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(54) **Engine control method**

Motorsteuerungsmethode

Méthode de commande de moteur

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DE-A- 3 138 058
GB-A- 2 085 619
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Description

CROSS REFERENCE OF RELATED APPLICATIONS

This application relates to the subject-matter of EP-A-110312.

The present invention relates to an engine control method for a car employing a microcomputer, and particularly to an engine control method in which the engine revolution can be controlled stably andlor smoothly in idle running.

Recently, general control for an engine is performed by using a microcomputer for the purpose of improvement in engine control performance.

Various functions are required for the engine control depending on the kind or type/use of car, and, therefore, in the engine control system utilizing a microcomputer, a general purpose software, that is a software in which correction, modification or addition can be effected onto the various control functions depending on the kind/use of car, is required in view of improvement in cost and/or in controllability.

Conventionally, in idle running, that is, in the ON state of an idling switch, the ON duty factor of a bypass valve is determined on the basis of the sum of a value determined in accordance with the cooling water of the engine and a value representing the quantity of feedback of the number of engine revolution for controlling the number of engine revolution to be a reference number of engine revolution for idle running. In idle running, however, it is difficult to control the number of engine revolution to be the reference number of engine revolution for idle running stably and/or smoothly, when the engine state is changed from normal running to idle one.

GB-A-2 053 508 discloses an intake air flow rate control system for an intemal combustion engine having an open-loop control system carried out in unstable engine driving condition. In the open-loop control, the pulse signal applied to an airflow rate control valve means is determined both by open loop ratio and feedback ratio. The pulse duty of the pulse signal can also be varied corresponding to engine load condition or an engine starting condition.

GB-A-2 073 451 disdoses an idling speed control system for an internal combustion machine. The control operation is thereby based on a cooling water temperature of the engine in either of open-loop control and feedback control mode. In cases of shifting from an open-loop control to a dosed-loop (feedback) control, at first a large amount of intake air is supplied to an engine and then the amount of intake air is gradually decreased, thereafter shifting to the dosed-loop control.

DE-A-3 138 058 disdoses that when a target engine speed is changed to a new target speed, a duty factor is not controlled so as to trace the new target speed but a target speed is gradually changed toward the new target speed and the duty factor is changed so as to trace the gradually changing target speed.

In contrast to the above cited publications the technical concept of the present invention resides in that the feedback control of the duty factor is not carried out immediately after the change of an idle switch from an OFF state to an ON state but carried out when the engine speed reached to a speed which is slightly higher than a desired engine speed.

Further, GB-A-2 085 619 discloses an engine control system comprising a plurality of sensors including a throttle opening sensor for detecting the closed state of a throttle valve which is provided in an intake path for controlling the flow rate of intake air being introduced into the engine, a bypass which is provided in parallel with the throttle valve and includes a bypass valve for controlling a flow rate of auxiliary intake air being introduced into the engine, central processing means for computing a value of a duty factor of said bypass valve in accordance with a real engine speed in order to keep the engine speed at a predetermined value and a pulse generating circuit for generating pulses in accordance with the value of the duty factor computed by said central processing means. The said system is operated using the step of judging whether the engine speed has decreased or not to an overrun recognition threshold which is higher than the engine speed desired in the engine idle operation, when said throttle valve has been closed, and in a case that it is judged that the engine speed has decreased to that threshold, the duty cycle of said bypass valve is controlled in accordance with the actual engine speed, and in a case that it is judged that the engine speed is greater than that threshold, the duty cycle of said bypass valve is controlled in an open loop manner.

An object of the present invention is to provide an engine control method in which the bypass valve ON duty factor is controlled so that the number of engine revolution can be smoothly changed when the idling switch is turned ON from the OFF state, that is when the engine state is changed from normal running to idle one.

This object is achieved according to the present invention by an engine control system which is characterized by the features recited in the claim.

The above and other objects, features and advantages of the present invention will be more clear from the following description with reference to the accompanying drawings, in which :

Fig. 1 is a schematic diagram of the control device for the whole of the engine system ;

Fig. 2 is a block diagram generally illustrating the engine control system;

Fig. 3 (A)-(F) is a time chart from OFF to ON of the idling switch ;

Fig. 4 (A)-(D) is a time chart of the number of engine revolution and the ISC duty factor when the engine brake is actuated ;

Fig. 5 is a flowchart of the ISC duty factor control in the loaded state.

Referring to the drawings the present invention will be described hereunder.

In Fig. 1 a control apparatus for the whole of an engine system is illustrated. In Fig. 1, suction air is supplied to a cylinder 8 through an air deaner 2, a throttle chamber 4, and a suction pipe 6. A gas burnt in the cylinder 8 is discharged from the cylinder 8 to the atmosphere through an exhaust pipe 10. An injector 12 for injecting fuel is provided in the throttle chamber 4. The fuel injected from the injector 12 is atomized in an air path of the throttle chamber 4 and mixed with the suction air to form a fuel-air mixture which is in turn supplied to a combustion chamber of the cylinder 8 through the suction pipe 6 when a suction valve 20 is opened.

Throttle valves 14 and 16 are provided in the vicinity of the output of the injector 12. The throttle valve 14 is arranged so as to mechanically interlocked with an accelerator pedal (not shown) so as to be driven by the driver. The throttle valve 16 is arranged to be driven by a diaphragm 18 such that it becomes its fully close state in a range where the air flow rate is small, and as the air flow rate increases the negative pressure applied to the diaphragm 18 also increases so that the throttle valve 16 begins to open, thereby suppressing the increase of suction resistance.

An air path 22 is provided at the upper stream of the throttle valves 14 and 16 of the throttle chamber 4 and an electrical heater 24 constituting a thermal air flow rate meter is provided in the air path 22 so as to derive from the heater 24 an electric signal which changes in accordance with the air flow velocity which is determined by the relation between the air flow velocity and the amount of heat transmission of the heater 24. Being provided in the air path 22, the heater 24 is protected from the high temperature gas generated in the period of back fire of the cylinder 8 as well as from the pollution by dust or the like in the suction air. The outlet of the air path 22 is opened in the vicinity of the narrowest portion of the venturi and the inlet of the same is opened at the upper stream of the venturi.

Throttle opening sensors (not shown in Fig. 1 but generally represented by a throttle opening sensor 116 in Fig. 2) are respectively provided in the throttle valves 14 and 16 for detecting the opening thereof and the detection signals from these throttle opening sensors, that is the sensor 116, are taken into a multiplexer 120 of a first analog-to-digital converter as shown in Fig. 2.

The fuel to be supplied to the injector 12 is first supplied to a fuel pressure regulator 38 from a fuel tank 30 through a fuel pump 32, a fuel damper 34, and a filter 36. Pressurized fuel is supplied from the fuel pressure regulator 38 to the injector 12 through a pipe 40 on one hand and fuel is retumed on the other hand from the fuel pressure regulator 38 to the fuel tank 30 through a return pipe 42 so as to maintain constant the difference between the pressure in the suction pipe 6 into which fuel is injected from the injector 12 and the pressure of the fuel supplied to the injector 12.

