(54) **Method for controlling idling speed of internal combustion engine**

Methode zur Steuerung der Leerlaufdrehzahl einer Innenbrennkraftmaschine

Méthode de commande du régime de ralenti d'un moteur à combustion interne

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(56) References cited:
**US-A- 4 471 735   US-A- 4 520 778
US-A- 5 251 598   US-A- 5 642 707**

EP 1 245 809 B1

Description

[0001] The present invention relates to a method for controlling an idling speed of an internal combustion engine in which an injection amount is controlled by a feedback method so as to keep a target engine speed when a vehicle runs under an idling condition after a driver takes his or her foot off an accelerator while the vehicle runs.

[0002] An idling speed of an engine becomes stable at a rotating speed where a generated torque of the engine and a load torque caused by a friction in the engine itself balance. For example, if temperature is low, the idling speed is lowered since the friction in the engine itself is increased resulted from an increased viscosity of the engine lubricant oil. However, if the idling speed is lowered, the engine speed gets unstable, therefore there is a possibility that the driver get an uncomfortable feeling. On the other hand, if the idling speed is too high, the engine noise may be increased and the fuel economy may be lowered.

[0003] To avoid above disadvantages, it is proposed that a method for controlling the injection amount to a value that is necessary to keep the target idling speed even if the load torque of the engine is changed. That is called as an idling speed control.

[0004] For example, in the idling speed control for an diesel engine, an actual engine speed and a target engine speed obtained based on conditions such as a engine cooling water temperature and a load of a compressor for an air conditioner, and the injection amount is controlled by a PI type feedback method so that the target engine speed is achieved in accordance with a difference between those of the engine speeds.

[0005] However, according to the conventional idling speed control, when a driver takes foot off an accelerator in a running condition of a vehicle and runs the vehicle under an idling condition, the actual engine speed may repeat overshoots until the actual engine speed Ne convergences to the target engine speed Neisc. The repeated overshoots are triggered by insignificant hunting oscillations caused by the PI type feedback control, and causes a disadvantage that the driver may have unevenness about a drive feeling. US5251598 discloses the control of the fuel injection quantity for regulating the idling speed using a PID with a variable differential component.

[0006] The present invention was accomplished in consideration of the above-mentioned circumstances, it is an abject of the present invention to provide a method for controlling an idling speed of an internal combustion engine, which is capable of approaching the actual engine speed to the target engine speed smoothly during the idling speed control executed when the vehicle runs under the idling condition after the driver takes foot off the accelerator while running the vehicle.

[0007] The method for controlling the idling speed of the present invention is characterized by executing a injection correcting control for correcting the injection amount in order to suppress an excessive drop of the engine speed (decreasing speed) caused by a feedback control of the injection amount in accordance with a difference between an actual engine speed and a target engine speed.

[0008] Accordingly, it is possible to prevent the actual engine speed from the excessive drop with respect to the target engine speed, and to approaches the actual engine speed smoothly to the target engine speed.

[0009] The injection correcting control may comprises a step of calculating a corrective injection amount based on a decreasing speed of the engine speed. It is possible to suppress a decreasing speed of the engine speed relative to a decreasing speed caused by injecting a usual injection amount.

[0010] The injection correcting control may comprises a step of gradually increasing the corrective injection amount as the actual engine speed approaches to the target engine speed when the actual engine speed closely approaches to the target engine speed so that 100 % of the corrective injection amount affects the engine speed. It is possible to prevent the engine speed from an excessive quick deviation, and the driver is prevented from an uncomfortable shock feeling.

[0011] The corrective injection amount may be different with respect to an engine load. It is possible to execute the injection correcting control appropriately by varying the corrective injection amount in accordance with the engine load, e.g. the corrective injection amount is increased as the gear ratio is increased.

[0012] Features and advantages of embodiments will be appreciated, as well as methods of operation and the function of the related parts, from a study of the following detailed description, the appended claims, and the drawings, all of which form a part of this application. In the drawings:

FIG. 1 is a control block diagram according to an embodiment of the present invention;
FIG. 2 is a flowchart showing a base routine of the embodiment;
FIG. 3 is a flowchart showing a subroutine of the embodiment;
FIG. 4 is a flowchart showing a subroutine of the embodiment;
FIG. 5 is a graph showing flags corresponding to an engine speed;
FIG. 6 is graph showing an affecting ratio coefficient Kd1;
FIG. 7 is a map showing a relationship among a load and a coefficient Kd2; and
FIG. 8 is a graph showing behaviors of the engine speed.

[0013] Hereinafter, an embodiment of the present invention is described with reference to drawings.

[0014] FIG. 1 is a control block diagram of the embodiment, FIGS. 2 through 4 are flowcharts showing processing order of an ECU which executes an idling speed control.

