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(54) **ENGINE UNIT AND SADDLED VEHICLE**

MOTOREINHEIT UND SATTELFAHRZEUG

UNITÉ DE MOTEUR ET VÉHICULE À SELLE

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(73) Proprietor: **YAMAHA HATSUDOKI KABUSHIKI KAISHA**
Iwata-shi, Shizuoka 438-8501 (JP)

(72) Inventors:
- **HARA, Takahiko**
  Iwata-shi, Shizuoka, 438-8501 (JP)
- **WATANABE, Yuichiro**
  Iwata-shi, Shizuoka, 438-8201 (JP)
- **OKUWA, Yoshinori**
  Iwata-shi, Shizuoka, 438-8501 (JP)

(74) Representative: **Zimmermann, Tankred Klaus et al**
Schoppe, Zimmermann, Stöckeler
Zinkler, Schenk & Partner mbB
Patentanwälte
Radlkoferstrasse 2
81373 München (DE)

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Description

Technical Field

[0001] The present invention relates to an engine unit and a straddled vehicle.

Background Art

[0002] Some vehicles are provided with canisters. A canister accommodates therein an adsorbent which adsorbs fuel vapor generated in a fuel tank. There is a technique for actively introducing air containing fuel vapor from the canister into a combustion chamber, to reduce the amount of fuel vapor adsorbed by the adsorbent and then discharged from the canister to the atmosphere. This technique is widely used in engine units mounted on automobiles (four-wheeled vehicles). In Patent Literature 1, a tank with a large capacity is provided to a passage through which fuel vapor is introduced from the canister to an intake passage member.

Citation List

Patent Literature

[0003] Patent Literature 1: Japanese Unexamined Patent Publication No. 2009-57844

Summary of Invention

Technical Problem

[0004] It has been desired to apply the technique described in Patent Literature 1 to engine units used in straddled vehicles such as motorcycles. As a result of technical developments pursued by the present inventors, the following fact was found. If the technique of Patent Literature 1 is applied as it is to an engine unit widely used in straddled vehicles, a disadvantage may be caused. That is, there is a possibility that a desired amount of fuel vapor cannot be introduced from the canister to the combustion chamber.

[0005] An object of the present invention is to provide an engine unit and a straddled vehicle each of which enables introduction of a desired amount of fuel vapor to a combustion chamber.

Solution to Problem

[0006] According to an embodiment of the present teaching, a multi-cylinder four-stroke engine unit includes: an engine including a combustion chamber; an intake passage member which is connected to the engine and allows air to be introduced into the combustion chamber; and a throttle valve provided in an intermediate portion of the intake passage member. The combustion chamber, the intake passage member, and the throttle valve are provided for each cylinder. Pressure in a downstream intake passage portion of the intake passage member that is downstream of the throttle valve varies in a pressure-variation manner such that: a smaller depression having a smaller difference from atmospheric pressure and a larger depression having a larger difference from atmospheric pressure are created in each four-stroke cycle; and the creation of the smaller and larger depressions is repeated on a four-stroke basis. The engine unit further includes: a canister connected to a fuel tank and accommodating therein an adsorbent configured to adsorb fuel vapor contained in incoming air from the fuel tank; a communication passage member configured to establish communication between an inside of the canister and the downstream intake passage portion for each cylinder, the communication passage member having a branched portion for each cylinder, the branched portions respectively connected to the downstream intake passage portions; a valve provided to each branched portion of the communication passage member so that a capacity of a part of the communication passage member, the part extending from the intake passage member to the valve, is smaller than a half of a displacement of the engine, an opening degree of the valves being changeable; and a controller configured to control operation of the valves on a basis of the pressure-variation manner in which the creation of the smaller and larger depressions is repeated on the four-stroke basis.

[0007] The present inventors strived to find out the reason why a desired amount of fuel vapor cannot be introduced from the canister to the combustion chamber when the technique of Patent Literature 1 is applied as it is to the engine unit widely used in straddled vehicles. The amount of fuel vapor introduced from the canister to the combustion chamber changes depending on the amount of the depression in the downstream intake passage portion, i.e., the difference between the negative pressure in the downstream intake passage portion and atmospheric pressure. The downstream intake passage portion is connected with the communication passage member extending from the canister. Taking the above into consideration, the present inventors compared depressions created in the downstream intake passage portion in the engine unit widely used in straddled vehicles with those in the engine unit widely used in automobiles. As a result of the comparison, the following difference was found.

[0008] In some of engine units widely used in automobiles, pressure variation in the downstream intake passage portion is suppressed due to a surge tank provided downstream of a throttle valve. Furthermore, in an automobile's engine unit with independent throttle bodies as described in Patent Literature 1, pressure variation for each cylinder is suppressed, for example, by providing one or more communication pipes to establish communication between the downstream intake passage portions.

[0009] Now, reference is made to the engine unit widely used in straddled vehicles. A multi-cylinder engine unit with individual throttle bodies is widely used in straddled vehicles. In such an engine unit for straddled vehicles, pressure in its downstream intake passage portion varies widely below atmospheric pressure, i.e., a large depression is created in its downstream intake passage portion. Such a large depression is created in each four-stroke cycle, and the creation of the depression is repeated on a four-stroke basis. In Patent Literature 1, a tank with a large capacity is provided to a passage through which fuel vapor is introduced into the downstream intake passage portion. Suppose that the arrangement of Patent Literature 1 is applied as it is to an engine unit widely used in straddled vehicles, in which pressure in its downstream intake passage portion varies greatly. It was found that, this tends to cause a delay in the timing for introducing fuel vapor into the combustion chamber, and as a consequence, there is a possibility that a desired amount of fuel vapor cannot be introduced.

[0010] Taking into consideration the above, in the present teaching, the operation of the valve is controlled on the premise that the pressure variation exists, or rather, with the use of the pressure variation. Specifically, the valve is provided so that the capacity of the part of the communication passage member, the part being between the downstream intake passage portion and the valve, is smaller than a half of the displacement of the engine. Furthermore, the valve is controlled so that the amount of introduced fuel vapor is changed on the basis of the pressure-variation manner in which the creation of the smaller and larger depressions is repeated on the four-stroke basis.

[0011] With this arrangement, the operation of the valve is controlled on the basis of the pressure-variation manner in which a great variation in pressure is repeated on the four-stroke basis. This makes it possible to control the valve so that a suitable amount of fuel vapor is introduced into the combustion chamber. The capacity of the part of the communication passage member, the part extending from the intake passage portion to the valve, is smaller than a half of the displacement of the engine. This reduces the delay in the timing for introducing fuel vapor into the combustion chamber in conditions where pressure in the downstream intake passage portion greatly varies. Accordingly, introduction of a desired amount of fuel vapor into the combustion chamber is achieved in the engine unit in which pressure varies greatly on the four-stroke basis.

[0012] Furthermore, in the present teaching, it is preferable that: the engine unit further includes a sensor for each downstream intake passage portion, the sensors configured to detect negative pressure in the downstream intake passage portions; and the controller is configured to control the operation of the valve on a basis of a detection result obtained by the sensors.

[0013] In this arrangement, pressure variation is directly detected, and the operation of the valve is controlled based on the detection result. Due to this, the amount of introduced fuel vapor is properly adjustable in accordance with the pressure variation.

[0014] Furthermore, in the present teaching, it is preferable that: the controller is configured to control the valves so that a ratio of an amount of fuel vapor introduced from the communication passage member to the downstream intake passage portion to a combustion chamber-introduction air amount, which is an amount of air introduced from the downstream intake passage portion into the combustion chamber, increases with an increase in the combustion chamber-introduction air amount.

[0015] In this arrangement, the valve is controlled so that the ratio of the amount of introduced fuel vapor increases with the increase in the combustion chamber-introduction air amount. Thus, fuel vapor is introduced to the combustion chamber in such a manner that the influence of the fuel vapor on the combustion in the combustion chamber is small. Accordingly, the control of the engine is easier when fuel vapor is actively introduced to the combustion chamber.

[0016] Furthermore, in the present teaching, it is preferable that: each of the valves is switchable from a closed state to an open state and is switchable from the open state to the closed state, the closed state being the state where the valve prevents communication of air between the inside of the canister and the downstream intake passage portion, the open state being the state where the valve allows communication of air between the inside of the canister and the downstream intake passage portion; and the controller is configured to control each of the valves to perform a valve switching operation in association with the pressure-variation manner in which the creation of the smaller and larger depressions is repeated on a four-stroke basis, the valve switching operation being a set of switching-on and switching-off operations, one of the operations being performed first and then the other one of the operations being performed, the switching-on operation being an operation to switch the valve from the closed state to the open state, the switching-off operation being an operation to switch the valve from the open state to the closed state.

[0017] In this arrangement, the amount of introduced fuel vapor is adjusted on the premise that the above-described pressure variation exists in the downstream intake passage portion, or rather, with the use of the pressure variation. Specifically, the valve switching operation to introduce fuel vapor is performed in association with the pressure-variation manner in which the creation of the smaller and larger depressions in each four-stroke cycle is repeated on a four-stroke basis. With this arrangement, the amount of introduced fuel vapor is properly adjusted in association with the pressure-variation manner when fuel vapor is actively introduced from the canister to the combustion chamber. In the present teaching, the valve is provided so that the capacity of the part of the communication passage member, the part extending between the downstream intake passage portion and the valve, is smaller than a half of the displacement of the engine. Because of this, a variation in pressure in the downstream intake passage portion is transmitted to the valve in a shorter time. This facilitates smooth association between the operation of the valve and the variation in pressure, and reduces the delay in the timing for introducing fuel vapor into the combustion chamber. Due to this, the amount of fuel vapor introduced into the combustion chamber is more properly adjustable.

[0018] Furthermore, in the present teaching, it is preferable that: when each of the four strokes constituting a four-stroke cycle is counted as one stroke, the controller is configured to control each of the valves so as to perform the valve switching operation in association with an n-stroke period, where n is 1, 2, or a multiple of 4.

[0019] The control to perform the valve-switching operations in association with the one-stroke period (i.e., on the basis of the one-stroke period) and the control to perform the valve-switching operations in association with the two-stroke period (i.e., on the basis of the two-stroke period) are both included in the control in association with the four-stroke cycle. When the valve-switching operations are performed in association with the n-stroke period (i.e., on the basis of the n-stroke period), where n is a multiple of 4, the operations are performed on the basis of the four-stroke cycle, or in association with a four-stroke cycle in the n-stroke period, with intervals of one or more four-stroke cycles. Thus, with the above-described arrangement, the purge amount is adjusted, in any of the above cases, in association with the pressure-variation manner in which the creation of the smaller and larger depressions in each four-stroke cycle is repeated on a four-stroke basis.

[0020] Furthermore, in the present teaching, it is preferable that: the controller is configured to control each of the valves so as to perform at least one of the switching-on and switching-off operations in synchronization with an n-stroke period, where n is 1, 2, or a multiple of 4.

[0021] In this arrangement, at least one of the switching operations is performed in synchronization with the n-stroke period, where n is 1, 2, or a multiple of 4. Thus, the control of the switching operations is easier.

[0022] In the present teaching, the controller may control each of the valves so as to perform the switching-on operation and then to perform the switching-off operation in each n-stroke period, where n is 1, 2, or a multiple of 4. In the present teaching, the controller may control each of the valves so as to perform the switching-off operation and then to perform the switching-on operation in each n-stroke period, where n is 1, 2, or a multiple of 4. In the present teaching, the controller may control each of the valves so as to perform each of the switching-on and switching-off operations once in each n-stroke period, where n is 1, 2, or a multiple of 4. In the present teaching, the controller may control each of the valves so as to perform each of the switching-on and switching-off operations once in each one-stroke or two-stroke period. In the present teaching, the controller may control each of the valves so as to perform each of the switching-on and switching-off operations once in a four-stroke cycle in each n-stroke period, where n is a multiple of 4. In the present teaching, the controller may control each of the valves so as to perform each of the switching-on and switching-off operations once in each four-stroke period. In the present teaching, the controller may control each of the valves so as to perform each of the switching-on and switching-off operations twice or more in each n-stroke period, where n is a multiple of 4. In the present teaching, the controller may control each of the valves so as to perform one of the switching-on and switching-off operations and then perform the other in each n-stroke period, where n is 1, 2, or a multiple of 4, timings to perform the switching-on and switching-off operations in each period being different among the n-stroke periods.

[0023] Furthermore, in the present teaching, it is preferable that: each of the valves is capable of being in an open state in which each of the valves allows communication of air between an inside of the canister and the intake passage member through the communication passage member, and an opening degree of each of the valves in the open state is adjustable; and the controller is configured to control the opening degree of each of the valves in the open state, on a basis of a four-stroke-based manner of pressure variation included in the pressure-variation manner in which the creation of the smaller and larger depressions is repeated on the four-stroke basis.

[0024] In this arrangement, the amount of introduced fuel vapor is adjusted on the premise that the above-described pressure variation exists in the downstream intake passage portion, or rather, with the use of the pressure variation. That is, the opening degree of the valve in the open state is controlled on the basis of the four-stroke-based manner of the pressure variation included in the pressure-variation manner in which the creation of the smaller and larger depressions is repeated on the four-stroke basis. Due to this, the amount of introduced fuel vapor is properly adjustable on the basis of the four-stroke-based manner of the pressure variation when fuel vapor is actively introduced from the canister into the combustion chamber. In the present teaching, the valve is provided so that the capacity of the part of the communication passage member, the part extending between the downstream intake passage portion and the valve, is smaller than a half of the displacement of the engine. Because of this, a variation in pressure in the intake passage member is transmitted to the valve in a shorter time. This reduces the delay in the timing for introducing fuel vapor into the combustion chamber when the valve is controlled on the basis of the manner of the pressure variation. Due to this, the amount of fuel vapor introduced into the combustion chamber is more properly adjustable.

[0025] Furthermore, in the present teaching, it is preferable that when four strokes are counted as one cycle, the controller is configured to control the opening degree of each of the valves in the open state on a basis of the four-stroke-based manner of the pressure variation for each n-cycle span, where n is a natural number.

[0026] In this arrangement, the amount of introduced fuel vapor is adjusted on the basis of the four-stroke-based manner of the pressure variation for each n-cycle span. This makes the control of the engine easier.

[0027] Furthermore, in the present teaching, the engine unit may further include a sensor for each downstream intake passage portion, the sensors configured to detect negative pressure in the downstream intake passage portion; and the controller may control the opening degree of each of the valves in the open state on a basis of a detection result obtained by the sensors in each cycle included in the n-cycle span, the detection result functioning to indicate the four-stroke-based manner of the pressure variation for each n-cycle span. Furthermore, in the present teaching, when four strokes are counted as one cycle, the controller may control each of the valves in such a manner that after the controller keeps the opening degree of the valve in the open state constant over a plurality of cycles, the controller changes the opening degree of each of the valves in the open state on the basis of the four-stroke-based manner of the pressure variation.

[0028] According to an embodiment of the present teaching, a straddled vehicle includes: the engine unit of the above aspect of the present teaching; a vehicle body frame supporting the engine unit; a rider seat; handlebars provided frontward of the rider seat; and a fuel tank connected to the canister included in the engine unit.

[0029] Due to this, introduction of a desired amount of fuel vapor into the combustion chamber is achieved in a straddled vehicle having an engine unit in which pressure varies greatly on a four-stroke basis.

[0030] In the present teaching, "a smaller depression having a smaller difference from atmospheric pressure and a larger depression having a larger difference from atmospheric pressure" indicates that there are two depressions, one of which has a difference from atmospheric pressure larger than that of the other's.

Brief Description of Drawings

[0031]

[FIG. 1] FIG. 1 shows a side view of a motorcycle related to a first example of the present teaching.

[FIG. 2] FIG. 2 shows a schematic diagram illustrating an engine unit of the motorcycle in FIG. 1 and its peripherals. The diagram includes a partial cross-section of an engine in the engine unit, and partially illustrates the internal structure of the engine.

[FIG. 3] FIG. 3 shows a schematic diagram illustrating: how a communication passage member extending from a canister to a downstream intake passage portion is connected; and the structure of a solenoid valve provided to an intermediate portion of the communication passage member. The diagram includes partial cross-sections of these parts.

[FIGs. 4A and 4B] FIG. 4A and FIG. 4B each shows a cross-section of the solenoid valve in FIG. 3. Each cross-section partially includes a front view of the internal structure of the valve.

[FIG. 5] FIG. 5 shows a combination of: charts respectively showing the open/closed states of an intake valve, an exhaust valve, and the solenoid valve; and a graph showing the variation in pressure in the downstream intake passage portion.

[FIGs. 6A and 6B] FIG. 6A and FIG. 6B show graphs of conditions for controlling the solenoid valve.

[FIG. 7] FIG. 7 shows a graph of changes in the inflow amount of fuel vapor when the solenoid valve is controlled in accordance with various control methods.

[FIG. 8] FIG. 8 relates to a modification of the example. Specifically, FIG. 8 is a combination of: charts showing the open/closed state of the solenoid valve; and a graph showing the variation in pressure in the downstream intake passage portion.

[FIG. 9] FIG. 9 relates to another modification of the example. Specifically, FIG. 9 is a combination of: charts showing the open/closed state of the solenoid valve; and a graph showing the variation in pressure in the downstream intake passage portion.

[FIGs. 10A and 10B] FIG. 10A and FIG. 10B each shows a cross-section of a flow regulating valve used in a second example of the present teaching, in place of the solenoid valve in the first example. Each cross-section partially includes a front view of the internal structure of the valve.

[FIG. 11] FIG. 11 shows a combination of: charts respectively showing the open/closed states of the intake valve and the exhaust valve; and a graph showing the variation in pressure in the downstream intake passage portion.

[FIGs. 12A and 12B] FIG. 12A and FIG. 12B are graphs showing conditions for controlling the flow regulating valve.

[FIG. 13] FIG. 13 shows a combination of: a graph showing a change in the manner of pressure variation in the downstream intake passage portion; and a graph showing an operation to change the opening degree of the flow regulating valve under the control on the basis of the change in the manner of pressure variation.

[FIG. 14] FIG. 14 shows a schematic diagram for an embodiment of the invention in which the present teaching is applied to a multi-cylinder engine unit.

[FIG. 15] FIG. 15 shows a graph for a modification with respect to the control method for the flow regulating valve.

[0032] Description of Examples useful for understanding the invention and Embodiments of the invention.

[0033] The following will describe a first example with reference to a motorcycle 1 by way of example. The motorcycle 1 is provided with an engine unit 100 which embodies an engine unit of the present teaching.

[0034] In the following description, a front-back direction refers to a vehicle's front-back direction as seen from a rider R seated on a rider seat 11 of the motorcycle 1. The rider seat 11 will be described later. A left-right direction refers to a vehicle's left-right direction (vehicle width direction) as seen from the rider R seated on the rider seat 11. Arrows F and B in the drawings respectively indicate a frontward direction and a backward direction. Arrows L and R in the drawings respectively indicate a leftward direction and a rightward direction.

[0035] As shown in FIG. 1, the motorcycle 1 includes a front wheel 2, a rear wheel 3, a vehicle body frame 4, and the rider seat 11. A handle unit 9 is provided to a portion of the vehicle body frame 4 which is frontward of the rider seat 11. A grip 9R is provided at a right end portion of the handle unit 9, and a grip 9L is provided at a left end portion of the handle unit 9. It should be noted that only the grip 9L is illustrated in FIG. 1. The grip 9R is located on the other side from the grip 9L in the left-right direction. The grip 9R is a throttle grip. A brake lever is attached in the vicinity of the grip 9R. A clutch lever 10 is attached in the vicinity of the grip 9L. An upper end portion of a front fork 7 is secured to the handle unit 9. A lower end portion of the front fork 7 supports the front wheel 2.

[0036] A swingarm 12 is swingably supported, at its front end portion, by a lower portion of the vehicle body frame 4. A rear end portion of the swingarm 12 supports the rear wheel 3. A rear suspension connects a portion of the swingarm 12 which is not a swingarm pivot to the vehicle body frame 4. The rear suspension absorbs shock in the up-down direction.

[0037] The vehicle body frame 4 supports a single-cylinder engine unit 100. The vehicle body frame 4 may directly support the engine unit 100, or may indirectly support the engine unit 100 via another member. The engine unit 100 includes a four-stroke engine 130. The detailed structure of the engine unit 100 will be described later. An air cleaner 31 is connected to the engine 130. The air cleaner 31 is configured to clean incoming outside or external air. The air, having been cleaned by the air cleaner 31, is introduced into the engine 130. A muffler 41 is connected to the engine 130. A fuel tank 14 is provided above the engine 130.

[0038] A transmission having a plurality of shift gears is provided rearward of the engine 130. The driving force of the engine 130 is transmitted to the rear wheel 3 via the transmission and a chain 26. A shift pedal 24 for changing the gears of the transmission is provided to the left of the transmission. Footrests 23 are provided to the right and left of the vehicle body frame 4. The footrests 23 are located slightly frontward of the rear wheel 3. The footrests 23 are configured to support the feet of the rider R riding the motorcycle.

[0039] A front cowling 15 is located above the front wheel 2 and in front of the grips 9R and 9L. A meter unit 16 is located between the front cowling 15 and the grips 9R and 9L in the front-back direction. The display surface of the meter unit 16 is configured to display thereon vehicle speed, engine speed, vehicle state, traveled distance, clock time, measured time, and the like.