The fuel-air mixture sucked through the suction valve 20 is compressed by a piston 50, burnt by a spark produced by an ignition plug 52, and the combustion is converted into kinetic energy. The cylinder 8 is cooled by cooling water 54, the temperature of the cooling water is measured by a water temperature sensor 56, and the measured value is utilized as an engine temperature. A high voltage is applied from an ignition coil 58 to the ignition plug 52 in agreement with the ignition timing.

A crank angle sensor (not shown) for producing a reference angle signal at a regular interval of predetermined crank angles (for example 180 degrees) and a position signal at a regular interval of a predetermined unit crank angle (for example 0.5 degrees) in accordance with the rotation of engine, is provided on a not-shown crank shaft.

The output of the crank angle sensor, the output 56A of the water temperature sensor 56, and the electrical signal from the heater 24 are inputted into a control circuit 64 constituted by a microcomputer or the like so that the injector 12 and the ignition coil 58 are driven by the output of this control circuit 64.

In the engine system controlled by the arrangement as described above, a bypass 26 bypassing the throttle valve 16 to communicate with the suction pipe 6 is provided and a bypass valve 62 is provided in the bypass 26. A control signal is inputted to a drive section of the bypass valve 62 from the control circuit 64 to control the opening of the bypass valve 62.

That is, the opening of the bypass valve 62 is controlled by pulse current such that the cross-sectional area of the bypass 26 is changed by the amount of lift of valve which is in tum controlled by a drive system driven by the output of the control circuit 64. That is, the control circuit 64 produces an open/close period signal for controlling the drive system so that the drive system responds to this open/close period signal to apply a control signal for controlling the amount of lift of the bypass valve 62 to the drive section of the bypass valve 62.

Fig. 2 is a diagram showing the whole configuration of the control system which is constituted by a central processing unit (hereinafter abbreviated as CPU) 102, a read only memory (hereinafter abbreviated as a ROM) 104, a random access memory (hereinafter abbreviated as RAM) 106, and an input/output (hereinafter abbreviated as I/O) circuit 108. The CPU 102 operates input data from the I/O circuit 108 in accordance with various programs stored in the ROM 104 and retums the result of operation to the I/O circuit 108. Temporary data storage necessary for such an operation is performed by using the RAM 106. Exchange of various data among the CPU 102, the ROM 104, the RAM 106, and the I/O circuit 108 is performed through a bus line 110 constituted by a data bus, a control bus, and an address bus.

The I/O circuit 108 includes input means such as the above-mentioned first analog-to-digital converter (hereinafter abbreviated as ADC1), a second analog-to-digital converter (hereinafter abbreviated as ADC2), an angular signal processing circuit 126, and a discrete I/O circuit (hereinafter abbreviated as DIO) for inputting/outputting one bit information.

In the ADC1, the respective output signals of a battery voltage sensor (hereinafter abbreviated as VBS) 132, the above-mentioned cooling water temperature sensor (hereinafter abbreviated as TWS) 56, an atmosphere temperature sensor (hereinafter abbreviated as TAS) 112, a regulation voltage generator (hereinafter abbreviated as VRS) 114, the above-mentioned throttle opening sensor (hereinafter referred to as θTHS) 116, and a λ sensor 118 (hereinafter abbreviated as λS) 118 are applied to the above-mentioned multiplexer 120 (hereinafter abbreviated as MPX) 120 which selects one of the respective input signals and inputs the selected signal to an analog-to-digital converter circuit (hereinafter abbreviated as ADC) 122. The digital value of the output of the ADC 122 is stored in a register (hereinafter abbreviated as REG) 124.

An output signal of an air flow rate sensor (hereinafter abbreviated as AFS) 24 is inputted to the ADC2 in which the signal is A/D converted in an ADC 128 and set in a REG 130.

An angle sensor (hereinafter abbreviated as ANGS) 146 produces a reference signal representing a reference crank angle (hereinafter abbreviated as REF), for example as a signal generated at an interval of 180 degrees of crank angle, and a position signal representing a small crank angle (hereinafter abbreviated as POS), for example 1 (one) degree. The REF and POS are applied to the angular signal processing circuit 126 to be waveform-shaped therein.

The respective output signals of an idle switch 148 (hereinafter abbreviated as IDLE-SW) 148, a top gear switch (hereinafter abbreviated as TOP-SW) 150, and a starter switch 152 (hereinafter abbreviated as START-SW) are inputted into the DIO.

Next, a circuit for outputting pulses in accordance with the result of operation of the CPU 102 and an object to be controlled will be described hereunder. An injector circuit (hereinafter abbreviated as INJC) 134 is provided for converting the digital value of the result of operation into a pulse output Accordingly, a pulse having a pulse width corresponding to the amount of fuel injection is generated in the INJC 134 and applied to the injector 12 through an AND gate 136.

An ignition pulse generating circuit (hereinafter abbreviated as IGNC) 138 includes a register (hereinafter referred to as ADV) for setting ignition timing and another register (hereinafter referred to as DWL) for setting initiating timing of the primary current conduction of the ignition coil 58 and these data are set by the CPU 102.

The rate of opening of the bypass valve 62 is controlled by a pulse supplied thereto by a control circuit (hereinafter referred to as ISCC) 142 through an AND gate 144. The ISCC 142 has a register ISCD for setting a pulse width and another register ISCP for setting a repetitive pulse period.

The one-bit I/O signals are controlled by the circuit DIO. The I/O signals include the respective output signals of the IDLE-SW 148, the TOP-SW 150 and the START-SW 152 as input signals, and include a pulse signal for controlling the fuel pump 32 as an output signal. The DIO includes a register DDR for determining whether a terminal be used as a data inputting one or a data outputting one, and another register DOUT for latching the output data.

A register (hereinafter referred to as MOD) 160 is provided for holding commands instructing various internal states of the I/O circuit 108 and arranged such that, for exmaple, all the AND gates 136, 140, 144, and 156 are turned on/off by setting a command into the MOD 160. The stoppage/start of the respective outputs of the INJC 134, IGNC 138, and ISCC 142 can be thus controlled by setting a command into the MOD 160.

An embodiment of the invention will be explained referring to Figs. 3 to 5, in which the bypass valve ON duty factor is controlled so that the number of engine revolution can be smoothly changed when the idling switch is tumed ON from the OFF state, that is when the engine state is changed from normal running to idle one.

