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(54) **Fuel injection control apparatus**

(57) The invention avoids an over-rich state which temporarily occurs when a stop valve is switched from an inactive state to an active state.

To achieve this, a valve stopping mechanism 53 holds at least one of a plurality of intake valves provided for each cylinder in a closed state in a scheduled engine speed zone. A fuel injection valve 16 is provided at a common intake path which is branched to a plurality of intake ports 441 and 451 which are opened/closed with a plurality of intake valves. A fuel injection amount calculating unit 15 determines a fuel request amount on the basis of an engine state. A lean-burn coefficient reducing unit 13 decreases a lean-burn coefficient with respect to a fuel request amount to set an air-fuel mixture to the lean side in an operation zone which is out of the scheduled engine speed zone and in which the valve stopping mechanism 53 is switched to the inactive state. The operation of setting the air-fuel mixture to the lean side is performed in stages.

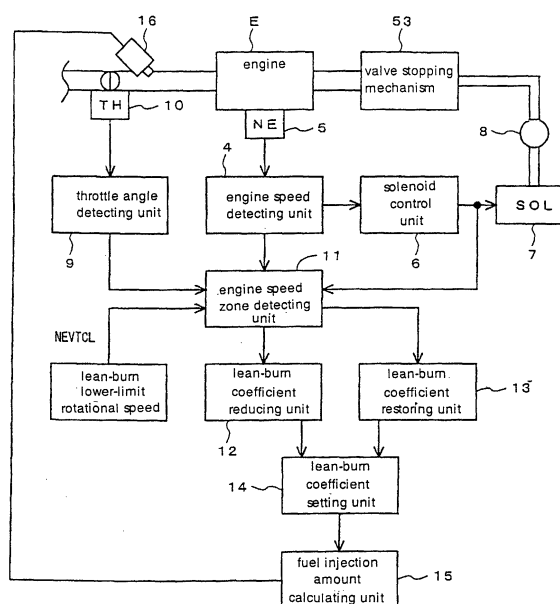


FIG. 1

Description

[0001] The present invention relates to a fuel injection control apparatus and, more particularly, to a fuel injection control apparatus of an engine having a plurality of pairs of intake and exhaust valves per cylinder.

[0002] As an engine having a plurality of pairs of intake and exhaust valves per cylinder, an engine having a valve stopping mechanism for making at least one intake valve inactive in a scheduled operation zone (for example, a low engine speed zone) to hold a valve closed state is known. By holding one intake valve in a closed state, a swirl is generated in a combustion chamber to realize lean burn, thereby achieving reduction in fuel consumption. In an engine having the valve stopping mechanism, when the engine is out of the scheduled operation zone, the intake valve in the inactive (stop) state is switched to an active state. At this time, however, a fuel supply state suddenly changes. Consequently, the engine operating conditions also suddenly change, and the driver may feel something is wrong.

[0003] Proposals have been made to solve the problem. For example, Japanese Unexamined Patent Application No. 2000-204956 discloses an engine in which, in order to prevent a fuel accumulated in a stopped intake path from flowing into a combustion chamber at once, an intake path extending to a plurality of intake ports is communicated with a communication path, thereby preventing the fuel from being accumulated in the intake path extending to a stopped intake valve.

[0004] Japanese Unexamined Utility Model No. Sho-63-15553 discloses an engine in which a supply fuel increase timing is delayed in expectation of a delay in timing of opening the valve in a stopped state to prevent an over-rich state of an air-fuel mixture due to a delay in timing of activating the valve in a stopped state.

[0005] Further, Japanese Unexamined Patent Application No. Hei-7-293305 discloses an engine having a fuel injection valve dedicated to an intake port corresponding to an intake valve (stop intake valve) accompanying a stop state and a fuel injection valve dedicated to an intake port corresponding to an intake valve (regular intake valve) which is not accompanying a stop state, and the fuel injection valves are independently controlled.

[0006] The above-described conventional apparatuses still have problems to be solved. First, in the engine for making the accumulated fuel escape to the intake path corresponding to the regular valve via the communication path, in the case where fuel spray of the fuel injection valve is directed to both of the stop valve and the regular valve, there is the possibility that the accumulated fuel cannot be sufficiently escaped to the regular valve side. Although the engine in which the supply fuel increase timing is delayed can deal with a mechanical activation delay of a valve, it does not solve a problem such as a temporary over-rich state due to inflow of the accumulated fuel. Further, the engine having a plu-

ality of fuel injection valves has problems such that the number of assembling steps is increased due to an increase in the number of parts and the flexibility of layout of an air intake system deteriorates.

[0007] In consideration of the problems, an object of the present invention is to provide a fuel injection control apparatus capable of preventing a temporary over-rich state due to inflow of a fuel accumulated in an intake path corresponding to a stop valve.

[0008] To achieve the object, as a first characteristic, the invention provides a fuel injection control apparatus for determining a fuel request amount on the basis of an engine state, including: valve stopping means for holding at least one of a plurality of intake valves provided for each cylinder in a closed state in a scheduled operation zone; and a fuel injection system provided for a common intake path which is branched to a plurality of intake ports opened/closed by the plurality of intake valves, characterized by comprising lean-burn means for correcting an A/F ratio to a lean side with respect to the fuel request amount in an operation zone which is out of the scheduled operation zone and in which the valve stopping means is switched to an inactive state.

[0009] The invention has a second characteristic that restoration canceling means is provided for canceling the lean-burn correction in stages in an operation zone after the valve stopping means is switched to the inactive state.

[0010] The invention has a third characteristic that the operation zone is set on the basis of an engine speed, the valve stopping means is switched to the inactive state in a zone in which the engine speed is higher than a scheduled engine speed, and the lean-burn correction is made in stages from a rotation speed zone lower than the scheduled engine speed.

[0011] The invention has a fourth characteristic that the degree of correcting the A/F ratio to the lean side by the lean-burn means is determined to be high when the engine temperature is low and to be low when the engine temperature is high. The invention has a fifth characteristic that when the lean-burn correction is continued for planned time or longer, the lean-burn correction is canceled in stages.

[0012] A fuel accumulated in an intake port which is closed when the valve stopping means is active flows in at once from the intake port which is opened when the valve stopping means is made inactive, and an air-fuel mixture tends to enter an over-rich state. According to the first characteristic, the lean-burn correction is made in the operation zone in which the valve stopping means is switched to an inactive state, so that the over-rich state can be avoided.

[0013] Particularly, according to the second characteristic, after the operation zone (stop switching operation zone) in which the valve stopping means is switched to the inactive state, the fuel supply amount is gradually restored to the fuel request amount. According to the third characteristic, the switching of the active/inactive

state of the valve stopping means is made on the basis of the engine speed. The lean-burn correction is started from the engine speed zone lower than the engine speed zone which is set for the switching. Therefore, by the time the valve stopping means is switched to the active state, the lean-burn correction is sufficiently made. According to the second and third characteristics, the lean-burn correction and restoration are performed in stages, so that fluctuations in an output of the engine are small.

[0014] According to the fourth characteristic, the amount of fuel accumulated in the intake port which remains closed increases as the engine temperature decreases. Consequently, the lean-burn correction is performed largely when the engine temperature is low. According to the fifth characteristic, when the engine is continuously operated in the valve stopping means switching operating zone, the A/F ratio can be prevented from being excessively corrected to the lean side.