[0015] For instance, in this embodiment, the idling speed control is applied to a diesel engine 1. The idling speed control executes a feedback control of an injection amount by driving an injection device 3 via an Electronic Control Unit 2 so as to coincide an actual engine speed Ne with a target engine speed Neisc when a vehicle runs under an idling condition after a driver takes foot off an accelerator pedal while running a vehicle. That is, during the driver taking foot off the accelerator, an operating degree of the accelerator is 0. The ECU 2 inputs the operating degree of the accelerator and other sensor signals such as the engine speed Ne. The ECU 2 has a block 2a for obtaining a proportional component of an injection amount in accordance with a difference (Neisc - Ne) between the engine speed Ne and the target engine speed Neisc. The ECU 2 has a block 2b for obtaining an integral component of the injection amount in accordance with the difference. The ECU 2 also has a block 2c for obtaining a differential component of the injection amount in accordance with the decreasing speed of the engine speed. The ECU 2 has a switch block 2d for controlling the differential component in accordance with conditions of the vehicle and the engine. The ECU 2 has adding blocks 2e and 2f for adding the components to obtain a conclusive corrective injection amount Qisc. The ECU 2 has a block 2g for calculating a base injection amount Qbase for maintaining the engine rotation in accordance with the operating degree of the accelerator and the engine speed, for calculating a conclusive injection amount Q by summing the base injection amount Qbase and the conclusive corrective injection amount Qisc, and for controlling the injection device 3 so as to inject and supply the conclusive injection amount Q to the engine 1.

[0016] A processing order of the idling speed control with the ECU 2 is explained with reference to a base routine shown in FIG. 2 and subroutines shown in FIGS. 3 and 4. Hereinafter, functions of each step are explained step by step.

[0017] In a step 100, a corrective amount Pi for P term, proportional component, is calculated by the following expression (1). In this embodiment, the corrective amount Pi is calculated as a base injection amount for an idling speed control.

$$Pi = Kp \cdot (Neisc - Ne) \ldots\ldots\ldots(1)$$

[0018] In a step 200, corrective amounts Ii and Di for I and D terms, integral and differential components, are calculated and read into the main routine.

[0019] In a step 300, a conclusive corrective injection amount Qisc is calculated by summing the corrective amounts Pi, Ii and Di.

[0020] Next, a process in the step 200 is explained.

[0021] In a step 201, it is determined that whether an initial process is completed or not. In the initial process, for instance, it is determined that whether an engine-starting switch (an ignition key) is turned on or not. If the engine-starting switch is turned on (YES) the process proceeds to a step 202, if the engine-starting switch is already turned on (NO) the process proceeds to a step 203.

[0022] In a step 202, initial values are set to flags for showing conditions of the vehicle used in the process as follows: an ISC executing flag F0 = 1, a running condition flag F1 = 0, and a D term correction flag F2 = 0.

[0023] In steps 203 through 210, conditions of the vehicle are determined into three categories as shown in FIG. 5.

[0024] In a step 203, a value of the flag F2 is identified. If F2 = 1 (YES), the process proceeds to the step 204, if F2 = 0 (NO), the process proceeds to the step 206.

[0025] In a step 204, it is determined that whether the following EVENT A is satisfied or not. EVENT A: Ne < Neisc + ΔN2, or the driver takes foot off the accelerator and Ne is not changed (is stable). Here, ΔN2 is a threshold value to determine whether the correction of D term should be stopped or not a shown in FIG. 5. If the EVENT A is satisfied (YES) the process proceeds to the step 205, if it is not satisfied (NO) the process proceeds to the step 208.

[0026] In a step 205, in this case, since the engine speed Ne is decreased from a D term correction region II to an ISC region I, the process proceeds to a step 211 after setting the flags as follows: the ISC executing flag F0 = 1, F1 = 1, F2 = 0.

[0027] In a step 206, a value of the flag F1 is identified. If F1 = 1 (YES) the process proceeds to the step 207, if the F1 = 0 (NO) the process proceeds to the step 209.

[0028] In a step 207, it is determined that whether the following EVENT B is satisfied or not. EVENT B: Ne < Neisc + ΔN1. Here ΔN1 is a threshold value to determine whether the Di term correction should be executed or not as shown in FIG. 5. If the EVENT B is satisfied (YES) the process proceeds to the step 208, if it is not satisfied (NO) the process proceeds to the step 210.

[0029] In a step 208, in this case, since the engine speed Ne is decreased from a running region III to the D term correction region II as shown in FIG. 5, the process proceeds to a step 211 after setting the flags as follows: the Di term correction executing flag F2 = 1, F0 = 0, F1 = 0.

[0030] In a step 209, it is determined that whether the following EVENT C is satisfied or not. EVENT C : Ne ≥ Neisc + ΔN1. If the EVENT C is satisfied (YES) the process proceeds to the step 210, if the EVENT C is not satisfied (NO) the process proceeds to the step 205. Here, the ΔN1 is a greater value than the ΔN2.

[0031] In a step 210, in this case, since the engine speed (Ne) is increased from the ISC region I to the running region III as shown in FIG. 5, the process proceeds to a step 211 after setting the flags as follows: the running condition flag F1 = 1, F0 = 0, F2 = 0.

[0032] Next, the corrective amounts Ii and Di for the I term and the D term are calculated in accordance with the running condition of the engine.

[0033] In a step 211, a value of the flag F2 is identified. If F2 = 1 (YES) the process proceeds to a step 212, if F2 = 0 (NO) the process proceeds to a step 214. In a step 212, a differential component is calculated. The step 212 is activated only when the engine speed is approaching to the target engine speed and the engine speed is within a predetermined range. In the step 212, the process proceeds to a step 213 after calculating the corrective amount Di for the D term by the following expression (2).

$$Di = Kd \cdot dNe/dt \ldots\ldots\ldots(2)$$

[0034] Kd: coefficient (affecting ratio coefficient), dNe/dt: decreasing speed of the Ne.