If the idling switch is turned ON from its OFF state at the time t_1 as shown in Fig. 3(A), the feedback control with respect to the bypass valve ON duty factor is started as shown in Fig. 3(B). That is, the ON duty factor for the OFF state of the idlinge switch, i.e. the value ($Ko + ISC_{FB}$) which is the sum of the ON duty factor fixed component Ko and the ON duty factor feedback component ISC_{FB} corresponding to the difference AN between the actual value of the number of engine revolution N and the reference value of the number of engine revolution for idle running N_{REF}, is outputted as the ON duty factor at this time. That is, if the feedback component ISC_{FB} has a negative value (hereinafter, it is assumed that the value ISC_{FB} is negative in this embodiment), the value ISC_{FB} is decreased at regular or predetermined intervals of time by a feedback component changing value ΔD (negative value) which is determined by the above-mentioned difference value ΔN in the number of engine revolution and therefore the bypass valve ON duty factor gradually decreases after the time t_1, as shown in Fig. 3(B). In the case where the ON duty factor is determined to control the number of engine revolution to the reference number of engine revolution N_{REF} by feedback control, however, the number of engine revolution may be so reduced below the reference number of engine revolution N_{REF} (overshoot) as shown in Fig. 3(C) when it is reduced toward the reference number of engine revolution by the feedback control, with the possibility of occurrence of engine stoppage. If the number of engine revolution N comes below the reference number of engine revolution for idle running N_{REF} (at the time t_3), the difference $\Delta N = N - N_{REF}$ becomes negative and therefore the changing value ΔD becomes positive so that the feedback component ISC_{FB} increases gradually. To cope with this problem, a method has been proposed conventionally, in which the feedback control is started upon the turning ON of the idling switch at the time t_1 as shown in Fig. 3(D) so as to decrease the ON duty factor step by step by the ON duty factor changing value ΔD to thereby reduce the number of engine revolution N toward the reference number of engine revolution N_{REF}, and when the number of engine revolution N has reached a given value which is the sum ($N_{REF} + \Delta No$) of the reference number of engine revolution N_{REF} and a predetermined fixed value ΔNo (for example, 400 r.p.m.) at the time t_2, the ON duty factor feedback control is stopped, that is the decreasing of the value ISC_{FB} is stopped, so that the bypass valve ON duty factor is caused to come back to the fixed component Ko and the feedback control is effected again to thereby converge the number of engine revolution to the desired value, as shown by the broken curve in Fig. 3(C). In this method, however, the number of engine revolution may overshoot to downward exceed the desired value N_{REF} as shown by the broken curve in Fig. 3(C) even if the ON duty factor is increased at the time where the number of engine revolution has reached the value which is the sum of the desired value N_{REF} and the predetermined value ΔNo.

In the embodiment according to the present invention, therefore, the feedback control is not immediately effected upon the turning ON of the idling switch at the time t_1 but started when the number of engine revolution has reduced to the value which is larger than the reference or desired value N_{REF} by a predetermined value ΔNo (for example, 400 r.p.m.), as shown in Fig. 3(E) and (F). Although it takes a longer time for the number of engine revolution to reach the value of the sum of the desired number of engine revolution N_{REF} and the fixed value ΔNo in comparison with the case of Fig. 3(D) (actually, the period of time is so short that it is difficult to clearly find the difference by measurement), the number of engine revolution can be quickly converged, after the initiation of the feedback control, to the desired reference value in comparison with the conventional case without overshooting.

In such a method in which the feedback control is started from the time where the number of engine revolution has reached the value which is larger than the desired reference value N_{REF} by the fixed value ΔNo, assume that after normal running, the accelerator is released at the third, fourth, or top gear position to effect engine braking to gently decrease the number of engine revolution and the clutch is turned OFF before the number of engine revolution has reached a sufficiently low value at which knocking may occur. Then, the number of engine revolution may largely fall down at the time t_2 as shown in Fig. 4(A) because the engine load becomes light at that time. That is, if the idling switch is turned ON and the engine braking is effected at time t_1 where the number of engine revolution has reached the value N_1 ($N_1 = N_{REF} + \Delta No$), the decrease of the number of engine revolution becomes gentle so that rate of reduction of the value ΔN = (N_{REF}) becomes smaller to maintain the changing value ΔD of the feedback component ISC_{FB} large, whereby the ON duty factor (Ko + ISC_{FB}) decreases rapidly as shown in Fig. 4(B) to rapidly reduce the number of engine revolution toward the desired value. In such a case where the changing value ΔD of the feedback component ISC_{FB} has reached a large value, if the dutch is turned OFF at the time t_2 where the number of engine revolution is N_2 so as to provide non-braking condition, the engine load decreases rapidly and the number of engine revolution falls down rapidly to overshoot or downward exceed the reference value N_{REF}. If the number of engine revolution becomes lower than the reference value N_{REF}, the reduction of the number of engine revolution cannot be sufficiently recovered although the changing value ΔD becomes positive to act to increase the value ISC_{FB}. To cope with this problem, the rate of change of the number of engine revolution upon the initiation of the feedback control, i.e. immediately after the idling switch has been turned ON from its OFF state, is obtained so that when the rate of change is smaller than a predetermined value, the gain of feedback control, i.e. the feedback changing value ΔD, is made small to increase the rate of change of the ON duty factor (Ko + ISC_{FB}) to effect the feedback control gently as shown in Fig. 4(C). Thus, the number of engine revolution can be converged to the desired value rapidly without overshooting, as shown in Fig. 4(D).

Referring to the flowchart shown in Fig.5, the embodiment in which the bypass valve ON duty factor after the turning-ON of the idling switch is controlled as shown in Figs. 3 and 4 will be described hereunder. It is assumed that the processing flow of Fig. 5 is executed every 160 msec and that the feedback component ISC_{FB} has a negative value in this processing flow as shown in Figs. 3 to 5.

In the step 1201, first, the number of engine revolution is read and be stored as N_{NEW} in a predetermined area of the RAM and the previously read value is shifted as N_{OLD} to another area in the RAM. Next, judgement is made as to whether the ON duty factor increment ISCD is zero or not in the step 1202. If the result of judgement proves that the increment ISCD is not zero, a predetermined ON duty factor value Δd is subtracted from the ON duty factor increment ISCD and the resulted value is stored in a predetermined area of the RAM in the step 1203, and the processing is shifted to the step 1204. When the result of judgement proves that the increment ISCD is zero in the step 1202 on the contrary, the processing is shifted to the step 1204. In the step 1204, judgement is made as to whether the idling switch is in the ON state or not. If the result of judgement in this step proves that the idling switch is in the OFF state, a flag 1 is set to "1" in the step 1205 and a flag 2 is reset to "0" in the step 1206. The flag 1 is for indicating the

OFF state of the idling switch and the flag 2 is for executing the control to minimize the changing value ΔD for the ON duty factor feedback component ISC_{FB}. When the result of judgement proves that the idling switch is in the OFF state, it is considered that system is to be subjected to open loop control and the ON duty factor fixed component Ko is map-retrieved on the basis of the cooling water temperature in the step 1207 so as to be set into the register ISCC 142.