[0015] According to the invention of claims 1 to 5, an over-rich state caused when a fuel accumulated in a resting intake port flows in at once can be solved by correcting the A/F mixture to the lean-burn side. Therefore, fluctuations in output of the engine and occurrence of unburned hydrocarbon can be suppressed. Particularly, such effects can be achieved without employing a complicated structure of, for instance, providing a plurality of fuel injection valves for each cylinder.

[0016] According to the invention of claims 2 and 3, the correction to the lean side and restoration can be gradually performed, so that fluctuations in output of the engine can be further lessened.

[0017] According to the invention of claim 4, in consideration of the fact that the accumulated fuel at the time of stop depends on the engine temperature, when the engine temperature is low, the degree of setting the A/F mixture to the lean side can be increased. Further, according to the invention of claim 5, it is suppressed so that the A/F mixture is set to the lean side excessively when the engine speed is stable in the stop switching operating zone, thereby enabling the stability in outputs in the stop switching operating zone can be assured.

Fig. 1 is a block diagram showing the functions of a main portion of a control apparatus according to an embodiment of the invention.

Fig. 2 is a side view of a motorcycle having the control apparatus according to the embodiment of the invention.

Fig. 3 is a cross section of a cylinder head of an engine.

Fig. 4 is a bottom view of the cylinder head of the engine.

Fig. 5 is a cross section of a valve stopping mechanism.

Fig. 6 is a timing chart of a fuel supply control.

Fig. 7 is a flowchart (NO. 1) of the fuel supply control.

Fig. 8 is a flowchart (NO. 2) of the fuel supply control.

[0018] An embodiment of the invention will be described hereinbelow with reference to the drawings. Fig. 2 is a side view of a motorcycle having a fuel injection control apparatus according to the embodiment of the invention. A body frame 21 of a motorcycle 2 has a head pipe 23 provided in the front part of the body and a main frame 22 whose front end is coupled to the head pipe 23 and which is branched to right and left parts of the body and extends to the rear part of the body. The main frame 22 has an almost U letter shape which opens upward in a side view. A seat stay 25 extending obliquely upward to the rear is coupled to the rear ends of the main frame 22, and the rear ends are coupled to each other via a coupling frame 24.

[0019] A front fork 26 pivoted on the head pipe 23 is provided, a steering handle 27 is coupled to the upper part of the front fork 26, and a front wheel WF is attached to the lower part of the front fork 26. A rear fork 28 supporting a rear wheel WR is pivoted at one of the rear parts of the main frame 22 so as to be swingable vertically, and a pair of right and left cushion units 29 are provided between the seat stay 25 and the rear wheel WR.

[0020] A fuel tank 31 is mounted on the main frame 22 and the coupling frame 24 so as to be positioned above an engine E, and a tandem-type seat 32 is attached on the seat stay 25.

[0021] The engine E is supported by the main frame 22 and coupling frame 24, and an output of the engine E is transmitted to the rear wheel WR via a transmission assembled in the engine E and a chain transmission unit 30. A radiator 33 is disposed in front of the engine E. The engine E can have a plurality of cylinders (four cylinders in this case), and each cylinder is provided with a plurality of intake ports and exhaust ports.

[0022] Fig. 3 is a cross section of a main portion of a cylinder head of the engine E. Fig. 4 is a cross section taken along line A-A of Fig. 3. The portions shown in the diagrams of the number equal to the number of cylinders are provided. In the diagrams, the cylinder head 40 is provided with a first intake port 44 and a second intake port 45 which open toward a combustion chamber 43 and a first exhaust port 46 and a second exhaust port 47 which open toward the combustion chamber 43. The first intake port 44 and the first exhaust port 46 are disposed almost symmetrical with respect to the center of the combustion engine 43, and the second intake port 45 and the second exhaust port 47 are similarly disposed.

[0023] The first intake port 44 and the first exhaust port 46 have a stop intake valve and a stop exhaust valve, respectively, which become inactive in a low rotational speed zone. On the other hand, the second intake port 45 and the second exhaust port 47 have a regular intake valve and a regular exhaust valve, respec-

tively, which are opened/closed at predetermined timings in association with rotation of the engine irrespective of the engine speed.

[0024] A first intake path 441 extended to the first intake port 44 and a second intake path 451 extended to the second intake port 45 are integrated and connected to an intake port 48. An intake pipe (not shown) is connected to the intake port 48 and a fuel injection valve (not shown) is provided for the intake pipe. Similarly, a first exhaust path 461 extended to the first exhaust port 46 and a second exhaust path 471 extended to the second exhaust port 47 are integrated and connected to an exhaust port 49. A not-illustrated exhaust pipe is coupled to the exhaust port 49. As shown in Fig. 4, a coupling path 50 is provided near to the combustion chamber 43 to couple the first intake path 441 and the second intake path 451 of a bifurcated portion. Via the coupling path 50, a fuel accumulated in the first intake path 441 during the stop intake valve is being stopped or closed escapes to the second intake path 451 side.

[0025] Each of the first and second intake ports 44 and 45 and first and second exhaust ports 46 and 47 is provided with a valve mechanism for opening/closing the port. The valve mechanisms for the first intake port 44 and the second exhaust port 47 will be described by referring to Fig. 3. A valve element 51 as a stop intake valve which is fit to the first intake port 44 has a stem 511 extending upward. The stem 511 is supported so as to be slidable in a guide cylinder 52 fixed to the cylinder head 40. The upper end of the stem 511 is fit into a not-illustrated cam for intake valve via a valve stopping mechanism 53.

[0026] The valve stopping mechanism 53 is a mechanism for stopping transmission of driving force by an intake valve cam to the valve element 51 to hold the first intake port 44 in a closed state in a scheduled low rotational speed zone. A coil spring 54 for energizing the stem 511 upward (in the direction of closing the valve) is provided between the stem 511 and the cylinder head 40, and a coil spring (which will be described hereinafter) is provided also between the valve stopping mechanism 53 and the cylinder head 40.

[0027] The valve element 55 fit to the second exhaust port 47 has a stem 551 which is supported so as to be slidable in a guide cylinder 56 fixed to the cylinder head 40. The upper end of the stem 551 is fit in a not-illustrated cam for exhaust valve. A coil spring 57 for energizing the stem 551 upward (in the direction of closing the valve) is provided between the stem 551 and the cylinder head 40.

[0028] The valve mechanism of the second intake port 45 is constructed in a manner similar to the valve mechanism provided for the second exhaust port 47, and does not have a valve stopping mechanism. On the other hand, the first exhaust port 46 pairing with the first intake port 44 can have a valve stopping mechanism in a manner similar to the first intake port 44. In this case, the cross-sectional shape including the second intake

port 45 and the first exhaust port 46 is similar to the shape of Fig. 3 except that the right and left parts are reversed.

