(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 434 136 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
28.03.2012 Bulletin 2012/13

(51) Int Cl.:
F02M 31/18 *(2006.01)*

(21) Application number: **11175942.9**

(22) Date of filing: **29.07.2011**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(30) Priority: **22.09.2010 JP 2010211682**

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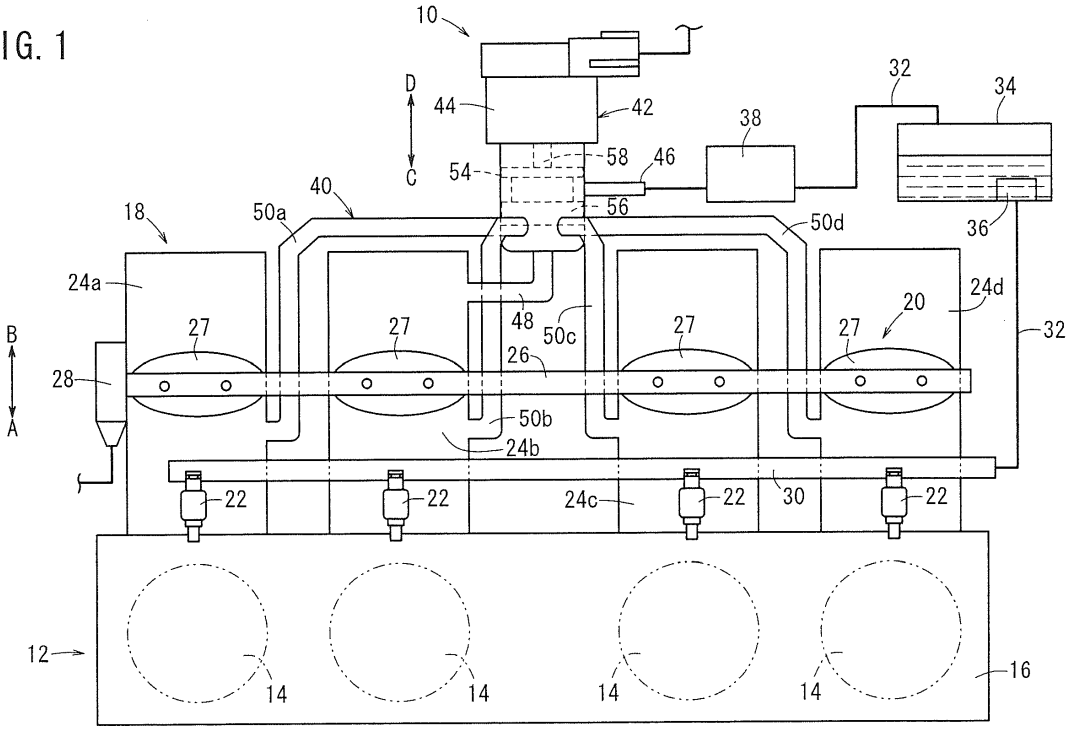
(54) Evaporative fuel control apparatus for internal combustion engine

(57) In an evaporative fuel control apparatus (10), a first passage (48) of a bypass conduit (40) is connected between an upstream side of an intake passage (24b) and a switching valve (42), and second passages (50a to 50d) interconnect the switching valve (42) and downstream sides of respective intake passages (24a to 24d), whereas a purge conduit (46) to which the evaporative fuel is supplied is connected with respect to the switching valve (42). The switching valve (42) is operated responsive to a driven state of the internal combustion engine (12), thus switching between a communication state between the first passage (48) and the second passages (50a to 50d), and a communication state between the purge conduit (46) and the second passages (50a to 50d), such that intake air or evaporative fuel is made to flow to the intake passages (24a to 24d).

FIG. 1



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Description

BACKGROUND OF THE INVENTION

Field of the Invention:

[0001] The present invention relates to an evaporative fuel control apparatus for an internal combustion engine, which serves to circulate to the internal combustion engine an evaporative fuel, which is evaporated from a fuel in a liquid state, in an internal combustion engine installed in a motor vehicle.

Description of the Related Art:

[0002] Heretofore, an evaporative fuel control apparatus has been known, in which an evaporative fuel generated in the fuel tank of a vehicle is adsorbed by a canister, and then the evaporative fuel, which is desorbed from the canister, is purged into the inlet system of an internal combustion engine.

[0003] For example, with the evaporative fuel control apparatus disclosed in Japanese Laid-Open Patent Publication No. 04-342863, in order to correspond to a multi-cylinder internal combustion engine, a first purge conduit is connected on a downstream side of the canister, and second purge conduits are provided on a downstream side of the first purge conduit so as to be branched in a forked shape. Further, four third purge conduits are connected respectively on downstream sides of the second purge conduits so as to be branched in forked shapes, and respective throttle bodies having respective throttle valves are connected respectively to the third purge conduits. Additionally, the evaporative fuel desorbed from the canister is supplied respectively to the four throttle bodies through the first through third purge conduits, and the evaporative fuel is purged into the internal combustion engine.

[0004] However, with the aforementioned evaporative fuel control apparatus, when assembled with respect to the internal combustion engine, assembly operations for the multiple first through third purge conduits are extremely troublesome, while additionally, due to the necessity for joints to connect the third purge conduits with respect to the throttle bodies, the efficiency with which the evaporative fuel control apparatus can be assembled is decreased, and there is a concern that manufacturability will be worsened.