[0040] The following will describe the engine unit 100 in detail, with reference to FIG. 2. The engine unit 100 includes, in addition to the engine 130, an intake passage member 110 and an exhaust passage member 120. The intake passage member 110 and the exhaust passage member 120 are connected to the engine 130. The engine unit 100 further includes a canister 161, and an ECU (Electronic Control Unit) 150. The engine 130 is a four-stroke single-cylinder engine. In this engine 130, a crankshaft 134 (to be described later) rotates two revolutions in one engine cycle. One engine cycle is constituted by four strokes, which are the intake stroke, the compression stroke, the combustion stroke, and the exhaust stroke. The ECU 150 is configured by hardware such as a CPU (Central Processing Unit), a ROM (Read Only Memory), a RAM (Random Access Memory), and an ASIC (Application Specific Integrated Circuit), and by software such as program data stored in the ROM and/or the RAM. The CPU executes various types of information processing based on the software such as the program data. The ASIC controls components of the engine 130 based on the results of the above information processing. With this configuration, the ECU 150 controls the components of the engine 130 so that the above-mentioned four strokes are smoothly performed.

[0041] The engine 130 includes a cylinder 131, a piston 132, and the crankshaft 134. The piston 132 is provided in the cylinder 131. The crankshaft 134 is connected to the piston 132 via a connecting rod 133. A combustion chamber 130a is provided in the cylinder 131. The combustion chamber 130a is formed by an outer surface 132a of the piston 132 and an inner wall surface 131a of the cylinder 131. The combustion chamber 130a is a space in the cylinder 131 that is created above the piston 132 at top dead center. The combustion chamber 130a communicates with an intake passage 110a and an exhaust passage 120a. The intake passage 110a is in the intake passage member 110, and the exhaust passage 120a is in the exhaust passage member 120. The following description will be given on the premise that: the space in the cylinder 131 and the intake passage 110a do not overlap each other; and the space in the cylinder 131 and the exhaust passage 120a do not overlap each other.

[0042] An intake valve 141 is provided at a communication opening between the intake passage 110a and the combustion chamber 130a. An exhaust valve 142 is provided at a communication opening between the exhaust passage 120a and the combustion chamber 130a. The engine 130 is provided with a valve operating mechanism configured to operate the intake valve 141 and the exhaust valve 142 in association with the movement of the crankshaft 134. The valve operating mechanism includes members such as a camshaft, rocker arms, rocker shafts, and the like. These members transmit power generated by the rotating crankshaft 134 to the intake valve 141 and the exhaust valve 142. This arrangement enables the intake valve 141 and the exhaust valve 142 to repeatedly open/close their respective communication openings between the intake and exhaust passages 110a and 120a and the combustion chamber 130a, at proper timings. The timings for opening/closing the valves are associated with the four strokes constituting one engine cycle. An ignition plug 143 is provided to ignite an air-fuel mixture in the combustion chamber 130a. The leading end of the ignition plug 143 is located in the combustion chamber 130a. The ignition plug 143 is electrically connected with the ECU 150. The ECU 150 controls the ignition by the ignition plug 143.

[0043] The intake passage 110a communicates with the combustion chamber 130a at one end of the intake passage member 110. The other end of the intake passage member 110 is connected to the air cleaner 31. Outside air is taken through the air cleaner 31. The air cleaner 31 cleans the air taken therethrough. Air, having been cleaned by the air cleaner 31, is introduced into the intake passage member 110. Air, having been introduced from the air cleaner 31 into the intake passage member 110, passes through a throttle body 111 toward the engine 130. The throttle body 111 forms a part of the intake passage member 110. The throttle body 111 houses therein a throttle valve 112 so that its throttle opening angle is changeable. The throttle valve 112 is supported by the throttle body 111 so that the opening degree of a portion of the intake passage 110a that is located in the throttle body 111 changes depending on the throttle opening angle of the throttle valve 112. As the throttle opening angle of the throttle valve 112 changes, the flow rate of the air passing through the throttle body 111 changes. The throttle body 111 is provided with an electric motor configured to change the throttle opening angle of the throttle valve 112. The electric motor is electrically connected with the ECU 150. The ECU 150 controls how much the throttle valve 112 is rotated by the electric motor. Due to this, the ECU 150 controls the amount of air flowing from the air cleaner 31 into the engine 130 through the intake passage member 110. As described above, the throttle valve used in this embodiment is an electrically-driven throttle valve driven by an electric motor. Alternatively, a mechanical throttle valve may be used. The mechanical throttle valve is configured so that operation on the throttle grip is transmitted to the valve through a transmission mechanism.

[0044] A fuel injector 144 is provided to the intake passage member 110. The fuel injector 144 is configured to inject fuel into the intake passage 110a. The fuel injector 144 is connected to the fuel tank 14 via a fuel supply pipe 33. Fuel is supplied to the fuel injector 144 from the fuel tank 14 through the fuel supply pipe 33. The fuel injector 144 is electrically connected with the ECU 150. The ECU 150 controls fuel injection by the fuel injector 144 into the intake passage 110a.

[0045] The exhaust passage 120a communicates with the combustion chamber 130a at one end of the exhaust passage member 120. The other end of the exhaust passage member 120 is connected to the muffler 41. Exhaust gas from the engine 130 is discharged to the muffler 41 through the exhaust passage member 120. A three-way catalyst is provided in the exhaust passage 120a. The catalyst purifies the exhaust gas flowing from the engine 130 into the exhaust passage member 120. The exhaust gas purified by the catalyst is discharged to the outside through the muffler 41.

[0046] The engine unit 100 is provided with various sensors. For example, the throttle body 111 is provided with an intake pressure sensor 151. The intake pressure sensor 151 detects the pressure in a portion of the intake passage 110a that is downstream of the throttle valve 112. The throttle body 111 is further provided with a throttle position sensor 152 which detects the throttle opening angle of the throttle valve 112. The crankshaft 134 is provided with an rpm sensor 153 which detects the rpm (revolutions per minute) of the crankshaft 134. The rpm sensor 153 also detects the position of the crankshaft 134. Signals of the detection results obtained by the sensors are transmitted to the ECU 150. The ECU 150 controls the operation of the components of the engine unit 100 based on the detection results transmitted by the sensors.

[0047] The engine unit 100 further includes a canister 161. The canister 161 is provided to suppress the discharge of fuel vapor from the fuel tank 14 to the atmosphere by collecting fuel vapor in the fuel tank 14. The canister 161 accommodates therein an adsorbent such as activated charcoal. The canister 161 is connected with the fuel tank 14 via a vent pipe 162. Fuel vapor in the fuel tank 14 flows into the canister 161 through the vent pipe 162. The fuel vapor introduced in the canister 161 is adsorbed by the adsorbent in the canister 161.

[0048] The canister 161 is also coupled to the intake passage member 110 via a communication passage member 163. The inside of the canister 161 communicates with a communication passage 163a provided in the communication passage member 163 at one end of the communication passage member 163. The other end of the communication passage member 163 is connected to a downstream intake passage portion 110d of the intake passage member 110. The downstream intake passage portion 110d is the portion of the intake passage member 110 that is downstream of the throttle valve 112.

[0049] As shown in FIG. 3, a connection portion 113 is provided to the downstream intake passage portion 110d. The communication passage member 163 is coupled to the downstream intake passage portion 110d via the connection portion 113. The connection portion 113 has, inside thereof, a communication passage 113a. The connection portion 113 projects or protrudes outward relative to the outer surface of the downstream intake passage portion 110d. The communication passage member 163 is secured to the connection portion 113 via a connection fitting 164. An outer surface of the connection fitting 164 and an inner surface of the connection portion 113 are threaded. As the threaded connection fitting 164 is screwed into the threaded portion of the connection portion 113, these members are secured to each other. A communication passage 164a is provided in the connection fitting 164. The communication passage 163a in the communication passage member 163 communicates with the intake passage 110a in the downstream intake passage portion 110d via the communication passages 113a and 164a. As a consequence, the inside of the canister 161 communicates with a downstream intake passage 110x of the intake passage 110a via the communication passages 163a, 164a, and 113a. The downstream intake passage 110x is the portion of the intake passage 110a that is located in the downstream intake passage portion 110d. In FIG. 2, the downstream intake passage 110x is shown as a part encircled by two-dot chain lines. Instead of the connection portion 113 and the connection fitting 164, a connection portion and a connection fitting each having no threaded portion may be used. For example, a connection fitting may be a union joint, and may be inserted into a connection portion having no threaded portion. In this case, the connection fitting may be inserted into the connection portion so that the leading end of the connection fitting sticks out into the downstream intake passage 110x, or so that the leading end of the connection fitting does not stick out into the downstream intake passage 110x. Alternatively, the leading end of the connection fitting may be flush with an inner wall surface of the downstream intake passage 110x.

[0050] A solenoid valve 170 is provided to an intermediate portion of the communication passage member 163. As shown in FIG. 4A, the solenoid valve 170 includes: a case 171, a core 172, a plunger 173, a coil 174, a valve body 175, and a spring 176. The case 171 is fixed to the communication passage member 163. The core 172 is provided in the case 171. Furthermore, a communication passage 163x is provided in the case 171. The communication passage 163x is bent in an Ω (ohm) shape. The communication passage 163x is a part of the communication passage 163a. The communication passage 163x contains an opening 163y. The spring 176 biases the valve body 175 downward in FIG. 4A so that the valve body 175 keeps closing the opening 163y when no current flows through the coil 174. The valve body 175 is fixed to the leading end of the plunger 173. The state shown in FIG. 4A where the valve body 175 closes the opening 163y is hereinafter referred to as a closed state. In the closed state, fuel vapor cannot flow from the canister 161 to the downstream intake passage portion 110d through the communication passage 163a.

[0051] In response to the flow of electric current through the coil 174, the plunger 173 moves upward in this figure. The valve body 175 moves upward with the plunger 173, against the biasing force of the spring 176. As a result, the solenoid valve 170 is switched to the state shown in FIG. 4B. This state is hereinafter referred to as an "open state". When the solenoid valve 170 is in the open state, the valve body 175 opens the opening 163y. This allows fuel vapor to flow from the canister 161 to the downstream intake passage portion 110d through the communication passage 163a.

[0052] The solenoid valve 170 is switchable between the open state and the closed state under the control of the ECU 150. Hereinafter, an operation of switching the solenoid valve 170 from the closed state to the open state under the control of the ECU 150 is referred to as a "switching-on operation". Meanwhile, an operation of switching the solenoid valve 170 from the open state to the closed state under control of the ECU 150 is referred to as a "switching-off operation".

[0053] Switching the solenoid valve 170 into the open state establishes communication between the inside of the canister 161 and the downstream intake passage 110x. Meanwhile, pressure is transmitted from the combustion chamber 130a to the downstream intake passage 110x. For example, the pressure in the downstream intake passage 110x is mostly below atmospheric pressure in or during the intake stroke. If the solenoid valve 170 is in the open state in the intake stroke, the pressure below atmospheric pressure is transmitted from the downstream intake passage 110x to the canister 161 through the communication passage 163a. As a result, fuel vapor in the canister 161 flows into the downstream intake passage 110x through the communication passage 163a. The fuel vapor having flowed into the downstream intake passage 110x further flows into the combustion chamber 130a. The fuel vapor introduced into the combustion chamber 130a ignites in the combustion chamber 130a. Fuel vapor in the canister 161 is thus introduced into the combustion chamber 130a, and this reduces the discharge of the fuel vapor in the canister 161 to the atmosphere.

[0054] Now, in the field of automobiles (four-wheeled vehicles), the following technique is known. A valve is provided to a passage through which fuel vapor is introduced from a canister to an intake system. With this valve, the amount of fuel vapor introduced into the canister to the intake system is controlled. As a result of technical developments pursued by the present inventors, the following fact was found. If the above technique for automobiles is applied to an engine unit widely used in straddled vehicles, a disadvantage may be caused. That is, there is a possibility that a desired amount of fuel vapor cannot be introduced from the canister to the combustion chamber. Due to this, the present inventors strived to find out a technique to ensure that a desired amount of fuel vapor is introduced from the canister to the combustion chamber. As a result of the wholehearted research, the present inventors arrived at the following arrangement.

[0055] First of all, the present inventors made an arrangement so that the capacity of a passage for fuel vapor, which is from the opening 163y to the downstream intake passage 110x, is smaller than a half of the displacement of the engine 130. The opening 163y is closeable by the valve body 175 of the solenoid valve 170.

The above-mentioned passage is the passage enclosed by a two-dot chain line in FIG. 3. The passage enclosed by the two-dot chain line in FIG. 3 is formed by: a portion of the communication passage 163a; the communication passage 113a; and the communication passage 164a. The portion of the communication passage 163a is from the opening 163y to an end of the passage 163a that is connected to the connection fitting 164. The displacement of the engine 130 equals the difference between: a capacity of the space in the cylinder 131 that is created above the piston 132 at bottom dead center; and a capacity of the combustion chamber 130a.

[0056] Furthermore, the present inventors arrived at a control method regarding the solenoid valve 170. This control method will be described with reference to FIG. 5 and FIG. 6.

[0057] Each line segment L1 in FIG. 5 shows the period during which the intake valve 141 is open in a four-stroke cycle. Each line segment L2 shows the period during which the exhaust valve 142 is open in the four-stroke cycle. Curves P1 and P2 show pressure variation in the downstream intake passage 110x. Numerical values plotted on the abscissa in FIG. 5 represent crank angles in degrees. In this embodiment, the crank angle of 0 degree corresponds to the timing around the midpoint of the period from the timing for opening the intake valve 141 to the timing for closing the exhaust valve 142. The ordinate in FIG. 5 represents pressure values, for a graph showing the pressure variation in the downstream intake passage 110x.

[0058] The curve P1 shows the pressure variation in the condition where the crankshaft 134 rotates at a predetermined rpm. The curve P2 shows the pressure variation in the condition where: the throttle opening angle of the throttle valve 112 is the same as that for the curve P1; and the crankshaft 134 rotates at an rpm higher than that for the curve P1. As shown in the curves P1 and P2, the pressure in the downstream intake passage 110x starts to drop from atmospheric pressure a short time after the intake valve 141 starts to open. For the curve P1, the pressure reaches a bottom or a lowest value at around a crank angle of 180 degrees, and then turns to rise. After the intake valve 141 is closed, the pressure returns to the vicinity of the atmospheric pressure, at around a crank angle of 360 degrees. Then, the pressure slightly fluctuates around the atmospheric pressure and gradually becomes substantially constant. Meanwhile, for the curve P2, after the pressure reaches a bottom or a lowest value at around a crank angle of 200 degrees, the pressure returns to the atmospheric pressure more gently than in the pressure variation of the curve P1. In addition, the smallest pressure value in the curve P2 is smaller than that in the curve P1.

[0059] As such, a larger depression having a larger difference from atmospheric pressure and a smaller depression having a smaller difference from atmospheric pressure are created in order or sequence in each four-stroke cycle, in response to opening and closing of the intake valve 141. The larger depression appears around the range from 180 to 200 degrees, in the curves P1 and P2. The smaller depression appears in the range from 360 to 720 degrees in the curve P1, and in the range from 540 to 720 degrees in the curve P2. As the four-stroke cycle is repeated, the above pressure variation is repeatedly caused in the downstream intake passage 110x. Thus, the pressure varies in a pressure-variation manner such that the creation of the larger and smaller depressions is repeated on a four-stroke basis. This pressure-variation manner can be observed in the engine unit widely used in four-stroke straddled vehicles. The shift from the curve P1 to the curve P2 is caused by the increase in the rpm of the crankshaft, as described above. The curve P1 shifts in the same manner also when the throttle opening angle of the throttle valve 112 is decreased without changing the rpm of the crankshaft. That is to say, the smaller the throttle opening angle of the throttle valve 112 is, the greater the amount of pressure variation is.

[0060] The present inventors devised the following method for controlling the solenoid valve 170 by the ECU 150: switching operations of the solenoid valve 170 are controlled in association with the above-described pressure-variation manner observed in the engine unit widely used in four-stroke straddled vehicles. Note that "in association with the pressure-variation manner" means that the switching operations are controlled with reference to the timing at which a depression is created.

[0061] To be more specific, the present inventors used the control methods based on timing charts C1 to C3 in the lower portion of FIG. 5. The charts C1 to C3 correspond to the control methods different from one another. Any of the control methods based on the charts C1 to C3 may be used as the method for controlling the valve by the ECU 150. Alternatively, a combination of any two or more of the control methods based on the charts C1 to C3 may be used. In each of the charts C1 to C3, lines at the level labelled with "open" in FIG. 5 represent the periods during which the solenoid valve 170 is in the open state. Lines at the level labelled with "closed" in FIG. 5 represent the periods during which the solenoid valve 170 is in the close state.

[0062] In each of the control methods based on the charts C1 to C3, each of switching-on and switching-off operations is performed once in each four-stroke cycle. The switching-on operation is the operation to switch the solenoid valve 170 from the closed state to the open state. The switching-off operation is the operation to switch the solenoid valve 170 from the open state to the closed state. As a result of the above operations, fuel vapor flows from the communication passage 163a into the downstream intake passage 110x while the solenoid valve 170 is in the open state in each four-stroke cycle. The period during which the solenoid valve 170 is in the open state may be hereinafter referred to as an "open period of the solenoid valve 170". The length of the open period of the solenoid valve 170 is adjustable by changing at least one of the timings for the switching-on operation and for the switching-off operation.

[0063] In this example, the timing for the switching-on operation is fixed in the four-stroke cycle. The length of the open period of the solenoid valve 170 is adjusted by changing the timing for the switching-off operation. Now, the timings for switching-on and switching-off operations in each four-stroke cycle are expressed in crank angles from 0 to 720 degrees. As shown in FIG. 5, the timing T1 for the switching-on operation in the chart C1 is at a crank angle of 660 degrees in each four-stroke cycle. The timing for the switching-on operation is the same among all the four-stroke cycles. The switching-on operation in the chart C1 is timed immediately before the timing for opening the intake valve 141 in each cycle. The timing for opening the intake valve 141 is indicated by the left end of each line segment L1 in FIG. 5. The timing for switching-on operation in the chart C2 is at a crank angle of 90 degrees in every four-stroke cycle. The switching-on operation in the chart C2 is timed in the course of pressure drop in the downstream intake passage 110x and before the pressure reaches the smallest value. The timing for the switching-on operation in the chart C3 is at a crank angle of 270 degrees in every four-stroke cycle. The switching-on operation in the chart C3 is timed after the pressure in the downstream intake passage 110x reaches the smallest value and in the course of the pressure rising to atmospheric pressure.

[0064] Each of the charts C1 to C3 in FIG. 5 shows the case where the length of the open period of the solenoid valve 170 is half of the length of the period corresponding to the four-stroke cycle. In other words, supposing the length of the period corresponding to the four-stroke cycle is 100%, the length of the open period of the solenoid valve 170 is 50% in each of the charts C1 to C3 in FIG. 5. Hereinafter, when the length of the open period of the solenoid valve 170 is expressed as a percentage, such an expression will be given on the premise that the length of the period corresponding to the four-stroke cycle is 100%.

[0065] The length of the open period of the solenoid valve 170 is adjusted by changing the timing for the switching-off operation. For example, in the chart C1, the timing for the switching-off operation can be changed from T2 (300 degrees) to T3 (120 degrees). Due to this, the length of the open period of the solenoid valve 170 is changed from 50% to 25%. In the chart C1, the switching-off operation is performed first and then the switching-on operation is performed in each four-stroke cycle. Contrary to this, in the charts C2 and C3, the switching-on operation is performed first and then the switching-off operation is performed in each four-stroke cycle. Thus, it does not matter in which order the switching-on and switching-off operations are performed in each four-stroke cycle.

[0066] The above-mentioned timings (crank angles) for the switching-on and switching-off operations are controlled based on the crank position of the crankshaft 134 detected by the rpm sensor 153.

[0067] Now, consideration is given to the amount of fuel vapor flowing from the communication passage 163a into the downstream intake passage 110x according to the control methods based on the charts C1 to C3. The amount of introduced fuel vapor depends on the relationship between the open period of the solenoid valve 170 and the pressure in the downstream intake passage 110x. For example, the period from T1 to T2 in the chart C1 is the open period of the solenoid valve 170. In this period, a larger depression having a relatively large difference from atmospheric pressure is created in both the curves P1 and P2, as shown in portions thereof enclosed with a two-dot chain line A1 in FIG. 5. During this period, fuel vapor flows from the communication passage 163a into the downstream intake passage 110x, the amount of which changes as the amount of the depression varies.

[0068] As described above, the timing for the switching-off operation is changeable in this example. When the timing for the switching-off operation is changed, a change is caused in the relationship between the open period of the solenoid valve 170 and the pressure in the downstream intake passage 110x. For example, suppose that the timing for the switching-off operation is changed from T2 to T3 in the chart C1 (see a broken line shown in the chart C1.) With this change, the length of the open period of the solenoid valve 170 is changed from 50% to 25%. Then, the portions of each of the curves P1 and P2 indicating the larger depression created during the open period of the solenoid valve 170 are changed from the portions enclosed with the two-dot chain line A1 to the portions enclosed with a two-dot chain line A2. As a result, the amount of fuel vapor flowing from the communication passage 163a into the downstream intake passage 110x decreases.

[0069] Thus, in the control methods based on the charts C1 to C3, which are included in the control method of this embodiment, the ECU 150 is able to change the timing for the switching-off operation, while the timing for the switching-on operation is fixed. As such, in these control methods, the switching-on operation is performed in synchronization with the four-stroke cycle (four-stroke period). The expression "in synchronization with the four-stroke cycle" means that the timing for an operation in each four-stroke cycle is the same among the four-stroke cycles. By changing the timing for the switching-off operation in each four-stroke cycle, a change is caused in the relationship between the open period of the solenoid valve 170 and the pressure variation in each four-stroke cycle. Alternatively, an arrangement contrary to the above may be adopted: the timing for the switching-off operation may be synchronized with the four-stroke cycles, while the timing for the switching-on operation is changeable. The open period of the solenoid valve 170 may be changed by this arrangement.

[0070] The amount of fuel vapor flowing from the communication passage 163a into the downstream intake passage 110x is adjustable by changing the open period of the solenoid valve 170 in the above way. The control method of this embodiment makes it less likely that the amount of fuel vapor flowing from the communication passage 163a into the downstream intake passage 110x unexpectedly varies unless the manner of pressure variation in each four-stroke cycle widely changes.