[0029] Subsequently, the valve stopping mechanism 53 will be described in detail. Fig. 5 is a cross section of the valve stopping mechanism 53. A lifter 61 having a bottomed cylinder shape is provided upside down so as to be slidable in a supporting hole 60 provided for the cylinder head 40. On the inside of the lifter 61, a pin holder 62 is fit. The pin holder 62 has an annular groove 621 in its periphery. The outer circumferences of upper and lower flanges forming the annular groove 621 are in contact with the inside of the lifter 61. The annular groove 621 and the inner face of the lifter 621 define a path of a working fluid to be described hereinafter in teamwork with each other.

[0030] In the pin holder 62, a space 622 for housing a pin, that is, a plunger 63 so as to be slidable is formed. The space 622 passes through the center of the pin holder 62 and extends in the diameter direction of the pin holder 62, and the plunger 63 is slidably housed in the space 622. In the space 622, a coil spring 64 for energizing the plunger 63 to the right in the diagram is housed. The limit of deflection of the plunger 63 is specified by a stopper pin 65. The stopper pin 65 specifies the limit of deflection of the plunger 63 and also the position of the rotation direction of the plunger 63 with respect to the pin holder 62. The pin holder 62 and plunger 63 have escape holes 623 and 631 which are aligned on the extension of the stem 511 of the valve mechanism when the plunger 63 is deflected to the right part of the drawing and positioned at the limit of deflection.

[0031] In the support hole 60, an annular groove 401 is formed along the circumferential direction of the lifter 61. The lifter 61 is provided with a communication port 611 connecting the annular groove 621 formed in the periphery of the pin holder 62 and the annular groove 401. The positions of the annular grooves 401 and 621 and the communication port 611 are set so that they communicate with each other irrespective of the position of the lifter 61 in the supporting hole 60.

[0032] A working fluid supplying path 65 connected to the annular groove 401 is provided. The working fluid supplying path 65 is connected to a working fluid supplying source (not shown) via a working fluid control valve (not shown). The working fluid is supplied to the working fluid supplying path 65, annular groove 401, communication port 611, and annular path 621 and acts pressure to the open end of the pin holder 62, that is, the right end of the plunger 63 in the direction of making the coil spring 64 contract.

[0033] A coil spring 66 for energizing the lifter 61 upward is provided between the lifter 61 and the cylinder head 40. The upper end of the spring 54 for energizing the valve element 51 upward is in contact with a stopper 512 fixed to the stem 511. On the other hand, the upper end of the lifter 61 is in contact with an intake valve cam 67 and swings (in the vertical direction) along the pe-

riphery of the cam 67 when the cam 67 turns.

[0034] With the configuration, in response to the intake valve cam and the exhaust valve cam which rotate as the engine rotates, the valve mechanisms provided for the first and second intake ports 44 and 45 and first and second exhaust ports 46 and 47 operate. The valve mechanisms provided for the second intake port 45 and second exhaust port 47 always perform operation of opening/closing the valves in response to the intake valve cam and exhaust valve cam. On the other hand, the valve mechanisms provided for the first intake port 44 and the first exhaust port 46 do not operate in the scheduled engine low speed zone by the action of the valve stopping mechanism 53 irrespective of rotation of the intake valve cam and the exhaust valve cam. As a result, the valve element 51 as a component of the valve mechanism is maintained to be energized upward by the coil spring 54.

[0035] Specifically, the operation of making the first intake port 44 remain closed is as follows. In an active state of the valve mechanism, the working fluid is supplied to the annular groove 401 via the working fluid supplying path 65. The hydraulic pressure consequently acts on the end portion (right end portion in the drawing) of the plunger 63 via the communication port 611 and annular groove 621, and the plunger 63 makes the coil spring 64 contract and is deflected to the left part in the diagram. As a result, the escape holes 631 and 623 do not align on the extension line of the stem 511 and the upper end of the stem 511 faces the under face of the plunger 63. Therefore, when the cam 67 rotates and the lifter 61 is pressed downward in accordance with the deviation amount, the stem 511 pressed by the under face of the plunger 63 goes down, the valve mechanism opens, and the first intake port 44 is opened.

[0036] When the cam 67 rotates and comes into contact with the lifter 61 in a portion of a small eccentricity amount, the lifter 61 energized by the coil spring 66 follows the cam 67, accordingly, the stem 511 is pushed up by the coil spring 54 and the valve is closed. In such a manner, the first intake port 44 operates with the cam 67 rotating in association with the engine rotation.

[0037] On the other hand, in an inactive state of the valve mechanism, the working fluid is allowed to escape via a not-shown path, thereby lowering the hydraulic pressure. Since the plunger 63 is energized by the coil spring 64, the plunger 63 is deflected to the right part of the drawing. As a result, the escape holes 631 and 623 are aligned on the extension line of the stem 511 and it enables the upper end of the stem 511 to enter the escape holes 631 and 623. Therefore, even when the cam 67 rotates and the lifter 61 is pressed downward by the eccentricity amount, the stem 511 escapes into the escape holes 631 and 623, so that the stem 511 does not follow the movement of the lifter 61. Therefore, the valve mechanism is held in a closed state and the first intake port 44 and the first exhaust port 46 remain closed. The valve mechanism of the first intake port 44 and the valve

mechanism of the first exhaust port 46 operate similarly.

[0038] The details of the valve stopping mechanism 53 are also disclosed in the publication (Japanese Unexamined Patent Application No. 2000-20456) applied by the inventor herein. To understand the present invention more, the invention disclosed in the publication can be referred to.

[0039] A fuel supply control performed at the time of switching the valve mechanism from the inactive state to the active state will be described. In the embodiment, at the time of switching, the fuel injection amount is set to be smaller than the engine request fuel amount, and the fuel-air mixture is controlled to be on the lean side.

[0040] Fig. 6 is a timing chart of the fuel supply control. In Fig. 6, by using a control switch rotational speed NEVTC (for example, 6800 rpm) as a reference, when engine speed NE is lower than the control switch rotational speed NEVTC, the solenoid for supplying the hydraulic pressure to the valve stopping mechanism 53 is turned off, so that the first intake port 44 and first exhaust port 46 are maintained to be closed. On the other hand, when the engine speed NE is higher than the control switch rotational speed NEVTC, the solenoid for supplying the hydraulic pressure to the valve stopping mechanism 53 is turned on so that the first intake port 44 and the first exhaust port 46 are opened/closed in accordance with the engine speed.

[0041] When the solenoid is turned on, the valves (stop valves) provided for the first intake port 44 and the first exhaust port 46 are driven after planned time (time corresponding to a lean-side restoration start timer tm-KVTLNH which will be described hereinafter, for example, 50 msec) has elapsed since the solenoid is turned on.

[0042] A process of setting the air-fuel mixture to the lean side, that is, lowering a lean-burn coefficient KVTLN is executed at the time point when the engine speed exceeds a lower-limit rotational speed NEVTCL (for example, 6400 rpm). After the engine speed exceeds the lower-limit rotational speed NEVTCL, the lean-burn coefficient KVTLN is lowered step by step (lean-burn coefficient transition amount) every predetermined process cycle to the scheduled minimum lean coefficient (for example, 0.57). The lower the engine cooling water temperature is, the lower the minimum lean-burn coefficient is set.