[0005] Consequently, for improving assembly efficiency and simplifying the complex piping structure, for example, it may be contemplated to apply the piping structure for an engine, as disclosed in Japanese Laid-Open Patent Publication No. 2000-186653, with respect to an evaporative fuel control apparatus. In such an engine, a bypass flow passage is connected with respect to a surge tank to which intake air is introduced, a downstream side of the bypass flow passage is branched into passages and the passages are connected respectively to an intake manifold, and together therewith, a vapor tank in which fuel is stored and a midway location of the bypass flow passage are connected by a vent passage. Further, in the bypass flow passage, a control valve is provided on a downstream side of the connection location where the vent passage is connected, such that upon occurrence of a valve open state in an idle state of the internal combustion engine, intake air is caused to flow through the bypass flow passage and into the intake manifold.

[0006] Notwithstanding, in the piping system disclosed in Japanese Laid-Open Patent Publication No. 2000-186653, although the piping structure thereof is simplified compared with the aforementioned structure of the evaporative fuel control apparatus, the control valve for controlling intake air is disposed on the downstream side of the connection location in the bypass passage. Consequently, in the event that a purge gas, which is vaporized by the vapor tank, flows to the intake manifold through the vent passage and the bypass flow passage, although it is possible for such a flow to take place solely during an idle state, such a flow cannot occur during normal operation (running) of the internal combustion engine.

SUMMARY OF THE INVENTION

[0007] A general object of the present invention is to provide an evaporative fuel control apparatus for an internal combustion engine, having a simplified structure, and which is capable of reducing the number of assembly steps and causing combustion of the evaporative fuel reliably and efficiently.

[0008] The present invention is characterized by an evaporative fuel control apparatus for use in an internal combustion engine having intake passages that supply intake air to plural cylinder chambers, and a throttle valve disposed in the intake passages for controlling a flow rate of the intake air, wherein vaporized evaporative fuel is supplied through the intake passages into the cylinder chambers, the evaporative fuel control apparatus comprising:

a bypass passage made up from an upstream side passage connected to an upstream side of the throttle valve in the intake passages, and plural downstream side passages, which are connected to downstream sides of the throttle valve in the intake passages;

a switching valve connected to the bypass passage, and having a body, a valve body disposed displaceably inside the body, and a drive unit for displacing the valve body in an axial direction, the switching valve being capable of switching a communication state of the bypass passage by displacement of the valve body; and

a purge passage connected to the switching valve through which the evaporative fuel flows,

wherein the purge passage and the bypass passage

are connected to the body while being separated mutually in the axial direction, and a communication state of the upstream side passage or the purge passage with respect to the downstream side passages via a communication section provided on the valve body is switched by displacement of the valve body.

[0009] In accordance with the present invention, based on the running speed of the vehicle, the rotational speed of the internal combustion engine, etc., by displacement of the valve body of the switching valve along the axial direction, the communication state of the upstream side passage or the purge passage with respect to the downstream side passage in the bypass passage can be switched via the communication section provided on the valve body. As a result, supply of intake air to multiple intake passages, and supply of evaporative fuel through the purge passage can be controlled respectively by means of a single switching valve. Therefore, it is unnecessary to provide individual pipes separately for supplying evaporative fuel to each of the intake passages, the piping structure can be simplified, the number of parts that make up the evaporative fuel control apparatus can be reduced, and assembly efficiency can be improved. Further, under a switching action of the switching valve, because evaporative fuel can be made to flow to the intake passages at a desired timing, the evaporative fuel can be supplied reliably and efficiently to the intake passages to enable combustion of the evaporative fuel in the cylinder chambers.

[0010] The above and other objects, features, and advantages of the present invention will become more apparent from the following description when taken in conjunction with the accompanying drawings in which a preferred embodiment of the present invention are shown by way of illustrative example.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

FIG. 1 is an outline structural view showing an evaporative fuel control apparatus according to an embodiment of the present invention, and an internal combustion engine in which the evaporative fuel control apparatus is used;

FIG. 2A is a cross sectional view showing a state in which a first passage and second passages are placed in communication in a switching valve that constitutes the evaporative fuel control apparatus of FIG. 1;

FIG. 2B is a cross sectional view showing a fully closed state in which the first and second passages and a purge conduit are closed by a valve body in the switching valve of FIG. 2A;

FIG. 2C is a cross sectional view showing a state in which the valve body of FIG. 2B is lowered, and the purge conduit and the second passages are placed in communication;

FIG. 3 is a cross sectional view taken along line III-III of FIG. 2C;

FIG. 4A is an overall cross sectional view of a switching valve according to a modified example;

FIG. 4B is an overall cross sectional view showing a state in which the valve body of FIG. 4A is lowered; and

FIG. 4C is a cross sectional view taken along line IVC-IVC of FIG. 4B.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0012] In FIG. 1, reference numeral 10 indicates an evaporative fuel control apparatus for an internal combustion engine according to an embodiment of the present invention.

[0013] First, explanations shall be made briefly with reference to FIG. 1 concerning an internal combustion engine 12 in which the evaporative fuel control apparatus 10 is installed. The internal combustion engine 12 may be installed, for example, in an automobile, or on a two-wheeled motor vehicle.

[0014] The internal combustion engine 12 includes a main body 16 having a plurality of cylinder chambers 14 in which non-illustrated pistons are accommodated, an intake manifold 18 to which the cylinder chambers 14 are connected and intake air is introduced, a throttle valve 20 disposed in the interior of the intake manifold 18 and which is capable of controlling a flow rate of the intake air, and injectors 22 provided in the intake manifold 18 for injecting fuel. A case shall be explained in which the evaporative fuel control apparatus 10 is installed in a four cylinder internal combustion engine 12 having four cylinder chambers 14.