[0071] For example, suppose that the open period of the solenoid valve 170 is fixed to 50% in the chart C1. In this case, the portions of the curve P1 indicating the larger depression created during the open period of the solenoid valve 170 are the portions enclosed with the two-dot chain lines A1 and A1' in FIG. 5. As can be seen from the comparison between the portions of the curve P1 encircled with the two-dot chain lines A1 and A1', there is no substantial difference in the manner of pressure variation between these portions. That is, unless the manner of the pressure variation widely changes, a change is less likely to be caused in the relationship between the open period of the solenoid valve 170 and the pressure variation, as long as the open period is fixed. Consequently, the amount of fuel vapor flowing from the communication passage 163a into the downstream intake passage 110x is less likely to change.

[0072] In the meantime, if the driving status of the motorcycle 1 changes, a change is caused also in the manner of the pressure variation in the downstream intake passage 110x. For example, if the rpm of the engine 130 changes, the manner of the pressure variation in the downstream intake passage 110x changes from the manner shown by the curve P1 to that shown by the curve P2. Therefore, even though the open period of the solenoid valve 170 is fixed, for example, under the control based on the chart C1, the change in the rpm causes a difference in the amount of fuel vapor flowing from the communication passage 163a into the downstream intake passage 110x. Specifically, there is a difference in the amount of fuel vapor between the case where the engine 130 runs at the rpm in the curve P1 and the case where the engine 130 runs at the rpm in the curve P2. Furthermore, the change in the rpm of the engine 130 also causes a change in the amount of air flowing into the combustion chamber 130a. Thus, the change in the rpm changes the amounts of inflow of fuel vapor and inflow of air. This changes the degree of influence of fuel vapor on the air-fuel ratio of the air-fuel mixture in the combustion chamber 130a. For this reason, introduction of fuel vapor into the combustion chamber 130a may hinder stable burning of the air-fuel mixture in the combustion chamber 130a at a desired air-fuel ratio.

[0073] Hence, for the purpose of stable burning of fuel in the combustion chamber 130a, the ECU 150 of this embodiment is configured to control the amount of fuel vapor introduced into the combustion chamber 130a as follows. The ECU 150 controls the length of the open period of the solenoid valve 170 based on the following detection values. The detection values are: the detection value for the rpm of the engine 130; and the detection value for the pressure in the downstream intake passage 110x or the detection value for the throttle opening angle of the throttle valve 112. These detection values are obtained from detection results obtained by the sensors 151 to 153. Which of the detection values (the detection value for the pressure in the downstream intake passage 110x and the detection value for the throttle opening angle of the throttle valve 112) is used is determined based on the driving status. For example, the detection value for the pressure in the downstream intake passage 110x may be used when the rpm of the engine 130 is low, and the detection value for the throttle opening angle of the throttle valve 112 may be used when the rpm of the engine 130 is high. Each detection value used for the control may be an average of values detected in a predetermined period of time. Alternatively, periodically detected values may be used for the control. The frequency of such detection may be once in each four-stroke cycle, or once in a plurality of four-stroke cycles.

[0074] The ECU 150 performs the control so that the ratio of the amount of inflow of fuel vapor per four-stroke cycle to the amount of air taken into the engine satisfies the relationship shown in FIG. 6A. Note that the amount of air taken into the engine may be referred to as an "engine-intake air amount". The engine-intake air amount is equivalent to a "combustion chamber-introduction air amount" in the present teaching. The abscissa of the graph in FIG. 6A represents the engine-intake air amount. The engine-intake air amount is the amount of air flowing into the combustion chamber 130a per four-stroke cycle. This amount is obtainable from: the rpm of the engine 130; and the throttle opening angle of the throttle valve 112 or the pressure in the downstream intake passage 110x. The ordinate of the graph in FIG. 6A represents the ratio of the amount of inflow of fuel vapor to the engine-intake air amount. Hereinafter, this ratio is referred to as a "fuel vapor ratio". The fuel vapor ratio is a percentage of the amount of fuel vapor flowing from the communication passage 163a into the downstream intake passage 110x per four-stroke cycle relative to the engine-intake air amount.

[0075] As shown in FIG. 6A, when the engine-intake air amount is smaller than a first value q1, the control is made so that the fuel vapor ratio simply increases with the increase in the engine-intake air amount. The larger the engine-intake air amount is, the smaller the influence of the fuel vapor introduced into the combustion chamber 130a on the combustion of the fuel is. Accordingly, by increasing the amount of fuel vapor introduced into the combustion chamber 130a with the increase in the engine-intake air amount, a large amount of fuel vapor is introduced into the combustion chamber 130a with a small influence on the combustion of the fuel. When the engine-intake air amount exceeds the first value q1, the control is made so that the fuel vapor ratio is kept constant at a predetermined value of R%. This is because, if the percentage of the amount of fuel vapor to the engine-intake air amount exceeds R%, control of the combustion in the engine 130 is difficult. When the engine-intake air amount further increases (e.g., when the engine-intake air amount exceeds a second value q2 larger than the first value q1), the fuel vapor ratio decreases with an increase in the engine-intake air amount. This is because, if the engine-intake air amount exceeds the second value q2, the fuel vapor ratio decreases with the increase in the engine-intake air amount even though the length of the open period of the solenoid valve 170 is set to 100%. The reason why the fuel vapor ratio decreases is as follows. The difference in the pressure in the downstream intake passage 110x from atmospheric pressure decreases when the engine-intake air amount increases at a constant rpm. The decreased difference in pressure makes it difficult for the fuel vapor to flow into the downstream intake passage 110x. This makes the increment in the amount of inflow of fuel vapor smaller than the increment in the engine-intake air amount.

[0076] In order to adjust the fuel vapor ratio to satisfy the relationship shown in FIG. 6A, the amount of introduced fuel vapor to the engine-intake air amount has to be controlled at a desired value. The amount of fuel vapor flowing from the communication passage 163a to the downstream intake passage 110x depends on the pressure in the downstream intake passage 110x. Then, the ECU 150 controls the solenoid valve 170 so that the length of the open period of the solenoid valve 170 is changed depending on the pressure in the downstream intake passage 110x, so as to satisfy the relationship shown in FIG. 6B. The pressure in the downstream intake passage 110x corresponds to a value detected by the intake pressure sensor 151, for example. As shown in FIG. 6B, the length of the open period of the solenoid valve 170 is adjusted so that the length increases as the pressure in the downstream intake passage 110x approaches the atmospheric pressure. A desired amount of inflow of fuel vapor is ensured by increasing the length of the open period of the solenoid valve 170 as the pressure in the downstream intake passage 110x approaches the atmospheric pressure.

[0077] The ECU 150 of this embodiment is configured to control the length of the open period of the solenoid valve 170 without calculating any of the engine-intake air amount and the fuel vapor ratio, as described below. The ECU 150 includes a storage unit. The storage unit stores therein: information for the length of the open period of the solenoid valve 170; and information for the rpm of the engine 130 and for the pressure in the downstream intake passage 110x. These pieces of information are associated with each other. The storage unit of the ECU 150 further stores therein: information for the length of the open period of the solenoid valve 170; and information for the rpm of the engine 130 and for the throttle opening angle of the throttle valve 112. These pieces of information are associated with each other. These pieces of information have been associated with each other in such a manner that the control by the ECU 150 satisfies the relationships shown in FIG. 6A and FIG. 6B when the ECU 150 controls the solenoid valve 170 based on the stored information and detection values. The ECU 150 obtains a piece of information for the length of the open period of the solenoid valve 170 from the storage unit. This piece of information is obtained based on: the detection value for the rpm of the engine 130; and the detection value for the pressure in the downstream intake passage 110x or the detection value for the throttle opening angle of the throttle valve 112. The ECU 150 controls the switching operations of the solenoid valve 170 so that the length of the open period of the solenoid valve 170 in each four-stroke cycle is equal to the length indicated by the piece of information obtained from the storage unit. In this embodiment, based on the charts C1 to C3, the timing for the switching-off operation is adjusted in each four-stroke cycle with the timing for the switching-on operation fixed, as described above.

[0078] FIG. 7 is a graph showing changes in the amount of inflow of fuel vapor as a function of the length of the open period of the solenoid valve 170, under the control of the solenoid valve 170 based on the charts C1 to C3. A curve Q1 shows the change in the amount of inflow of fuel vapor under controls based on the charts C1 to C3 in the situation where the throttle opening angle of the throttle valve 112 is relatively small or the rpm of the engine 130 is relatively high. When the throttle opening angle of the throttle valve 112 is relatively small or the rpm of the engine is relatively high, the pressure in the downstream intake passage 110x is generally kept below atmospheric pressure over the period of four strokes, as shown by the curve P2 in FIG. 5, for example. Therefore, whichever of the charts C1 to C3 the control is based on, the amount of inflow of fuel vapor increases substantially linearly with an increase in the length of the open period of the solenoid valve 170, as shown by the curve Q1.

[0079] Meanwhile, when the throttle opening angle of the throttle valve 112 is relatively large or the rpm of the engine is relatively low, the manner of increase in the amount of inflow of fuel vapor differs depending on which of the charts C1 to C3 the control is based on. A curve Q2 shows the change in the amount of inflow of fuel vapor under control based on the chart C1 when the throttle opening angle of the throttle valve 112 is relatively large or the rpm of the engine is relatively low. The curve Q2 shows that the amount of inflow of fuel vapor substantially stably increases over the whole range from 0% to 100%. However, the increase of the curve Q2 is not as linear as that of the curve Q1. Furthermore, there is a smaller difference in the amount of inflow between the curves Q1 and Q2. Curves Q3 and Q4 respectively show the changes in the amount of inflow of fuel vapor under controls based on the chart C2 and C3 when the throttle opening angle of the throttle valve 112 is relatively large or the rpm of the engine is relatively low. As shown in these curves, under the control based on the chart C2 or C3, the amount of inflow of fuel vapor is smaller in most of the range from 0% to 100% than those in the cases shown by the curves Q1 and Q2. Furthermore, the manner of increase in the amount of inflow is less stable.

[0080] The reason why the change in the rpm causes differences among the curves showing the change in the amount of inflow of fuel vapor is as follows. As shown in the curves P1 and P2 in FIG. 5, for example, the manner of the pressure variation in the downstream intake passage 110x changes depending on the rpm. Particularly under the controls based on the charts C2 and C3, the switching-on operation is timed after the pressure in the downstream intake passage 110x starts to widely drop below atmospheric pressure. As shown in FIG. 5, the difference in the manner of pressure variation caused by the difference in the rpm mainly appears in the period after the timing at which the pressure in the downstream intake passage 110x reaches its smallest value. For this reason, under the controls based on the charts C2 and C3, a larger difference is caused in the amount of inflow of fuel vapor by the difference in the rpm. Meanwhile, the switching-on operation in the chart C1 is timed immediately before the intake valve 141 is open. That is, for both the curves P1 and P2, the switching-on operation in the chart C1 is timed immediately before the pressure in the downstream intake passage 110x starts to widely drop below atmospheric pressure. For this reason, under the control based on the chart C1, the smaller difference is caused in the amount of inflow of fuel vapor by the difference in the rpm.

[0081] As a consequence, the chart C1 is suitable for the control of the amount of inflow of fuel vapor. In the chart C1, the switching-on operation is timed immediately before the intake valve 141 opens. The control based on the chart C1 is effective also on the following point. After the intake valve 141 is switched from the closed state to the open state, the pressure in the downstream intake passage 110x starts to drop. In view of the above, the solenoid valve 170 is opened in advance, before the completion of the period during which the intake valve 141 is closed. This enables fuel vapor to flow from the canister 161 into the intake passage 110a promptly in response to the start of the pressure drop in the downstream intake passage 110x. Note that there may be some time lag between the timing for the switching-on operation and the timing for opening the intake valve 141. For example, the timing for the switching-on operation may be before that in the chart C1, as long as the timing for the switching-on operation is within the last half of the period during which the intake valve 141 is closed.

[0082] The solenoid valve 170 may be controlled based on the engine-intake air amount calculated based on the detection values. The detection values are: the detection value for the rpm of the engine 130; and the detection value for the pressure in the downstream intake passage 110x or the detection value for the throttle opening angle of the throttle valve 112. For example, the ECU 150 may be configured as follows. The storage unit of the ECU 150 stores therein data indicating the graphs of FIG. 6A and FIG. 6B. The ECU 150 calculates the engine-intake air amount using the detection values. Then, the ECU 150 obtains the fuel vapor ratio corresponding to the thus calculated engine-intake air amount, with reference to the graph of FIG. 6A. Subsequently, the ECU 150 obtains the length of the open period of the solenoid valve 170 corresponding to the pressure in the downstream intake passage 110x derived from the detection value, with reference to the graph of FIG. 6B. Furthermore, the ECU 150 switches the solenoid valve 170 based on the thus obtained length of the open period of the solenoid valve 170.

[0083] It should be noted that the graphs of FIG. 6A and FIG. 6B are merely ideal examples referred to in the control by the ECU 150. It is just preferable that the control is made so as to satisfy the relationships shown in these graphs as much as possible. Note that the control does not have to be made so that its result strictly satisfies the relationships shown in these graphs.

[0084] According to the example described above, a desired amount of fuel vapor is able to be introduced to the combustion chamber 130a, unlike the case where the arrangement for automobiles is applied as it is to a straddled vehicle. The following will describe the reason why the desired amount of fuel vapor is introduced.

[0085] The present inventors compared depressions created in the intake passage in the engine unit widely used in straddled vehicles with those in the engine unit widely used in automobiles. As a result of the comparison, the present inventors found that there is the following difference between straddled vehicles and automobiles. In some of the engine units widely used in automobiles, pressure variation in the downstream intake passage portion is suppressed by virtue of a surge tank provided downstream of the throttle valve, for example. Furthermore, in an automobile's engine unit with independent throttle bodies, pressure variation for each cylinder is suppressed, for example by providing one or more communication pipes to establish communication between the downstream intake passage portions. In such a case, pressure in the downstream intake passage portion(s) is relatively stable. For this reason, when a communication passage is provided to establish communication between the canister and the downstream intake passage portion(s), pressure in the communication passage is also relatively stable. This makes it easier to stabilize the amount of fuel vapor introduced into the intake passage through this communication passage.

[0086] To the contrary, in the motorcycle 1, which is an example of straddled vehicles, the four-stroke-basis large negative-pressure variation is caused in the downstream intake passage 110x. This is shown by the curves P1 and P2 in FIG. 5. Suppose that, under the above circumstance, a tank with a large capacity is provided to the passage through which fuel vapor is introduced from the canister to the downstream intake passage, as in the known technique for automobiles. This makes it difficult for the pressure in the passage for introducing fuel vapor to quickly follow the variation in pressure in the downstream intake passage. It was found that the above arrangement may cause a delay in the timing for introducing fuel vapor into the downstream intake passage, and as a consequence, there is a possibility that a desired amount of fuel vapor cannot be introduced.

[0087] To deal with this, in the present embodiment, the amount of introduced fuel vapor is adjusted on the premise that the above-described pressure variation exists, or rather, with the use of the pressure variation. That is, the solenoid valve 170 is controlled on the basis of a pressure-variation manner in which: a smaller depression having a smaller difference from atmospheric pressure and a larger depression having a larger difference from atmospheric pressure are created in each four-stroke cycle; and the creation of the smaller and larger depressions is repeated on a four-stroke basis. Specifically, the switching operations of the solenoid valve 170 are controlled to be performed in association with a pressure-variation manner such that: a smaller depression having a smaller difference from atmospheric pressure and a larger depression having a larger difference from atmospheric pressure are created in each four-stroke cycle; and the creation of the smaller and larger depressions is repeated on a four-stroke basis.

[0088] Meanwhile, in the control of the solenoid valve 170 in association with the above pressure-variation manner in which the pressure greatly varies in each four-stroke cycle, the variation in pressure in the communication passage 163a has to promptly follow the operation of the valve. If the portion of the communication passage that is from the solenoid valve 170 to the intake passage 110a has a relatively large capacity, it is difficult for the pressure in the communication passage 163a to promptly react to the variation in pressure in the downstream intake passage 110x. This may cause a delay in the timing for introducing fuel vapor into the combustion chamber 130a because the variation in pressure cannot promptly follow the operation of the solenoid valve 170.

[0089] To deal with the above problem, the following arrangement is made in this embodiment. In order to realize the control in which high followability is required as above, the solenoid valve 170 (the valve body 175) is provided so that the capacity of the passage for fuel vapor, which is from the opening 163y to the downstream intake passage 110x, is smaller than a half of the displacement of the engine 130. The above-mentioned passage is the passage enclosed by the two-dot chain line in FIG. 3. Because the capacity of the passage from the downstream intake passage 110x to the opening 163y is small as described above, a variation in pressure in the downstream intake passage 110x is transmitted to the opening 163y in a shorter time. This facilitates smooth association between the operation of the solenoid valve 170 and the variation in pressure, and reduces the delay in the timing for introducing fuel vapor into the combustion chamber 130a. With the above-described arrangement, introduction of a desired amount of fuel vapor into the combustion chamber 130a is achieved in the engine unit 100 in which pressure varies greatly on a four-stroke basis.

[0090] In the control of the solenoid valve 170 in association with the pressure-variation manner, in this embodiment, the timing for the switching-off operation of the solenoid valve 170 is adjusted while the timing for the switching-on operation of the solenoid valve 170 synchronized with the four-stroke cycle. This makes it possible to adjust the length of the period in which the solenoid valve 170 is in the open state. As such, the solenoid valve 170 is controlled in association with the four-stroke-basis pressure-variation manner. This arrangement makes it easier to control the amount of fuel vapor introduced from the communication passage 163a into the downstream intake passage 110x in each four-stroke cycle at a desired level.

[0091] It should be noted that the timing for the switching-on operation may be changed as follows. Specifically, instead of being synchronized with the four-stroke cycle, the timing for the switching-on operation may be shifted earlier as the rpm of the engine 130 increases. In other words, the crank angle at which the switching-on operation is performed may be decreased with the increase in the rpm. There is a short time lag between the timing at which fuel vapor actually starts to flow from the communication passage 163a into the downstream intake passage 110x and the timing for the switching-on operation. Meanwhile, when the rpm increases, the absolute length of the period for the four-stroke cycle decreases. Therefore, as the rpm increases, the time lag between the timing for the switching-on operation and the start of the inflow of the fuel vapor increases relative to the length of the period for the four-stroke cycle. To deal with this, the timing for the switching-on operation in each four-stroke cycle may be shifted earlier as the rpm increases. This makes the influence caused by the above time lag smaller.

[0092] As described above, the timings for the switching-on and switching-off operations are controlled based on the crank position (crank angle) of the crankshaft 134 detected by the rpm sensor 153. However, the switching-on and switching-off operations may be performed based on the detection result obtained by the intake pressure sensor 151 or the like. That is, these operations may be performed at their respective timings directly associated with the pressure variation caused in the downstream intake passage 110x in each four-stroke cycle and detected by the intake pressure sensor 151 or the like.

[0093] The following will describe control methods other than the control methods based on the charts C1 to C3, with reference to FIG. 8 and FIG. 9. In FIG. 8 and FIG. 9, a curve P3 shows how the pressure in the downstream intake passage 110x varies under the condition where the rpm of the engine 130 is constant. As well as the curves P1 and P2, the curve P3 also shows the pressure-variation manner such that the creation of the larger and smaller depressions is repeated on a four-stroke basis.

[0094] In the above-described control methods based on the charts C1 to C3, each of the switching-on and switching-off operations of the solenoid valve 170 is performed once in each four-stroke cycle. Meanwhile, in the control methods based on the charts C4 to C6 in FIG. 8, each of the switching-on and switching-off operations is performed twice or more in each four-stroke cycle. The chart C4 shows the case where each of the switching-on and switching-off operations is performed once in each one-stroke period. The charts C5 and C6 each shows the case where each of the switching-on and switching-off operations is performed once in each two-stroke period. As shown in these charts, the solenoid valve 170 may be controlled in association with the one-stroke or two-stroke period. It should be noted that the control in association with the one-stroke or two-stroke period is encompassed by the control in association with the four-stroke cycle. That is, within the control in association with the four-stroke cycle, the control is further subdivided to the control in each one-stroke or two-stroke period. For this reason, the control methods based on the charts C4 to C6 are included in the control in association with the four-stroke-basis pressure-variation manner.

[0095] In the control based on the chart C4, the timing for the switching-on operation may be synchronized with the one-stroke period. In other words, the timing for the switching-on operation in each one-stroke period may be the same among the one-stroke periods. Furthermore, in the control based on the chart C5 or C6, the timing for the switching-on operation may be synchronized with the two-stroke period. In other words, the timing for the switching-on operation in each two-stroke period may be the same among the two-stroke periods. When the timing for the switching-on operation is synchronized with the one-stroke or two-stroke period as described above, the length of the open period of the solenoid valve 170 is changed by changing the timing for the switching-off operation. Alternatively, the length of the open period of the solenoid valve 170 may be changed by changing the timing for the switching-on operation while the timing for the switching-off operation is synchronized with the one-stroke or two-stroke period. In addition, the control in association with the two-stroke period may be made as shown in the chart C6. That is, the period from the switching-on operation to the switching-off operation may stride the boundary between two strokes.

[0096] A chart C7 shown in FIG. 9 shows the control in association with the period corresponding to two four-stroke cycles, instead of one four-stroke cycle. That is, the chart C7 shows the control in association with the eight-stroke period. Charts C8 and C9 each shows the control in association with the period corresponding to three four-stroke cycles, i.e., the twelve-stroke period. Thus, the control may be made in association with an n-stroke period, where n is a multiple of 4. Under such a control, fuel vapor is introduced into the downstream intake passage 110x in a four-stroke cycle of the n-stroke period, where n is a multiple of 4, but fuel vapor is not introduced in the remaining four-stroke cycle(s). In each of the four-stroke cycles in which fuel vapor is introduced, the solenoid valve 170 is controlled in association with the manner of pressure variation in each four-stroke cycle.

