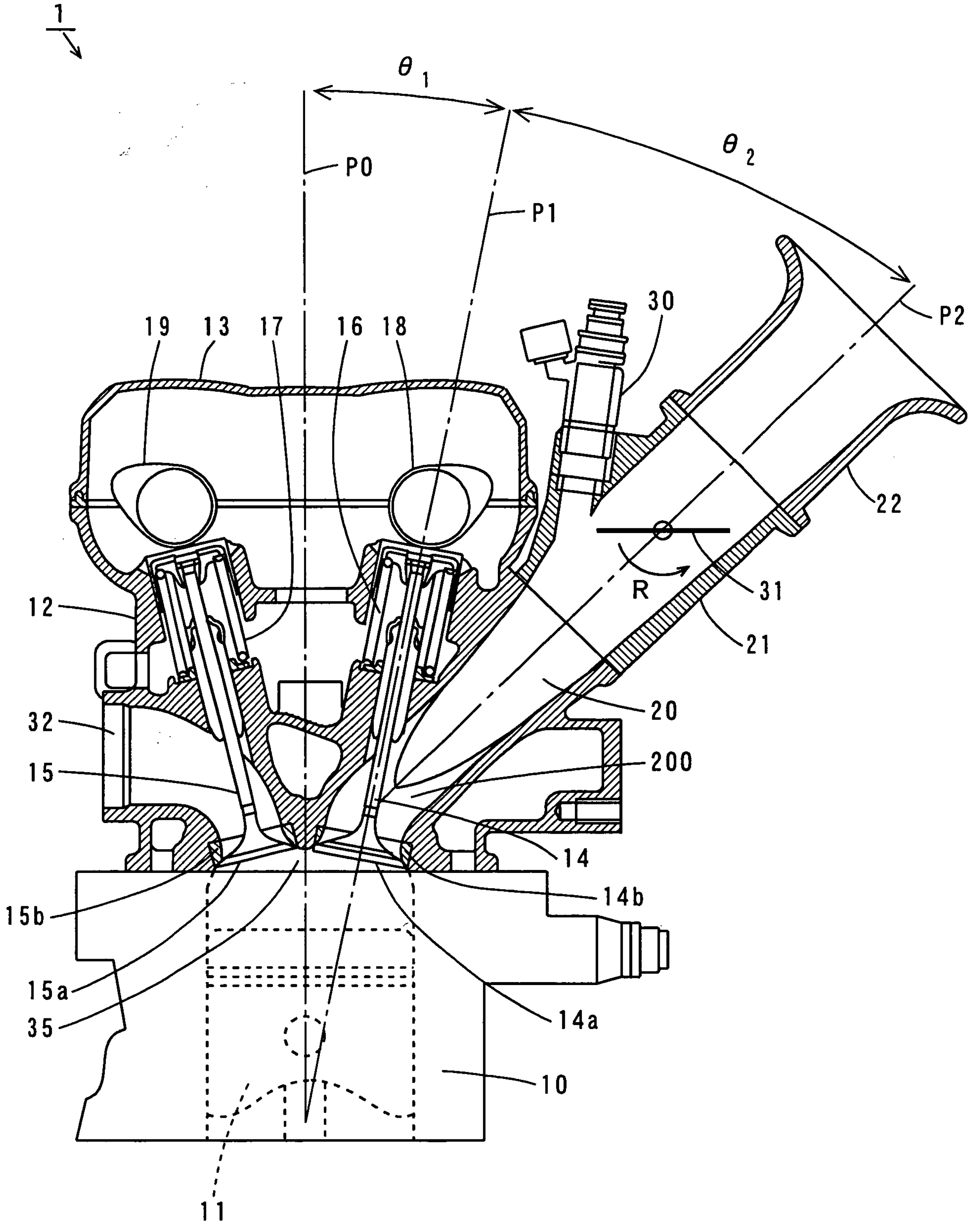
8. The vehicle according to claim 6, further comprising an intake pipe having an inner space that communicates with said intake port,
wherein said intake port and the inner space of said intake pipe form an approximately linear-shaped air intake passage,
said throttle valve is provided such that its upper end opens to a downstream side and its lower end opens to an upstream side in said intake pipe, and

said fuel injection device is provided on an upper side of said intake pipe such that said fuel injection device injects the fuel toward a lower side of the inner wall of said intake port.

9. The vehicle according to claim 6, wherein an angle between a direction in which said fuel injection device injects the fuel and a center axis of said intake port is set to be not less than 42 degrees nor more than 55 degrees.

10. The vehicle according to claim 6, wherein the fuel injection by said fuel injection device is started in a period in which said plurality of intake valves are closed.