[0015] The intake manifold 18 includes a plurality of intake passages 24a to 24d through which intake air flows. The throttle valve 20 is disposed so as to be capable of opening and closing for controlling the flow rate of intake air respectively to the intake passages 24a to 24d, which are disposed in parallel. A non-illustrated intake duct is provided on an upstream side of the intake manifold 18, external air being introduced through the intake duct.

[0016] The throttle valve 20, for example, is a multiple throttle valve on which respective valves 27 are provided corresponding to each of the intake passages 24a to 24d, the valves 27 being connected integrally through a shaft 26. Each of the passage cross sectional areas of the intake passages 24a to 24d is changed as a result of the valves 27 being rotated by a rotary drive source 28 (for example, a stepping motor) disposed on an external portion of the intake manifold 18, thereby controlling the flow rate of intake air.

[0017] The injectors 22 are disposed on a downstream side (in the direction of the arrow A) of the throttle valve 20 in the intake manifold 18. Based on a control signal from a non-illustrated control unit, the injectors inject fuel

(e.g., gasoline) into the intake passages 24a to 24d, whereby the fuel and the intake air are mixed and supplied to the cylinder chambers 14 of the main body 16 in a mixed condition. The injectors 22 are connected respectively to a fuel tube 30 for injecting fuel that is supplied through the interior of the fuel tube 30.

[0018] The fuel tube 30 is connected through a fuel conduit 32 to a fuel tank 34 in which the fuel is stored. The fuel is supplied by a fuel pump 36, which is disposed in the interior of the fuel tank 34.

[0019] Further, the fuel tank 34 is connected to a canister 38 via a fuel conduit 32. Evaporative fuel vaporized inside the fuel tank 34 is adsorbed by the canister 38.

[0020] Next, explanations shall be made with reference to FIGS. 1 to 3 concerning the evaporative fuel control apparatus 10, which is used in the aforementioned internal combustion engine 12. The evaporative fuel control apparatus 10 includes a bypass conduit (bypass passage) 40, which interconnects an upstream side and a downstream side in the intake passages 24a to 24d of the intake manifold 18, a switching valve 42 that switches a communication state of the bypass conduit 40, a drive unit 44 that carries out switching of the switching valve 42, and a purge conduit (purge passage) 46, through which evaporative fuel flows that is desorbed from the canister 38 connected to the switching valve 42.

[0021] The bypass conduit 40 is made up from a first passage (upstream side passage) 48 connected to an upstream side of the throttle valve 20 (in the direction of the arrow B) in the intake passage 24b, and which communicates with a later-described communication chamber 52 of the switching valve 42, and second passages (downstream side passages) 50a to 50d, which are connected respectively at a downstream side of the throttle valve 20 (in the direction of the arrow A) between the communication chamber 52 and each of the intake passages 24a to 24d of the intake manifold 18. A single first passage 48 is connected to one of the plural intake passages 24a to 24d, whereas four second passages 50a to 50d are provided corresponding to the number of intake passages 24a to 24d (four intake passages in this case).

[0022] Stated otherwise, the first passage 48 forms an upstream passage, which is connected to an upstream side of the throttle valve 20 (in the direction of the arrow B) in the intake passages 24a to 24d, whereas the second passages 50a to 50d form downstream passages, which are connected to a downstream side of the throttle valve 20 (in the direction of the arrow A) in the intake passages 24a to 24d.

[0023] The switching valve 42 comprises a bottomed cylindrical shaped body 54 with the communication chamber 52 formed therein, and a valve body 56, which is disposed for displacement along the communication chamber 52 of the body 54. The first passage 48, which constitutes part of the bypass conduit 40, is connected to a lower end along the axial direction (the direction of arrows C and D) of the body 54 and communicates with the interior of the body 54. On the other hand, a drive unit 44 is connected to an upper end along the axial direction of the body 54, and serves to block the upper opening of the body 54.

[0024] In the drive unit 44, for example, a stepping motor (rotary drive source) is used, which is rotationally displaced based on control signals from a non-illustrated control unit, the valve body 56 being screw engaged with respect to a drive shaft 58 disposed in a center portion of the rotary drive source. Additionally, by rotation of the drive shaft 58 under a rotary action of the drive unit 44, the valve body 56 is displaced vertically (in the direction of arrows C and D) along the body 54. The drive shaft 58 is formed, for example, from a metallic material.

[0025] Further, a plurality of the second passages 50a to 50d are connected to a lower part of the side surface of the body 54 on the side of the first passage 48 (in the direction of the arrow C), communicating respectively with the communication chamber 52 in the interior of the body 54. As shown in FIG. 3, the second passages 50a to 50d are separated at equal intervals mutually along the circumferential surface of the body 54. The second passages 50a to 50d extend radially outward in directions away from the body 54, and are arranged substantially in the same plane in the axial direction of the body 54.

[0026] Furthermore, on a side surface of the body 54, a purge conduit 46 is connected upwardly (in the direction of the arrow D) with respect to the second passages 50a to 50d toward the side of the drive unit 44, the purge conduit 46 communicating with the communication chamber 52 of the body 54. The purge conduit 46 is disposed so as to be connected between the canister 38 and the switching valve 42, and supplies evaporative fuel desorbed from the canister 38 into the switching valve 42.