[0097] A chart C10 shows an example of controls in association with the four-stroke cycle but not in synchronization with the four-stroke cycle. As shown in the chart C10, none of the timings for the switching-on and off operations is synchronized with the four-stroke cycle. Thus, the expression "in association with" in the present teaching encompasses the case where the timing for an operation is synchronized with the four-stroke cycle and the case where the timing for an operation is not synchronized with the four-stroke cycle. For example, suppose that it is desired to keep the amount of fuel vapor introduced into the downstream intake passage 110x in each four-stroke cycle at a desired level. In this case, the open period of the solenoid valve 170 does not have to be the same among the four-stroke cycles. The open period may be different among the four-stroke cycles as shown in the chart C10, as long as the following condition is satisfied. That is, it is only required that the amount of fuel vapor introduced into the downstream intake passage 110x in each four-stroke cycle is kept at a desired value as a result of the control of the switching-on and switching-off operations of the solenoid valve 170 in association with the four-stroke-basis pressure-variation manner.

[0098] The following will describe a second example of the present teaching. Some of the components in the second example are the same as those in the first embodiment. The following description mainly deals with the components in the second example that are different from those of the first example. Furthermore, the components the same as those in the first embodiment are given the same reference numerals, and description thereof are not repeated if appropriate.

[0099] In the second example, an ECU 250 is provided in place of the ECU 150 of the first example. The ECU 250 is configured to control each part of a motorcycle related to the second example. The control by the ECU 250 is similar to that by the ECU 150, except the control related to the components different from those of the first example.

[0100] Furthermore, in the second example, a flow regulating valve 270 is provided instead of the solenoid valve 170 of the first example. As shown in FIG. 10A, the flow regulating valve 270 includes: a case 271, a stepping motor 272, a rotor shaft 273, a valve body 275, and a spring 276. The case 271 is fixed to the communication passage member 163. The stepping motor 272 is provided in the case 271. Furthermore, a communication passage 163x is provided in the case 271. The communication passage 163x is bent in an Ω (ohm) shape. The communication passage 163x is a part of the communication passage 163a. The spring 276 biases the valve body 275 downward in FIG. 10A. The valve body 275 has a leading end portion 275a. The leading end portion 275a has a conical frustum shape tapering narrower toward its lower end in FIG. 10A. In the state shown in FIG. 10A, the leading end portion 275a of the valve body 275 completely closes an opening 163y. The opening 163y is contained in the communication passage 163x. The valve body 275 has a threaded hole 275b. The rotor shaft 273 is inserted into the threaded hole 275b from above in FIG. 10A. The rotor shaft 273 has a threaded portion 273a at its leading end portion. The threaded portion 273a is screwed into the threaded hole 275b.

[0101] The stepping motor 272 is configured to rotate the rotor shaft 273. The angle of rotation of the rotor shaft 273 by the stepping motor 272 is controllable in a stepwise manner. The valve body 275 has a restriction portion 275c. The restriction portion 275c projects or protrudes outward from a main body of the valve body 275. The rotation of the valve body 275 is restricted by the restriction portion 275c when the restriction portion 275c comes into contact with an inner surface of the communication passage 163x. As described above, the threaded portion 273a of the rotor shaft 273 is screwed in the threaded hole 275b of the valve body 275. Thus, when the rotor shaft 273 rotates in a first direction, the valve body 275 moves upward in FIG. 10A against the spring 276 biasing the valve body 275. When the valve body 275 reaches an upper limit position, the leading end portion 275a of the valve body 275 opens the opening 163y with the maximum opening degree, as shown in FIG. 10B. Meanwhile, when the rotor shaft 273 rotates in a second direction opposite to the first direction, the valve body 275 moves downward in FIG. 10B. When the valve body 275 reaches a lower limit position, the leading end portion 275a completely closes the opening 163y again, as shown in FIG. 10A.

[0102] Reference is made to FIG. 10A where the valve body 275 completely closes the opening 163y. In this state, communication of fuel vapor between the canister 161 and the downstream intake passage portion 110d is not possible. Meanwhile, when the valve body 275 opens the opening 163y, communication of fuel vapor between the canister 161 and the downstream intake passage portion 110d via the opening 163y is allowed. The amount of fuel vapor passable through the opening 163y depends on the opening degree of the opening 163y opened by the valve body 275. In the state of FIG. 10B, the valve body 275 opens the opening 163y with the maximum opening degree. The amount of fuel vapor passable through the opening 163y is at the maximum in this state.

[0103] The ECU 250 controls the opening degree of the opening 163y opened by the valve body 275, by controlling the angle of rotation of the rotor shaft 273 by the stepping motor 272 in a stepwise manner. As such, the ECU 250 controls the opening degree of the opening 163y in the flow regulating valve 270. Hereinafter, this opening degree is referred to as an "opening degree of the flow regulating valve 270." The amount of fuel vapor introduced from the canister 161 into the combustion chamber 130a depends on: the opening degree of the flow regulating valve 270; and the pressure in the downstream intake passage 110x. The amount of introduced fuel vapor is changeable to one of a plurality of levels, by adjusting the opening degree of the flow regulating valve 270 to corresponding one of a plurality of levels.

[0104] This example is also arranged so that the capacity of the passage for fuel vapor, which is from the opening 163y to the downstream intake passage 110x, is smaller than a half of the displacement of the engine 130. The opening 163y is closeable by the valve body 275 of the flow regulating valve 270.

[0105] Now, the control of the flow regulating valve 270 by the ECU 250 will be more specifically described with reference to FIG. 11 and FIG. 12. Note that the line segments L1 and L2 and the curves P1 and P2 are similar to those in the graph in FIG. 4.

[0106] The ECU 250 obtains the pressure in the downstream intake passage 110x at a specific timing in each four-stroke cycle (each cycle), based on the detection results obtained by the sensors 151 to 153. The specific timing is, for example, a timing T4 in FIG. 11. The timing T4 corresponds to the crank angle of approximately 210 degrees. Then, at least based on the obtained pressure, the ECU 250 controls the opening degree of the flow regulating valve 270 so as to be an appropriate degree in accordance with the pressure in the downstream intake passage 110x. On the basis of the detected pressure in the downstream intake passage 110x, the ECU 250 keeps or changes the opening degree of the flow regulating valve 270. The timing to change the opening degree of the flow regulating valve 270 may be within a four-stroke cycle, or may correspond to the boundary between four-stroke cycles, i.e., at a crank angle of 0 or 720 degrees.

[0107] The ECU 250 may control the flow regulating valve 270 based on the values of pressure in the downstream intake passage 110x detected at a plurality of timings in a four-stroke cycle. For example, the ECU 250 may control the flow regulating valve 270 as follows: the ECU 250 obtains pressure values at timings of T4, T5 and T6 in FIG. 11, and calculates the average of the obtained pressure values. Then, the ECU 250 controls the valve 270 on the basis of the thus obtained average. The timing T5 corresponds to the crank angle of approximately 120 degrees. The timing T6 corresponds to the crank angle of approximately 300 degrees. The timings T4 to T6 are described by way of example, and may be freely set. Furthermore, pressure values detected at two timings, or four or more timings may be used for the control. The timings T4 to T6 (crank angles) are obtained based on the crank position of the crankshaft 134 detected by the rpm sensor 153.

[0108] As described above, if the driving status of the motorcycle 1 changes, a change is caused also in the manner of the pressure variation in the downstream intake passage 110x. For example, if the rpm of the engine 130 changes, the manner of the pressure variation in the downstream intake passage 110x changes from the manner shown by the curve P1 to that shown by the curve P2. Suppose that the opening degree of the flow regulating valve 270 is fixed. Based on this premise, the amount of fuel vapor flowing from the communication passage 163a into the downstream intake passage 110x differs between the case where the engine 130 runs at the rpm in the curve P1 and the case where the engine 130 runs at the rpm in the curve P2. Furthermore, the change in the rpm of the engine 130 also causes a change in the amount of air flowing into the combustion chamber 130a. Thus, the change in the rpm changes the amounts of inflow of fuel vapor and inflow of air. This changes the degree of influence of fuel vapor on the air-fuel ratio of the air-fuel mixture in the combustion chamber 130a. For this reason, introduction of fuel vapor into the combustion chamber 130a may hinder stable burning of the air-fuel mixture in the combustion chamber 130a at a desired air-fuel ratio.

[0109] Hence, for the purpose of stable burning of fuel in the combustion chamber 130a, the ECU 250 of this embodiment is configured to control the amount of fuel vapor introduced into the combustion chamber 130a as follows. The ECU 250 controls the opening degree of the flow regulating valve 270 based on the detection value for the rpm of the engine 130 and the detection value for the pressure in the downstream intake passage 110x. These detection values are obtained from detection results obtained by the sensors 151 to 153. The detection result obtained by the intake pressure sensor 151 may be directly used as the detection value for the pressure in the downstream intake passage 110x. Alternatively, the value for the pressure in the downstream intake passage 110x may be derived from the detection results obtained by the throttle position sensor 152 and the rpm sensor 153. Which of the above ways is used is determined depending on the driving status. That is, either the detection result obtained by the intake pressure sensor 151 or the pressure value derived from the detection results obtained by the throttle position sensor 152 and the rpm sensor 153 is selected depending on the driving status. For example, the detection result obtained by the intake pressure intake pressure sensor 151 may be used when the rpm of the engine 130 is low, and the pressure value derived from the detection results obtained by the throttle position sensor 152 and the rpm sensor 153 may be used when the rpm of the engine 130 is high. As described above, the detection value for the pressure in the downstream intake passage 110x may be a pressure value at a specific timing within each four-stroke cycle, or may be the average of pressure values at multiple timings in each four-stroke cycle.

[0110] Similarly to the ECU 150, the ECU 250 performs the control so that the relationship between the fuel vapor ratio and the engine-intake air amount forms the curve shown in FIG. 12A. Furthermore, the ECU 250 controls the flow regulating valve 270 so that the opening degree of the flow regulating valve 270 relative to the pressure in the downstream intake passage 110x satisfies the relationship shown in FIG. 12B. As shown in FIG. 12B, the opening degree of the flow regulating valve 270 is adjusted so that the opening degree increases toward its fully open state as the detection value for the pressure in the downstream intake passage 110x approaches the atmospheric pressure. A desired amount of inflow of fuel vapor is ensured by increasing the opening degree of the flow regulating valve 270 as the detection value for the pressure in the downstream intake passage 110x approaches the atmospheric pressure.

[0111] The ECU 250 of this embodiment is configured to control the opening degree of the flow regulating valve 270 without calculating any of the engine-intake air amount and the fuel vapor ratio, as described below. The ECU 250 includes a storage unit. The storage unit of the ECU 250 stores therein: information for the rpm of the engine 130 and the throttle opening angle of the throttle valve 112; and information for the pressure in the downstream intake passage 110x. These pieces of information are associated with each other. With reference to the stored information, the ECU 250 derives the pressure in the downstream intake passage 110x from the rpm of the engine 130 and the throttle opening angle of the throttle valve 112. Alternatively, the ECU 250 directly obtains the pressure in the downstream intake passage 110x from the detection result obtained by the intake pressure sensor 151. The storage unit of the ECU 250 further stores therein: information for the opening degree of the flow regulating valve 270; and information for the rpm of the engine 130 and for pressure in the downstream intake passage 110x. These pieces of information are associated with each other. These pieces of information have been associated with each other in such a manner that the control by the ECU 250 satisfies the relationships shown in FIG. 12A and FIG. 12B when the ECU 250 controls the flow regulating valve 270 based on the stored information and detection values. The ECU 250 obtains a piece of information for the opening degree of the flow regulating valve 270 that is associated with the detection value for the rpm of the engine 130 and the detection value for the pressure in the downstream intake passage 110x. Then, the ECU 250 controls the flow regulating valve 270 so that the opening degree of the flow regulating valve 270 is equal to the value of the information obtained from the storage unit.

[0112] The driving status such as the rpm of the engine 130 changes smoothly. In contrast to the smooth change, the ECU 250 controls the flow regulating valve 270 so that the opening degree of the valve 270 changes in a stepwise manner. For example, when the rpm increases with the throttle opening angle of the throttle valve 112 unchanged, the manner of the pressure variation in the downstream intake passage 110x does not greatly change promptly in response to the increase in the rpm. Rather, the manner of the pressure variation changes gradually over multiple four-stroke cycles (over a plurality of cycles), as indicated by a curve P4 in FIG. 13. The

ECU 250 does not change the opening degree of the flow regulating valve 270 immediately when the manner of the pressure variation in the downstream intake passage 110x changes slightly. As indicated by a line D1 in FIG. 13, the ECU 250 keeps the opening degree of the flow regulating valve 270 at $\alpha 1$ over multiple four-stroke cycles. Then, the ECU 250 changes the opening degree of the valve 270 from $\alpha 1$ to $\alpha 2$ only after the amount of change in the manner of the pressure variation in the downstream intake passage 110x exceeds a predetermined value. Thus, under the control by the ECU 250, the opening degree of the flow regulating valve 270 is kept unchanged over multiple four-stroke cycles; and the opening degree is changed in a stepwise manner in relation to the change in the rpm and the change in the manner of the pressure variation in the downstream intake passage 110x.

[0113] The above is an example in which the opening degree of the flow regulating valve 270 is controlled without calculating any of the engine-intake air amount and the fuel vapor ratio. Alternatively, the flow regulating valve 270 may be controlled based on the engine-intake air amount calculated based on the following detection values. The detection values are: the detection value for the rpm of the engine 130; and the detection value for the pressure in the downstream intake passage 110x or the detection value for the throttle opening angle of the throttle valve 112. For example, the ECU 250 may be configured as follows. The storage unit of the ECU 250 stores therein data indicating the graphs of FIG. 12A and FIG. 12B. The ECU 250 calculates the engine-intake air amount using the detection values. Then, the ECU 250 obtains the fuel vapor ratio corresponding to the thus calculated engine-intake air amount, with reference to the graph of FIG. 12A. Subsequently, the ECU 250 obtains the opening degree of the flow regulating valve 270 corresponding to the pressure in the downstream intake passage 110x derived from the detection values, with reference to the graph of FIG. 12B. Furthermore, the ECU 250 controls the flow regulating valve 270 based on the thus obtained opening degree.

[0114] The ECU 250 may be arranged to control the flow regulating valve 270 without deriving the pressure in the downstream intake passage 110x. For example, the following arrangement is possible. The storage unit of the ECU 250 stores therein information for the rpm of the engine 130 and the throttle opening angle of the throttle valve 112 and information for the opening degree of the flow regulating valve 270. These pieces of information are associated with each other. Then, the ECU 250 directly obtains the piece of information for the opening degree of the flow regulating valve 270 from the storage unit, that is associated with the values for the rpm of the engine 130 and the throttle opening angle of the throttle valve 112. In this arrangement, it is not necessary for the ECU 250 to derive the pressure in the downstream intake passage 110x. Thereafter, the ECU 250 controls the flow regulating valve 270 so that the opening degree of the flow regulating valve 270 is equal to the value of the information obtained from the storage unit. In this case, the storage unit of the ECU 250 does not have to store the information for the pressure in the downstream intake passage 110x associated with the information for the rpm of the engine 130 and for the throttle opening angle of the throttle valve 112. That is, in the above case, it is only required for the storage unit of the ECU 250 to store the information for the opening degree of the flow regulating valve 270 associated with the information for the rpm of the engine 130 and throttle opening angle of the throttle valve 112. Furthermore, in the above case, a detector configured to directly detect the pressure in the downstream intake passage 110x does not have to be provided. That is, the intake pressure sensor 151 may be omitted in the above case.

[0115] It should be noted that the graphs of FIG. 12A and FIG. 12B are merely ideal examples referred to in the control by the ECU 250. It is preferable that the control is made so as to satisfy the relationships shown in these graphs as much as possible. Note that the control does not have to be made so that its result strictly satisfies the relationships shown in these graphs.

[0116] According to the above-described example, the amount of introduced fuel vapor is adjusted on the premise that the pressure varies in the above-described pressure-variation manner, or rather, with the use of the pressure-variation manner. The pressure-variation manner is such that: a smaller depression having a smaller difference from atmospheric pressure and a larger depression having a larger difference from atmospheric pressure are created in each four-stroke cycle; and the creation of the smaller and larger depressions is repeated on a four-stroke basis. That is, in this example, the flow regulating valve 270 is provided. The flow regulating valve 270 is configured so that the amount of introduced fuel vapor is changeable to one of the plurality of levels by adjusting the opening degree of the valve to the corresponding one of the plurality of levels. Furthermore, the amount of introduced fuel vapor is controlled by adjusting the opening degree of the flow regulating valve 270 with the valve kept open. The opening degree of the flow regulating valve 270 is controlled on the basis of a four-stroke-based manner of the pressure variation included in the pressure-variation manner in which the creation of the smaller and larger depressions is repeated on a four-stroke basis. Specifically, the opening degree of the flow regulating valve 270 is controlled based on the value(s) of pressure in the downstream intake passage 110x at a specific timing or multiple timings in each four-stroke cycle. Thus, control is made on the basis of the four-stroke-based manner of the pressure variation. Therefore, proper control is made to follow a change in the pressure-variation manner in which pressure varies widely on a four-stroke basis.

[0117] In the present example, as shown in FIG. 13, the opening degree of the flow regulating valve 270 is changed in a stepwise manner when the manner of the pressure variation in the downstream intake passage 110x changes as a result of a change in the driving status such as the rpm of the engine 130. That is, the opening degree of the flow regulating valve 270 is not changed immediately in response to the smooth change in the rpm of the engine 130 over multiple four-stroke cycles. Instead, the opening degree of the flow regulating valve 270 is changed only after the amount of the change in the manner of the pressure variation in the downstream intake passage 110x exceeds the predetermined value. Thus, the opening degree of the flow regulating valve 270 is not frequently changed in response to every change in the manner of the pressure variation in the downstream intake passage 110x. This stabilizes the amount of introduced fuel vapor. Accordingly, the control is made so as to properly follow a change in the manner of the pressure variation, while fuel vapor is stably introduced into the combustion chamber 130a. It should be noted that the opening degree of the flow regulating valve 270 may be changed immediately in response to a change in the driving status such as the rpm of the engine 130. For example, the opening degree of the flow regulating valve 270 may be changed in each four-stroke cycle.

[0118] Thus, also in this example, the flow regulating valve 270 (valve body 175) is provided so that the capacity of the passage for fuel vapor, which is from the opening 163y to the intake passage 110a, is smaller than a half of the displacement of the engine 130, and then control is made on the basis of the four-stroke-based manner of the pressure variation. This reduces the delay in the timing for introducing fuel vapor into the combustion chamber 130a, under the above control of the opening degree of the flow regulating valve 270. Accordingly, the valve is properly controlled to follow the pressure-variation manner in which pressure varies greatly on a four-stroke basis. This enables introduction of a desired amount of fuel vapor into the combustion chamber.

[0119] As described above, it has been desired to apply the technique used for automobiles to the engine unit used in straddled vehicles including the motorcycle 1. This is the background to the development of the first and second examples. It was found that, if the technique for automobiles is applied as it is to the engine unit widely used in straddled vehicles, a disadvantage may be caused. That is, there is a possibility that a desired amount of fuel vapor cannot be introduced from the canister to the combustion chamber. That is, the following fact was found: there is a possibility that a desired amount of fuel vapor cannot be introduced from the canister into the combustion chamber in the engine unit in which the creation of the smaller and larger depressions is repeated on a four-stroke basis. Therefore, the first and second examples have been developed for the purpose of introducing a desired amount of fuel vapor into the combustion chamber in the engine unit in which the creation of the smaller and larger depressions is repeated on a four-stroke basis.

[0120] In the above-described first example, the present teaching is applied to the single-cylinder engine unit 100. According to a first embodiment of the invention, the present teaching is applied to a multi-cylinder engine unit 300 shown in FIG. 14A. The engine unit 300 includes four engines 130, four intake passage members 110, a canister 161, an ECU 350, and a communication passage member 363. The four intake passage members 110 are respectively connected to the four engines 130. Fuel vapor is introduced from the canister 161 to the intake passage members 110 through the communication passage member 363. An air cleaner 331 is configured to clean air. Cleaned air is supplied to the four intake passage members 110. A throttle valve 112 is individually provided in each of the intake passage members 110. That is to say, the engine unit 300 is the engine unit with individual throttle bodies. Also in this engine unit with the individual throttle bodies, pressure in each downstream intake passage portion 110d that is downstream of the corresponding throttle valve 112 varies in the same manner as above. That is, pressure in each downstream intake passage portion 110d varies in the pressure-variation manner such that: a smaller depression having a smaller difference from atmospheric pressure and a larger depression having a larger difference from atmospheric pressure are created in each four-stroke cycle; and the creation of the smaller and larger depressions is repeated on a four-stroke basis. Because of the above structure, the communication passage member 363 has four branched portions respectively connected to the downstream intake passage portions 110d. A solenoid valve 170 is provided to each of the branched portions. Each of the branched portions of the communication passage member 363 is arranged so that the capacity of a passage for fuel vapor, which is from the opening 163y of its solenoid valve 170 to the corresponding downstream intake passage 110x, is smaller than a half of the displacement of the corresponding engine 130. The ECU 350 controls each of the four solenoid valves 170 in association with the pressure variation in the corresponding downstream intake passage portion 110d. The control method for each solenoid valve 170 is similar to that by the ECU 150 in the first embodiment. The above arrangement reduces the delay in the timing for introducing fuel vapor into each combustion chamber 130a. Thus, with the above-described arrangement, introduction of a desired amount of fuel vapor into each combustion chamber 130a is achieved also in the engine unit 300 with the individual throttle bodies, in which pressure varies greatly on a four-stroke basis. In this modification, the engine unit 300 has four cylinders. It should be noted that the present teaching may be applied to a two-cylinder, three-cylinder, or five or more-cylinder engine unit.