[0043] When the lean-burn coefficient KVTLN is held in the lean state (1.0 or less) for planned time, that is, when the engine speed is stable in a planned low rotational speed zone, the lean-burn coefficient KVTLN is controlled to 1.0 again. After the stop valve is driven, a process of restoring the lean-burn coefficient KVTLN is performed. The process of restoring the lean-burn coefficient KVTLN is increased step by step (by a lean-burn coefficient restoration amount).

[0044] The fuel injection amount is determined by a known method by using a map or the like in accordance with the engine request fuel amount determined by us-

ing various parameters. By multiplying the determined fuel injection amount with the lean-burn coefficient KVTLN, the fuel injection amount is corrected. From the lower-limit rotational speed NEVTCL, the air-fuel mixture is becoming lean and is maintained in a lean state until the operation of restoring the lean-burn coefficient KVTLN is completed. There is a case such that the fuel accumulated in the intake path on the stopped side flows in at once at the time of valve opening operation, and A/F ratio temporarily drops from the stoichiometric A/F ratio. However, according to the embodiment, the lean-burn operation of reducing the fuel supply amount is performed in advance, so that a sudden drop in the A/F ratio is suppressed.

[0045] Figs. 7 and 8 are flowcharts of fuel supply control and, particularly, flowcharts of a coefficient used to setting the air-fuel mixture to the lean side. In Fig. 7, in step S1 whether the lean-burn coefficient KVTLN for determining the degree of setting the air-fuel mixture to the lean side is lower than 1.0 or not is determined. If the lean coefficient KVTLN is not lower than 1.0, the program advances to step S2 where the transmission is switched to either a high gear ratio (low gear side) or a low gear ratio (high gear side) is determined according to whether the ratio NE/V between the engine speed NE and vehicle speed V is higher than a threshold value or not in order to set data according to the switch position of the transmission.

[0046] At the time of low gear side, the program advances to step S3. At the time of the high gear side, the program advances to step S4. In steps S3 and S4, data for the low gear side and data for the high gear side are set. Data of a lean-burn lower-limit throttle angle (hereinafter, called "lower-limit throttle angle") THVTLN, a lean-burn lower-limit engine speed (lower-limit engine speed) NEVTCL, data TMKVTH for a lean-burn restoring timer at the time of four valves (in a state where four valve mechanisms of cylinders are active), data TMKVTL for a lean-burn restoring timer at the time of two valves (in a state where a pair of intake and exhaust valves out of the four valve mechanisms of cylinders are active), lean-burn coefficient transition amount DKVTL at the time of two valves, and a lean-burn coefficient restoring amount DKTLD at the time of four valves are read from a storage (such as a ROM) and the read data is set. The last digit "1" of a reference numeral of data which is set indicates data for the low gear side, and the last digit "2" indicates data for the high gear side.

[0047] In steps S5 and S6, tables in which the minimum lean-burn coefficients TW-KVTLNOL and TW-KVTLNOLH are set in correspondence with engine water temperature are searched, and the minimum lean-burn coefficient KVTLNOL is set.

[0048] In step S7, a flag F-VTSH indicating whether the solenoid for applying a hydraulic pressure of a working fluid to the valve stopping mechanism 53 is ON or not is discriminated. When the solenoid is ON, it is assumed that the plunger 63 of the valve stopping mechanism

53 is energized by the hydraulic pressure and the valve mechanism is in a state of moving in response to the cam 67 (active state). When the solenoid is ON, the program advances to step S8.

[0049] In step S8, the data TMKVTL for the lean-burn restoring timer at the time of two valves is set to the lean-burn restoring timer tmKVTL at the time of two valves. In step S9, whether the lean-burn restoration starting timer tmKVTLNH at the time of four valves becomes "0" or less is determined. The value of the timer tmKVTLNH corresponds to delay time since the solenoid is energized until the operation of restoring the lean-burn coefficient KVTLN to 1.0 is started. If YES in step S9, the program advances to step S10 where whether the lean-burn coefficient KVTLN is lower than 1.0 or not is determined.

[0050] If the lean-burn coefficient KVTLN is lower than 1.0, the program advances to step S11, a lean-burn restoration amount DKVTL is added to the present lean-burn coefficient KVTLN, thereby updating the lean-burn coefficient KVTLN. In step S12, whether the lean-burn coefficient KVTLN becomes equal to or higher than 1.0 is determined. If YES in step S12, that is, when the lean-burn coefficient KVTLN has been restored to 1.0 or higher, the program advances to step S13 where 1.0 is set as the lean-burn coefficient KVTLN. On the other hand, also in the case where it is determined in step S10 that the lean-burn coefficient KVTLN is not less than 1.0, the program advances to step S13 where 1.0 is set as the lean-burn coefficient KVTLN.

[0051] As described above, when the solenoid is ON, that is, when all the valve mechanisms regarding the first and second intake ports 44 and 45 and the first and second exhaust ports 46 and 47 are switched to a state where they are always active (at the time of four valves), the lean-burn coefficient KVTLN is restored to 1.0. Consequently, the fuel supply amount is controlled so that the air-fuel mixture is set as the engine requires, and the operation of setting the air-fuel mixture to the lean side is canceled.

[0052] When it is determined in step S7 that the solenoid is OFF, the two-valve state is determined. A process performed at the time of two valves will be described by referring to Fig. 8. In Fig. 8, in step S14, the data TMKVTH for the lean-burn restoring timer at the time of four valves is set to the lean-burn restoring timer tmKVTH at the time of four valves. In step S15, whether switching from the four-valve state to the two-valve state is permitted or not is determined by detecting the flag F-TWVTS. When the cooling water temperature of the engine E is higher than a planned value, it is regarded that warming-up is finished, the switching to the two-valve state is permitted, and the flag F-TWVTS is set (= 1). On the other hand, when the cooling water temperature of the engine E is lower than the planned value, it is regarded that warming-up is not performed, the switching to the two-valve state is inhibited, and the flag F-TWVTS is cleared (= 0).

[0053] If the switching to the two-valve state is permitted, the program advances to step S16 and whether the engine E is in a no-load state or not is determined on the basis of a flag F-NOLOAD. For example, when the clutch is off or the transmission is in the neutral position, it is regarded that there is no load, and the flag F-NOLOAD is set. When the clutch is on or the transmission is in a position other than the neutral position, it is regarded that a load is applied, and the flag F-NOLOAD is cleared.

[0054] When a load is applied, the program advances to step S17 and whether the throttle angle TH is equal to or larger than the lower-limit throttle angle THVTLN or not is determined. That is, when the throttle angle is equal to or lower than the lower-limit throttle angle, the operation of setting the air-fuel mixture to the lean side is not performed. If YES in step S17, the program advances to step S18 where whether the engine speed is equal to or higher than the lower-limit rotational speed NEVTCL is determined. That is, when the engine speed is lower than the lower-limit rotation speed, the operation of setting the air-fuel mixture to the lean side is not performed.

[0055] In the case where the engine water temperature is higher than the scheduled temperature (YES in step S15), a load is applied to the engine E (NO in step S16), and each of the throttle angle TH and the engine speed NE exceeds its corresponding lower limit value (YES in steps S17 and S18), the program advances to step S19.