[0027] The valve body 56 is formed in a cylindrical columnar shape. An outer circumferential surface of the valve body 56 abuts against the inner wall surface of the body 54, and is guided for displacement along the axial directions (the directions of arrows C and D). A drive shaft 58, by which a driving force of the drive unit 44 is transmitted, is connected to an upper end center portion of the valve body 56, the valve body 56 being urged in upward and downward directions (the directions of arrows C and D) through the drive shaft 58.

[0028] Further, an annular recess 60 is formed on the outer circumferential surface of the valve body 56, the annular recess 60 being recessed in a radial direction roughly in a center portion along the axial direction of the valve body 56. The outer circumferential surface of the valve body 56 also is equipped with a first land 62 provided on an upper portion of the annular recess 60, and a second land 64 provided on a lower portion of the annular recess 60. Additionally, a space, which is formed between the annular recess 60 and an inner wall surface of the body 54 serves as a communication passage (communication part) through which intake air and evaporative fuel flow.

[0029] Furthermore, as shown in FIG. 3, on the outer

circumferential surface of the valve body 56, a guide groove 66 is formed along the axial direction (the direction of arrows C and D), and a guide pin 68, which is fixed in the body 54 and projects toward the interior thereof, is inserted through the guide groove 66. More specifically, rotational displacement of the valve body 56 with respect to the body 54 is regulated by insertion of the guide pin 68 through the guide groove 66, such that the valve body 56 is capable of displacement only in the axial directions (the directions of arrows C and D).

[0030] Stated otherwise, the guide pin 68 and the guide groove 66 function as a rotational displacement regulating means for regulating rotational displacement of the valve body 56.

[0031] The evaporative fuel control apparatus 10 for an internal combustion engine 12 according to the embodiment of the present invention is constructed basically as described above. Next, operations and advantages of the evaporative fuel control apparatus 10 shall be described.

[0032] First, a fast idol condition, immediately after initiation of the internal combustion engine 12, in which the accelerator pedal (not shown) is not operated by the driver, shall be explained. In this case, a control signal is output to the switching valve 42 from a non-illustrated control unit, whereby, as shown in FIG. 2A, the valve body 56 of the switching valve 42 moves upwardly, such that the second land 64 becomes positioned above the second passages 50a to 50d of the bypass conduit 40. Thus, the first passage 48 and the second passages 50a to 50d of the bypass conduit 40 are placed in communication with each other through the communication chamber 52.

[0033] On the other hand, because the opening of the purge conduit 46 is closed by the second land 64, communication thereof with the communication chamber 52 is blocked, and evaporative gas cannot be supplied into the communication chamber 52. Moreover, in the idle state, communication between upstream and downstream sides of each of the intake passages 24a to 24d is blocked by the throttle valve 20.

[0034] As a result thereof, intake air, which is supplied to the intake passages 24a to 24d of the intake manifold 18, flows through the first passage 48 to the switching valve 42, and further flows via the communication chamber 52 into the second passages 50a to 50d. In addition, the intake air flows in each of the intake passages 24a to 24d toward the downstream side (in the direction of the arrow A) of the throttle valve 20, and is supplied to the interior of the cylinder chambers 14 of the main body 16.

[0035] Next, a case shall be explained concerning either a warmed-up state in which the internal combustion engine 12 is heated, or a normal condition in which the driver operates the accelerator pedal and the vehicle is driven at a constant speed. In this case, as shown in FIG. 2B, a control signal is output to the switching valve 42 from the non-illustrated control unit, and the valve body 56 of the switching valve 42 is lowered somewhat (in the direction of the arrow C) from the condition shown in FIG. 2A, such that the second land 64 is positioned to confront the second passages 50a to 50d, and communication between the second passages 50a to 50d and the communication chamber 52 is blocked. Further, since the annular recess 60 is arranged to face toward the purge conduit 46, evaporative fuel introduced from the purge conduit 46 does not flow past the annular recess 60 to the first and second passages 48 and 50a to 50d.

[0036] Lastly, a case shall be explained, for example, of a condition in which the vehicle accelerates, at times when the internal combustion engine 12 runs at a high speed or under a heavy load. In this case, as shown in FIG. 2C, a control signal is output to the switching valve 42 from the non-illustrated control unit, and the valve body 56 of the switching valve 42 is lowered somewhat further (in the direction of the arrow C) from the state shown in FIG. 2B, such that the annular recess 60 is positioned to face toward both the second passages 50a to 50d of the bypass conduit 40, and the purge conduit 46.

[0037] Consequently, a state of communication is established via the communication chamber 52 between the purge conduit 46 and the second passages 50a to 50d, and evaporative fuel is supplied from the purge conduit 46, past the interior of the switching valve 42, and through the second passages 50a to 50d into each of the intake passages 24a to 24d. In addition, the evaporative fuel is introduced from the respective intake passages 24a to 24d into the cylinder chambers 14 of the main body 16, and is combusted together with the fuel supplied from the injectors 22.

[0038] At this time, because the first passage 48 of the bypass conduit 40 is closed by the second land 64 of the valve body 56, communication between the first passage 48 and the second passages 50a to 50d is blocked.

[0039] In the foregoing manner, with the present embodiment, for example, a control signal, which is based on the running speed of the vehicle or the rotational speed of the internal combustion engine 12 or the like, is output from a non-illustrated control unit to the switching valve 42 of the evaporative fuel control apparatus 10, and thus, by advancing and retracting movements of the valve body 56 in vertical directions (the directions of arrows C and D), the communication state of the purge conduit 46 and the bypass conduit 40 can be switched respectively by means of a single switching valve 42. Stated otherwise, supply of intake air and supply of evaporative fuel, with respect to each of the intake passages 24a to 24d, can be controlled respectively using a single switching valve 42.