[0035] Here, it is necessary to be effective the corrective amount smoothly as the actual engine speed Ne approaches to the target engine speed Neisc, since if all (100 %) of the calculated corrective amount Di for D term is injected at once the engine speed quickly deviates and the driver may feel an uncomfortable shock. Therefore, the coefficient Kd is obtained as the product of a coefficient Kd1 and Kd2 as shown in FIGS. 6 and 7. The coefficient Kd1 is obtained based on a difference between the Ne and the Neisc. The coefficient Kd1 is set to increase the corrective amount gradually so as to affect 100 % of the corrective amount for Di term when the engine speed Ne coincides with the target engine speed Neisc. The coefficient Fd2 is determined by parameters such as an engine load as shown in FIG. 7, if the vehicle runs on a flat road and is in a constant temperature condition. The load may be obtained by a signal from a transmission indicative of gear positions. For example, it is necessary to increase torque generated by the engine 1 to obtain an even torque (deceleration) on a driving wheel as a gear position (ratio) is increased. Therefore, the corrective injection amount is also increased.

[0036] In a step 213, the process proceeds to a step 220 after replacing the corrective amount Ii-1 calculated in the last time with the present corrective amount Ii.

[0037] In a step 214, a value of the flag F0 is identified. If F0 = 1 (YES) the process proceeds to a step 215, if F0 = 0 (No) the process proceeds to a step 218. In a step 215, it is determined that whether the flag F0 = 1 is set in the present process or not. If the determination is YES the process proceeds to a step 216, if the determination is NO (the ISC control has been already executed) the process proceeds to a step 219.

[0038] In a step 216, the process proceeds to a step 217 after calculating the corrective amount Ii for the I term by the following expression (3).

$$Ii = Ii-1 + Di \ldots\ldots\ldots (3)$$

[0039] In this step, the corrective amount Di calculated in the step 212 is added only when the flags are changed from F2 = 1 to F0 = 1, i.e. only when the corrective amount Ii is calculated for the first time. Accordingly, it is possible to suppress drop of the engine speed Ne when it is changed from the D term correction region II to the ISC executing region I, and to provide a smooth transition of the corrective amount.

[0040] In a step 217, the process proceeds to a step 220 after setting Di = 0. In this step, Di = 0 is set so that adding the corrective amount Di is substantially inhibited for a second or later calculation of the corrective amount Ii.

[0041] In a step 218, the process proceeds to the step 220 after calculating the corrective amount Ii by the following expression (4).

$$Ii = Ii-1 \ldots\ldots\ldots(4)$$

[0042] In a step 210, the process proceeds to the step 220 after calculating the corrective amount Ii by the following expression (5).

$$Ii = Ii\text{-}1 + f(Neisc - Ne) \ldots\ldots\ldots(5)$$

[0043] In a step 220, the corrective amounts Ii-1 and Di-1 calculated in the last time are replaced with the corrective amounts Ii and Di calculated in the present process.

(Advantages of the embodiment)

[0044] According to the embodiment, if the engine speed is decreased when the driver takes foot off the accelerator while the running condition of the vehicle, a corrective injection amount for correcting the injection amount is obtained on a vicinity of the target engine speed (Neisc + ΔN2 ≤ Ne < Neisc + ΔN1). Therefore, it is possible to suppress a decreasing speed of the engine speed relative to a conventional idling speed control using a PI type feedback control. Accordingly, it is possible to prevent the engine speed from an excessive drop (overshoot) with respect to the target engine speed. It is possible to approach the engine speed smoothly to the target engine speed as shown in FIG. 8 with a solid line. If the driver takes foot off the accelerator while the running condition of the vehicle, an engine speed decreases to a target engine speed for an idling condition. A corrective injection amount is calculated and added on a base injection amount when the engine speed is in a vicinity of the target engine speed (Neisc + ΔN2 ≤ Ne < Neisc + ΔN1). The corrective injection amount is calculated based on a decreasing speed dNe/dt of the Ne. The corrective amount is gradually increased by an affecting ratio coefficient Kd1 so that 100 % of the corrective amount is fully effective when the engine speed Ne coincides with the target engine speed Neisc. As a result, it is possible to suppress a decreasing speed of the engine speed. It is possible to prevent the engine speed from an excessive drop with respect to the target engine speed. It is possible to approach the engine speed smoothly to the target engine speed.

Claims

1. A method for controlling an idling speed of an internal combustion engine (1), wherein in the method an injection amount is controlled by a feedback method so as to maintain a target engine speed when a vehicle runs under an idling condition after a driver takes foot off an accelerator while running a vehicle,
   wherein the method comprises the steps of:

   calculating (2a) a corrective proportional injection amount (Pi) for an idling speed control in accordance with a difference (Neisc-Ne) between the actual engines speed Ne and the target engine speed Neisc;
   calculating (2c) a corrective differential injection amount (Di) based on the rate of decrease (dNe/dt) of the engine speed Ne; and
   obtaining (2e, 2f) a corrective conclusive injection amount (Qisc) for the idling speed control by summing the corrective proportional injection amount (Pi) and the corrective differential injection amount (Di),

   wherein the method is **characterized**
   in that the step of calculating (2c) the corrective differential injection amount (Di) based on the rate of decrease (dNe/dt) of the engine speed Ne is activated only when the engine speed Ne is decreased toward the target engine speed Neisc and only when the engine speed Ne is within a predetermined range, in which the engine speed Ne is smaller than a first threshold and grater than or equal to a second threshold, wherein the first threshold is greater than the target engine speed Neisc by a first threshold value ΔN1 and the second threshold is greater than the target engine speed Neisc by a second threshold value ΔN2 which is smaller than the first threshold value ΔN1.