[0056] In step S19, whether the lean-burn restoring timer tmKVTL at the time of two valves is equal to or smaller than "0" is determined. If NO in step S19, the program advances to step S20 and whether or not the present lean-burn coefficient KVTLN is equal to or lower than the minimum lean-burn coefficient KVTLN0 is determined. That is, whether or not the lean-burn coefficient KVTLN is reduced to the minimum lean-burn coefficient KVTLN0 corresponding to the engine water temperature is determined. If YES in step S20, the program advances to step S21 where the lean-burn coefficient KVTLN is replaced with a table value KVTLN0.

[0057] If the present lean-burn coefficient KVTLN is not equal to or lower than the minimum lean-burn coefficient KVTLN0, the program advances to step S22 where the lean-burn coefficient transition amount DKVTL is subtracted from the present lean-burn coefficient KVTLN, thereby updating the lean-burn coefficient KVTLN. In step S23, in a manner similar to step S20, whether the present lean-burn coefficient KVTLN is equal to or lower than the minimum lean-burn coefficient KVTLN0 or not is determined. If YES, the program goes to step S21.

[0058] In such a manner, the lean-burn coefficient KVTLN is reduced to the scheduled minimum lean-burn coefficient KVTLN0 in stages each only by the lean-burn coefficient transition amount DKVTL.

[0059] If YES in step S19, that is, when the lean-burn

restoring timer tmKVTL at the time of two valves is "0" or less, it is determined that the time scheduled to maintain the lean-burn state has elapsed, the program advances to step S24 where a process of restoring the lean-burn coefficient KVTLN is started. First, in step S24, whether the lean-burn coefficient KVTLN is lower than 1.0 or not is determined. If NO, the program advances to step S25 where 1.0 is set as the lean-burn coefficient KVTLN. If the lean-burn coefficient KVTLN is lower than 1.0, the process of setting the A/F mixture to the lean side is being performed. Consequently, the program advances from step S24 to step S26 where the lean-burn coefficient transition amount DKVTL is added to the present lean-burn coefficient KVTLN, thereby updating the lean-burn value KVTLN. In step S27, whether the lean-burn coefficient KVTLN is 1.0 or higher is determined. If YES in step S27, the program goes to step S25.

[0060] If NO in step S15, YES in step S16, NO in step S17, or NO in step S18, the program advances to step S28 where the data TMKVTL for the lean-burn restoring timer at the time of two valves is set to the lean-burn restoring timer tmKVTL at the time of two valves. In step S29, whether the lean-burn coefficient KVTLN is lower than 1.0 or not is determined. If NO in step S29, 1.0 is set as the lean-burn value KVTLN in step S30. If the lean-burn coefficient KVTLN is lower than 1.0, the program advances from step S29 to step S31 where the lean-burn coefficient transition amount DKVTL is added to the present lean-burn coefficient KVTLN, thereby updating the lean-burn coefficient KVTLN. In step S32, whether the lean-burn coefficient KVTLN is restored to 1.0 or higher is determined. If YES, it is regarded that the restoring operation has been completed, and the program goes to step S30 where 1.0 is set as the lean-burn value KVTLN.

[0061] Fig. 1 is a block diagram showing the functions in the main portion for calculating the lean-burn coefficient. In the diagram, an engine speed detecting unit 4 detects the engine speed NE on the basis of an output of an engine speed sensor 5. A solenoid control unit 6 outputs a command of driving a solenoid 7 for supplying a hydraulic pressure to the valve stopping mechanism 53 when the engine speed is equal to or higher than the control switch rotational speed NEVTEC. The solenoid 7 energizes a working fluid supplying source 8 to make the hydraulic pressure act on the valve stopping mechanism 53. A throttle angle detecting unit 9 detects a turn angle of a throttle sensor 10 to detect the throttle angle.

[0062] An engine speed zone determining unit 11 determines a scheduled zone for lean-burn in which the engine speed NE lies on the basis of the engine speed NE, throttle angle TH, the command of driving the solenoid, and the lean-burn lower-limit rotational speed NEVTCL. When the engine speed NE is equal to or higher than the lower-limit rotational speed NEVTCL, the throttle angle is equal to or larger than the lower-limit angle, and the command of driving the solenoid is off, a

lean-burn coefficient reducing unit 12 is energized to reduce the lean-burn coefficient KVTLN.

[0063] When the solenoid driving command enters an ON state, the lean-burn coefficient restoring unit 13 is energized, and a process of restoring (increasing) the lean-burn coefficient KVTLN is performed. The restoring process is finished when the lean-burn coefficient KVTLN reaches 1.0. Also in the case where the lean-burn coefficient reducing unit 12 is energized for scheduled time, a lean-burn coefficient restoring unit 13 is energized.

[0064] The lean-burn coefficient KVTLN of a lean-burn coefficient setting unit 14 is increased/decreased by the lean-burn coefficient reducing unit 12 or the lean-burn coefficient restoring unit 13. The resultant lean-burn coefficient KVTLN is supplied to a fuel injection amount calculating unit 15 where the fuel injection amount is calculated in consideration of the operation of setting the air-fuel mixture to the lean side. According to a duty ratio of ON time and OFF time based on the calculated fuel injection amount, a fuel injection valve 16 is driven.

[0065] In the foregoing embodiment, as a valve stopping mechanism, a hydraulic one is assumed. However, the invention is not limited to the above but can be widely applied to an engine including a mechanism for holding at least one intake port among a plurality of pairs of intake and exhaust ports in a closed state in a scheduled low rotational speed zone irrespective of rotation of the engine.

[0066] The invention avoids an over-rich state which temporarily occurs when a stop valve is switched from an inactive state to an active state.

[0067] To achieve this, a valve stopping mechanism 53 holds at least one of a plurality of intake valves provided for each cylinder in a closed state in a scheduled engine speed zone. A fuel injection valve 16 is provided at a common intake path which is branched to a plurality of intake ports 441 and 451 which are opened/closed with a plurality of intake valves. A fuel injection amount calculating unit 15 determines a fuel request amount on the basis of an engine state. A lean-burn coefficient reducing unit 13 decreases a lean-burn coefficient with respect to a fuel request amount to set an air-fuel mixture to the lean side in an operation zone which is out of the scheduled engine speed zone and in which the valve stopping mechanism 53 is switched to the inactive state. The operation of setting the air-fuel mixture to the lean side is performed in stages.

uled operation zone; and a fuel injection system including a fuel injection valve (16) provided for a common intake path which is branched to a plurality of intake ports (441, 451) opened/closed by said plurality of intake valves (52),

characterized by comprising lean-burn means (11 - 15) for correcting an A/F ratio to a lean side with respect to said fuel request amount in an operation zone which is out of said scheduled operation zone and in which said valve stopping means (53) is switched to an inactive state.

2. The fuel injection control apparatus according to claim 1,

characterized by comprising restoration canceling means for canceling said lean-burn correction in stages in an operation zone after said valve stopping means (53) is switched to the inactive state.

3. The fuel injection control apparatus according to claim 1,

characterized in that said operation zone is set on the basis of an engine speed, said valve stopping means (53) is switched to the inactive state in a zone in which the engine speed is higher than a scheduled engine speed, and said lean-burn correction is made in stages from a rotation speed zone lower than said scheduled engine speed.