F I G. 1


1
θ1
θ2
P0
P1
P2
30
19
13
17
16
18
22
31
R
12
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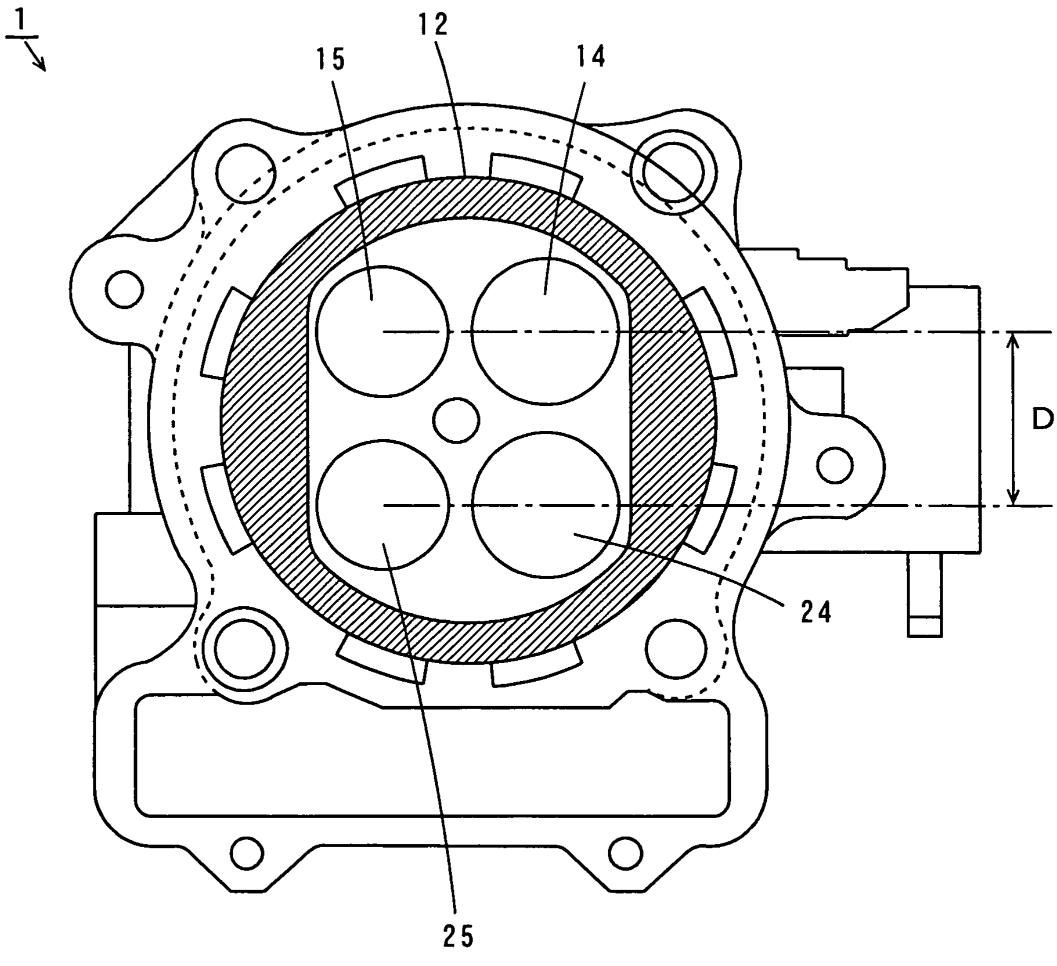
20
32
200
15
14
14b
15b
15a
35
14a
10
11

F I G. 2



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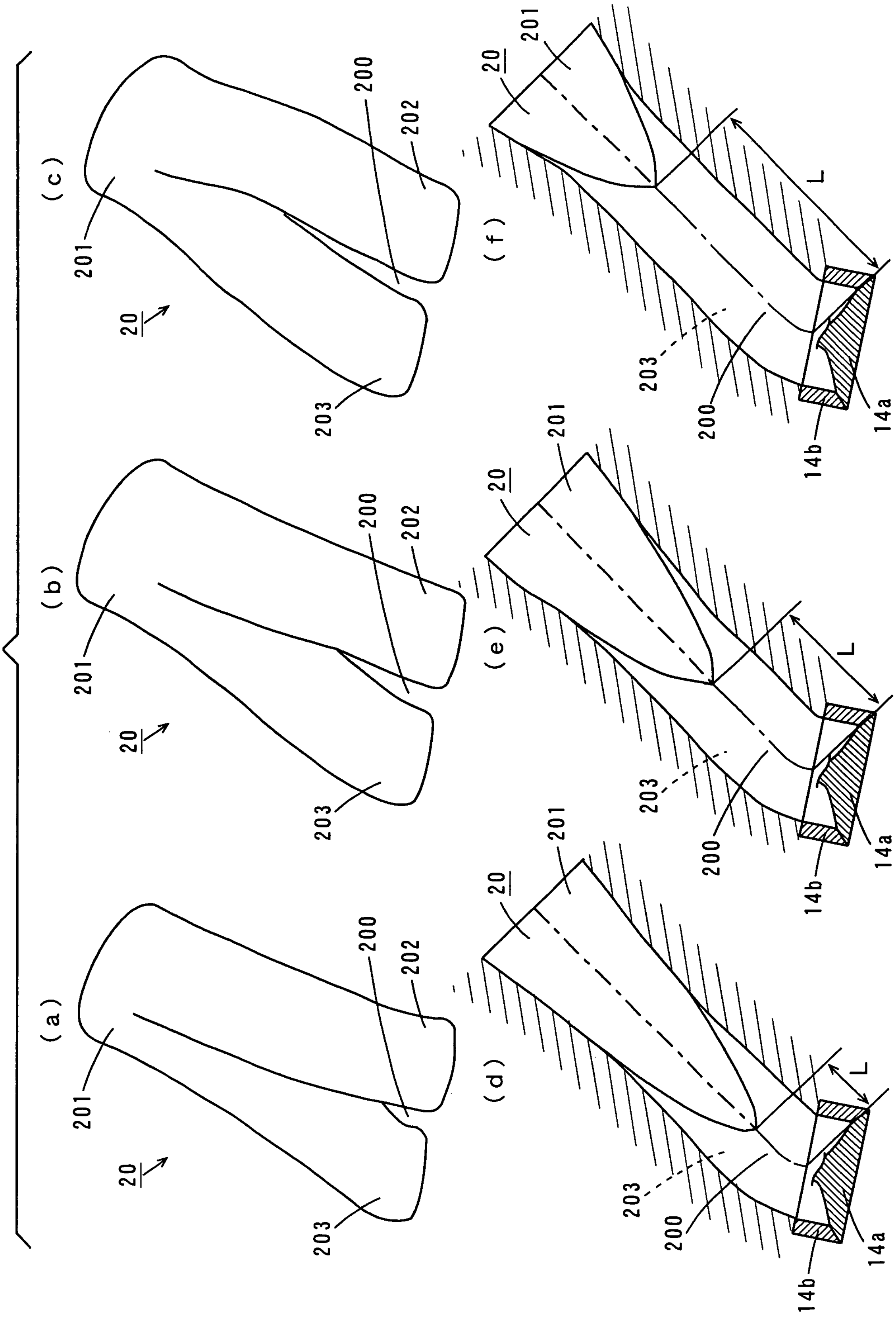