[0121] The above-described first embodiment describes the case where the solenoid valve 170 is controlled in association with one-stroke, two-stroke, four-stroke, eight-stroke, or twelve-stroke period. However, the solenoid valve 170 may be controlled in association with an n-stroke period, where n is a multiple of 4 and equal to or more than 16.

[0122] The above-described first embodiment describes the case where each of the switching-on and switching-off operations of the solenoid valve 170 is performed once, twice, or four times in each four-stroke cycle. However, each of the switching-on and switching-off operations may be performed three times or five or more times in each four-stroke cycle.

[0123] Furthermore, in the above-described first embodiment, the ECU 150 controls the solenoid valve 170 so as to satisfy the conditions shown in FIG. 6A and FIG. 6B. However, the ECU may control the solenoid valve 170 so as to satisfy conditions different from those shown in FIG. 6A and FIG. 6B.

[0124] Furthermore, in the above-described first embodiment, the storage unit of the ECU 150 stores therein: information for the length of the open period of the solenoid valve 170; and information for the rpm of the engine 130 and for the pressure in the downstream intake passage 110x. These pieces of information are associated with each other. In addition, the storage unit of the ECU 150 stores therein: information for the length of the open period of the solenoid valve 170; and information for the rpm of the engine 130 and for the throttle opening angle of the throttle valve 112. These pieces of information are associated with each other. When obtaining the length of the open period of the solenoid valve 170 based on the information stored in the storage device, the detection value for the pressure in the downstream intake passage 110x or the detection value for the throttle opening angle of the throttle valve 112 is used. Which one of them is used is determined based on the driving status. In this regard, the detection value for the throttle opening angle of the throttle valve 112 may be always used irrespective of the driving status. In this case, the storage unit of the ECU 150 may store only the information for the length of the open period of the solenoid valve 170 and the information for the rpm of the engine 130 and for the throttle opening angle of the throttle valve 112, associated with the information for the length. That is, the storage unit does not have to store the information for the rpm of the engine 130 and for the downstream intake passage 110x, associated with the information for the length of the open period of the solenoid valve 170. Furthermore, in the above case, a detector configured to directly detect the pressure in the downstream intake passage 110x does not have to be provided. That is, the intake pressure sensor 151 may be omitted in the above case.

[0125] The arrangement of the second example may also be applied to a multi-cylinder engine unit 400 shown in FIG. 14B according to a second embodiment of the invention. Some of the components of the engine unit 400 are the same as those of the engine unit 300 shown in FIG. 14A. The following will mainly describe the components different from those of the engine unit 300. In addition, the components the same as those of the engine unit 300 are given the same reference numerals, and description thereof are not repeated if appropriate. Similarly to the engine unit 300, the engine unit 400 includes four engines 130, four intake passage members 110, a canister 161, and a communication passage member 363. The four intake passage members 110 are respectively connected to the four engines 130. Fuel vapor is introduced from the canister 161 to the intake passage members 110 through the communication passage member 363. That is to say, the engine unit 400 is also the engine unit with individual throttle bodies. The flow regulating valve 270 is provided to each branched portion of the communication passage member 363. Each branched portion is connected to the corresponding intake passage member 110. Each of the branched portions of the communication passage member 363 is arranged so that the capacity of a passage for fuel vapor, which is from the opening 163y of its flow regulating valve 270 to the corresponding downstream intake passage 110x, is smaller than a half of the displacement of the corresponding engine 130. Furthermore, an ECU 450 controls the components of the engine unit 400.

[0126] The ECU 450 controls each of the four flow regulating valves 270 on the basis of the four-stroke-based manner of the pressure variation in the downstream intake passage portion 110d corresponding thereto. The control method for each flow regulating valve 270 is similar to that by the ECU 250 in the second embodiment. The four-stroke-based manner of the pressure variation is obtained based on results obtained by the sensors. Specifically, the results are obtained by the intake pressure sensor and the throttle position sensor provided for each of the downstream intake passage portions 110d individually, and the rpm sensor provided for each of the engines 130 individually. The above arrangement reduces the delay in the timing for introducing fuel vapor into each combustion chamber 130a. Thus, with the above-described arrangement, introduction of a desired amount of fuel vapor into each combustion chamber 130a is achieved also in the engine unit 400 with the individual throttle bodies, in which pressure varies greatly on a four-stroke basis. In this modification, the engine unit 400 has four cylinders. It should be noted that the present teaching may be applied to a two-cylinder, three-cylinder, or five or more-cylinder engine unit.

[0127] In the above-described second embodiment, the opening degree of the flow regulating valve 270 is controlled based on the pressure in the downstream intake passage 110x detected in each four-stroke cycle. The frequency of detection and the control method may be altered from those in the above-described embodiment. For example, FIG. 15 shows a modification in which the pressure is detected on a n-cycle basis, i.e., in each span of n cycles. Herein, n is a natural number equal to or larger than 2. In this modification, the pressure in the downstream intake passage 110x is not detected during the period from the first cycle to the (n-1)th cycle in each n-cycle span. The pressure in the downstream intake passage 110x is detected at a specific timing or at multiple timings in the nth cycle in each n-cycle span, to be used as a value(s) indicating the four-stroke-based manner of the pressure variation. The opening degree of the flow regulating valve 270 is controlled based on the detected pressure value(s). The above control is repeated on a n-cycle basis. Thus, the flow regulating valve 270 is controlled properly on the basis of the four-stroke-based manner of the pressure variation for each n-cycle span.

[0128] The above modification may be further arranged as follows: the pressure is detected at a specific timing in each of two or more cycles in each n-cycle span, and a value obtained by calculating the detected pressure values may be used as the pressure value indicating the four-stroke-based manner of the pressure variation for each n-cycle span. For example, the pressure may be detected at a specific timing in each of two or more four-stroke cycles in each n-cycle span, and the average of the detected pressure values may be calculated. Then, the average may be used for the control of the flow regulating valve 270, as a value indicating the four-stroke-based manner of the pressure variation for each n-cycle span.

[0129] Furthermore, in the above-described second embodiment, the ECU 150 controls the flow regulating valve 270 so as to satisfy the conditions shown in FIG. 12A and FIG. 12B. However, the ECU may control the flow regulating valve 270 so as to satisfy conditions different from those shown in FIG. 12A and FIG. 12B.

[0130] Furthermore, instead of the flow regulating valve 270 used in the above-described second embodiment, a variety of valves different in structure to narrow the passage may be used. Furthermore, the valve configured to change the amount of fuel vapor in the present teaching may change the flow rate discretely, or may change the flow rate continuously.

[0131] Note that, in this Specification, "control in association with the four-stroke-basis pressure-variation manner" means that control is made so that the valve is operated with a timing related to the pressure-variation manner in which the creation of the depressions is repeated on a four-stroke basis. This control may be made based on the time point of the present moment in the four-stroke cycle, by obtaining the time point. The above time point may be obtained in any way. For example, in the above-described embodiment, the crank position (crank angle) of the crankshaft 134 is detected by the rpm sensor 153. Based on the detection result, the switching-on and switching-off operations of the solenoid valve 170 are performed at respective specific crank angles. Furthermore, the "control in association with the four-stroke-basis pressure-variation manner" includes the control based on the detection result of the pressure variation repeated on a four-stroke basis. Examples of such control include the control directly associated with the pressure variation indicated by the detection results obtained by the intake pressure sensor 151 or the like. For example, the switching-on or switching-off operation may be performed when the value of the pressure detected by the intake pressure sensor 151 or the like is equal to a predetermined value.

[0132] There are a variety of manners of control in association with the four-stroke-basis pressure-variation manner. Examples of the control in association with the four-stroke-basis pressure-variation manner include: the control in association with the one-stroke period, the control in association with the two-stroke period, and the control in association with an n-stroke period, where n is a multiple of 4. Examples of the control in association with the one-stroke period include the control to perform the switching-on operation in each one-stroke period and the control to perform the switching-off operation in each one-stroke period, as shown in the chart C4. Examples of the control in association with the two-stroke period include the control to perform the switching-on operation in each two-stroke period and the control to perform the switching-off operation in each two-stroke period, as shown in the chart C5, C6 in FIG. 7. Examples of the control in association with the n-stroke period, where n is a multiple of 4, include the control to perform the switching-on operation in each four-stroke cycle and the control to perform the switching-off operation in each four-stroke cycle, as shown in the charts C1 to C3 in FIG. 4. Examples of the control in association with the n-stroke period, where n is a multiple of 4, further include the control to perform the switching-on operation and/or the switching-off operation in each eight-stroke or 12-stroke period, as shown in the charts C7 to C10 in FIG. 8. Examples of the control in association with the n-stroke period, where n is a multiple of 4, still further include the control to perform the switching-on and/or switching-off operations in each 16-stroke or 20-stroke period. The multiple of 4 may be equal to or more than 16.

[0133] Furthermore, in the "control in association with the four-stroke-basis pressure-variation manner", it does not matter whether the period from the switching-on operation to the switching-off operation strides the boundary between strokes or the boundary between four-stroke cycles. As shown in the chart C1 in FIG. 4 and the chart C6 in FIG. 7, for example, the period from the switching-on operation to the switching-off operation may stride the boundary between strokes or the boundary between four-stroke cycles. Alternatively, as shown in the charts C2 and C3 in FIG. 4 and the charts C4 and C5 in FIG. 7, the period from the switching-on operation to the switching-off operation may fall within the one-stroke period or the four-stroke cycle.

[0134] Moreover, in the "control in association with the four-stroke-basis pressure-variation manner", it does not matter whether the timing for the switching-on operation and/or the timing for the switching-off operation is/are synchronized with the period of one or more strokes, or the four-stroke cycle. For example, the control shown in the chart C10 is also included in the "control in association with the four-stroke-basis pressure-variation manner". In the control shown in the chart C10, the timings for the switching-on and switching-off operations are not synchronized with the four-stroke cycle. Note that "synchronized with/in synchronization with an n-stroke period" means that the timing for an operation within each n-stroke period, i.e., the location of the time point for an operation relative to the length of the n-stroke period, is the same among the n-stroke periods. Meanwhile, "synchronized with/in synchronization with the four-stroke cycle" means that the timing for an operation within each four-stroke cycle, i.e., the location of the time point for an operation relative to the length of the four-stroke cycle, is the same among the four-stroke cycles.

[0135] In this Specification, "to control the opening degree of the valve on the basis of the four-stroke-based manner of the pressure variation included in the pressure-variation manner in which the creation of the smaller and larger depressions is repeated on a four-stroke basis" means that the control is made as follows. As described in the above embodiment by way of example, the manner of the pressure variation changes as the rpm of the engine 130 changes, for example. The manner of the pressure variation is represented by the shape of a curve indicating pressure variation, such as the curves P1 and P2 in FIG. 11. Each of the curves P1 and P2 forms a valley in each four-stroke cycle. The valley shows the depression in pressure. As shown in FIG. 13, the depression valley in each four-stroke cycle becomes deeper as the rpm of the engine 130 increases. Now, "to control the opening degree of the valve on the basis of the four-stroke-based manner of the pressure variation included in the pressure-variation manner in which the creation of the smaller and larger depressions is repeated on a four-stroke basis" includes the control of the opening degree of the valve in relation to a change in the above-described four-stroke-based manner of the pressure variation. For example, in the above-described embodiment, the control is made as follows. As the rpm of the engine 130 increases, the four-stroke-based manner of the pressure variation changes. Specifically, the shape of the valley in the curve indicating the pressure variation changes with the increase in the rpm. In response to this change, control is made so as to increase the opening degree of the flow regulating valve 270.

[0136] In the above control, the opening degree of the valve may be controlled based on a pressure value derived from the detection result(s) of a sensor(s), or may be controlled based on a pressure value directly obtained by a sensor. For example, in the above-described embodiment, the opening degree of the flow regulating valve 270 is controlled based on a pressure in the downstream intake passage 110x derived from detection results for the rpm of the engine 130 and the throttle opening angle of the throttle valve 112. However, the opening degree of the flow regulating valve 270 may be controlled based on a pressure in the downstream intake passage 110x, which is directly obtained from the detection result obtained by the intake pressure sensor 151.

[0137] Furthermore, the control of the opening degree of the valve does not have to be performed directly based on the value of the pressure. For example, the valve may be controlled without deriving the value of the pressure in the downstream intake passage 110x from values for the rpm of the engine 130 and for the throttle opening angle of the throttle valve 112, and without directly obtaining the value of the pressure in the downstream intake passage 110x from the detection result obtained by the intake pressure sensor 151. For example, the valve may be controlled based on information stored in the storage unit. Specifically, the storage unit stores therein: information for the rpm of the engine 130 and the throttle opening angle of the throttle valve 112; and information for the opening degree of the flow regulating valve 270, and these pieces of information are associated with each other. Based on the values for the rpm of the engine 130 and the throttle opening angle of the throttle valve 112, a piece of information for the opening degree of the flow regulating valve 270 associated therewith is obtained from the storage unit. The valve may be controlled based on the obtained piece of information.

[0138] In this Specification, "the opening degree of the valve in the open state is adjustable" means that the opening degree of the valve in the open state is adjustable to two or more levels. This means that the number of levels to which the opening degree of the valve is adjustable is three or more, including the level of the opening degree of zero, at which the valve closes the communication passage to prevent communication of air between the canister and the intake passage. The valve may be configured so that its opening degree changes discretely, or may be configured so that its opening degree changes continuously.

[0139] In addition to the above, "creation of the smaller and larger depressions is repeated on a four-stroke basis" herein indicates that two depressions are present in each four-stroke cycle, and one of the depressions has a difference from atmospheric pressure larger than that of the other's. In other words, there are two depressions in each four-stroke cycle, the differences of which from atmospheric pressure are different from each other.

[0140] Furthermore, in this Specification, the valve, the opening degree of which is changeable, encompasses: a valve switchable from the open state to the closed state and switchable from the closed state to the open state; and a valve configured so that the opening degree of the valve in the open state is adjustable. That is, the above valve encompasses both the valves 170 and 270 in the first and second embodiments.

[0141] It should be noted that the straddled vehicle in the present teaching is not limited to the above-described motorcycle 1. The straddled vehicle may be any vehicle which a rider straddles to ride the vehicle. The straddled vehicle may be any other type of two-wheeled motor vehicle, such as an off-road motorcycle, a scooter, and a moped. In addition to the above, the straddled vehicle in the present teaching encompasses a tricycle and a four-wheeler (all terrain vehicle (ATV)).

Reference Signs List

[0142]

1: motorcycle
14: fuel tank
100: engine unit
110: intake passage member
110a: intake passage
110d: downstream intake passage portion
112: throttle valve
120: exhaust passage member
120a: exhaust passage
130: engine
130a: combustion chamber
141: intake valve
142: exhaust valve
150: ECU
151: intake pressure sensor
152: throttle position sensor
153: rpm sensor
161: canister
163: communication passage member
163a: communication passage
170: solenoid valve
200: engine unit
263: communication passage member
270: flow regulating valve
300: engine unit
350: ECU
363 communication passage member400: engine unit
450: ECU

Claims

1. A multi-cylinder four-stroke engine unit comprising:

an engine (130) including a combustion chamber (130a); an intake passage member (110) which is connected to the engine (130) and allows air to be introduced into the combustion chamber (130a); and a throttle valve (112) provided in an intermediate portion of the intake passage member (110), the combustion chamber (130a), the intake passage member (110), and the throttle valve (112) being provided for each cylinder (131), wherein a pressure in a downstream intake passage portion (110d) of the intake passage member (110), that is downstream of the throttle valve (112), varies in a pressure-variation manner such that: a smaller depression having a smaller difference from atmospheric pressure and a larger depression having a larger difference from atmospheric pressure are created in each four-stroke cycle; and the creation of the smaller and larger depressions is repeated on a four-stroke basis,

the engine unit further comprising:

a canister (161) connected to a fuel tank (14) and accommodating therein an adsorbent configured to adsorb fuel vapor contained in incoming air from the fuel tank (14); and

a communication passage member (363) configured to establish communication between an inside of the canister (161) and the downstream intake passage portion (110d) for each cylinder (131), the communication passage member (363) having a branched portion for each cylinder (131), the branched portions respectively connected to the downstream intake passage portions (110d),

the engine unit being **characterized by** comprising:

a valve (170, 270) provided to each branched portion of the communication passage member (363) so that a capacity of a part of the communication passage member (363), the part extending from the intake passage member (110) to the valve, is smaller than a half of a displacement of the engine (130), wherein an opening degree of the valves (170, 270) being changeable; and

a controller (150, 450) configured to control operation of the valves (170, 270) on a basis of the pressure-variation manner in which the creation of the smaller and larger depressions is repeated on the four-stroke basis.

2. The engine unit according to claim 1, further comprising a sensor (151, 152, 153) for each downstream intake passage portion (110d), the sensors (151, 152, 153) configured to detect negative pressure in the downstream intake passage portions (110d), wherein
the controller (150, 450) is configured to control the operation of the valves (170, 270) on a basis of a detection result obtained by the sensors (151, 152, 153).

3. The engine unit according to claim 1 or 2, wherein the controller (150, 450) is configured to control the valves (170, 270) so that a ratio of an amount of fuel vapor introduced from the communication passage member (363) to the downstream intake passage portion (110d) to a combustion chamber-introduction air amount, which is an amount of air introduced from the downstream intake passage portion (110d) into the combustion chamber (130a), increases with an increase in the combustion chamber-introduction air amount.

4. The engine unit according to any one of claims 1 to 3, wherein:

each of the valves (170) is switchable from a closed state to an open state and is switchable from the open state to the closed state, the closed state being the state where the valve (170) prevents communication of air between the inside of the canister (161) and the downstream intake passage portion (110d), the open state being the state where the valve (170) allows communication of air between the inside of the canister (161) and the downstream intake passage portion (110d); and

the controller (150, 450) is configured to control the valves (170) to perform a valve switching operation in association with the pressure-variation manner in which the creation of the smaller and larger depressions is repeated on a four-stroke basis, the valve switching operation being a set of switching-on and switching-off operations, one of the operations being performed first and then the other one of the operations being performed, the switching-on operation being an operation to switch the valve (170) from the closed state to the open state, the switching-off operation being an operation to switch the valve (170) from the open state to the closed state.

5. The engine unit according to claim 4, wherein, when each of the four strokes constituting a four-stroke cycle is counted as one stroke, the controller (150, 450) is configured to control each of the valves (170) so as to perform the valve switching operation in association with an n-stroke period, where n is 1, 2, or a multiple of 4.

6. The engine unit according to claim 5, wherein the controller (150, 450) is configured to control each of the valves (170) so as to perform at least one of the switching-on and switching-off operations in synchronization with an n-stroke period, where n is 1, 2, or a multiple of 4.

7. The engine unit according to claim 6, wherein the controller (150, 450) is configured to control each of the valves (170) so as to perform the switching-on operation and then to perform the switching-off operation in each n-stroke period, where n is 1, 2, or a multiple of 4.

8. The engine unit according to claim 6, wherein the controller (150, 450) is configured to control each of the valves (170) so as to perform the switching-off operation and then to perform the switching-on operation in each n-stroke period, where n is 1, 2, or a multiple of 4.

9. The engine unit according to claim 6, wherein the controller (150, 450) is configured to control each of the valves (170) so as to perform each of the switching-on and switching-off operations once in each n-stroke period, where n is 1, 2, or a multiple of 4.

10. The engine unit according to claim 9, wherein the controller (150, 450) is configured to control each of the valves (170) so as to perform each of the switching-on and switching-off operations once in each one-stroke or two-stroke period.

11. The engine unit according to claim 9, wherein the controller (150, 450) is configured to control each of the valves (170) so as to perform each of the switching-on and switching-off operations once in a four-stroke cycle in each n-stroke period, where n is a multiple of 4.

12. The engine unit according to claim 11, wherein the controller (150, 450) is configured to control each of the valves (170) so as to perform each of the switching-on and switching-off operations once in each four-stroke period.

13. The engine unit according to claim 6, wherein the controller (150, 450) is configured to control each of the valves (170) so as to perform each of the switching-on and switching-off operations twice or more in each n-stroke period, where n is a multiple of 4.

14. The engine unit according to claim 5, wherein the controller (150, 450) is configured to control each of the valves (170) so as to perform one of the switching-on and switching-off operations and then perform the other in each n-stroke period, where n is 1, 2, or a multiple of 4, timings to perform the switching-on and switching-off operations in each period being different among the n-stroke periods.

15. The engine unit according to any one of claims 1 to 3, wherein:

each of the valves (270) is capable of being in an open state in which the valve (270) allows communication of air between the inside of the canister (161) and the intake passage member (110) through the communication passage member (363), and the opening degree of each of the valves (270) in the open state is adjustable; and

the controller (150, 450) is configured to control the opening degree of each of the valves (270) in the open state, on a basis of a four-stroke-based manner of pressure variation included in the pressure-variation manner in which the creation of the smaller and larger depressions is repeated on the four-stroke basis.

16. The engine unit according to claim 15, wherein when four strokes are counted as one cycle, the controller (150, 450) is configured to control the opening degree of each of the valves (270) in the open state on a basis of the four-stroke-based manner of the pressure variation for each n-cycle span, where n is a natural number.

17. The engine unit according to claim 16, further comprising a sensor (151, 152, 153) for each downstream intake passage portion (110d), the sensors (151, 152, 153) configured to detect negative pressure in the downstream intake passage portion (110d), wherein
the controller (150, 450) is configured to control the opening degree of the valves (270) in the open state on a basis of a detection result obtained by the sensors (151, 152, 153) in each cycle included in the n-cycle span, the detection result functioning to indicate the four-stroke-based manner of the pressure variation for each n-cycle span.