4. The fuel injection control apparatus according to claim 1,

further comprising means for detecting an engine temperature, **characterized in that** the degree of correcting the A/F ratio to the lean side by said lean-burn means (11 - 15) is determined to be high when the engine temperature is low and to be low when the engine temperature is high.

5. The fuel injection control apparatus according to claim 1,

characterized in that when said lean-burn correction is continued for planned time or longer, the lean-burn correction is canceled in stages.

Claims

1. A fuel injection control apparatus for determining a fuel request amount on the basis of an engine state, comprising: valve stopping means (53) for holding at least one of a plurality of intake valves (52) provided for each cylinder in a closed state in a sched-

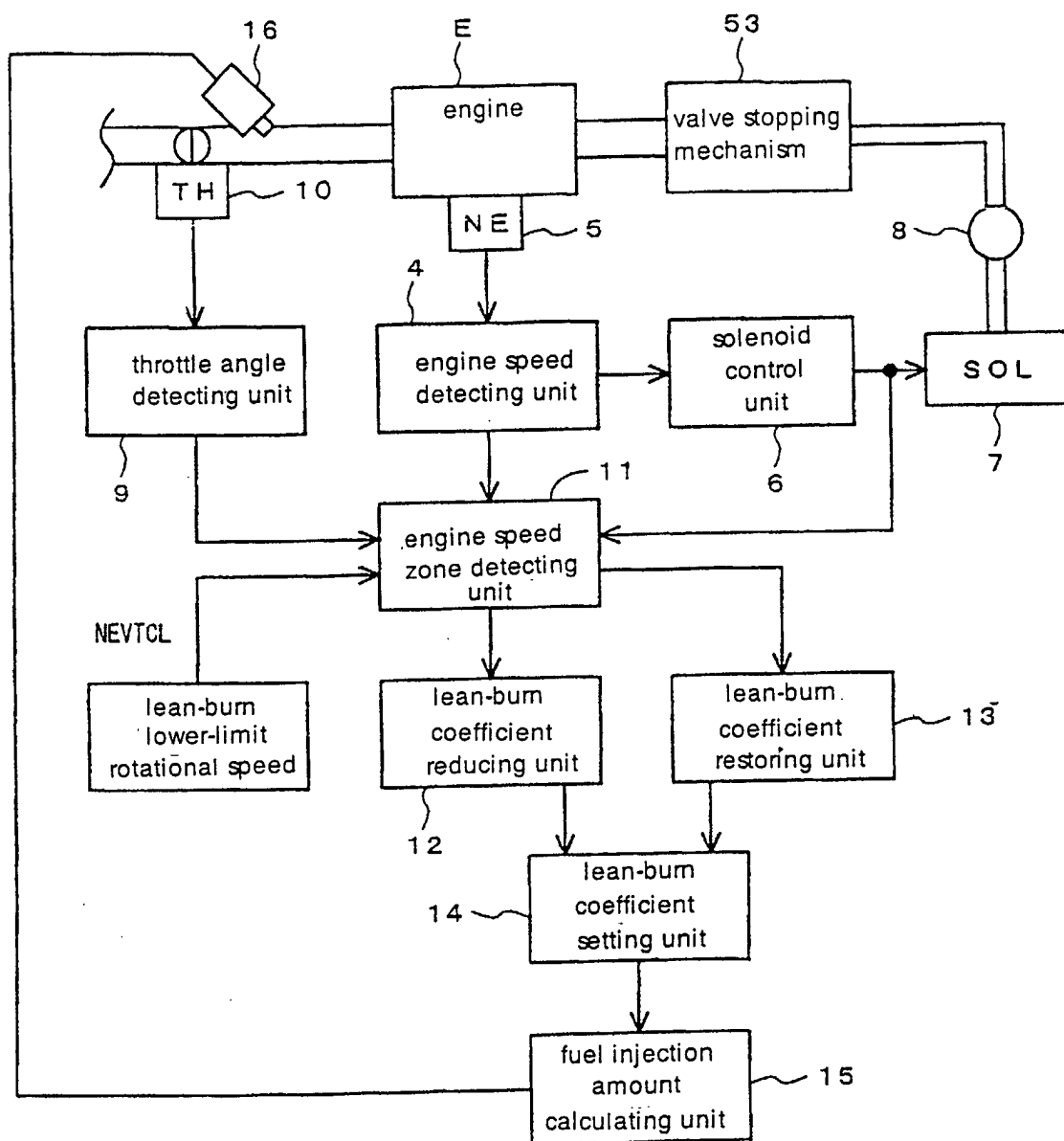


FIG. 1

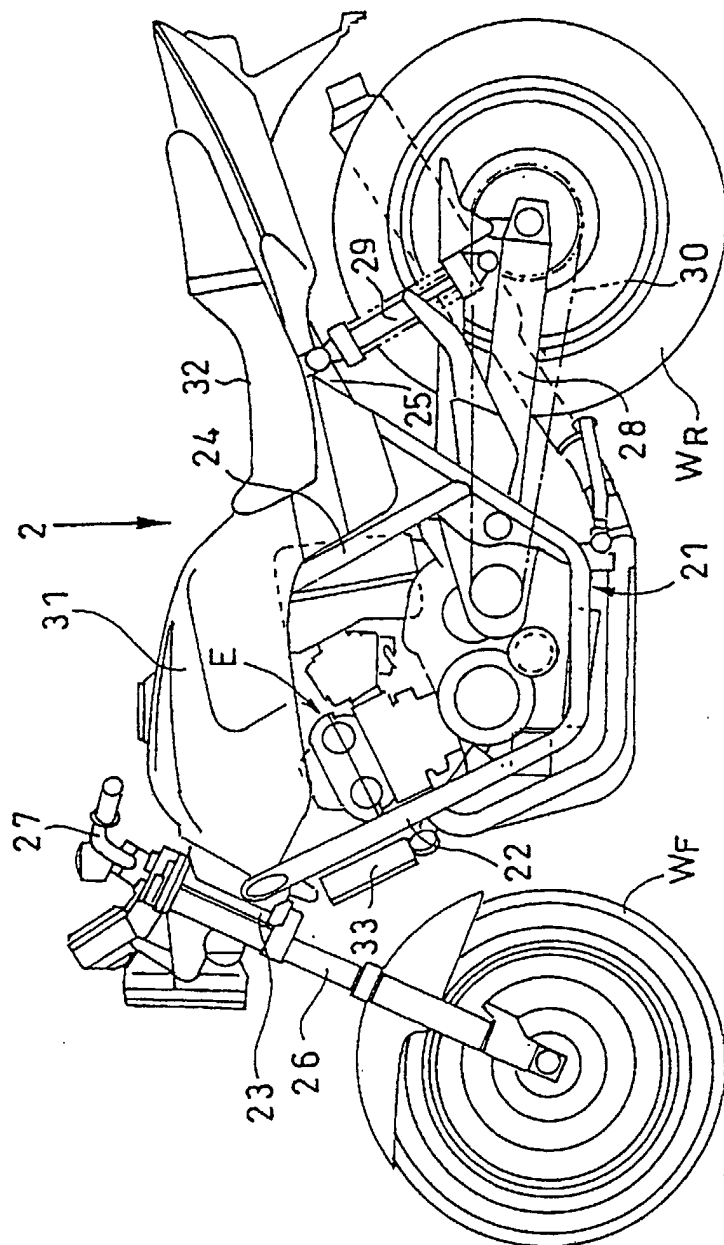


FIG. 2

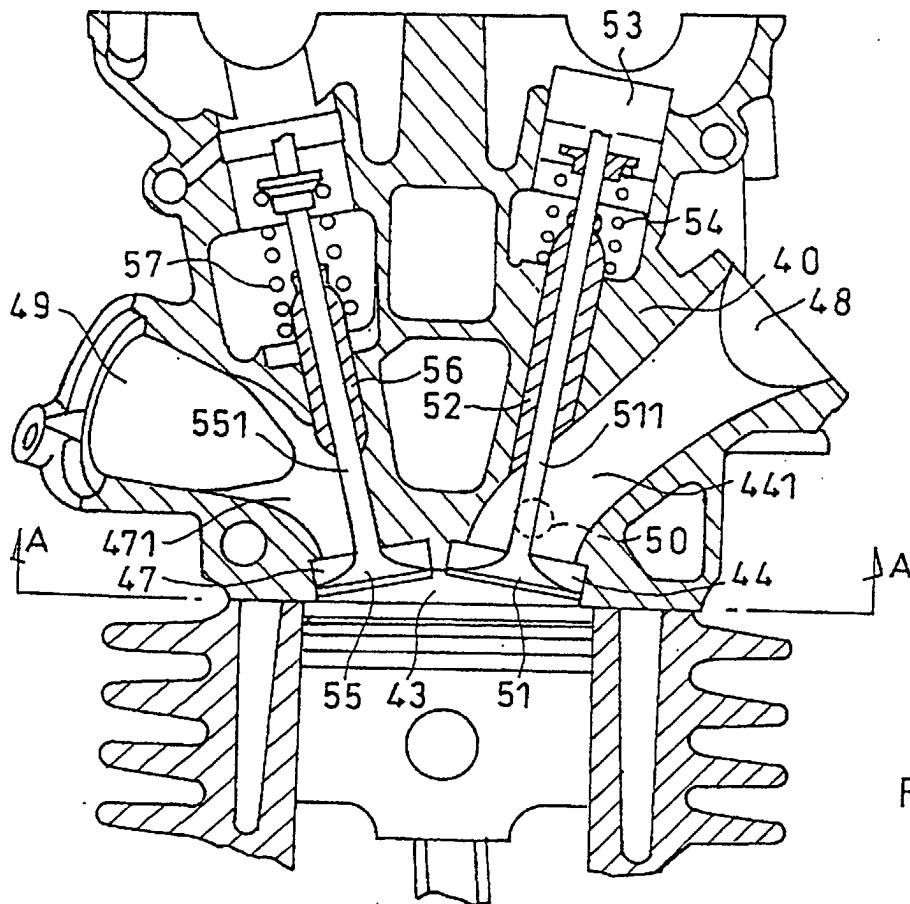


FIG. 3

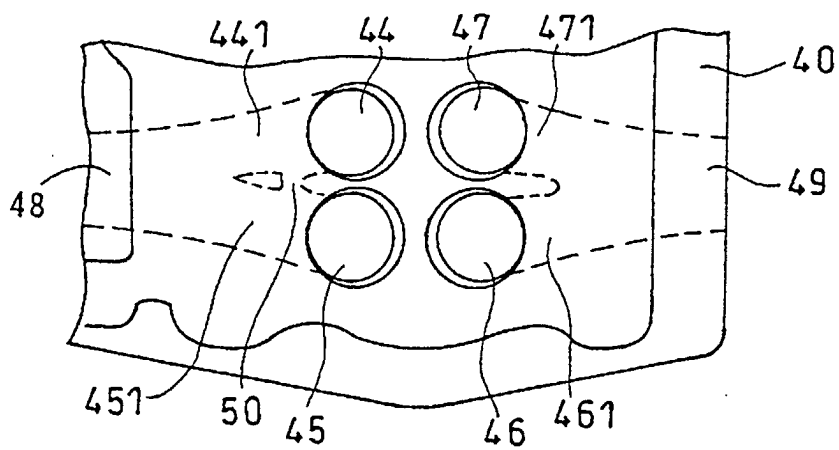


FIG. 4

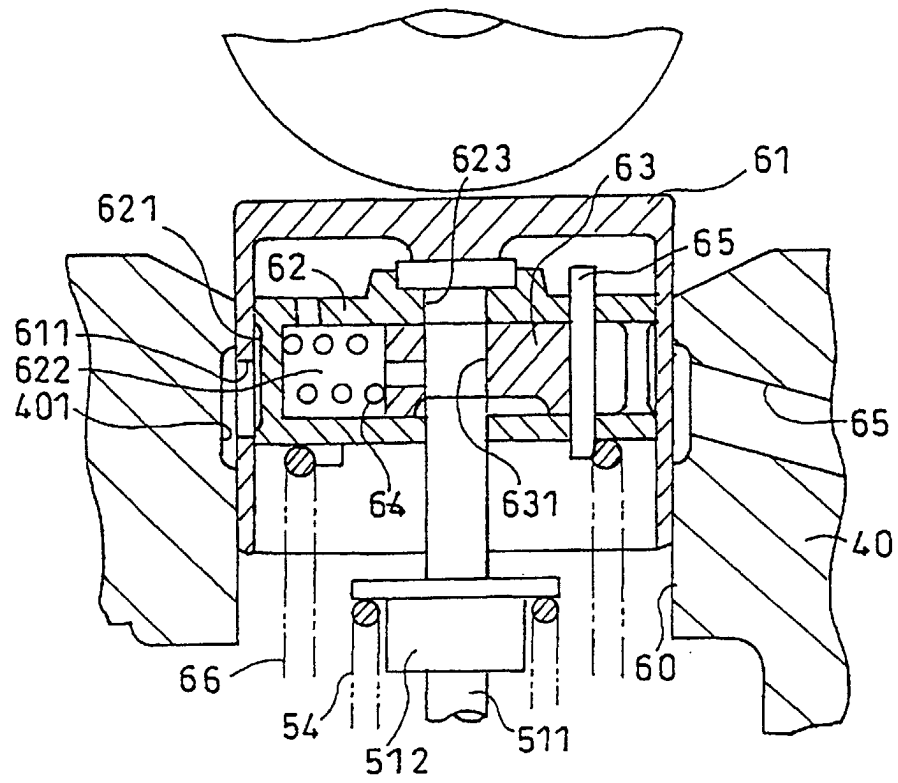


FIG. 5

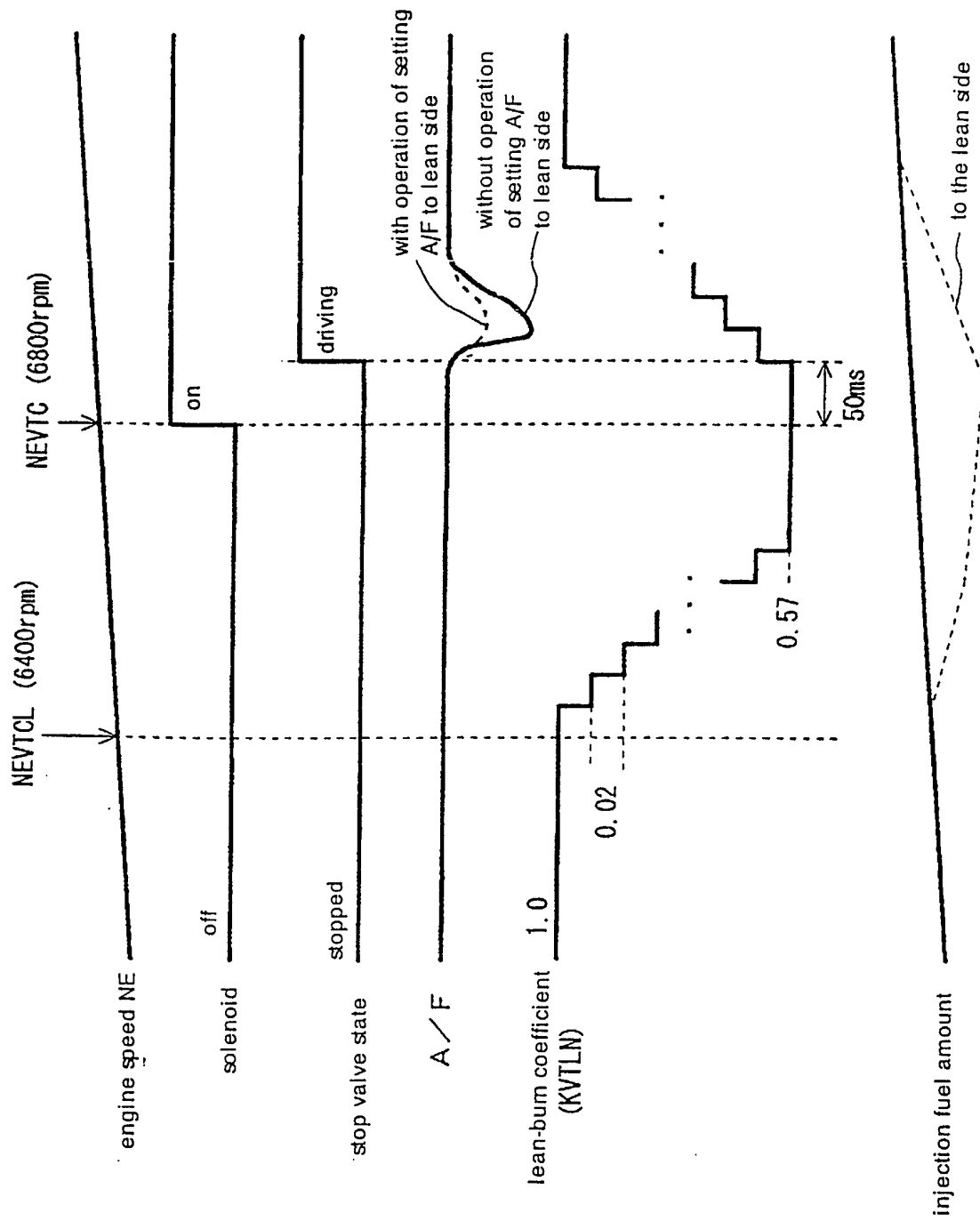


FIG. 6

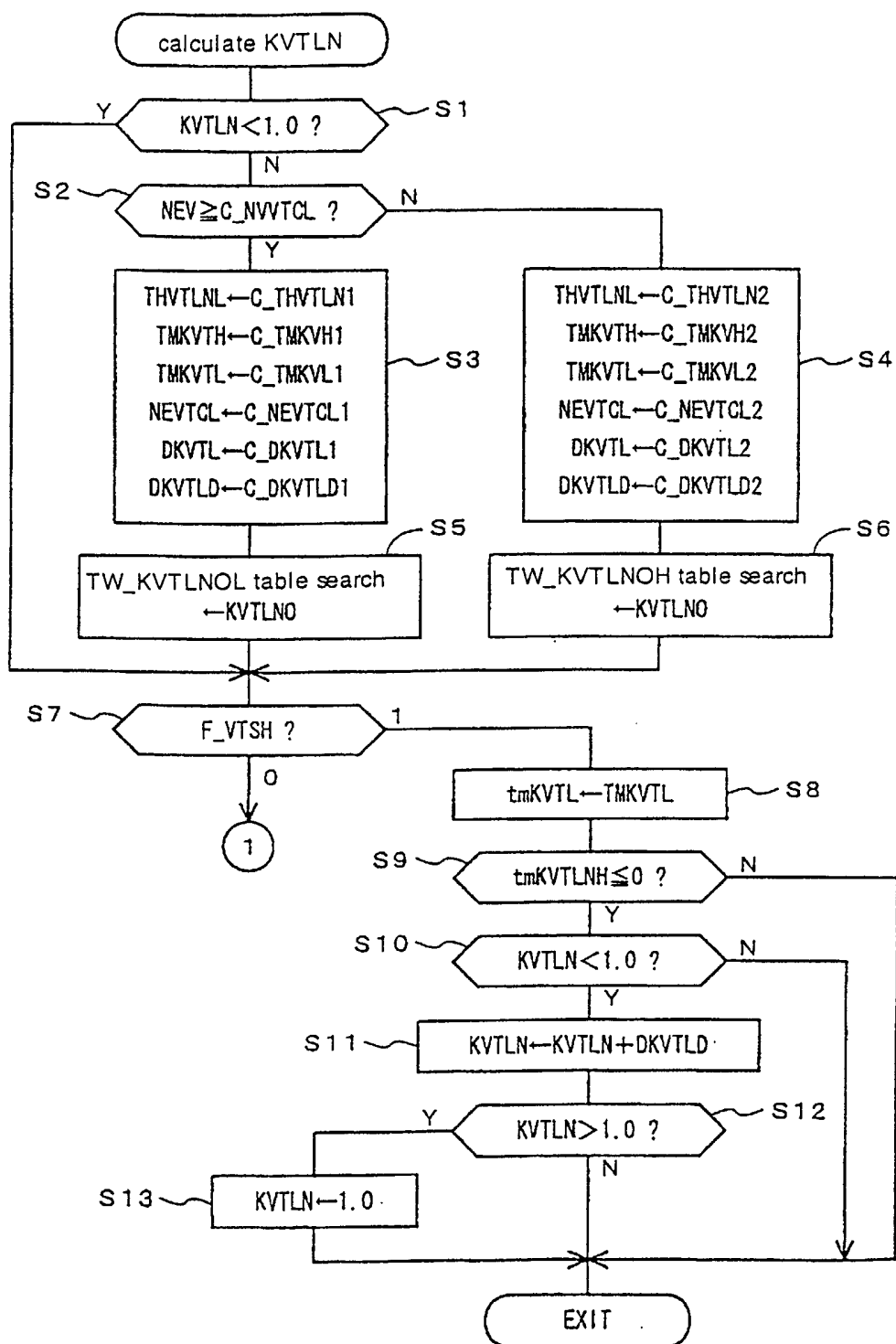


FIG. 7