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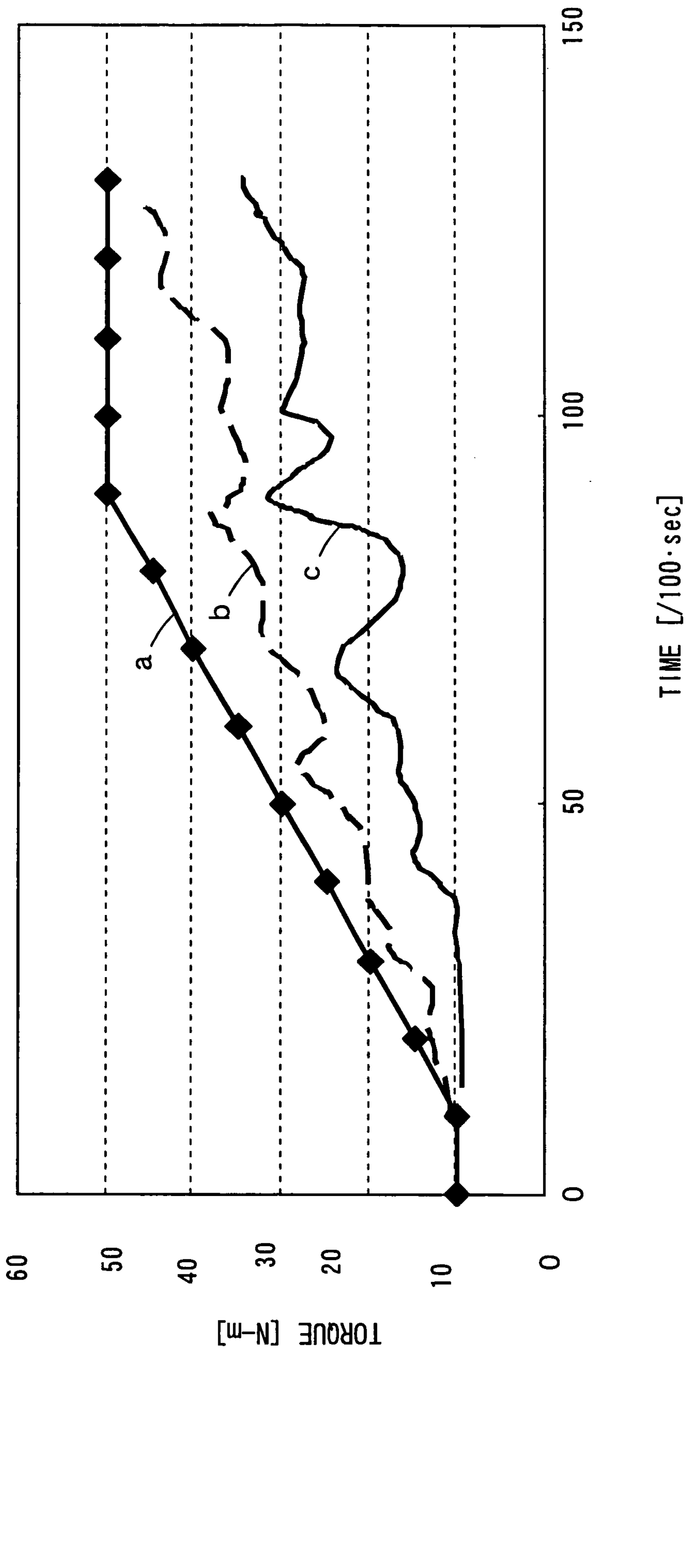