[0040] As a result, it is unnecessary to provide piping separately for the purpose of supplying evaporative fuel to the intake passages 24a to 24d, and compared with the conventional evaporative fuel control apparatus, the piping structure can be simplified, the number of parts that make up the evaporative fuel control apparatus 10 can be reduced, and assembly efficiency can be im-

proved.

[0041] The present invention is particularly effective in the case of being used with a multiple throttle valve 20 on which respective valves 27 are provided corresponding to each of the plural intake passages 24a to 24b.

[0042] Further, under a switching action of the switching valve 42, because evaporative fuel can be made to flow to the respective intake passages 24a to 24d at a desired timing, the evaporative fuel can be supplied reliably and efficiently to the intake passages 24a to 24d to enable combustion of the evaporative fuel inside the cylinder chambers 14.

[0043] Furthermore, a structure is provided in which the annular recess 60 is disposed on the outer circumferential surface of the valve body 56, whereby the purge conduit 46 and the second passages 50a to 50d in the bypass conduit 40 are placed in communication via the annular recess 60. Owing thereto, exposure of the drive shaft 58 of the drive unit 44 directly to the evaporative fuel is avoided, and deterioration of the drive shaft 58 by the evaporative fuel can be suppressed. As a result, durability of the drive unit 44 is enhanced, enabling operation thereof stably over a long period. In particular, when a shaft is used having screw threads engraved on an outer circumferential surface thereof, as with the drive shaft 58 of the present invention, deterioration of the drive shaft 58 can effectively be suppressed.

[0044] On the other hand, although the above-described switching valve 42 is constituted with an annular recess 60 formed in an annular shape on the outer circumferential surface of the valve body 56, the invention is not limited to this structure. For example, as with the switching valve 100 shown in FIGS. 4A to 4C, a valve body 102 may be used having on an outer circumferential surface thereof four grooves 104a to 104d, which extend along the axial direction on the outer circumferential surface, and which are separated at equal intervals in the circumferential direction.

[0045] The grooves 104a to 104d are formed, for example, with a rectangular shape in cross section, so as to be recessed a predetermined depth from the outer circumferential surface of the valve body 102, and extend downwardly (in the direction of the arrow C) from an upper end portion of the valve body 102.

[0046] Further, the length of the grooves 104a to 104d is set such that the grooves 104a to 104d are positioned upwardly (in the direction of the arrow D) with respect to the second passages 50a to 50d when the valve body 102 is raised, as shown in FIG. 4A, while in addition, the grooves 104a to 104d are positioned so that lower ends thereof face toward the second passages 50a to 50d when the valve body 102 is lowered, as shown in FIG. 4B (see also FIG. 4C).

[0047] In addition, as shown in FIG. 4A, in a fast idle condition of the internal combustion engine 12, the valve body 102 is raised under a driving action of the drive unit 44, whereby the first passage 48 and the second passages 50a to 50d constituting the bypass conduit 40 are placed in a state of communication through the communication chamber 52. Owing thereto, intake air supplied to the intake passages 24a to 24d of the intake manifold 18 passes through the bypass conduit 40 and flows to the downstream side of the throttle valve 20, and thereafter, is supplied to the main body 16.

[0048] At this time, the purge conduit 46 communicates with the purge communication chamber 106 provided above the valve body 102, whereby evaporative fuel introduced into the purge communication chamber 106 is guided into the respective grooves 104a to 104d.

[0049] On the other hand, when the internal combustion engine 12 is driven at high speeds or under heavy loads, the valve body 102 is lowered (in the direction of the arrow C) from the state shown in FIG. 4A, and as shown in FIGS. 4B and 4C, the lower ends of the grooves 104a to 104d are positioned to confront respective openings of the second passages 50a to 50d. Consequently, the evaporative fuel from the purge conduit 46 flows past the purge communication chamber 106 and the grooves 104a to 104d, and into the second passages 50a to 50d, and is supplied to each of the intake passages 24a to 24d. In addition, the evaporative fuel is introduced from the respective intake passages 24a to 24d into the cylinder chambers 14 of the main body 16, and is combusted together with the fuel supplied from the injectors 22.

[0050] More specifically, by utilizing the switching valve 100 having the valve body 102 constituted in the foregoing manner, in a case where the valve body 102 is formed, for example, using a mold, the grooves 104a to 104d can easily and simultaneously be formed together with formation of the valve body 102.

[0051] In an evaporative fuel control apparatus (10), a first passage (48) of a bypass conduit (40) is connected between an upstream side of an intake passage (24b) and a switching valve (42), and second passages (50a to 50d) interconnect the switching valve (42) and downstream sides of respective intake passages (24a to 24d), whereas a purge conduit (46) to which the evaporative fuel is supplied is connected with respect to the switching valve (42). The switching valve (42) is operated responsive to a driven state of the internal combustion engine (12), thus switching between a communication state between the first passage (48) and the second passages (50a to 50d), and a communication state between the purge conduit (46) and the second passages (50a to 50d), such that intake air or evaporative fuel is made to flow to the intake passages (24a to 24d).