2. The method according to claim 1, further comprising the steps of:

   calculating a base injection amount (Qbase) for rotating the engine in accordance with an operating degree of an accelerator (Acc) and the engine speed Ne,
   calculating a conclusive injection amount (Q) by summing the base injection amount (Qbase) and the corrective conclusive injection amount (Qisc) for the idling speed control; and
   injecting the conclusive injection amount (Q) into the engine.

3. The method according to claims 1 or 2, wherein the corrective differential injection amount (Di) is calculated so as to increase as the engine speed Ne approaches to the target engine speed Neisc.

4. The method according to claim 3, wherein the corrective differential injection amount (Di) is calculated so that 100% of the corrective differential injection amount (Di) affects the idling speed control when the engine speed Ne substantially coincides with the target engine speed Neisc.

5. The method according to one of claims 1 to 4, wherein the corrective differential injection amount (Di) is calculated so as to be different with respect to an engine load.

6. The method according to claim 5, wherein the corrective differential injection amount (Di) is calculated so as to increase as the engine load increases.

Patentansprüche

1. Verfahren zum Steuern einer Leerlaufdrehzahl einer Brennkraftmaschine (1), wobei bei dem Verfahren eine Einspritzmenge durch ein Regelungsverfahren gesteuert wird, um eine Solldrehzahl aufrechtzuerhalten, wenn ein Fahrzeug in einem Leerlaufzustand läuft, nachdem ein Fahrer seinen Fuß von einer Beschleunigungseinrichtung genommen hat, während ein Fahrzeug läuft,
wobei das Verfahren die nachfolgenden Schritte aufweist:

Berechnen (2a) einer Proportionalkorrektureinspritzmenge (Pi) für eine Leerlaufdrehzahlssteuerung in Übereinstimmung mit einem Unterschied (Neisc-Ne) zwischen der tatsächlichen Maschinendrehzahl Ne und der Sollmaschinendrehzahl Neisc;
Berechnen (2c) einer Differenzialkorrektureinspritzmenge (Di) basierend auf der Abnahmerate (dNe/dt) der Maschinendrehzahl Ne; und
Erlangen (2e, 2f) einer gefolgerten Korrektureinspritzmenge (Qisc) für die Leerlaufdrehzahlssteuerung durch Aufsummieren der Proportionalkorrektureinspritzmenge (Pi) und der Differenzialkorrektureinspritzmenge (Di), wobei das Verfahren **dadurch gekennzeichnet ist, dass**
der Schritt des Berechnens (2c) der Differenzialkorrektureinspritzmenge (Di) basierend auf der Abnahmerate (dNe/dt) der Maschinendrehzahl Ne nur dann aktiviert wird, wenn die Maschinendrehzahl Ne in Richtung zu der Sollmaschinendrehzahl Neisc hin verringert wird, und nur dann, wenn sich die Maschinendrehzahl Ne innerhalb eines vorbestimmten Bereichs befindet, in dem die Maschinendrehzahl Ne kleiner als ein erster Schwellenwert und größer als oder gleich wie ein zweiter Schwellenwert ist, wobei der erste Schwellenwert um einen ersten Schwellenwertbetrag ΔN1 größer als die Sollmaschinendrehzahl Neisc ist, und der zweite Schwellenwert um einen zweiten Schwellenwertbetrag ΔN2 größer als die Sollmaschinendrehzahl Neisc ist, der geringer als der erste Schwellenwertbetrag ΔN1 ist.

2. Verfahren nach Anspruch 1, dass des Weiteren die nachfolgenden Schritte aufweist:

Berechnen einer Basiseinspritzmenge (Qbase) zum Drehen der Maschine in Übereinstimmung mit einem Betätigungsbetrag einer Beschleunigungseinrichtung (Acc) und der Maschinendrehzahl Ne,
Berechnen einer gefolgerten Einspritzmenge (Q) durch Aufsummieren der Basiseinspritzmenge (Qbase) und der gefolgerten Korrektureinspritzmenge (Qisc) für die Leerlaufdrehzahlssteuerung; und
Einspritzen der gefolgerten Einspritzmenge (Q) in die Maschine.

3. Verfahren nach Anspruch 1 oder 2, wobei die Differenzialkorrektureinspritzmenge (Di) so berechnet wird, dass sie zunimmt, wenn sich die Maschinendrehzahl Ne der Sollmaschinendrehzahl Neisc annähert.

4. Verfahren nach Anspruch 3, wobei die Differenzialkorrektureinspritzmenge (Di) so berechnet wird, dass 100% der Differenzialkorrektureinspritzmenge (Di) die Leerlaufdrehzahlssteuerung beeinflussen, wenn die Maschinendrehzahl Ne im Wesentlichen mit der Sollmaschinendrehzahl Neisc übereinstimmt.

5. Verfahren nach einem der Ansprüche 1 bis 4, wobei die Differenzialkorrektureinspritzmenge (Di) so berechnet wird, dass sie sich bezüglich einer Maschinenlast unterscheidet.

6. Verfahren nach Anspruch 5, wobei die Differenzialkorrektureinspritzmenge (Di) so berechnet wird, dass sie zunimmt, wenn die Maschinenlast zunimmt.