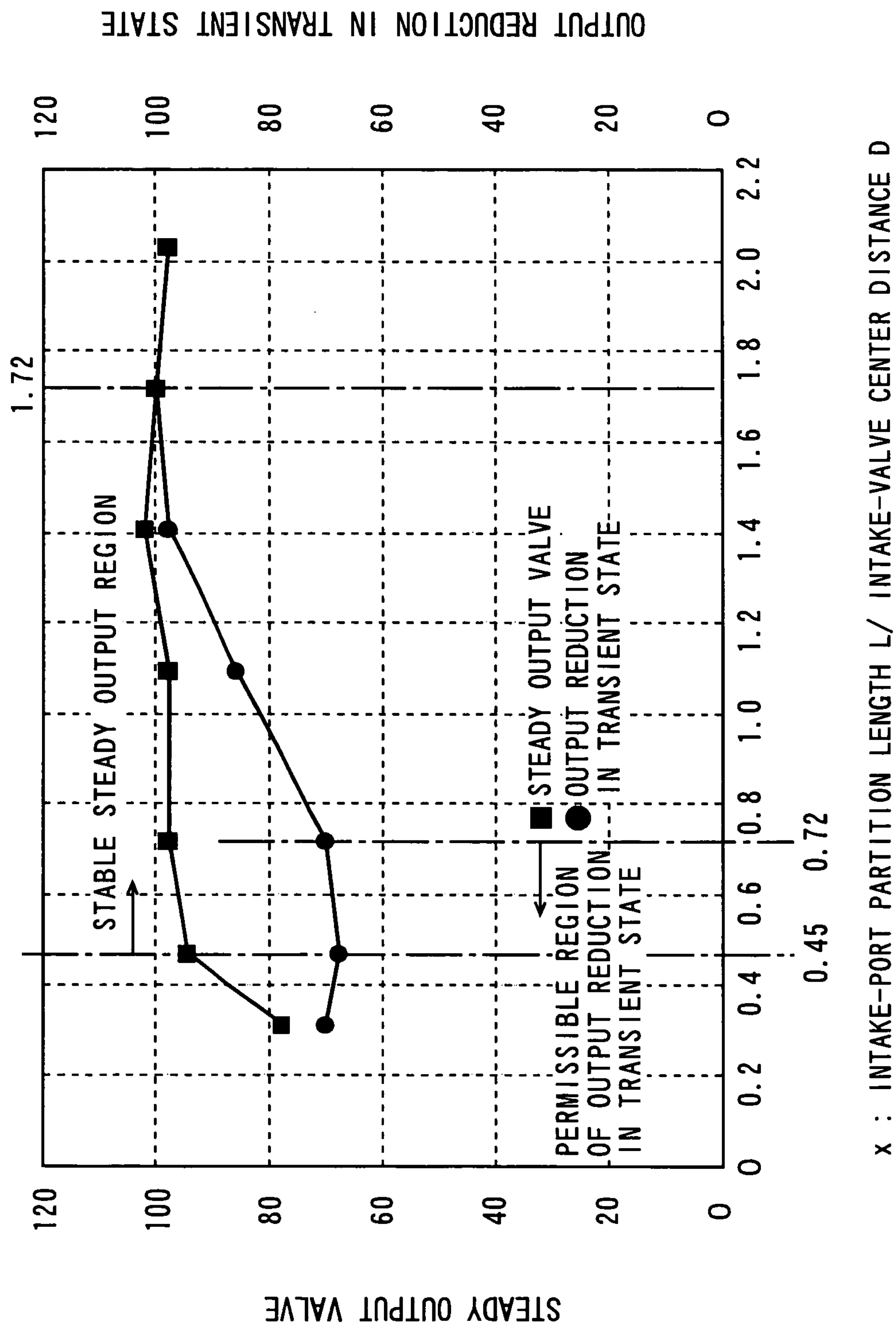
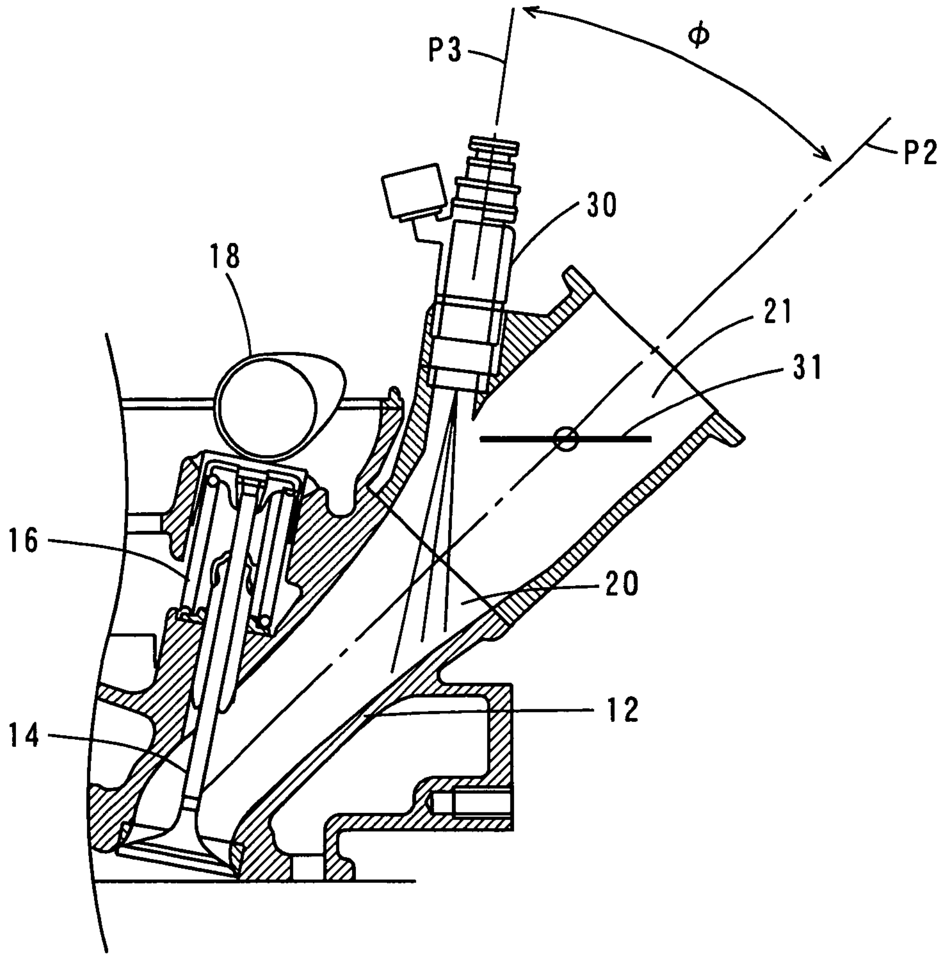