18. The engine unit according to claim 16 or 17, wherein when four strokes are counted as one cycle, the controller (150, 450) is configured to control each of the valves (270) in such a manner that after the controller (150, 450) keeps the opening degree of the valve (270) in the open state constant over a plurality of cycles, the controller (150, 450) changes the opening degree of the valve (270) in the open state on the basis of the four-stroke-based manner of the pressure variation.

19. A straddled vehicle (1) comprising:

the engine unit (300, 400) recited in any one of claims 1 to 18;
a vehicle body frame (4) supporting the engine unit (300, 400);
a rider seat (11);
handlebars (9) provided frontward of the rider seat (11); and
a fuel tank (14) connected to the canister (161) included in the engine unit (300, 400).

Patentansprüche

1. Eine Mehrzylinder-Viertakt-Motoreinheit, die folgende Merkmale aufweist:

einen Motor (130) mit einer Verbrennungskammer (130a); ein Einlassdurchgangsbauglied (110), das mit dem Motor (130) verbunden ist und durch das Luft in die Verbrennungskammer (130a) eingeführt werden kann; und ein Drosselventil (112), das in einem Zwischenabschnitt des Einlassdurchgangsbauglieds (110) bereitgestellt ist, wobei die Verbrennungskammer (130a), das Einlassdurchgangsbauglied (110) und das Drosselventil (112) für jeden Zylinder (131) bereitgestellt sind, wobei ein Druck in einem in Verarbeitungsrichtung nachgelagerten Einlassdurchgangsabschnitt (110d) des Einlassdurchgangsbauglieds (110), der zu dem Drosselventil (112) in Verarbeitungsrichtung nachgelagert ist, sich auf eine Druckänderungsweise derart ändert, dass ein kleinerer Unterdruck mit einer kleineren Differenz zu einem atmosphärischen Druck und ein größerer Unterdruck mit einer größeren Differenz zu einem atmosphärischen Druck in jedem Viertakthub erzeugt werden; und wobei die Erzeugung des kleineren und des größeren Unterdrucks auf einer Viertaktbasis wiederholt wird, und
wobei die Motoreinheit ferner folgende Merkmale aufweist:

einen Kanister (161), der mit einem Kraftstofftank (14) verbunden ist und ein Adsorbiermittel aufnimmt, das dazu ausgebildet, Kraftstoffdampf zu adsorbieren, welcher in eingehender Luft aus dem Kraftstofftank (14) enthalten ist; und
ein Kommunikationsdurchgangsbauglied (363), das dazu ausgebildet ist, eine Kommunikation zwischen einer Innenseite des Kanisters (161) und dem in Verarbeitungsrichtung nachgelagerten Einlassdurchgangsabschnitt (110d) für jeden Zylinder (131) herzustellen, wobei das Kommunikationsdurchgangsbauglied (363) einen verzweigten Abschnitt für jeden Zylinder (131) aufweist, wobei die verzweigten Abschnitte jeweils mit den in Verarbeitungsrichtung nachgelagerten Einlassdurchgangsabschnitten (110d) verbunden sind;

wobei die Motoreinheit **dadurch gekennzeichnet ist, dass** sie Folgendes aufweist:

ein Ventil (170, 270), das an jedem verzweigten Abschnitt des Kommunikationsdurchgangsbauglieds (363) bereitgestellt ist, so dass eine Kapazität eines Teils des Kommunikationsdurchgangsbauglieds (363), wobei sich der Teil von dem Einlassdurchgangsabschnitt (110) zu dem Ventil erstreckt, kleiner ist als eine Hälfte eines Hubraumes des Motors (130), wobei ein Öffnungsgrad der Ventile (170, 270) verän-

derbar ist; und
eine Steuerung (150, 450), die dazu ausgebildet ist, einen Betrieb der Ventile (170, 270) auf Basis der Druckänderungsweise zu steuern, bei der die Erzeugung des kleineren und des größeren Unterdrucks auf einer Viertaktbasis wiederholt wird.

2. Die Motoreinheit gemäß Anspruch 1, die ferner einen Sensor (151, 152, 153) für jeden in Verarbeitungsrichtung nachgelagerten Einlassdurchgangsabschnitt (110d) aufweist, wobei die Sensoren (151, 152, 153) dazu ausgebildet sind, einen Negativdruck in den in Verarbeitungsrichtung nachgelagerten Einlassdurchgangsabschnitten (110d) zu detektieren, wobei
die Steuerung (150, 450) dazu ausgebildet ist, den Betrieb der Ventile (170, 270) basierend auf einem Detektionsergebnis zu steuern, das von den Sensoren (151, 152, 153) erhalten wird.

3. Die Motoreinheit gemäß Anspruch 1 oder 2, wobei die Steuerung (150, 450) dazu ausgebildet ist, die Ventile (170, 270) so zu steuern, dass ein Verhältnis einer Menge an Kraftstoffdampf, der von dem Kommunikationsdurchgangsbauglied (363) in den in Verarbeitungsrichtung nachgelagerten Einlassdurchgangsabschnitt (110d) eingeführt wird, zu einer in die Verbrennungskammer eingeführten Menge an Luft, die eine Menge an Luft ist, die von dem in Verarbeitungsrichtung nachgelagerten Einlassdurchgangsabschnitt (110d) in die Verbrennungskammer (130a) eingeführt wird, mit einer Erhöhung der in die Verbrennungskammer eingeführten Menge an Luft zunimmt.

4. Die Motoreinheit gemäß einem der Ansprüche 1 bis 3, wobei:

jedes der Ventile (170) von einem geschlossenen Zustand in einen offenen Zustand umschaltbar ist und von dem offenen Zustand in den geschlossenen Zustand umschaltbar ist, wobei der geschlossene Zustand der Zustand ist, in dem das Ventil (170) eine Kommunikation von Luft zwischen der Innenseite des Kanisters (161) und dem in Verarbeitungsrichtung nachgelagerten Einlassdurchgangsabschnitt (110d) verhindert, wobei der offene Zustand der Zustand ist, in dem das Ventil (170) eine Kommunikation von Luft zwischen der Innenseite des Kanisters (161) und dem in Verarbeitungsrichtung nachgelagerten Einlassdurchgangsabschnitt (110d) ermöglicht; und
die Steuerung (150, 450) dazu ausgebildet ist, die Ventile (170) dahingehend zu steuern, einen Ventilumschaltvorgang in Verbindung mit der Druckänderungsweise auszuführen, bei der die Erzeugung des kleineren und des größeren Unterdrucks auf einer Viertaktbasis wiederholt wird, wobei der Ventilumschaltvorgang ein Satz an Einschalt- und Ausschaltvorgängen ist, wobei einer der Vorgänge zuerst ausgeführt wird und dann der andere der Vorgänge ausgeführt wird, wobei der Einschaltvorgang ein Vorgang ist, um das Ventil (170) von dem geschlossenen Zustand in den offenen Zustand umzuschalten, wobei der Ausschaltvorgang ein Vorgang ist, um das Ventil (170) von dem offenen Zustand in den geschlossenen Zustand umzuschalten.

5. Die Motoreinheit gemäß Anspruch 4, wobei dann, wenn jeder der vier Takte, die einen Viertakthub ausbilden, als ein Takt gezählt wird, die Steuerung (150, 450) dazu ausgebildet ist, jedes der Ventile (170) dahingehend zu steuern, den Ventilumschaltvorgang in Verbindung mit einer n-Takt-Zeitdauer auszuführen, wobei n 1, 2 oder ein Vielfaches von 4 ist.

6. Die Motoreinheit gemäß Anspruch 5, wobei die Steuerung (150, 450) dazu ausgebildet ist, jedes der Ventile (170) dahingehend zu steuern, den Einschalt- und/oder Ausschaltvorgang in Synchronisation mit einer n-Takt-Zeitdauer auszuführen, wobei n 1, 2 oder ein Vielfaches von 4 ist.

7. Die Motoreinheit gemäß Anspruch 6, wobei die Steuerung (150, 450) dazu ausgebildet ist, jedes der Ventile (170) dahingehend zu steuern, in jeder n-Takt-Zeitdauer den Einschaltvorgang auszuführen und dann den Ausschaltvorgang auszuführen, wobei n 1, 2 oder ein Vielfaches von 4 ist.

8. Die Motoreinheit gemäß Anspruch 6, wobei die Steuerung (150, 450) dazu ausgebildet ist, jedes der Ventile (170) dahingehend zu steuern, in jeder n-Takt-Zeitdauer den Ausschaltvorgang auszuführen und dann den Einschaltvorgang auszuführen, wobei n 1, 2 oder ein Vielfaches von 4 ist.

9. Die Motoreinheit gemäß Anspruch 6, wobei die Steuerung (150, 450) dazu ausgebildet ist, jedes der Ventile (170) dahingehend zu steuern, den Einschalt- und den Ausschaltvorgang jeweils einmalig in jeder n-Takt-Zeitdauer auszuführen, wobei n 1, 2 oder ein Vielfaches von 4 ist.

10. Die Motoreinheit gemäß Anspruch 9, wobei die Steuerung (150, 450) dazu ausgebildet ist, jedes der Ventile (170) dahingehend zu steuern, den Einschalt- und den Ausschaltvorgang jeweils einmalig in jeder Eintakt- oder Zweitakt-Zeitdauer auszuführen.

11. Die Motoreinheit gemäß Anspruch 9, wobei die Steuerung (150, 450) dazu ausgebildet ist, jedes der Ventile (170) dahingehend zu steuern, den Einschaltund den Ausschaltvorgang jeweils einmalig in einem Viertakthub in jeder n-Takt-Zeitdauer auszuführen, wobei n ein Vielfaches von 4 ist.

12. Die Motoreinheit gemäß Anspruch 11, wobei die Steuerung (150, 450) dazu ausgebildet ist, jedes der Ventile (170) dahingehend zu steuern, den Einschalt- und den Ausschaltvorgang jeweils einmalig in jeder Viertakt-Zeitdauer auszuführen.

13. Die Motoreinheit gemäß Anspruch 6, wobei die Steuerung (150, 450) dazu ausgebildet ist, jedes der Ventile (170) dahingehend zu steuern, den Einschalt- und den Ausschaltvorgang jeweils mindestens zweimalig in jeder n-Takt-Zeitdauer auszuführen, wobei n ein Vielfaches von 4 ist.

14. Die Motoreinheit gemäß Anspruch 5, wobei die Steuerung (150, 450) dazu ausgebildet ist, jedes der Ventile (170) dahingehend zu steuern, in jeder n-Takt-Zeitdauer einen des Einschalt- und des Ausschaltvorgangs auszuführen und dann den anderen Vorgang auszuführen, wobei n 1, 2 oder ein Vielfaches von 4 ist, wobei sich Zeitpunkte zum Ausführen des Einschalt- und des Ausschaltvorgangs in jeder Zeitdauer in den n-Takt-Zeitdauern unterscheiden.

15. Die Motoreinheit gemäß einem der Ansprüche 1 bis 3, wobei:

jedes der Ventile (270) dazu in der Lage ist, in einem offenen Zustand zu sein, in dem das Ventil (270) eine Kommunikation von Luft zwischen der Innenseite des Kanisters (161) und dem Einlassdurchgangsbauglied (110) durch das Kommunikationsdurchgangsbauglied (363) ermöglicht, und der Öffnungsgrad jedes der Ventile (270) in dem offenen Zustand einstellbar ist; und
die Steuerung (150, 450) dazu ausgebildet ist, den Öffnungsgrad jedes der Ventile (270) in dem offenen Zustand auf Basis einer Viertakt-basierten Druckänderungsart zu steuern, die in der Druckänderungsart enthalten ist, bei der die Erzeugung des kleineren und des größeren Unterdrucks auf der Viertakt-Basis wiederholt wird.

16. Die Motoreinheit gemäß Anspruch 15, wobei dann, wenn vier Takte als ein Hub gezählt werden, die Steuerung (150, 450) dazu ausgebildet ist, den Öffnungsgrad jedes der Ventile (270) in dem offenen Zustand auf Basis der Viertakt-basierten Druckänderungsart für jede n-Hub-Zeitspanne zu steuern, wobei n eine natürliche Zahl ist.

17. Die Motoreinheit gemäß Anspruch 16, die ferner einen Sensor (151, 152, 153) für jeden in Verarbeitungsrichtung nachgelagerten Einlassdurchgangsabschnitt (110d) aufweist, wobei die Sensoren (151, 152, 153) dazu ausgebildet sind, einen Negativdruck in dem in Verarbeitungsrichtung nachgelagerten Einlassdurchgangsabschnitt (110d) zu detektieren, wobei
die Steuerung (150, 450) dazu ausgebildet ist, den Öffnungsgrad der Ventile (270) in dem offenen Zustand auf Basis eines Detektionsergebnisses zu steuern, das von den Sensoren (151, 152, 153) in jedem Hub erhalten wird, der in der n-Hub-Zeitspanne enthalten ist, wobei das Detektionsergebnis dahingehend fungiert, die Viertakt-basierte Druckänderungsart für jede n-Hub-Zeitspanne anzugeben.

18. Die Motoreinheit gemäß Anspruch 16 oder 17, wobei dann, wenn vier Takte als ein Hub gezählt werden, die Steuerung (150, 450) dazu ausgebildet ist, jedes der Ventile (270) derart zu steuern, dass dann, nachdem die Steuerung (150, 450) den Öffnungsgrad des Ventils (270) in dem offenen Zustand über eine Mehrzahl von Huben konstant hält, die Steuerung (150, 450) den Öffnungsgrad des Ventils (270) in dem offenen Zustand auf der Basis der Viertakt-basierten Druckänderungsart ändert.

19. Ein Grätschsitzfahrzeug (1), das folgende Merkmale aufweist:

die Motoreinheit (300, 400) gemäß einem der Ansprüche 1 bis 18;
einen Fahrzeugkörperrahmen (4), der die Motoreinheit (300, 400) hält;
einen Fahrersitz (11);
einen Lenker (9), der vor dem Fahrersitz (11) bereitgestellt ist; und
einen Kraftstofftank (14), der mit dem in der Motoreinheit (300, 400) enthaltenen Kanister (161) verbunden ist.

Revendications

1. Unité de moteur à quatre temps multicylindre, comprenant:

un moteur (130) comportant une chambre de combustion (130a);
un élément de passage d'admission (110) qui est connecté au moteur (130) et qui permet que de l'air soit introduit dans la chambre de combustion (130a); et une soupape d'étranglement (112) prévue dans une partie intermédiaire de l'élément de passage d'admission (110), la chambre de combustion (130a), l'élément de passage d'admission (110) et la soupape d'étranglement (112) étant prévus pour chaque cylindre (131), où une pression dans une partie de passage d'admission aval (110d) de l'élément de passage d'admission (110), qui se trou-

ve en aval de la soupape d'étranglement (112), varie de manière à faire varier la pression de sorte que: une dépression plus faible présentant une différence plus petite par rapport à la pression atmosphérique et une plus grande dépression présentant une différence plus grande par rapport à la pression atmosphérique soit créée à chaque cycle de quatre temps; et la création des dépressions plus faibles et plus grandes est répétée à chaque quatre temps,
l'unité de moteur comprenant par ailleurs:

un bidon (161) connecté à un réservoir de carburant (14) et contenant un adsorbant configuré pour adsorber la vapeur de carburant contenue dans l'air entrant provenant du réservoir de carburant (14); and
un élément de passage de communication (363) configuré pour établir une communication entre l'intérieur du bidon (161) et la partie de passage d'admission aval (110d) pour chaque cylindre (131), l'élément de passage de communication (363) présentant une partie ramifiée pour chaque cylindre (131), les parties ramifiées étant connectées respectivement aux parties de passage d'admission aval (11Od),

l'unité de moteur étant **caractérisée en ce qu'**elle comprend:

une soupape (170, 270) prévue sur chaque partie ramifiée de l'élément de passage de communication (363) de sorte qu'une capacité d'une partie de l'élément de passage de communication (363), la partie s'étendant de l'élément de passage d'admission (110) à la soupape, soit inférieure à la moitié d'un déplacement du moteur (130), où un degré d'ouverture des soupapes (170, 270) peut être modifié; et
un moyen de commande (150, 450) configuré pour commander le fonctionnement des soupapes (170, 270) sur base de la manière de faire varier la pression selon laquelle est répétée la création des dépressions plus faible et plus grande à chaque quatre temps.

2. Unité de moteur selon la revendication 1, comprenant par ailleurs un capteur (151, 152, 153) pour chaque partie de passage d'admission aval (110d), les capteurs (151, 152, 153) étant configurés pour détecter une pression négative dans la partie de passage d'admission aval (110d), dans laquelle
le moyen de commande (150, 450) est configuré pour commander le fonctionnement des soupapes (170, 270) sur base d'un résultat de détection obtenu par les capteurs (151, 152, 153).

3. Unité de moteur selon la revendication 1 ou 2, dans laquelle le moyen de commande (150, 450) est configuré pour commander les soupapes (170, 270) de sorte qu'un rapport entre une quantité de vapeur de carburant introduite de l'élément de passage de communication (363) à la partie de passage d'admission aval (110d) et une quantité d'air introduite dans la chambre de combustion, qui est une quantité d'air introduite depuis la partie de passage d'admission aval (110d) dans la chambre de combustion (130a), augmente avec une augmentation de la quantité d'air introduite dans la chambre de combustion.

4. Unité de moteur selon l'une quelconque des revendications 1 à 3, dans laquelle:

chacune des soupapes (170) peut être commutée d'un état fermé à un état ouvert et peut être commutée de l'état ouvert à l'état fermé, l'état fermé étant l'état dans lequel la soupape (170) empêche la communication d'air entre l'intérieur du bidon (161) et la partie de passage d'admission aval (110d), l'état ouvert étant l'état dans lequel la soupape (170) permet la communication d'air entre l'intérieur du bidon (161) et la partie de passage d'admission aval (110d); et
le moyen de commande (150, 450) est configuré pour commander les soupapes (170) pour effectuer une opération de commutation de soupape en association avec la manière de faire varier la pression selon laquelle la création des dépressions plus faible et plus grande est répétée à chaque quatre temps, l'opération de commutation de soupape étant un ensemble d'opérations d'activation et de désactivation, une des opérations étant exécutée en premier lieu et ensuite étant effectuée l'autre des opérations, l'opération d'activation étant une opération de commutation de la soupape (170) de l'état fermé à l'état ouvert, l'opération de désactivation étant une opération de commutation de la soupape (170) de l'état ouvert à l'état fermé.

5. Unité de moteur selon la revendication 4, dans laquelle, lorsque chacun des quatre temps constituant un cycle de quatre temps est compté comme un temps, le moyen de commande (150, 450) est configuré pour commander chacune des soupapes (170) de manière à effectuer l'opération de commutation de soupape en association avec une période de n temps, où n est 1, 2 ou un multiple de 4.

6. Unité de moteur selon la revendication 5, dans laquelle le moyen de commande (150, 450) est configuré pour commander chacune des soupapes (170) de manière à effectuer au moins l'une parmi les opérations d'activation et de désactivation en synchronisation avec une période de n temps, où n est 1, 2, ou un multiple de 4.

7. Unité de moteur selon la revendication 6, dans laquelle le moyen de commande (150, 450) est configuré pour commander chacune des soupapes (170) de manière à effectuer l'opération d'activation et à effectuer ensuite l'opération de désactivation dans chaque période de n temps, où n est 1, 2, ou un multiple de 4.

8. Unité de moteur selon la revendication 6, dans laquelle le moyen de commande (150, 450) est configuré pour commander chacune des soupapes (170) de manière à effectuer l'opération de désactivation et à effectuer ensuite l'opération d'activation dans chaque période de n temps, où n est 1, 2, ou un multiple de 4.

9. Unité de moteur selon la revendication 6, dans laquelle le moyen de commande (150, 450) est configuré pour commander chacune des soupapes (170) de manière à effectuer chacune des opérations d'activation et de désactivation une fois dans chaque période de n temps, où n est 1, 2 ou multiple de 4.

10. Unité de moteur selon la revendication 9, dans laquelle le moyen de commande (150, 450) est configuré pour commander chacune des soupapes (170) de manière à effectuer chacune des opérations d'activation et de désactivation une fois dans chaque période d'un temps ou dans chaque période de deux temps.

11. Unité de moteur selon la revendication 9, dans laquelle le moyen de commande (150, 450) est configuré pour commander chacune des soupapes (170) de manière à effectuer chacune des opérations d'activation et de désactivation une fois dans un cycle de quatre temps dans chaque période de n temps, où n est un multiple de 4.

12. Unité de moteur selon la revendication 11, dans laquelle le moyen de commande (150, 450) est configuré pour commander chacune des soupapes (170) de manière à effectuer chacune des opérations d'activation et de désactivation une fois dans une période de quatre temps.

13. Unité de moteur selon la revendication 6, dans laquelle le moyen de commande (150, 450) est configuré pour commander chacune des soupapes (170) de manière à effectuer chacune des opérations d'activation et de désactivation deux ou plusieurs fois dans chaque période de n temps, où n est un multiple de 4.

14. Unité de moteur selon la revendication 5, dans laquelle le moyen de commande (150, 450) est configuré pour commander chacune des soupapes (170) de manière à effectuer l'une des opérations d'activation et de désactivation et à effectuer ensuite l'autre dans chaque période de n temps, où n est égal à 1, 2, ou un multiple de 4, les temps pour effectuer les opérations d'activation et de désactivation dans chaque période étant différents parmi les périodes de n temps.