Revendications

1. Procédé de commande d'un régime de ralenti d'un moteur à combustion interne (1), dans lequel dans le procédé une quantité d'injection est commandée par un procédé de rétroaction afin de maintenir un régime moteur cible lorsqu'un véhicule fonctionne dans une condition de ralenti après qu'un conducteur retire son pied de l'accélérateur lors du fonctionnement d'un véhicule,
dans lequel le procédé comprend les étapes consistant à :

   calculer (2a) une quantité d'injection proportionnelle correctrice (Pi) pour une commande de régime de ralenti conformément à une différence (Neisc - Ne) entre le régime moteur réel (Ne) et le régime moteur cible (Neisc) ;
   calculer (2c) une quantité d'injection différentielle correctrice (Di) sur la base du taux de réduction (dNe/dt) du régime moteur (Ne) ; et
   obtenir (2e, 2f) une quantité d'injection conclusive correctrice (Qisc) pour la commande de régime de ralenti en faisant la somme de la quantité d'injection proportionnelle correctrice (Pi) et la quantité d'injection différentielle correctrice (Di),

   dans lequel le procédé est **caractérisé**
   en ce que l'étape consistant à calculer (2c) la quantité d'injection différentielle correctrice (Di) sur la base du taux de réduction (dNe/dt) du régime moteur (Ne) est activée seulement lorsque le régime moteur (Ne) est réduit vers le régime moteur cible (Neisc) et seulement lorsque le régime moteur (Ne) est au sein d'une plage prédéterminée, dans laquelle le régime moteur (Ne) est inférieur à un premier seuil et supérieur ou égal à un second seuil, le premier seuil étant supérieur au régime moteur cible (Neisc) selon une première valeur de seuil (ΔN1) et le second seuil étant supérieur au régime moteur cible (Neisc) selon une seconde valeur de seuil (ΔN2) qui est inférieure à la première valeur de seuil (ΔN1).

2. Procédé selon la revendication 1, comprenant en outre les étapes consistant à :

   calculer une quantité d'injection de base (Qbase) pour faire tourner le moteur conformément à un degré d'actionnement d'un accélérateur (Acc) et au régime moteur (Ne) ;
   calculer une quantité d'injection conclusive (Q) en faisant la somme de la quantité d'injection de base (Qbase) et la quantité d'injection conclusive correctrice (Qisc) pour la commande de régime de ralenti ; et
   injecter la quantité d'injection conclusive (Q) dans le moteur.
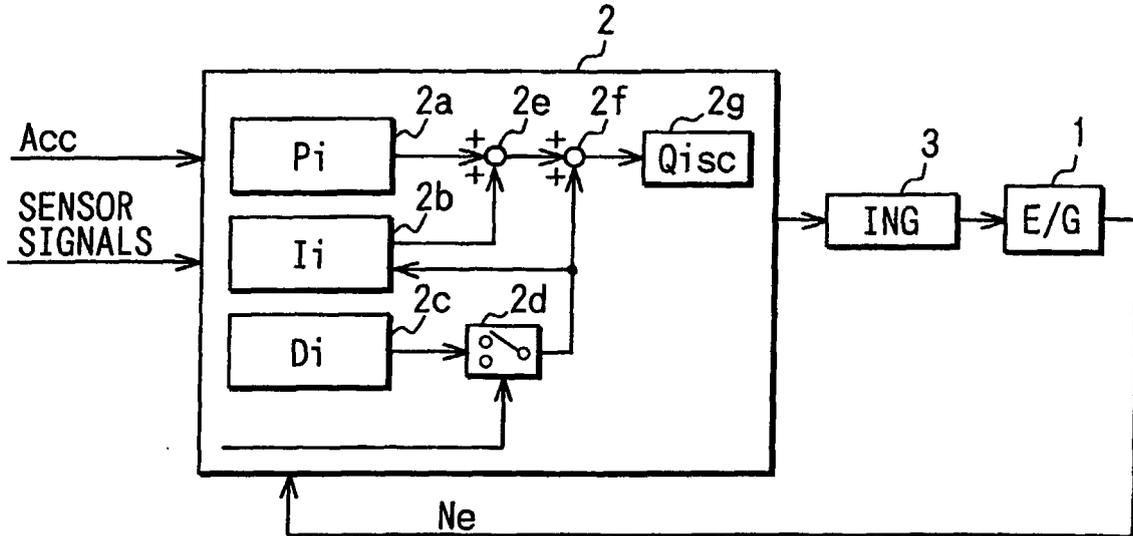
3. Procédé selon la revendication 1 ou 2, dans lequel la quantité d'injection différentielle correctrice (Di) est calculée afin d'augmenter lorsque le régime moteur (Ne) se rapproche du régime moteur cible (Neisc).

4. Procédé selon la revendication 3, dans lequel la quantité d'injection différentielle correctrice (Di) est calculée de sorte que 100 % de la quantité d'injection différentielle correctrice (Di) affecte la commande de régime moteur lorsque le régime moteur (Ne) coïncide sensiblement avec le régime moteur cible (Neisc).

5. Procédé selon une des revendications 1 à 3, dans lequel la quantité d'injection différentielle correctrice (Di) est calculée afin d'être différente par rapport à une charge de moteur.

6. Procédé selon la revendication 5, dans lequel la quantité d'injection différentielle correctrice (Di) est calculée afin d'augmenter lorsque la charge de moteur augmente.