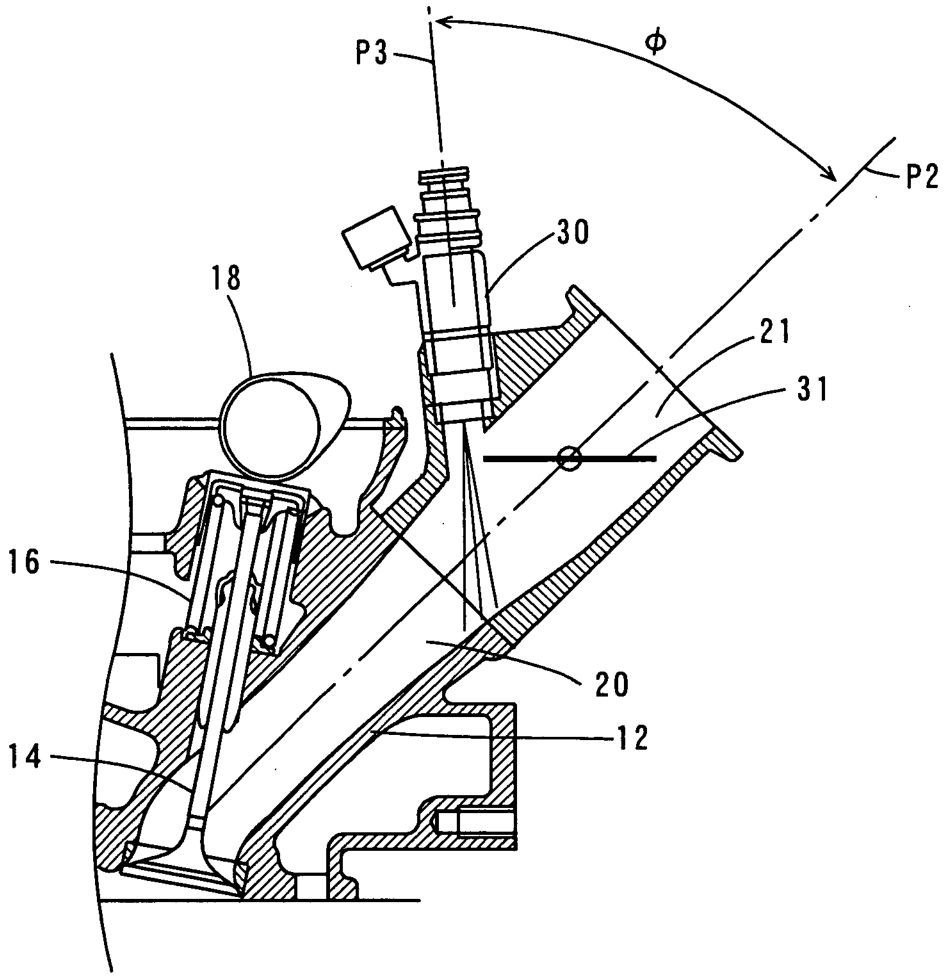

OUTPUT REDUCTION IN TRANSIENT STATE
STEADY OUTPUT VALVE
STABLE STEADY OUTPUT REGION
PERMISSIBLE REGION OF OUTPUT REDUCTION IN TRANSIENT STATE
STEADY OUTPUT VALVE
OUTPUT REDUCTION IN TRANSIENT STATE
1.72
0.45
0.72
120
100
80
60
40
20
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
x : INTAKE-PORT PARTITION LENGTH L/ INTAKE-VALVE CENTER DISTANCE D