Claims

1. An evaporative fuel control apparatus (10) for use in an internal combustion engine (12) having intake passages (24a to 24d) that supply intake air to plural cylinder chambers (14), and a throttle valve (20) disposed in the intake passages (24a to 24d) for controlling a flow rate of the intake air, wherein vaporized

evaporative fuel is supplied through the intake passages (24a to 24d) into the cylinder chambers (14), the evaporative fuel control apparatus (10) comprising:

a bypass passage (40) made up from an upstream side passage (48) connected to an upstream side of the throttle valve (20) in the intake passages (24a to 24d), and plural downstream side passages (50a to 50d), which are connected to downstream sides of the throttle valve (20) in the intake passages (24a to 24d);
a switching valve (42, 100) connected to the bypass passage (40), and having a body (54), a valve body (56, 102) disposed displaceably inside the body (54), and a drive unit (44) for displacing the valve body (56, 102) in an axial direction, the switching valve (42, 100) being capable of switching a communication state of the bypass passage (40) by displacement of the valve body (56, 102); and
a purge passage (46) connected to the switching valve (42, 100) through which the evaporative fuel flows,
wherein the purge passage (46) and the bypass passage (40) are connected to the body (54) while being separated mutually in the axial direction, and a communication state of the upstream side passage (48) or the purge passage (46) with respect to the downstream side passages (50a to 50d) via a communication section provided on the valve body (56, 102) is switched by displacement of the valve body (56, 102).

2. The evaporative fuel control apparatus according to claim 1, wherein the communication section comprises an annular recess (60) formed in a central portion of the valve body (56) along the axial direction on an outer circumferential surface of the valve body (56), the communication section enabling communication via the annular recess (60) between the purge passage (46) and the downstream side passages (50a to 50d).

3. The evaporative fuel control apparatus according to claim 1, wherein the communication section comprises grooves (104a to 104d) that extend along the axial direction on an outer circumferential surface of the valve body (102) and are formed facing toward openings of the downstream side passages (50a to 50d), the communication section enabling communication via the grooves (104a to 104d) between the purge passage (46) and the downstream side passages (50a to 50d).

4. The evaporative fuel control apparatus according to claim 2, wherein the downstream side passages (50a to 50d) are arranged in a radial fashion around the body (54), and are separated mutually at equal intervals along a circumferential direction of the body (54).

5. The evaporative fuel control apparatus according to claim 3, wherein the downstream side passages (50a to 50d) are arranged in a radial fashion around the body (54), and are separated mutually at equal intervals along a circumferential direction of the body (54).

6. The evaporative fuel control apparatus according to claim 1, wherein the drive unit (44) comprises a rotary drive source that rotates a drive shaft (58), the valve body (56, 102) being screw-engaged with respect to the drive shaft (58).

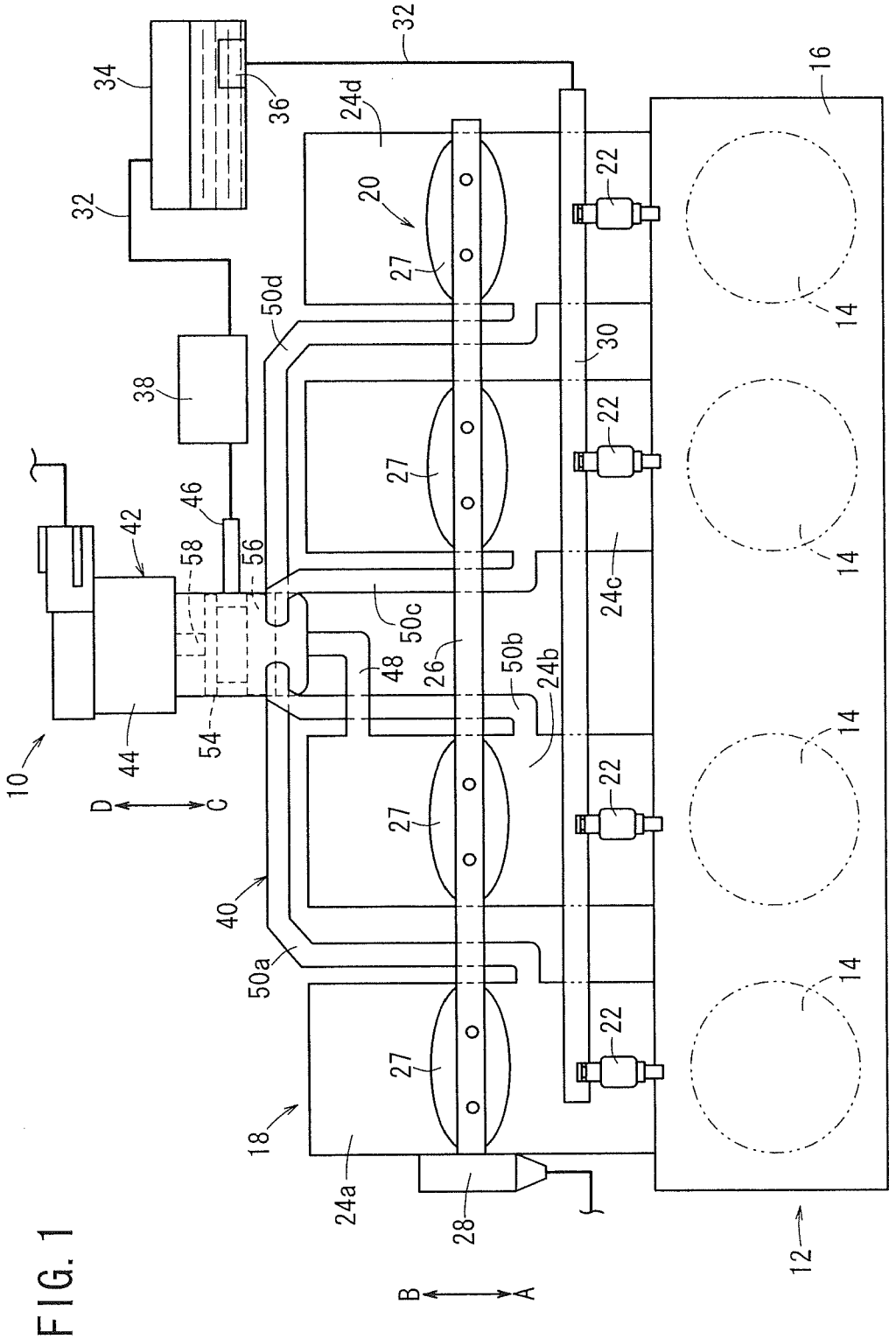
7. The evaporative fuel control apparatus according to claim 6, wherein a guide groove (66), which extends along the axial direction, is formed on the outer circumferential surface of the valve body (56, 102), and a pin (68), which is fixed to the body (54) and projects toward the valve body (56, 102), is inserted through the guide groove (66).