FIG. 1

FIG. 2

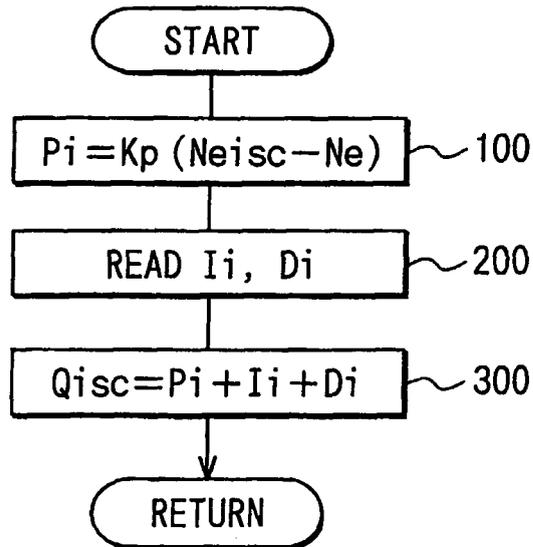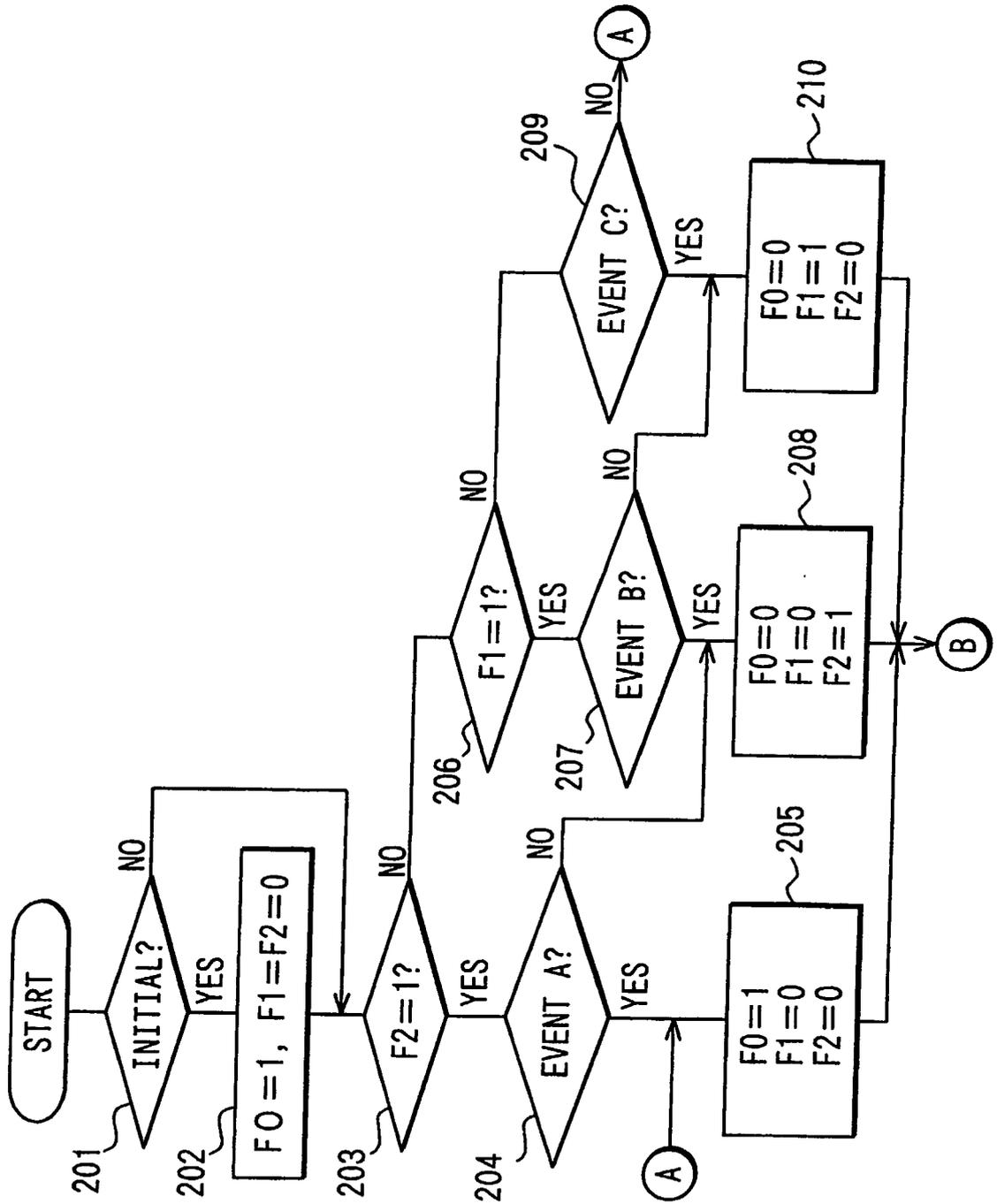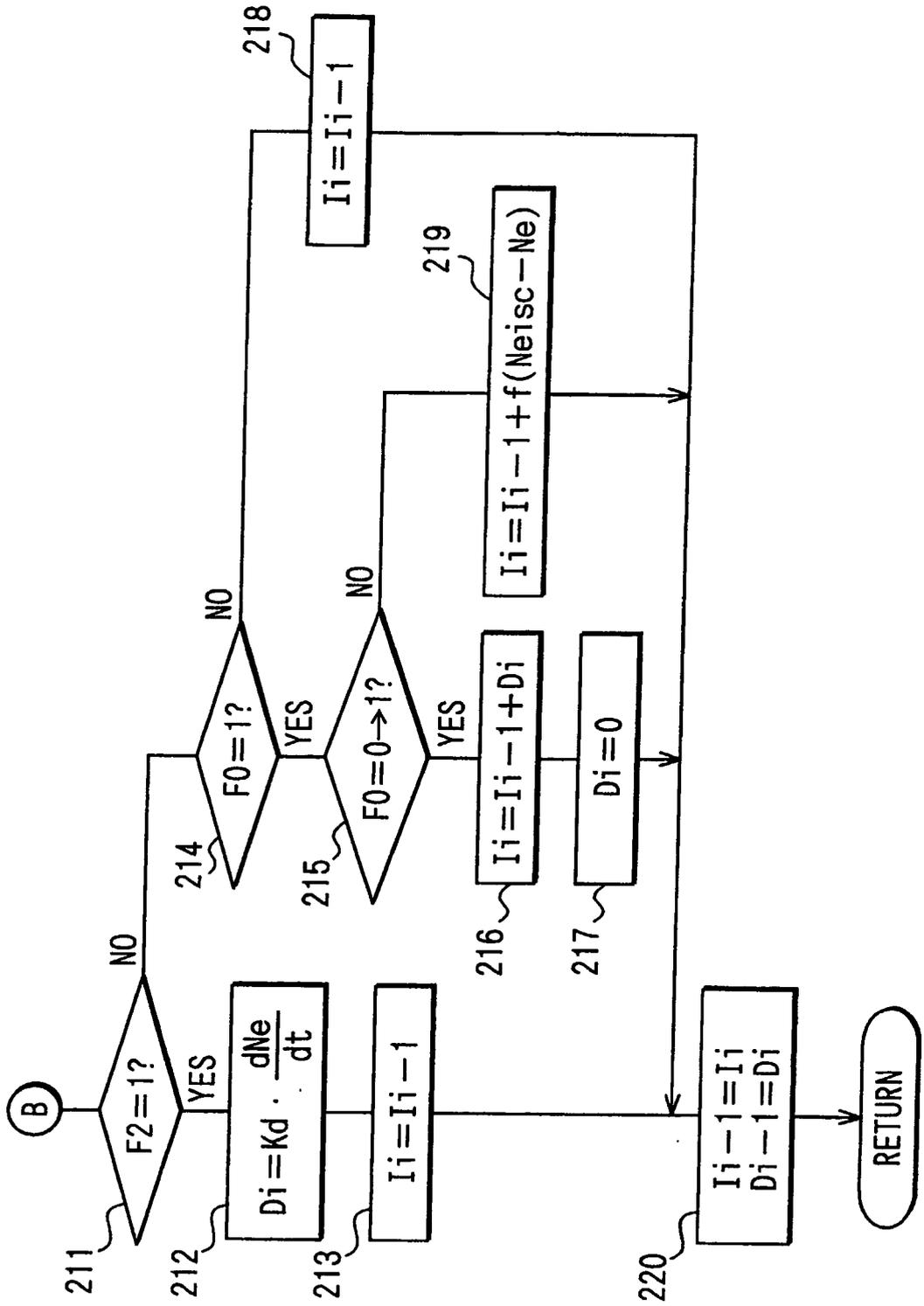START