If the result of judgement in the step 1204 proves that the idling switch is ON, the reference number of engine revolution for idle running N_{REF} is computed on the basis of the cooling water temperature and stored in a predetermined area of the RAM in the step 1208. In the step 1209, next judgement is made as to whether "1" is set in the flag I or not. If the result of judgement proves that "1" is not set to the flag 1, it is considered that the idling switch has been left in the ON state and the processing is shifted to the step 1214. If the result of judgement in the step 1209 proves that "1" is set in the flag 1, it is considered that the state of the idling switch has been changed from its OFF state to ON and judgement is made in the step 1210 as to whether the number of engine revolution N_{NEW} taken-in in the step 1201 is not smaller than the value obtained by adding the value ΔNo to the reference number of engine revolution N_{REF} for idle running. If the result of judgement in this step 1210 proves that the value N_{NEW} is equal to or larger than the sum of the value N_{REF} and the value ΔNo, it is considered that the ON duty factor is not yet to be subjected to the number-of-engine-revolution feedback control but to the open loop control and the processing is shifted to the step 1224. In the step 1224, the ON duty factor fixed component Ko is map-retrieved on the basis of the cooling water temperature and set into the register ISCC 142. Thus, open loop control is effected after the turning ON of the idling switch and before the time t_1. If the result of judgement in the step 1210 proves that the value N_{NEW} is smaller than the sum of the value N_{REF} and the value ΔNo, on the contrary, it is considered that the number-of-engine-revolution feedback control for the ON duty factor is to be effected and the flag 1 is reset in the step 1211. In the step 1212, then, the rate of change of the number of engine revolution ($\Delta N = N_{OLD} - N_{NEW}$) is obtained from the respective values of the number of engine revolution N_{NEW} and N_{OLD} taken-in in the step 1201 and judgement is made as to whether this Δn is smaller than a predetermined value Δn_o or not. If the result of judgement in the step 1212 proves that the rate of reduction of the number of engine revolution ($\Delta n = N_{OLD} - N_{NEW}$) is equal to or larger than the predetermined value Δn_o, the processing is shifted to the step 1214. If the value Δn is smaller than the predetermined value Δn_o, "1" is set in the flag 2 in the step 1213. That is, the changing value ΔD for the feedback component ISC_{FB} is set to a minimum value when the rate of reduction of the number of engine revolution Δn is smaller than the predetermined value Δn_o at the time t_1 as shown in Fig. 4, and "1" is set to the flag 1 to indicate such control.

Upon the resetting of the flag 1 in the step 1211, the processing is shifted from the step 1209 to the step 1214 after the time t_1. In the step 1214, next, the ON duty factor increment $ISCD_o$ is computed from the rate of reduction of the number of engine revolution $\Delta n = N_{OLD} - N_{NEW}$ and stored into the RAM.

The increment $ISCD_o$ is set such that it is larger as the rate of reduction Δn is larger and set to zero when it is smaller than the predetermined value Δn_1, i.e. ($\Delta n_1 < \Delta n_o$). That is when the rate of reduction of the number of engine revolution Δn is equal to or larger than the predetermined value Δn_1 after the time t_1, the increment ISCD in accordance with the rate of reduction Δn is add to the ON duty factor to prevent the sudden reduction in the engine speed.

Next, judgement is made as to whether the increment ISCD obtained in the step 1214 is larger than the increment $ISCD_o$ obtained in the step 1203. If the result of judgement proves that the increment $ISCD_o$ is not larger than the increment ISCD, that is when the rate of reduction of the number of engine revolution Δn is smaller than the previous value of the same, the processing is shifted to the step 1217, and the increment ISCD which has been decreased by Δd obtained in the step 1203 is used in the ON duty factor computing in the later step 1223. In this manner after the time t_2, the increment ISCD is decreased by Δd step by step at regular or predetermined intervals of time as the rate of reduction of engine speed becomes smaller so that the reference number of engine revolution N_{REF} can be reached smoothly.

If the result of judgement proves that the increment $ISCD_o$ is larger than the increment ISCD, that is when the rate of reduction of the number of engine revolution Δn is substantially equal to or larger than the previous value of the same, on the contrary, the increment $ISCD_o$ obtained in the step 1214 is made to be the increment ISCD which is used in the ON duty factor computing operation in the step 1223. This is because, when the rate of reduction of the number of engine revolution becomes larger after the ON duty factor feedback control has been started and the ON duty factor has been increased by the increment ISCD after the time t_1, the increment ISCD is renewed to a larger value determined corresponding to the rate of reduction of the number of engine revolution Δn to thereby prevent the engine speed from suddenly falling down.

In the step 1217, next, the reference number of engine revolution N_{REF} obtained in the step 1208 is compared with the number of engine revolution N_{NEW} taken-in in the step 1201 to judge whether the former is not smaller than the latter. If the result of judgement in this step 1201 proves that N_{REF} is smaller than N_{NEW}, the flag 2 is reset in the step 1218. That is, it is considered that the control to minimize the changing value ΔD for the ON duty factor feedback component ISC_{FB} has been completed.

In the step 1219, then, judgement is made as to whether "1" is set in the flag 2 or not, so that when the flag 2 is set to "1", the changing value ΔD for the feedback component ISC_{FB} is set to a minimum value in the step 1220, while if the result of judgement in the step 1219 proves that the flag 2 is not set to "1", the changing value ΔD for the feedback component ISC_{FB} is obtained in accordance with the value $\Delta N = N_{REF} - N_{NEW}$ in the step 1221. The changing value ΔD is set such that it is larger as the value $\Delta N = N_{REF} - N_{NEW}$ becomes larger.

In the step 1222, next, the new feedback component $ISC_{FB(NEW)}$ is obtained from the previous feedback component $ISC_{FB(OLD)}$ (this value is assumed to be negative, here) and the changing value ΔD obtained in the step 1221. That is, the value $(ISC_{FB(OLD)} - \Delta D)$ is made $ISC_{FB(NEW)}$.

In the step 1223, then, ON duty factor is obtained from the value of increment ISCD determined in the steps 1215 and 1216 and the feedback component $ISC_{FB(NEW)}$ obtained in the step 1222. That is the value $Ko + ISC_{FB(NEW)} + ISCD$ is computed and set in the ISCC 142.

Thus, as shown in Fig. 4, if the number of engine revolution decreases gradually when the engine brake is actuated at the third, the fourth, or the top gear position under the condition that the number of engine revolution feedback control has been started at the time t_1, the flag 2 is set to "1" in the steps 1212 and 1213 and the change value ΔD for the feedback component ISC_{FB} is minimized, as shown in the steps 1217 to 1220, to thereby prevent the number of engine revolution from falling down suddenly. It is noted that the ON duty factor increment ISCD is zero in this case.

If the engine load is large and the rate of reduction of the number of engine revolution is larger than the predetermined value Δn_1 under the condition that the number of engine revolution feedback control has been started at the time t_1, the ON duty increment ISCD is obtained in the step 1214 on the basis of Δn, the larger one between this value ISCD and the value of difference obtained by subtracting the predetermined value Δd from the previous increment obtained in the step 1203 is obtained in the step 1215 and 1216, and the thus obtained value is added to the fixed and feedback components of the ON duty factor in the step 1223. In this manner, the ON duty factor is made larger to prevent the number of engine revolution from falling down when the rate of reduction of the number of engine revolution is large.

Although the description as to the embodiment shown in Figs. 3 to 5 is made on the assumption that the feedback component ISC_{FB} of the ON duty factor is negative, the present invention can be applied to the case where the feedback component ISC_{FB} takes a positive value. In this case the feedback control is effected from the beginning because the number of engine revolution N is always smaller than the sum $N_{REF} + \Delta No$. Further, the changing value Δd in the step 1203 and the changing value ΔD in the step 1221 are assumed to be negative, and the changing value ISCD for the ON duty is also assumed to be negative.