8. The evaporative fuel control apparatus according to claim 1, wherein the downstream side passages (50a to 50d) are arranged substantially in the same plane in the axial direction of the body (54).

9. The evaporative fuel control apparatus according to claim 1, wherein the downstream side passages (50a to 50d) are substantially perpendicular to the upstream side passage (48).

10. The evaporative fuel control apparatus according to claim 1, wherein the bypass passage (40) and the purge passage (46) are separated from each other in the axial direction of the switching valve (42, 100).

11. The evaporative fuel control apparatus according to claim 1, wherein the throttle valve (20) comprises a multiple throttle valve on which respective valves (27) are provided corresponding to the intake passages (24a to 24d), the multiple throttle valve being connected to the intake passages (24a to 24d).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24b
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44
10
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12

FIG. 1

FIG. 2C

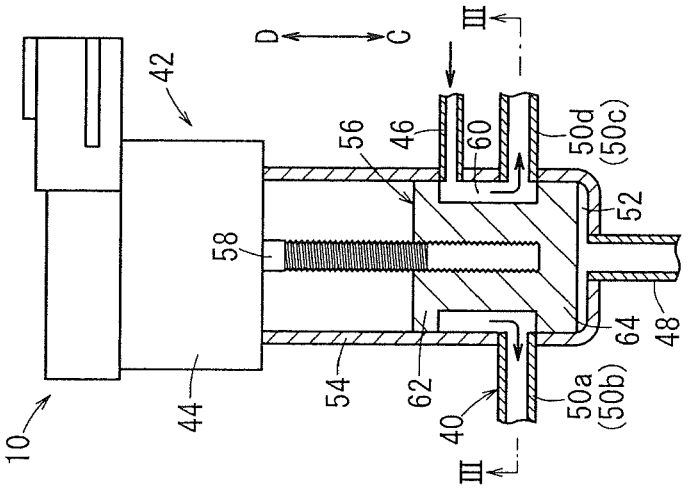


FIG. 2B

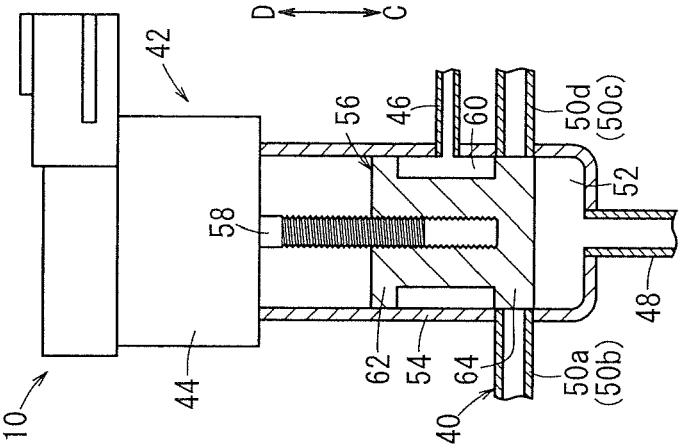


FIG. 2A

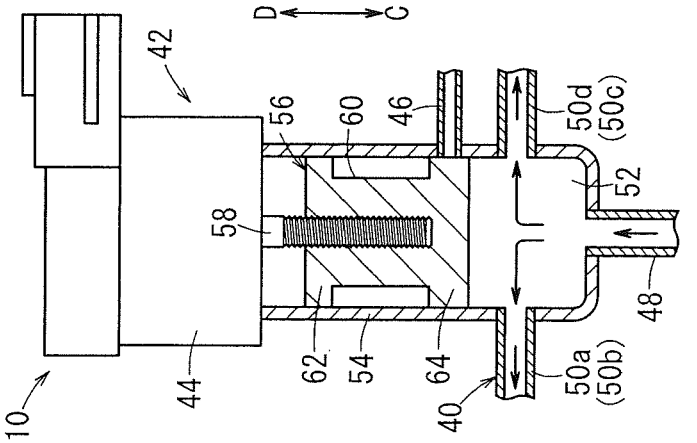


FIG. 3

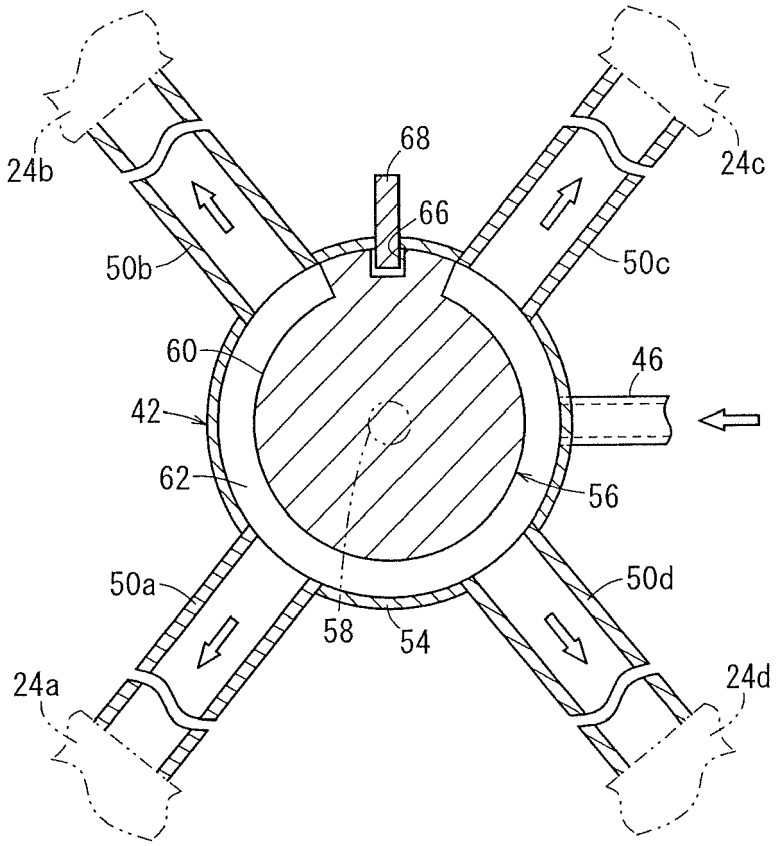


FIG. 4C

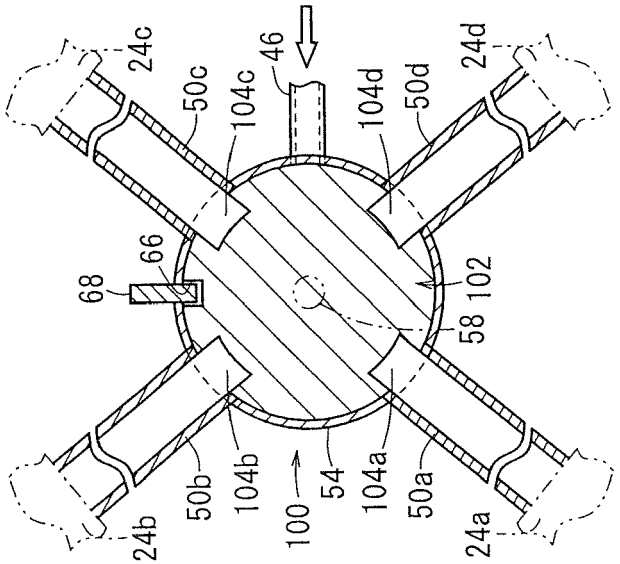


FIG. 4B

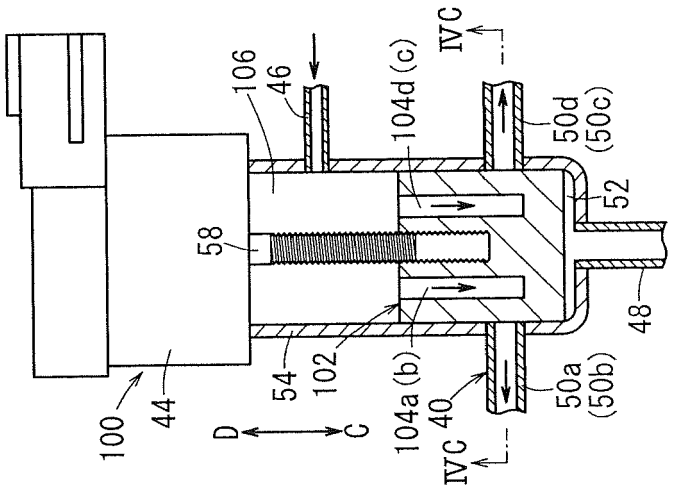
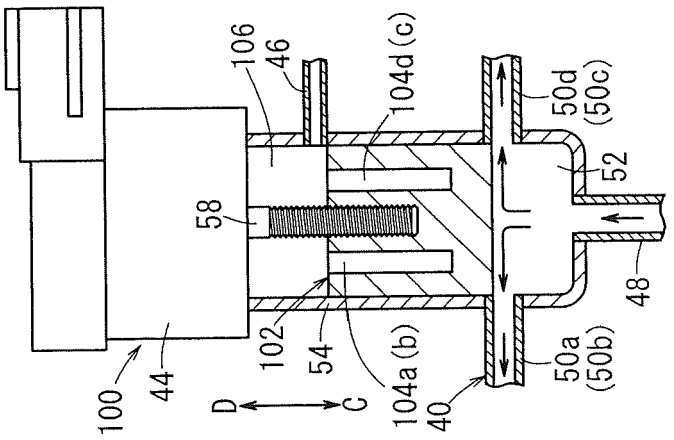


FIG. 4A



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 4342863 A **[0003]**
- JP 2000186653 A **[0005] [0006]**