15. Unité de moteur selon l'une quelconque des revendications 1 à 3, dans laquelle:

chacune des soupapes (270) est à même d'être dans un état ouvert dans lequel la soupape (270) permet la communication d'air entre l'intérieur du bidon (161) et l'élément de passage d'admission (110) par l'intermédiaire de l'élément de passage de communication (363), et le degré d'ouverture de chacune des soupapes (270) à l'état ouvert est réglable; et
le moyen de commande (150) est configuré pour commander le degré d'ouverture de chacune des soupapes (270) à l'état ouvert sur base d'une manière de faire varier la pression à base de quatre temps incluse dans la manière de faire varier la selon laquelle la création des dépressions plus faible et plus grande est répétée sur base de quatre temps.

16. Unité de moteur selon la revendication 15, dans laquelle, lorsque quatre temps sont comptés comme un cycle, le moyen de commande (150, 450) est configuré pour commander le degré d'ouverture de chacune des soupapes (270) à l'état ouvert sur base de la manière de faire varier la pression sur base de quatre temps pour chaque période de n cycles, où n est un nombre naturel.

17. Unité de moteur selon la revendication 16, comprenant par ailleurs un capteur (151, 152, 153) pour chaque partie de passage d'admission aval (110d), les capteurs (151, 152, 153) étant configurés pour détecter une pression négative dans la partie de passage d'admission aval (110d), dans laquelle
le moyen de commande (150, 450) est configuré pour commander le degré d'ouverture des soupapes (270) à l'état ouvert sur base d'un résultat de détection obtenu par les capteurs (151, 152, 153) dans chaque cycle inclus dans la période de n cycles, le résultat de la détection fonctionnant pour indiquer la manière de faire varier pression sur base de quatre temps pour chaque période de n cycles.

18. Unité de moteur selon la revendication 16 ou 17, dans laquelle, lorsque quatre temps sont comptés comme un cycle, le moyen de commande (150, 450) est configuré pour commander chacune des soupapes (270) de sorte qu'après que le moyen de commande (150, 450) maintienne le degré d'ouverture de la soupape (270) à l'état ouvert constant sur une pluralité de cycles, le moyen de commande (150, 450) modifie le degré d'ouverture de la soupape (270) à l'état ouvert sur base de la manière de faire varier la pression sur base de quatre temps.

19. Véhicule à selle (1), comprenant
l'unité de moteur (300, 400) selon l'une quelconque des revendications 1 à 18;
un châssis de carrosserie de véhicule (4) supportant l'unité de moteur (300, 400);
un siège de pilote (11);
des guidons (9) prévus à l'avant du siège de pilote (11); et
un réservoir de carburant (14) connecté au bidon (161) inclus dans l'unité de moteur (300, 400).

FIG.1

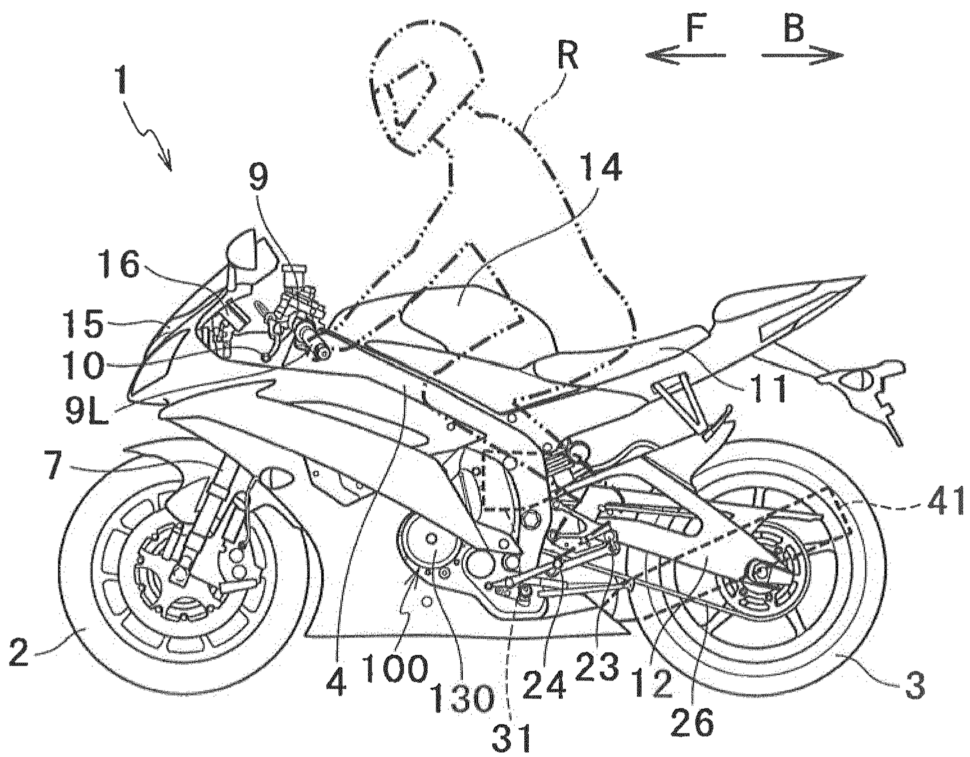


FIG.2

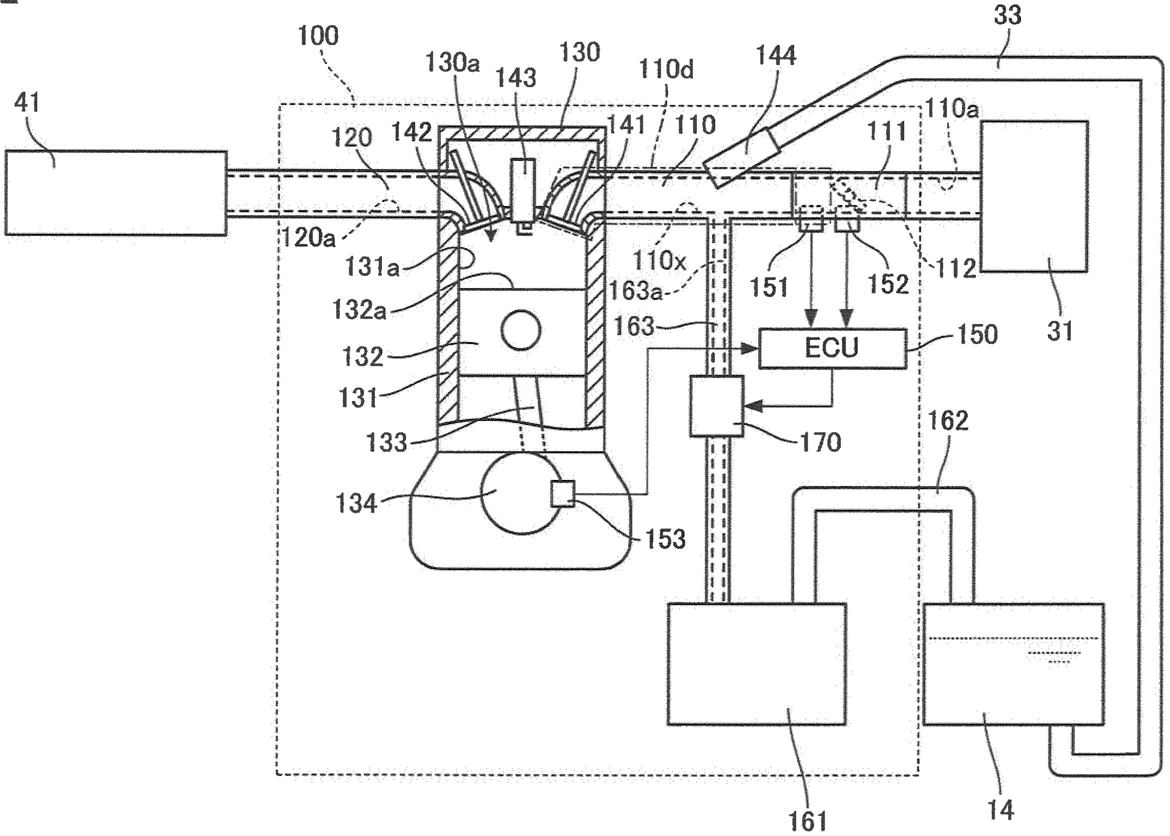

100
41
120
120a
130a
143
130
142
141
110d
110
144
33
110a
111
112
31
131a
132a
132
131
133
134
153
110x
163a
163
151
152
ECU
150
170
162
161
14

FIG.3

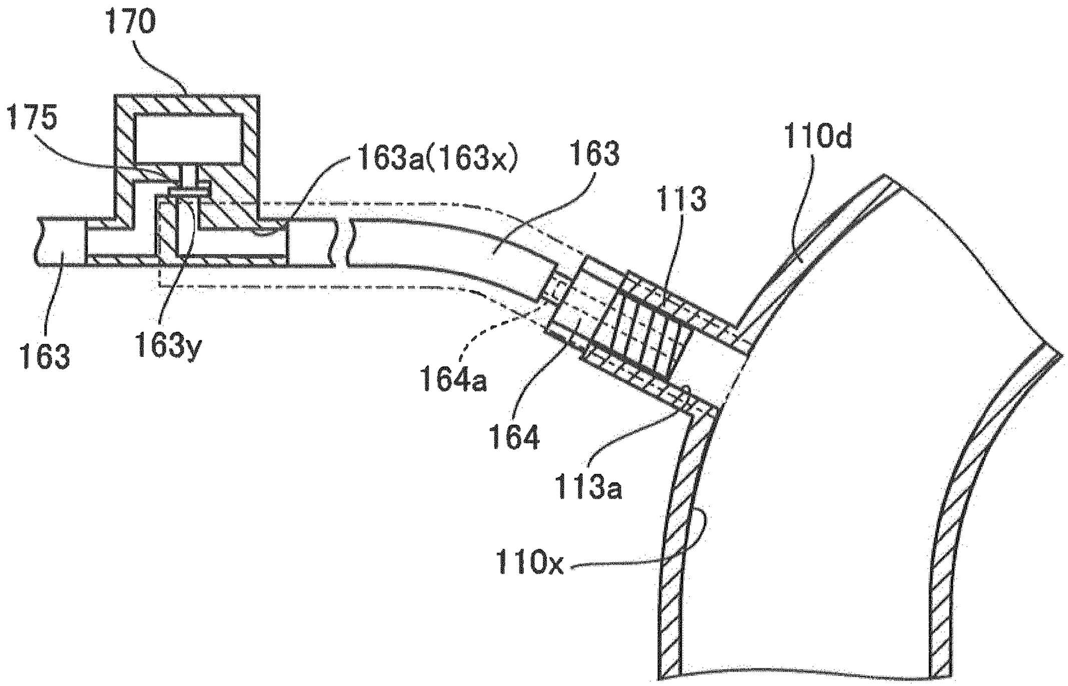


FIG.4A

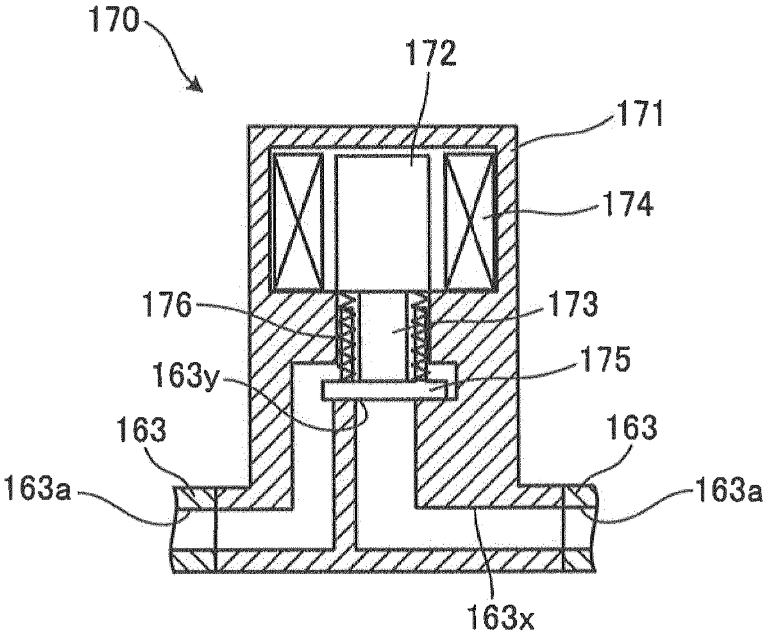

170
172
171
174
176
173
175
163y
163
163
163a
163a
163x

FIG.4B

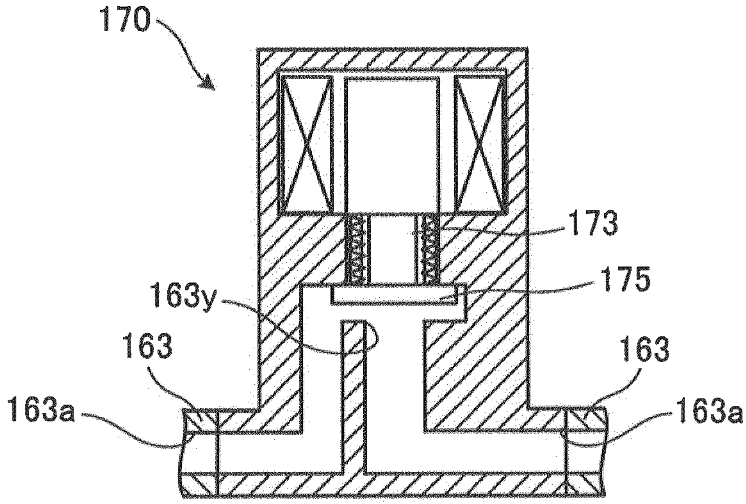

170
173
175
163y
163
163
163a
163a

FIG.5

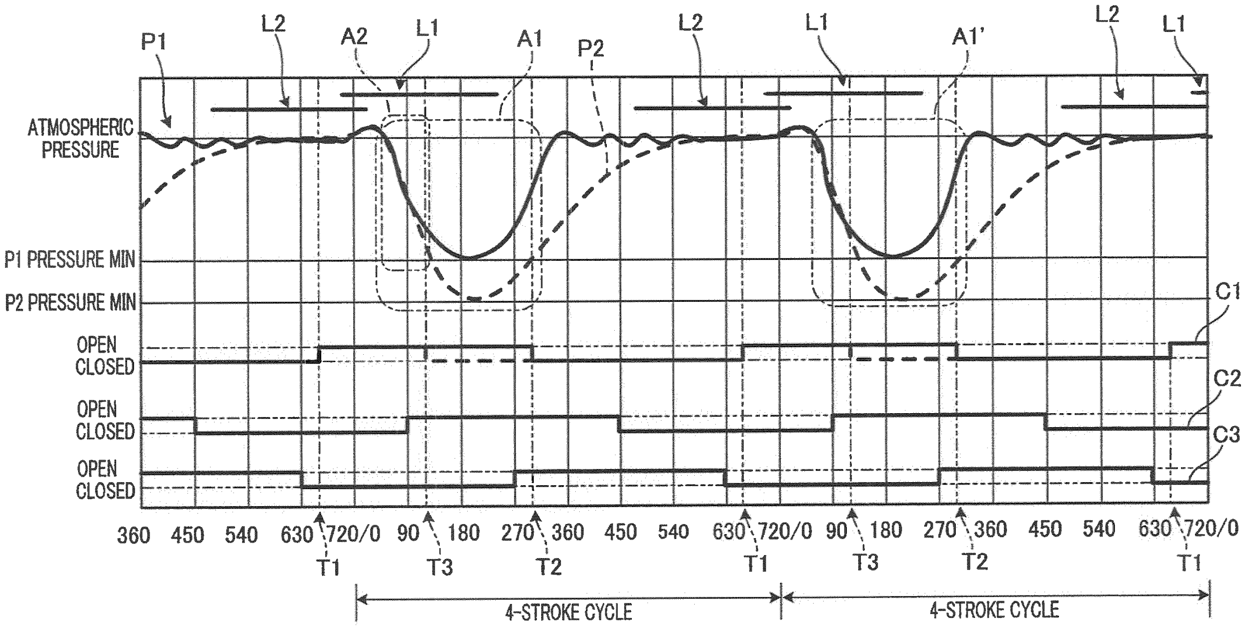

P1
L2
A2
L1
A1
P2
L2
L1
A1'
L2
L1
ATMOSPHERIC PRESSURE
P1 PRESSURE MIN
P2 PRESSURE MIN
OPEN
CLOSED
C1
OPEN
CLOSED
C2
OPEN
CLOSED
C3
360 450 540 630 720/0 90 180 270 360 450 540 630 720/0 90 180 270 360 450 540 630 720/0
T1
T3
T2
T1
T3
T2
T1
4-STROKE CYCLE
4-STROKE CYCLE

FIG.6A

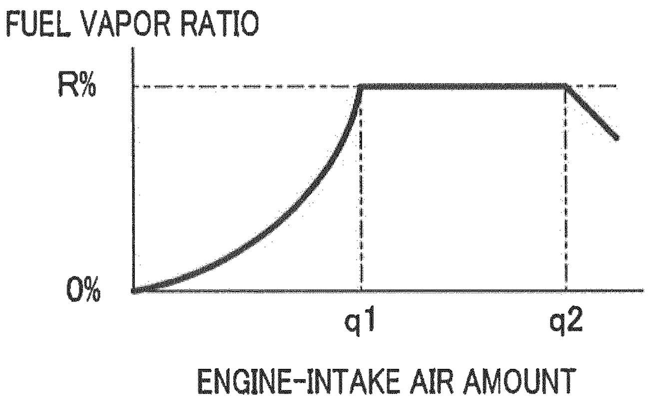

FUEL VAPOR RATIO
R%
0%
q1
q2
ENGINE-INTAKE AIR AMOUNT

FIG.6B

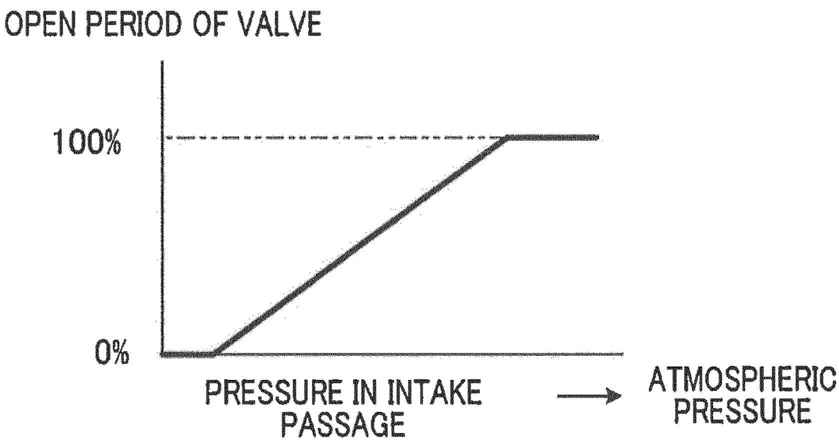

OPEN PERIOD OF VALVE
100%
0%
PRESSURE IN INTAKE PASSAGE
ATMOSPHERIC PRESSURE

FIG.7

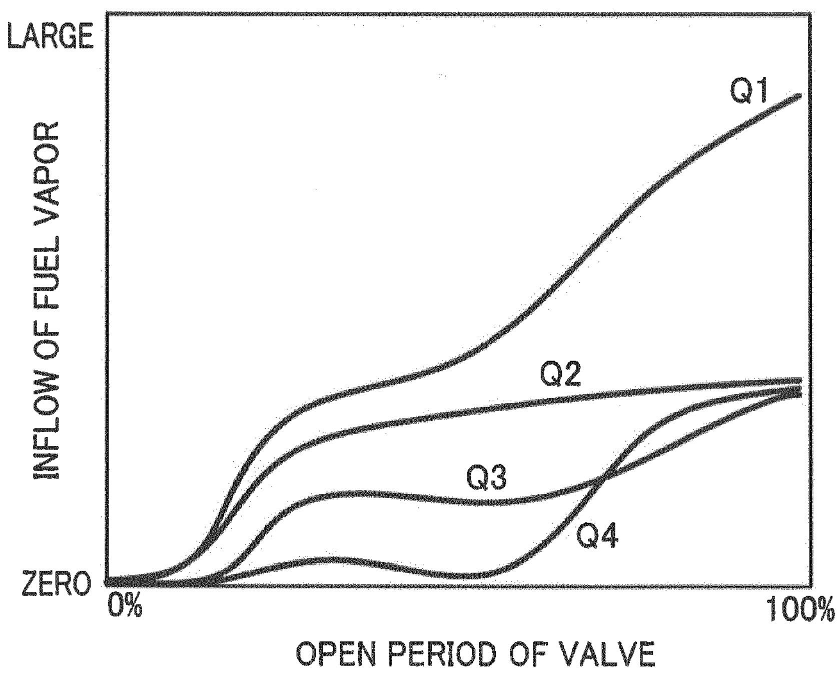

LARGE
ZERO
INFLOW OF FUEL VAPOR
Q1
Q2
Q3
Q4
0%
100%
OPEN PERIOD OF VALVE

FIG.8

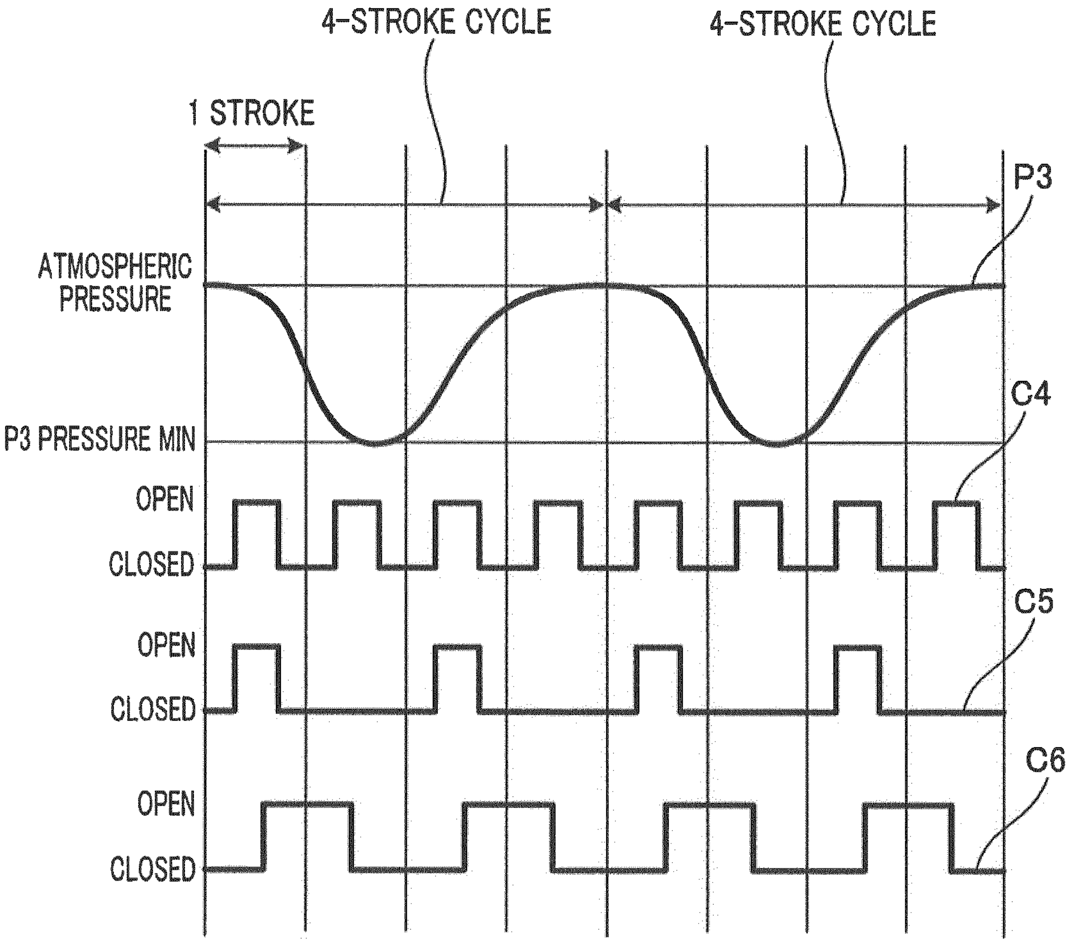

4-STROKE CYCLE
4-STROKE CYCLE
1 STROKE
P3
ATMOSPHERIC PRESSURE
C4
P3 PRESSURE MIN
OPEN
CLOSED
C5
OPEN
CLOSED
C6
OPEN
CLOSED