Claims

1. In an engine control system comprising

(A) a throttle valve (16) provided in an intake path (6) for controlling a flow rate of intake air being introduced into the engine,
(B) a bypass (26) provided in parallel with the throttle valve (16),
(C) a bypass valve (62) for controlling a flow rate of auxiliary intake air being introduced into the engine,
(D) a plurality of sensors including a throttle opening sensor (idle switch 148) for detecting the closed state of said throttle valve (16),
(E) central processing means (64) for computing a value of a duty factor of said bypass valve ((62) in accordance with a real engine speed in order to keep the engine speed at a predetermined value,
(F) a pulse generating circuit (42) for generating pulses in accordance with the value of said duty factor computed by said central processing means (64),

an engine control method comprising the steps of

(G) judging whether the engine speed has decreased or not to a predetermined engine speed ($N_1 = \Delta N_0 + N_{REF}e$) which is higher than a desired engine speed (N_1) in an engine idle operation, when said throttle valve (16) has been closed and
(H) in case that it is judged that the engine speed has decreased to said predetermined engine speed (N_1), the duty cycle of said bypass valve (62) being controlled in accordance with the actual engine speed and in a case that it is judged that the engine speed is greater than said predetermined engine (N_1), the duty cycle of said bypass valve (62) being controlled in an open loop manner,

characterised in that the said method further comprises the steps of

(I) detecting a changing ratio of the engine speed immediately after the closure of said idle switch (148) and
(J) in a case that it is judged that the changing ratio is smaller than a predetermined ratio, setting the changing ratio (ΔD) of the duty cycle in the closed loop control to a fixed minimum val-

ue.

Patentansprüche

1. In einem Steuersystem für eine Brennkraftmaschine mit:

(A) einer Drosselklappe (16) in einer Ansaugstrecke (6) zur Steuerung einer Durchflußmenge von in die Maschine eingeführter Ansaugluft,
(B) einem Bypass (26) parallel zur Drosselklappe (16),
(C) einem Bypassventil (62), das eine Durchflußmenge von in die Maschine eingeführter Zusatzansaugluft einstellt,
(D) mehreren Sensoren einschließlich eines Drosselklappenöffnungsgrad-Sensors (Leerlaufschalter 148), der den Schließzustand einer Drosselklappe (16) erfaßt,
(E) Zentralprozessoreinheit (64), die nach Maßgabe einer Ist-Maschinendrehzahl einen Wert der relativen Einschaltdauer des Bypassventils (62) errechnet, um die Maschinendrehzahl auf einem vorbestimmten Wert zu halten,
(F) einem Impulsgeber (42), der nach Maßgabe des von der Zentralprozessoreinheit (64) errechneten Werts der relativen Einschaltdauer Impulse erzeugt,

ein Steuerverfahren für eine Brennkraftmaschine, das die Schritte umfaßt:

(G) Feststellen, ob die Maschinendrehzahl auf eine vorbestimmte Maschinendrehzahl ($N_1 = \Delta N_0 + N_{REF}$), die höher als eine Soll-Maschinendrehzahl (N_1) im Leerlauf der Maschine ist, abgenommen hat, wenn die Drosselklappe (16) geschlossen ist, und
(H) wobei, wenn festgestellt wird, daß die Maschinendrehzahl auf die vorbestimmte Maschinendrehzahl (N_1) abgenommen hat, die relative Einschaltdauer des Bypassventils nach Maßgabe der Ist-Maschinendrehzahl gesteuert wird und, wenn festgestellt wird, daß die Maschinendrehzahl höher als die vorbestimmte Maschinendrehzahl (N_1) ist, die relative Einschaltdauer des Bypassventils rückführungslos gesteuert wird,

dadurch gekennzeichnet, daß das besagte Verfahren außerdem die Schritte umfaßt:

(I) Erfassen einer Änderungsrate der Maschinendrehzahl unmittelbar nach Schließen des besagten Leerlaufschalters (148) und
(J) für den Fall, daß festgestellt wird, daß die Änderungsrate kleiner als ein vorgegebenes Verhältnis ist, Einstellen der Änderungsrate (ΔD) des Auslassungsgrades im geschlossenen Regelkreis auf einen festen Minimalwert.

Revendications

1. Dans un système de commande d'un moteur comprenant :

(A) un papillon des gaz (16) disposé dans un trajet d'admission (6) pour commander un débit de l'air d'admission qui est introduit dans le moteur,

B) une dérivation (26) disposée en parallèle avec le papillon des gaz (16),

C) une vanne de dérivation (62) pour commander un débit d'air d'admission auxiliaire qui est introduit dans le moteur,

D) une pluralité de capteurs incluant un capteur de l'ouverture du papillon des gaz (commutateur de ralenti 148) pour détecter l'état fermé dudit papillon des gaz (16),

(E) des moyens centraux de traitement (64) pour calculer une valeur du facteur de marche de ladite vanne de dérivation (62) conformément à une vitesse réelle du moteur pour maintenir la vitesse du moteur à une valeur prédéterminée,

F) un circuit générateur d'impulsions (42) pour produire des impulsions en fonction de la valeur dudit facteur de marche calculée par lesdits moyens centraux de traitement (64),

un procédé de commande d'un moteur comprenant les étapes consistant à :

G) évaluer si la vitesse du moteur est tombée ou non à une vitesse de moteur prédéterminée ($N_1 = \Delta N_0 + N_{REF}$e), qui est supérieure à une vitesse désirée (N_1) du moteur lors du fonctionnement au ralenti de ce dernier, lorsque ledit papillon des gaz (16) a été fermé,

H) dans le cas où il est établi que la vitesse du moteur est tombée à ladite vitesse prédéterminée du moteur (N_1), commander le facteur de marche de ladite vanne de dérivation (62) en fonction de la vitesse réelle du moteur et, dans le cas où il est établi que la vitesse du moteur est supérieure à ladite vitesse prédéterminée de ce dernier (N_1), commander le facteur de marche de ladite vanne de dérivation (62) selon un mode en boucle ouverte,

caractérisé en ce que ledit procédé comprend en outre, les étapes consistant à :

I) détecter un taux de variation de la vitesse du moteur immédiatement après la fermeture dudit commutateur de ralenti (148),

J) dans le cas où il est établi que le taux de variation est inférieur à un taux prédéterminé, fixer le taux de variation (ΔD) du facteur de marche dans la commande en boucle fermée à une valeur minimale fixe.