F I G. 5

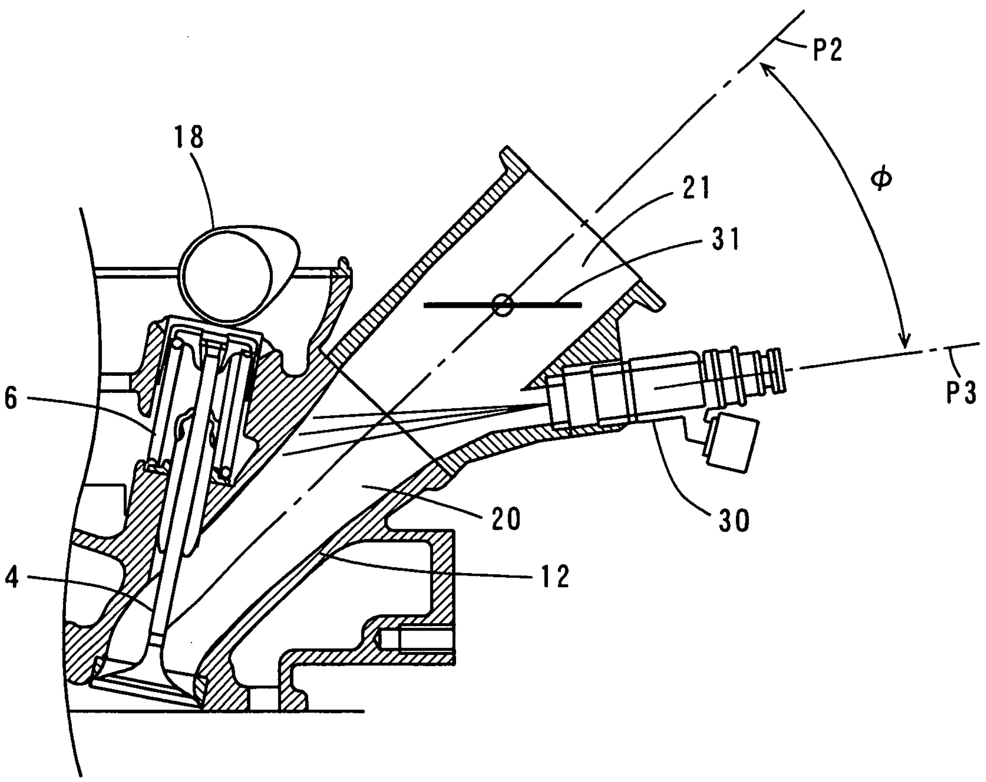
F I G. 6



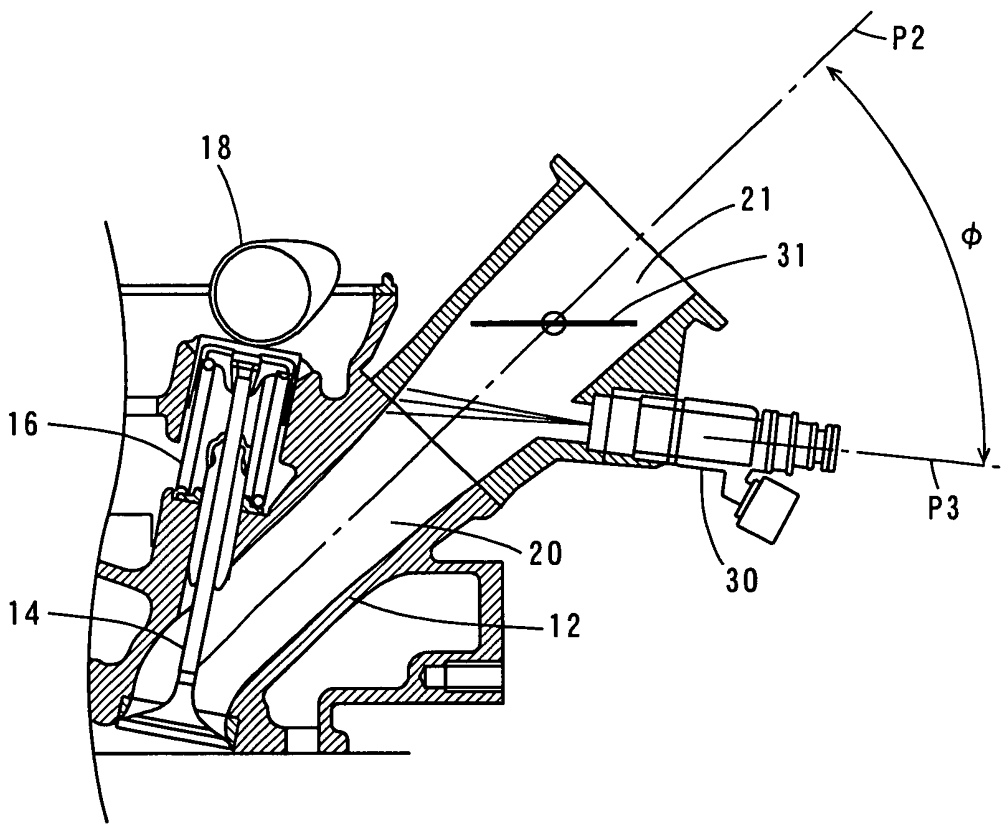
F I G. 7



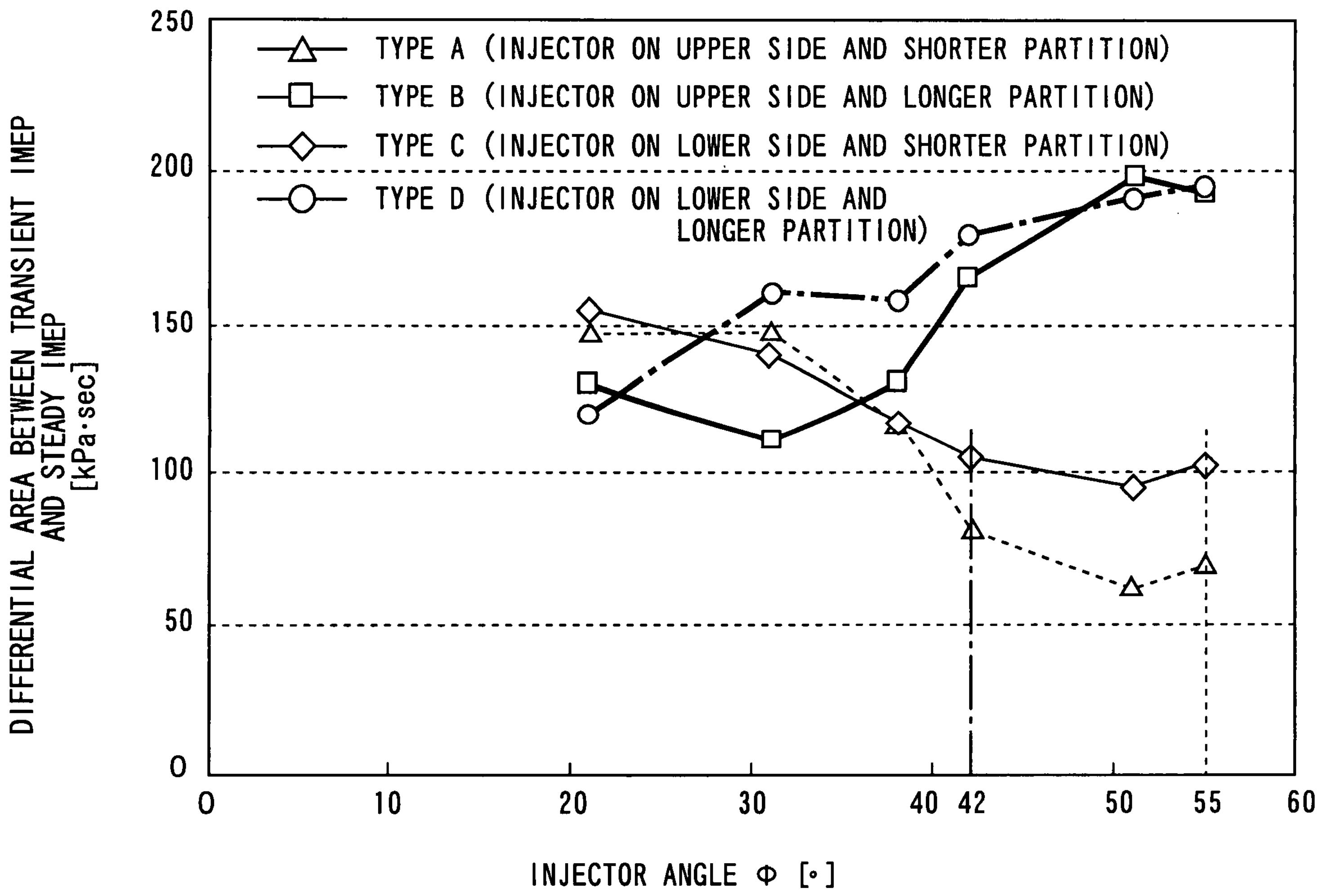
F I G. 8



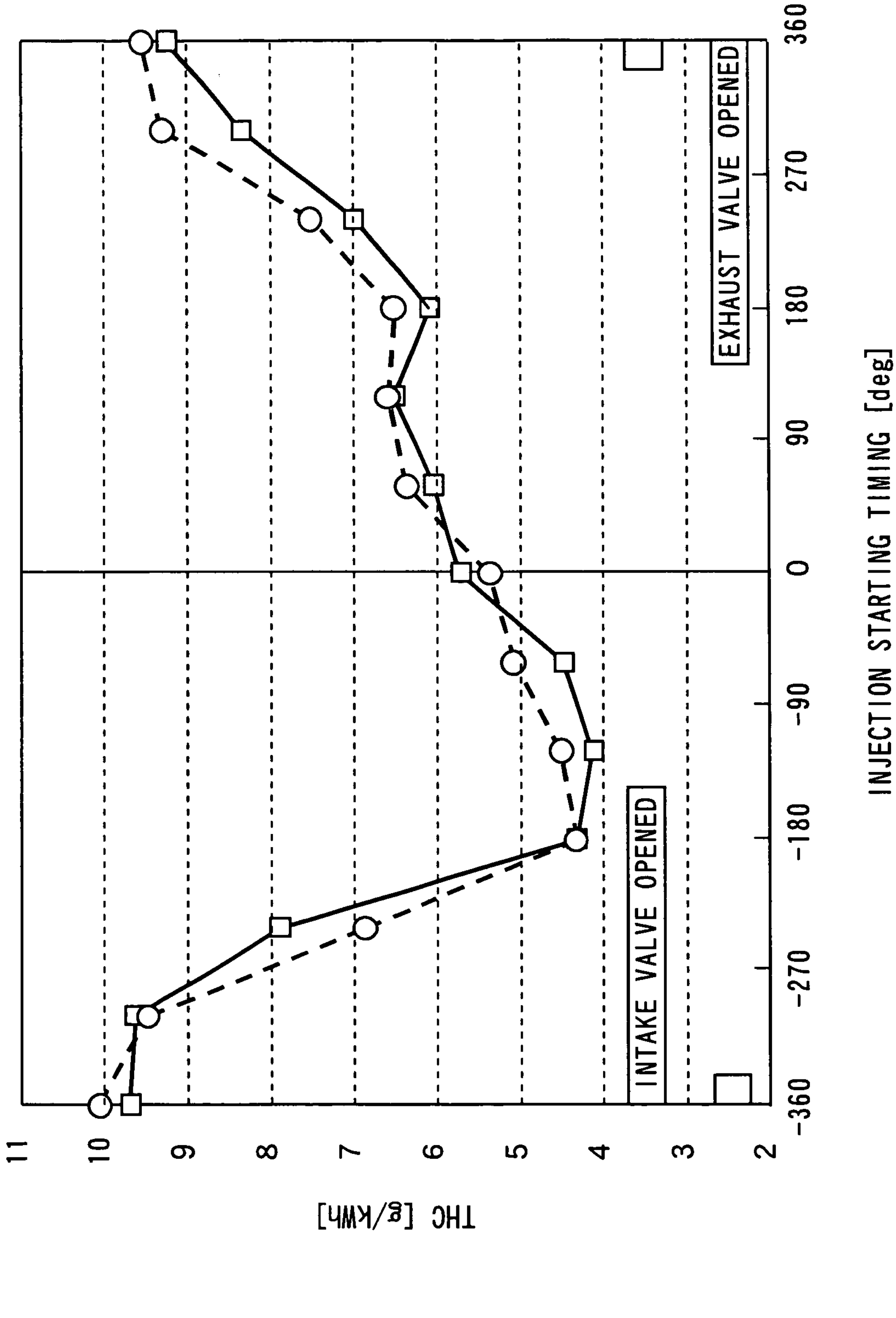
F I G. 9

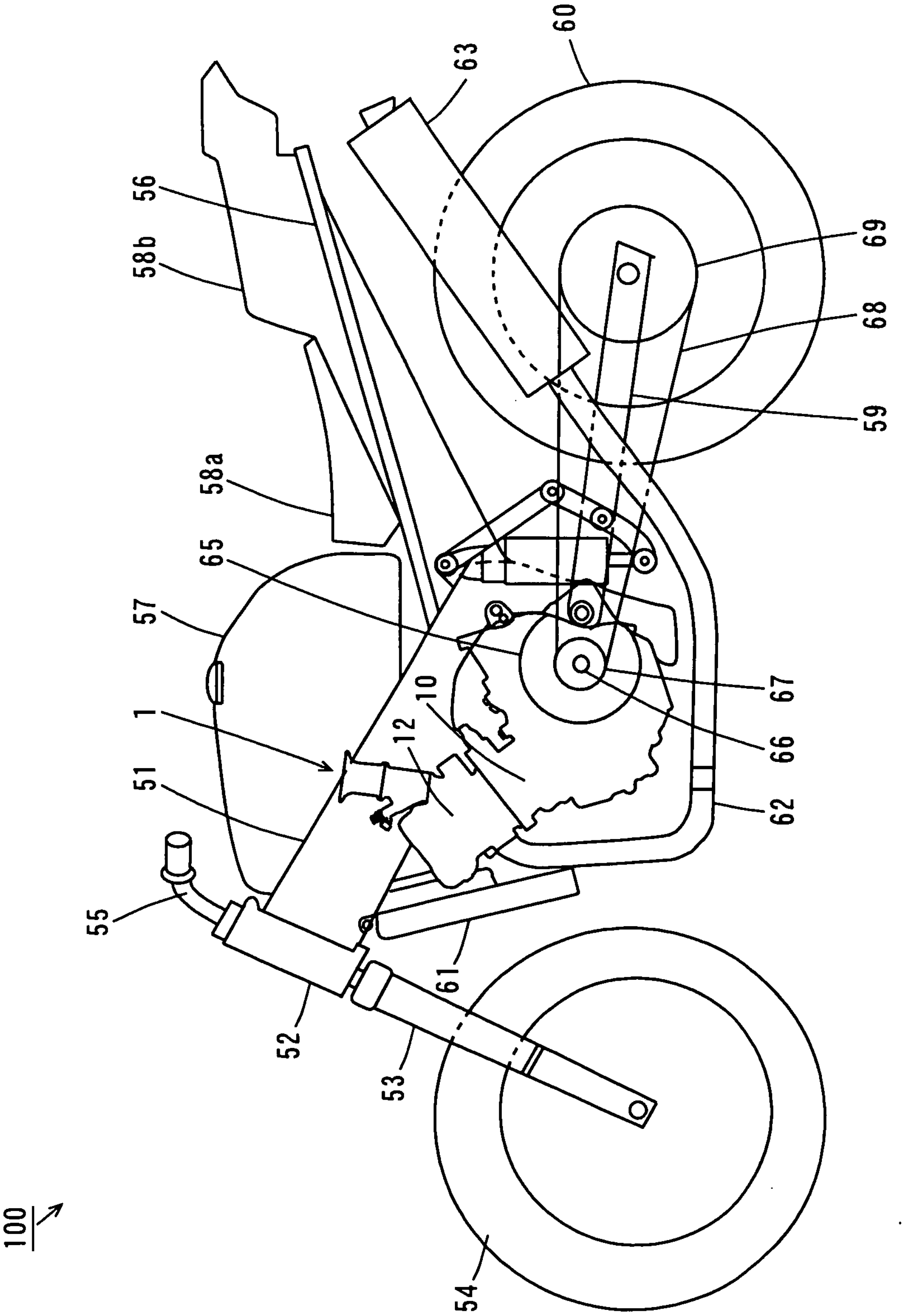


F I G. 1 0


TYPE A (INJECTOR ON UPPER SIDE AND SHORTER PARTITION)
TYPE B (INJECTOR ON UPPER SIDE AND LONGER PARTITION)
TYPE C (INJECTOR ON LOWER SIDE AND SHORTER PARTITION)
TYPE D (INJECTOR ON LOWER SIDE AND LONGER PARTITION)
DIFFERENTIAL AREA BETWEEN TRANSIENT IMEP AND STEADY IMEP [kPa·sec]
250
200
150
100
50
0
0
10
20
30
40
42
50
55
60
INJECTOR ANGLE Φ [°]

F I G. 11


THC [g/kWh]
11
10
9
8
7
6
5
4
3
2
-360
-270
-180
-90
0
90
180
270
360
INJECTION STARTING TIMING [deg]