FIG.9

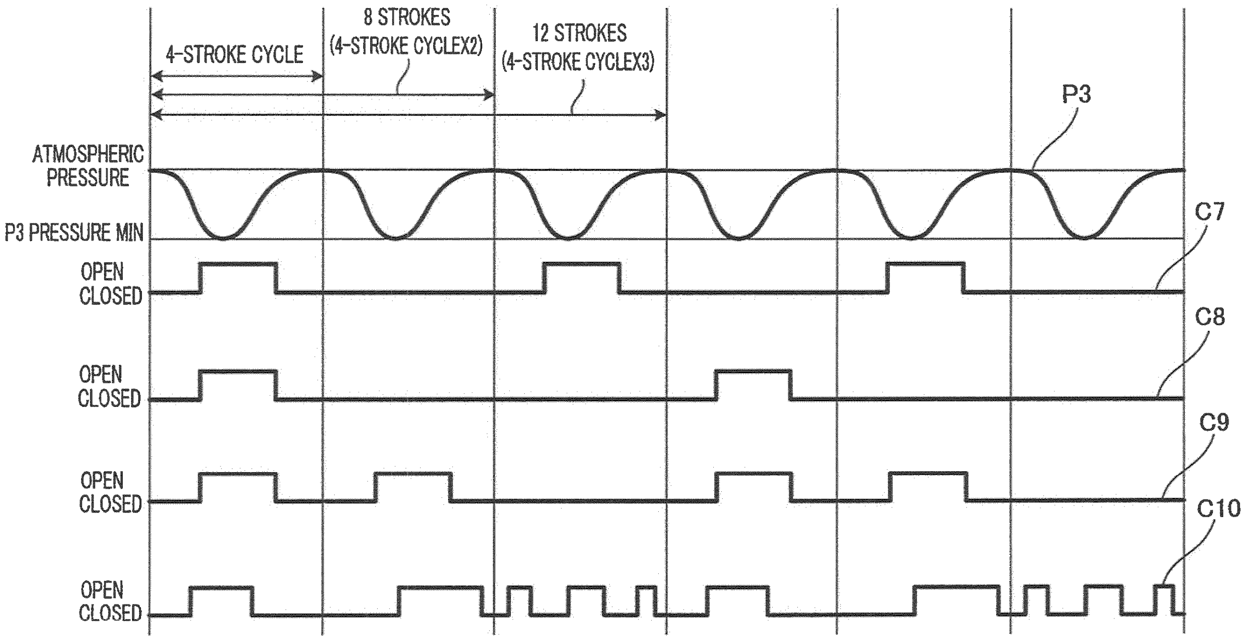

4-STROKE CYCLE
8 STROKES
(4-STROKE CYCLEX2)
12 STROKES
(4-STROKE CYCLEX3)
P3
ATMOSPHERIC
PRESSURE
P3 PRESSURE MIN
C7
OPEN
CLOSED
C8
OPEN
CLOSED
C9
OPEN
CLOSED
C10
OPEN
CLOSED

FIG.10A

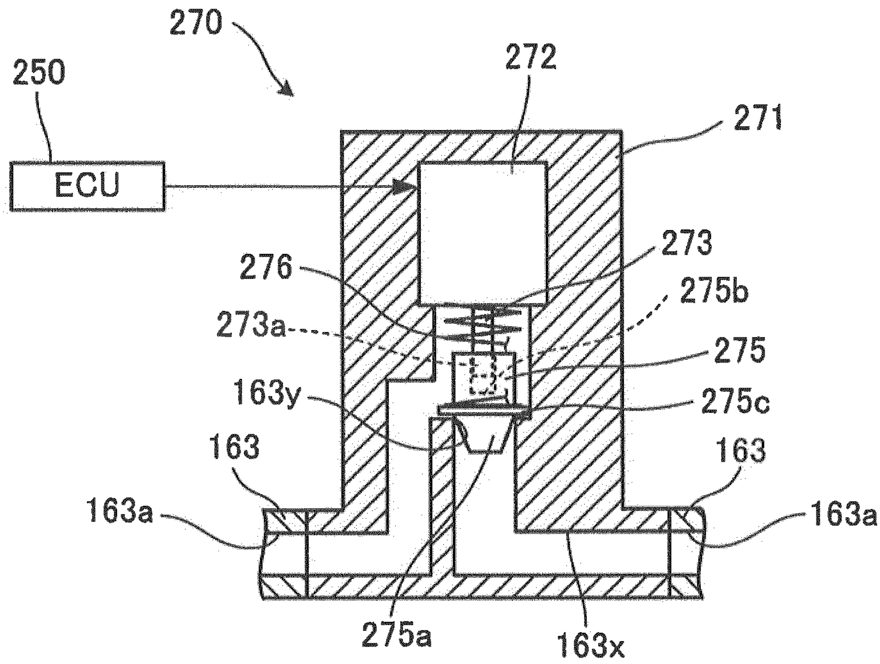


FIG.10B

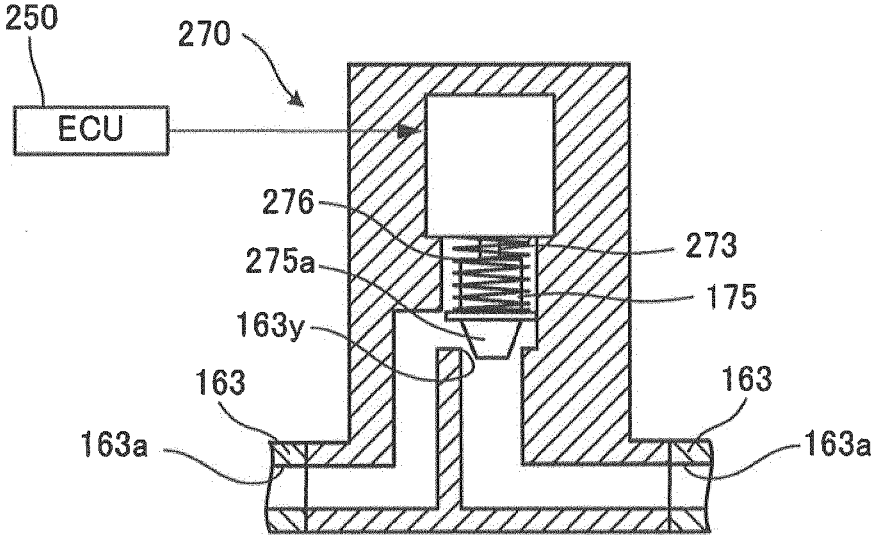


FIG.11

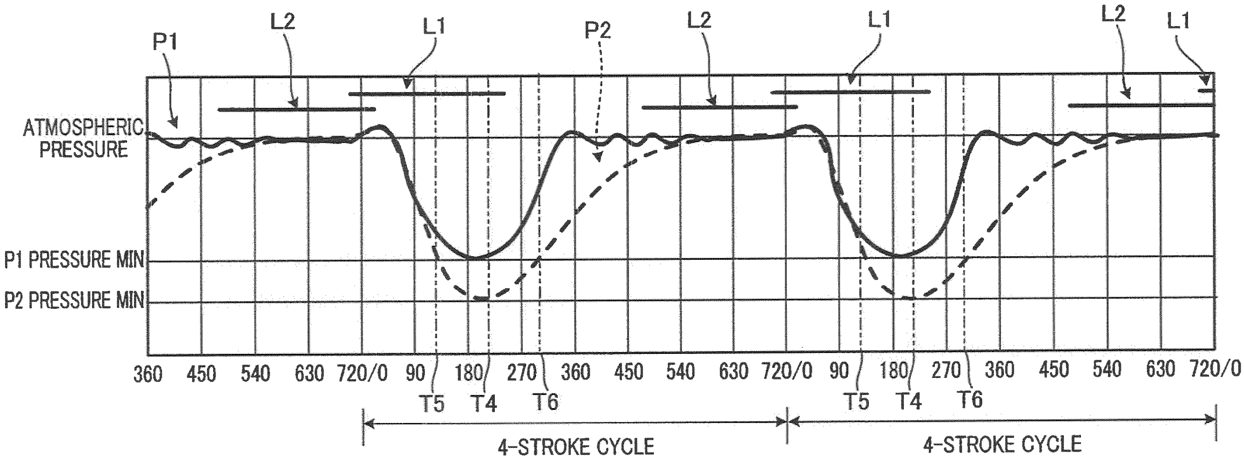

P1
L2
L1
P2
L2
L1
L2
L1
ATMOSPHERIC PRESSURE
P1 PRESSURE MIN
P2 PRESSURE MIN
360 450 540 630 720/0 90 180 270 360 450 540 630 720/0 90 180 270 360 450 540 630 720/0
T5 T4 T6
T5 T4 T6
4-STROKE CYCLE
4-STROKE CYCLE

FIG.12A

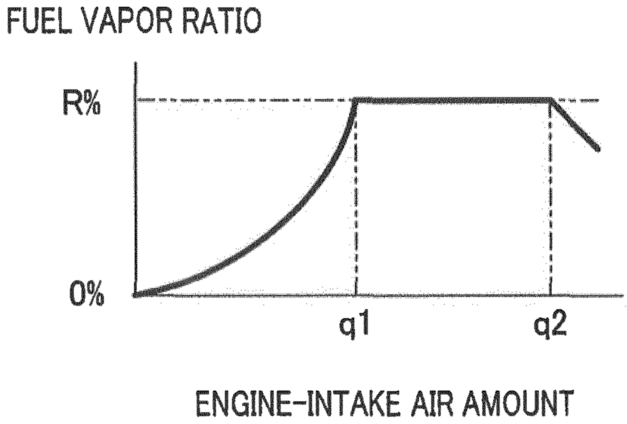


FIG.12B

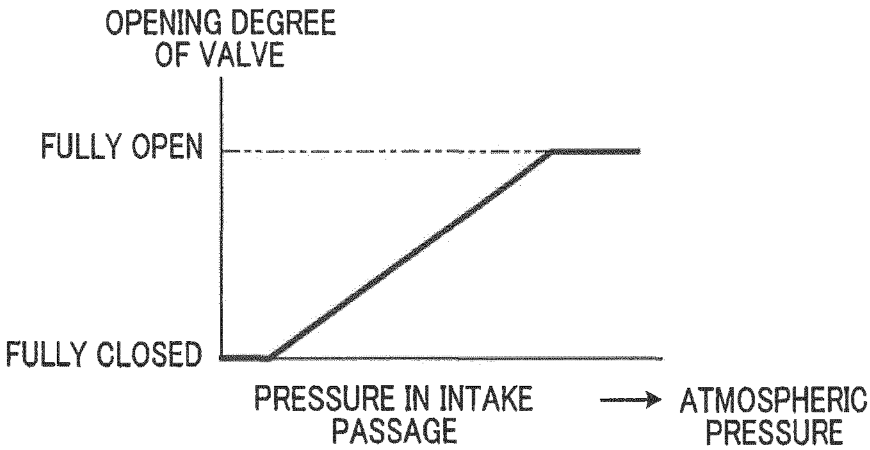


FIG.13

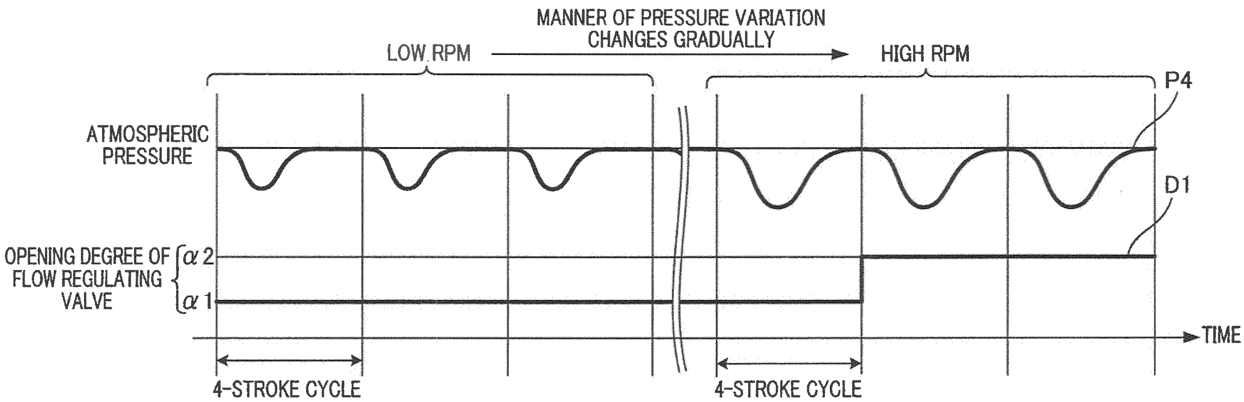

MANNER OF PRESSURE VARIATION CHANGES GRADUALLY
LOW RPM
HIGH RPM
P4
ATMOSPHERIC PRESSURE
D1
OPENING DEGREE OF FLOW REGULATING VALVE
α 2
α 1
TIME
4-STROKE CYCLE
4-STROKE CYCLE

FIG.14A

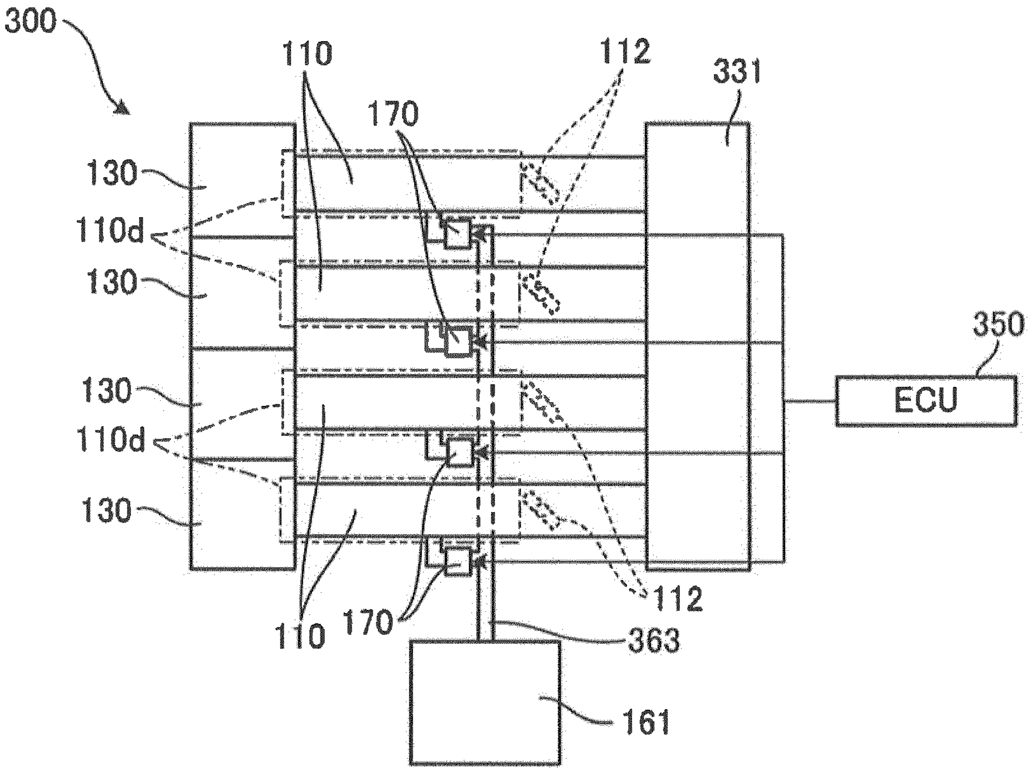


FIG.14B

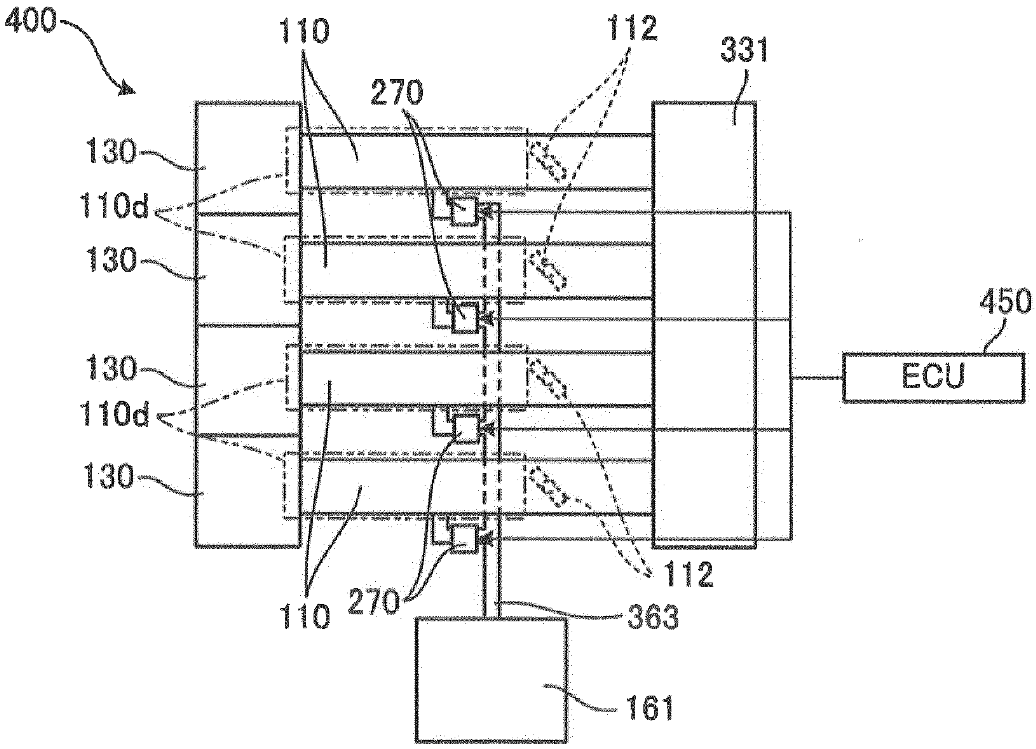
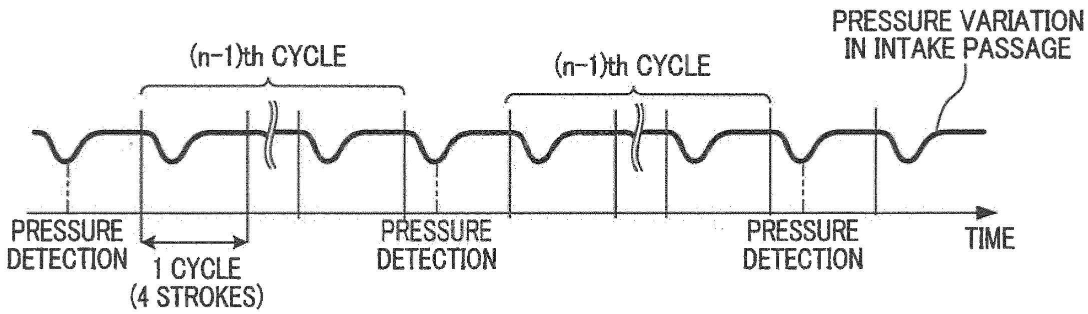


FIG.15



PRESSURE VARIATION IN INTAKE PASSAGE
(n-1)th CYCLE
(n-1)th CYCLE
PRESSURE DETECTION
1 CYCLE (4 STROKES)
PRESSURE DETECTION
PRESSURE DETECTION
TIME

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 2009057844 A **[0003]**