FIG. 1

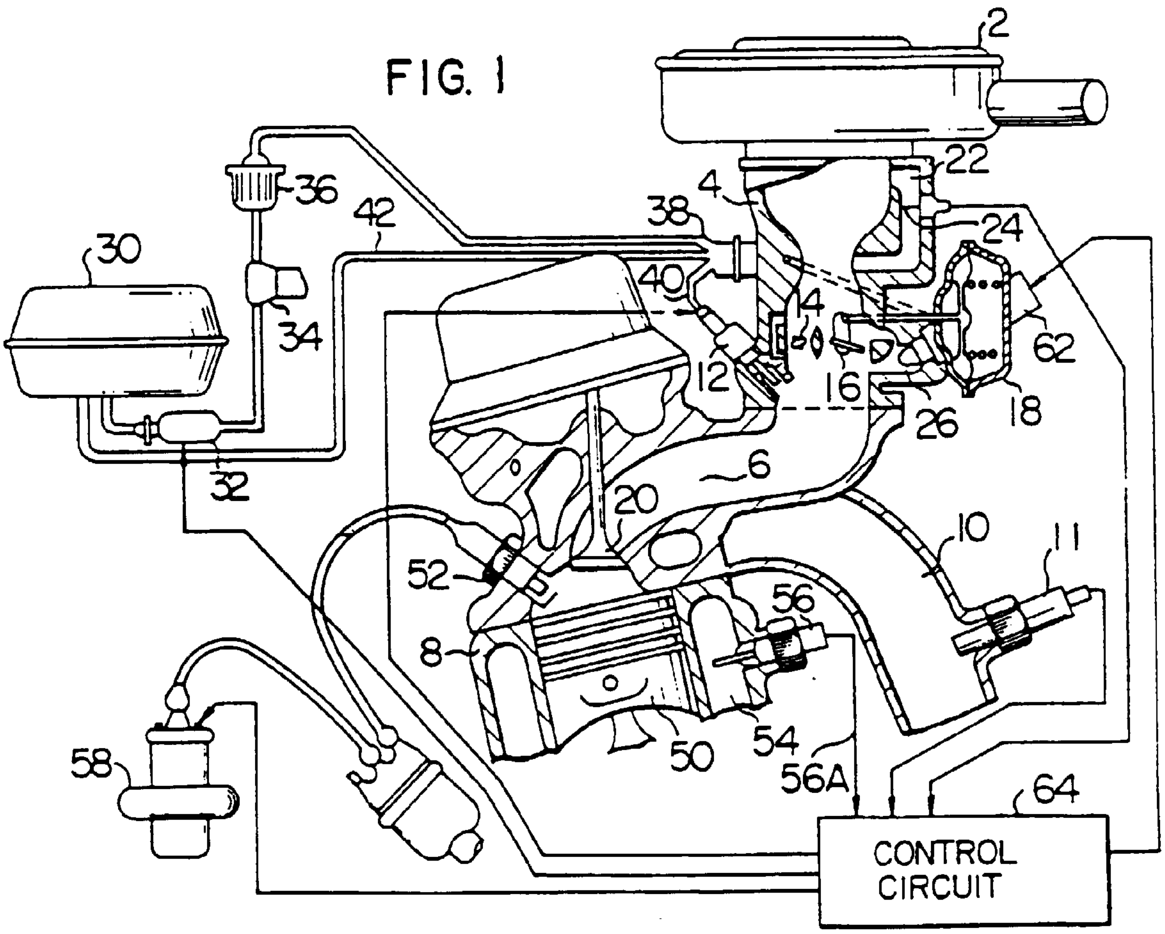

2
22
4
38
36
42
24
30
40
14
34
62
12
16
26
18
32
6
20
10
11
52
56
8
54
58
50
56A
64
CONTROL
CIRCUIT

FIG. 2

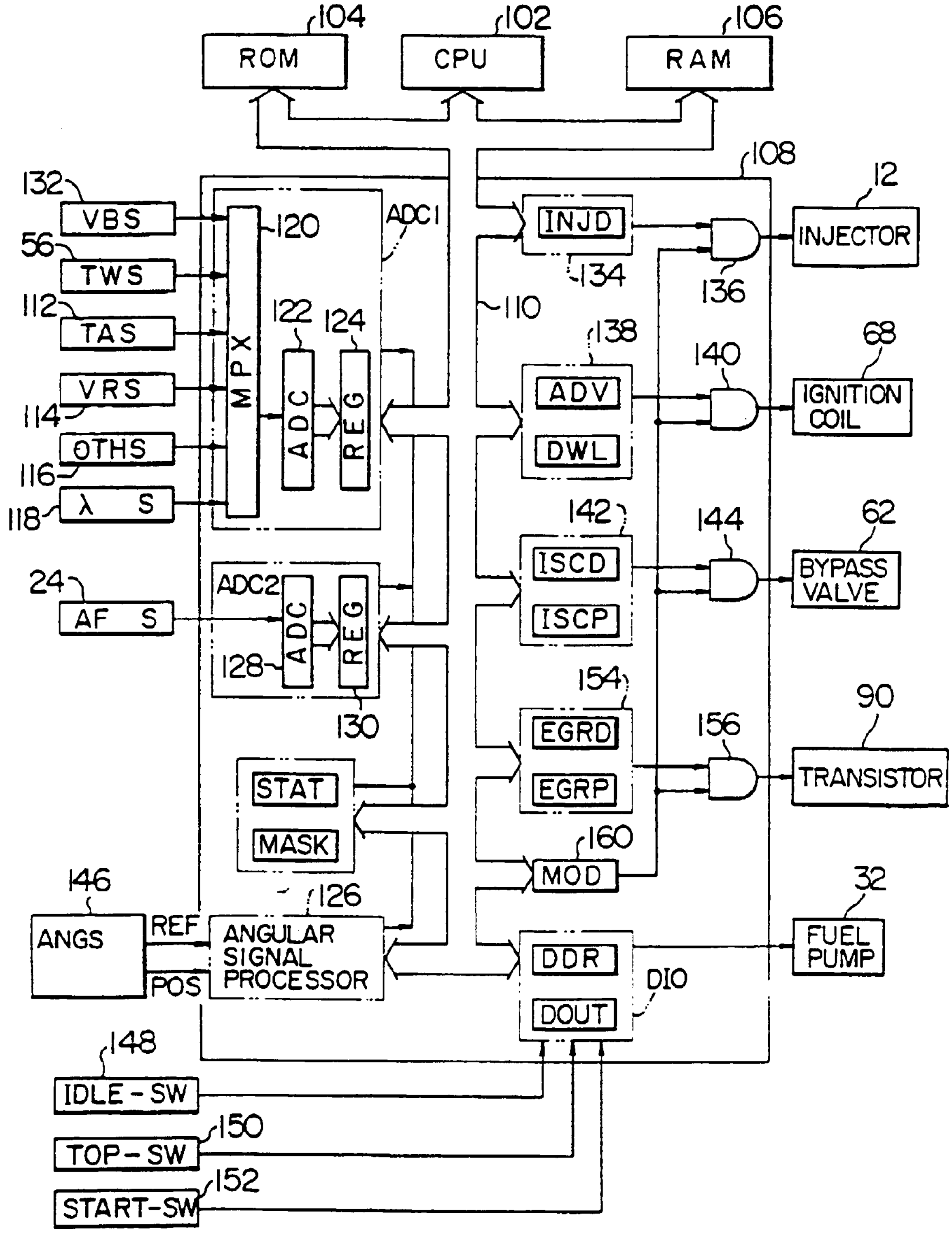
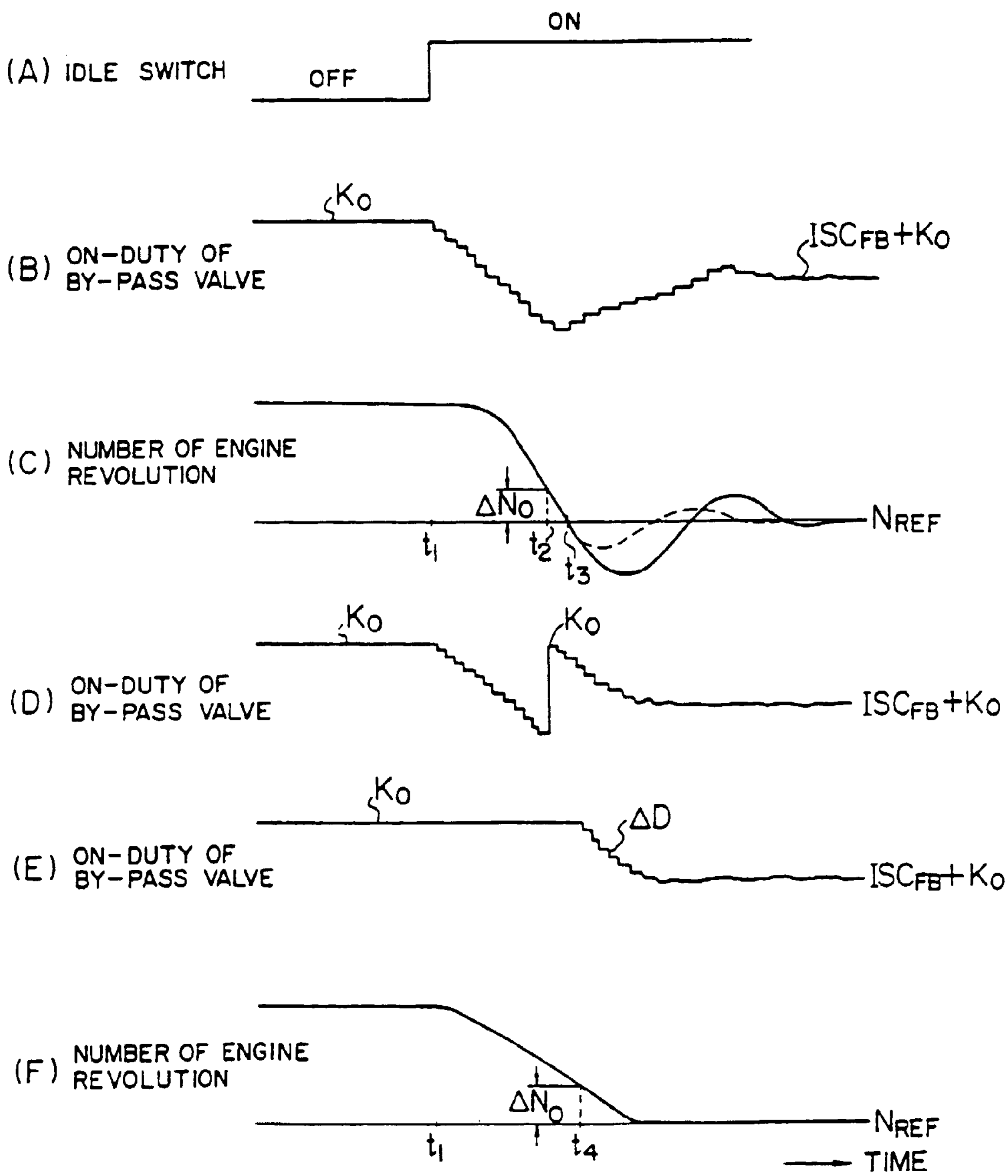