$Pi = Kp \, (Neisc - Ne)$ ～100

READ Ii, Di ～200

$Qisc = Pi + Ii + Di$ ～300

RETURN

FIG. 3

START

201 — INITIAL? — NO

YES

202 — F0=1, F1=F2=0

203 — F2=1? — NO

YES

204 — EVENT A? — NO

YES

205 — F0=1
F1=0
F2=0

A

206 — F1=1? — NO

YES

207 — EVENT B? — NO

YES

208 — F0=0
F1=0
F2=1

B

209 — EVENT C? — NO → A

YES

210 — F0=0
F1=1
F2=0

FIG. 4

$$Di = Kd \cdot \frac{dNe}{dt}$$

$Ii = Ii - 1$

$F2 = 1?$

$F0 = 1?$

$F0 = 0 \rightarrow 1?$

$Ii = Ii - 1 + Di$

$Di = 0$

$Ii = Ii - 1 + f(Neisc - Ne)$

$Ii = Ii - 1$

$Ii - 1 = Ii$
$Di - 1 = Di$

RETURN

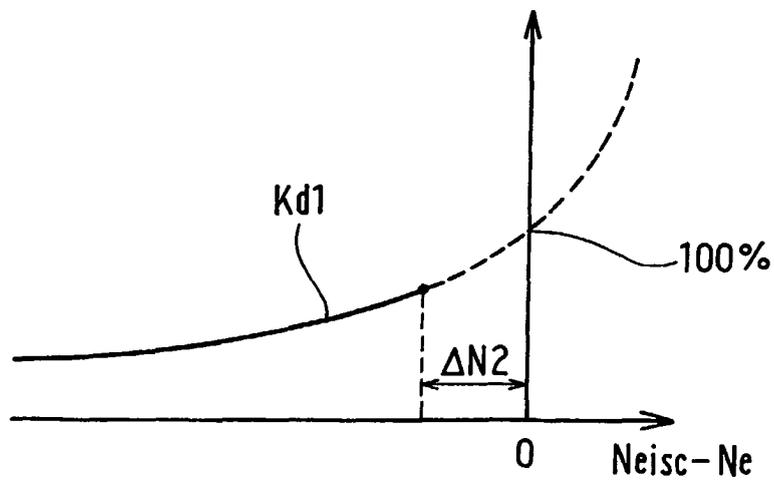211
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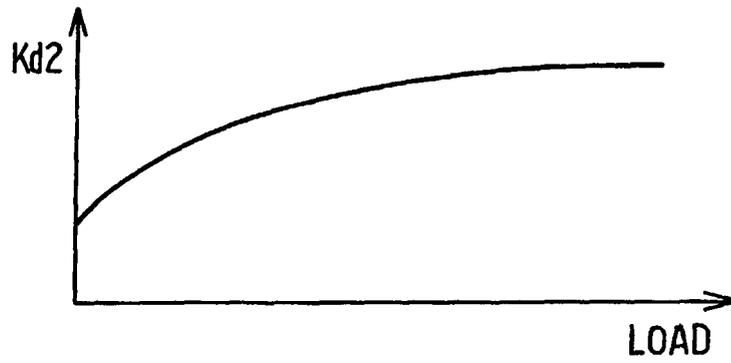213
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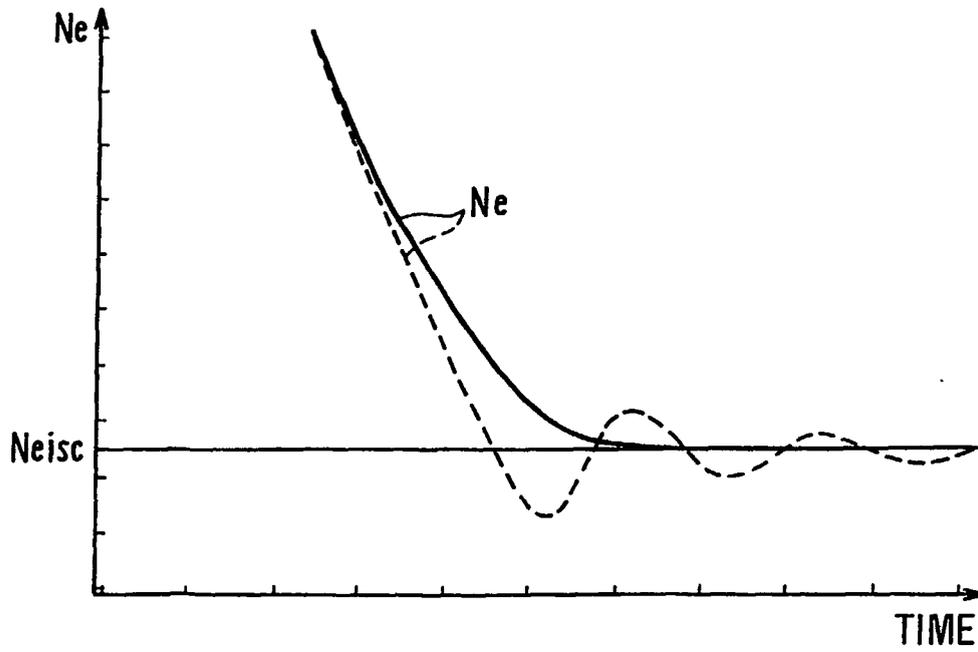216
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219
220

NO
YES
NO
YES
NO
YES

B

FIG. 5
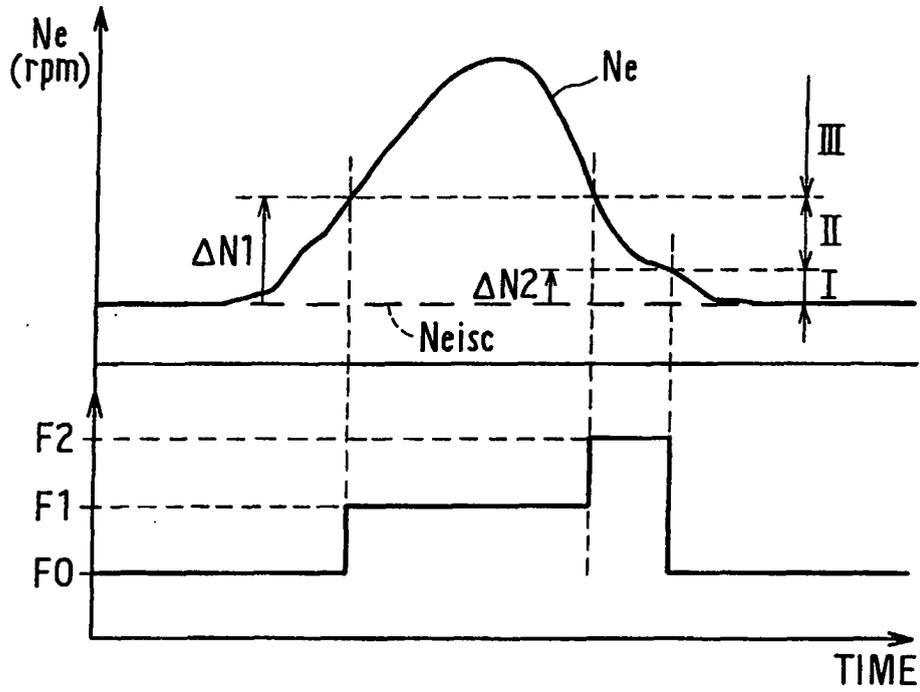
FIG. 6

FIG. 7

FIG. 8

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 5251598 A **[0005]**