INTAKE VALVE OPENED
EXHAUST VALVE OPENED



F I G. 1 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2005/013600

A. CLASSIFICATION OF SUBJECT MATTER
F02F1/42 (2006.01), ***B62M7/02*** (2006.01), ***F02D9/10*** (2006.01), ***F02D41/34*** (2006.01), ***F02M35/16*** (2006.01), ***F02M69/04*** (2006.01)

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F02F1/00-11/00 (2006.01), ***B62M7/02*** (2006.01), ***F02D9/10*** (2006.01), ***F02D41/00-45/00*** (2006.01), ***F02M35/16*** (2006.01), ***F02M39/00-71/04*** (2006.01)

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2005
Kokai Jitsuyo Shinan Koho	1971-2005	Toroku Jitsuyo Shinan Koho	1994-2005

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 7-224718 A (Toyota Motor Corp.), 22 August, 1995 (22.08.95), Full text; Figs. 1, 2, 5, 6 (Family: none)	1-10
Y	JP 4-66774 A (Honda Motor Co., Ltd.), 03 March, 1992 (03.03.92), Full text; Fig. 1 (Family: none)	1-10
Y	JP 8-4537 A (Yamaha Motor Co., Ltd.), 09 January, 1996 (09.01.96), Full text; Fig. 1 (Family: none)	3-5,8-10

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 October, 2005 (25.10.05)	01 November, 2005 (01.11.05)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2005/013600

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2003-13826 A (Hitachi, Ltd.), 15 January, 2003 (15.01.03), Par. No. [0093]; Fig. 23 (Family: none)	5,10

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 6272640 A **[0004]**