104
ROM
102
CPU
106
RAM
108
132
VBS
56
TWS
112
TAS
VRS
114
θTHS
116
λ S
118
MPX
120
ADC1
122
ADC
124
REG
24
AF S
ADC2
ADC
REG
128
130
STAT
MASK
146
ANGS
REF
POS
126
ANGULAR SIGNAL PROCESSOR
148
IDLE-SW
150
TOP-SW
152
START-SW
INJD
134
110
136
12
INJECTOR
138
ADV
DWL
140
68
IGNITION COIL
142
ISCD
ISCP
144
62
BYPASS VALVE
154
EGRD
EGRP
156
90
TRANSISTOR
160
MOD
DDR
DOUT
DIO
32
FUEL PUMP

FIG. 3



(A) IDLE SWITCH
OFF
ON
(B) ON-DUTY OF BY-PASS VALVE
KO
ISCFB+KO
(C) NUMBER OF ENGINE REVOLUTION
ΔNO
t1
t2
t3
NREF
(D) ON-DUTY OF BY-PASS VALVE
KO
KO
ISCFB+KO
(E) ON-DUTY OF BY-PASS VALVE
KO
ΔD
ISCFB+KO
(F) NUMBER OF ENGINE REVOLUTION
ΔNO
t1
t4
NREF
TIME

FIG. 4

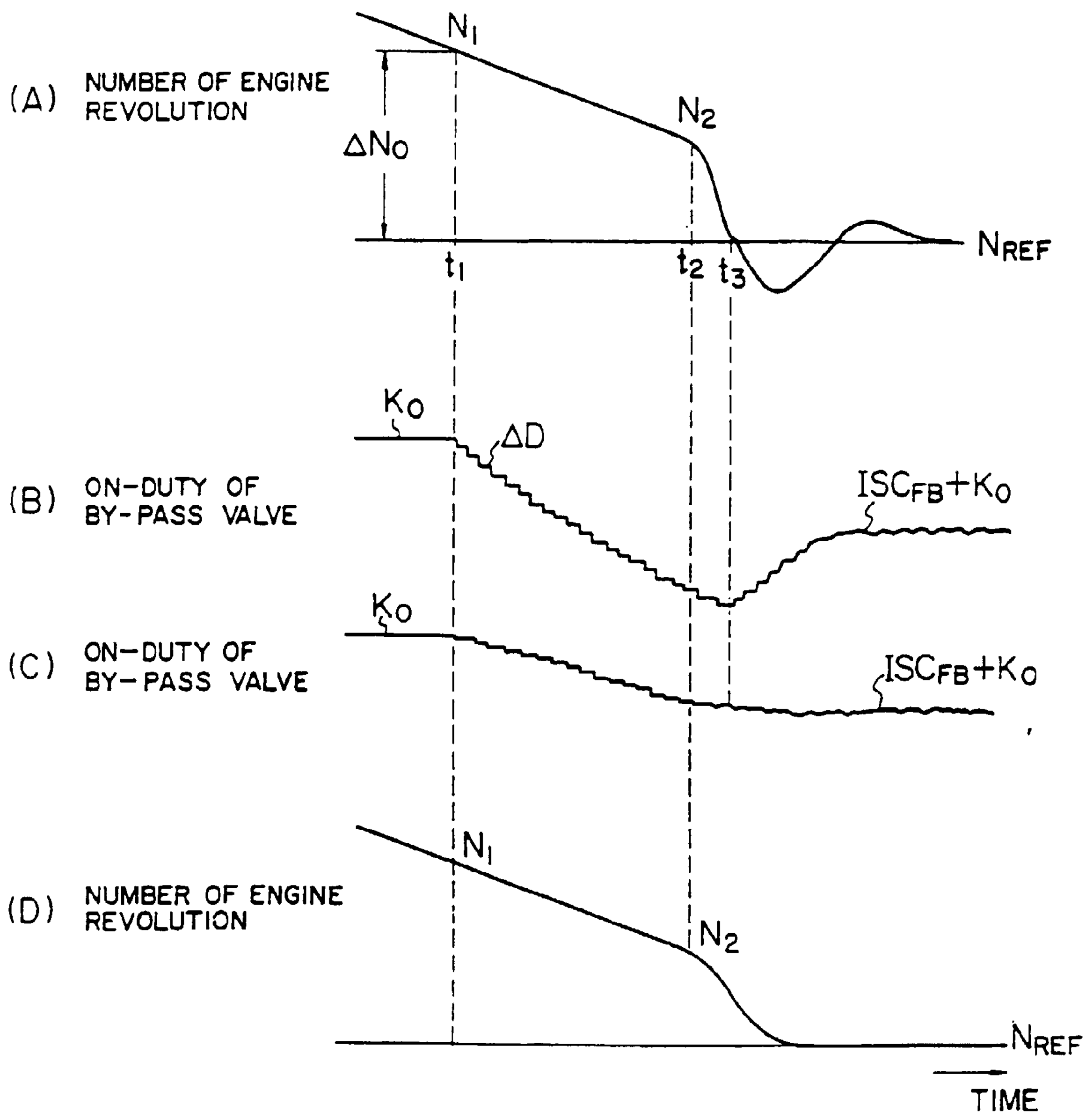
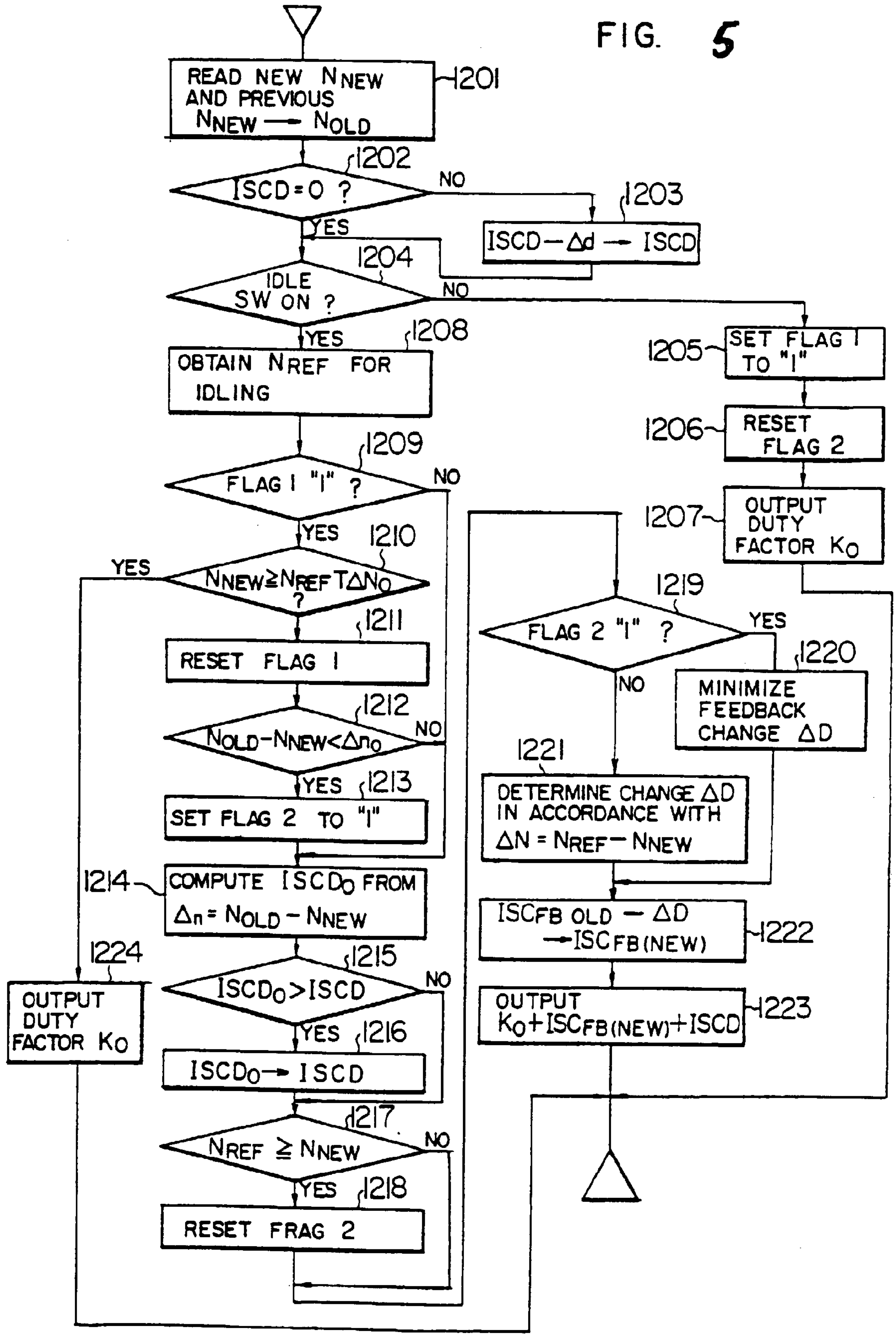

(A) NUMBER OF ENGINE REVOLUTION
N1
N2
ΔNO
NREF
t1
t2
t3
KO
ΔD
(B) ON-DUTY OF BY-PASS VALVE
ISCFB+KO
KO
(C) ON-DUTY OF BY-PASS VALVE
ISCFB+KO
N1
(D) NUMBER OF ENGINE REVOLUTION
N2
NREF
TIME

FIG. 5


READ NEW NNEW AND PREVIOUS NNEW → NOLD
1201
ISCD=0 ?
1202
NO
YES
1203
ISCD−Δd → ISCD
IDLE SW ON ?
1204
NO
YES
1208
OBTAIN NREF FOR IDLING
1205
SET FLAG 1 TO "1"
1206
RESET FLAG 2
1207
OUTPUT DUTY FACTOR KO
FLAG 1 "1" ?
1209
NO
YES
1210
NNEW≧NREF+ΔNO ?
YES
1211
RESET FLAG 1
1212
NOLD−NNEW<ΔnO
NO
YES
1213
SET FLAG 2 TO "1"
1214
COMPUTE ISCDO FROM Δn = NOLD − NNEW
1224
OUTPUT DUTY FACTOR KO
1215
ISCDO>ISCD
NO
YES
1216
ISCDO → ISCD
1217
NREF ≧ NNEW
NO
YES
1218
RESET FRAG 2
1219
FLAG 2 "1" ?
YES
NO
1220
MINIMIZE FEEDBACK CHANGE ΔD
1221
DETERMINE CHANGE ΔD IN ACCORDANCE WITH ΔN = NREF − NNEW
ISCFB OLD − ΔD → ISCFB(NEW)
1222
OUTPUT KO+ISCFB(NEW)+ISCD
1223