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

(11) EP 1 555 414 A1

(12) # EUROPEAN PATENT APPLICATION

(43) Date of publication:
20.07.2005 Bulletin 2005/29

(51) Int Cl.[7]: **F02D 41/16**, F02D 41/06

(21) Application number: **05008644.6**

(22) Date of filing: **11.12.2001**

(84) Designated Contracting States:
DE ES FR GB IT

(30) Priority: **15.03.2001 JP 2001074577**

(62) Document number(s) of the earlier application(s) in accordance with Art. 76 EPC:
01274026.2 / 1 369 570

(71) Applicants:
- **TOYOTA JIDOSHA KABUSHIKI KAISHA**
  Toyota-shi, Aichi 471-8571 (JP)
- **Kabushiki Kaisha Toyota Jidoshokki**
  Kariya-shi, Aichi-ken 448-8671 (JP)

(72) Inventors:
- **Ito, Yoshiyasu**
  Toyota-shi Aichi 471-8571 (JP)
- **Narita, Yuji**
  Kariya-shi Aichi 448-8671 (JP)

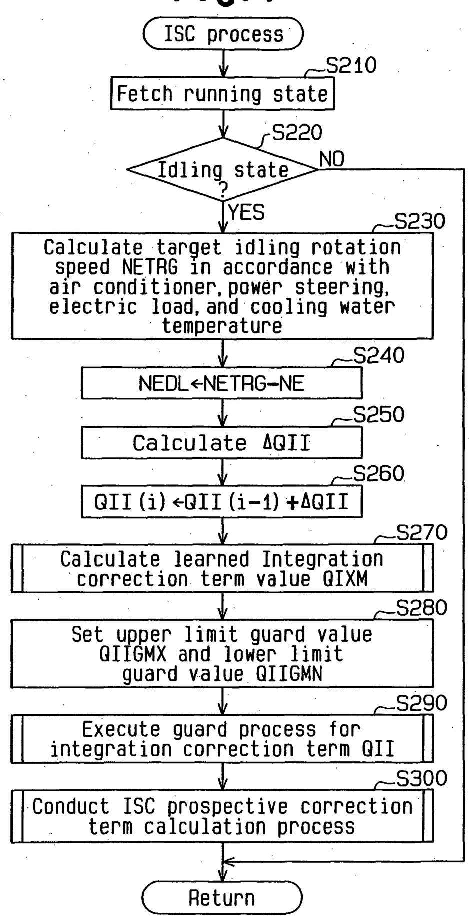
(74) Representative: **TBK-Patent**
Bavariaring 4-6
D-80336 München (DE)

Remarks:
This application was filed on 20 - 04 - 2005 as a divisional application to the application mentioned under INID code 62.

(54) **Method for controlling idling fuel supply amount and apparatus therefor**

(57) An integration correction term is calculated on the basis of a deviation of an actual rotation speed with respect to a target rotation speed of an internal combustion engine when the internal combustion engine is idling and used to correct a fuel supply amount, thus controlling an idling rotation speed of the internal combustion engine. At the time of and/or immediately after initiation of the internal combustion engine, prospective correction in accordance with friction which exists at an early initiation stage of the internal combustion engine is conducted on the fuel supply amount.

Fig.4



EP 1 555 414 A1

Description

Technical Field

[0001] The present invention relates to a method for controlling an idling fuel supply amount which controls the idling rotation speed of an internal combustion engine by correcting a fuel supply amount using an integration correction term, and an apparatus therefore.

Background Art

[0002] In a system for controlling the idling rotation speed by adjusting a fuel supply amount, for example, a system for controlling the idling rotation speed of a diesel engine disclosed in Japanese Laid-Open Patent Publication No. Hei 11-93747, a basic fuel amount is set from the rotation speed of an internal combustion engine based on a governor pattern. On this basic fuel amount, an integration correction term is calculated on the basis of an actual rotation speed deviation with respect to a target rotation speed. In such a manner, feed-back control is conducted on the idling rotation speed. Then, to accommodate a change in friction caused by a change in the temperature of the internal combustion engine and external load at the time of idling, various kinds of prospective correction is conducted in accordance with the temperature of the cooling water, the kind of external load such as an air conditioner or power steering, and the ON/OFF condition. Such prospective correction makes it possible to control the idling rotation speed in a stable manner.

[0003] Even with such prospective correction, immediately after the internal combustion engine is initiated, certain friction inherent to the early stage of the initiation thereof occurs that cannot be known by considering the friction alone which corresponds to the level of the temperature thereof. Accordingly, if the basic fuel amount is simply corrected on the basis of a calculation of the prospective correction term based on the friction which is estimated based on the temperature of the internal combustion engine, the fuel supply amount becomes insufficient during idling immediately after the internal combustion engine is initiated, thus giving rise to a drop in the rotation speed of the internal combustion engine.

[0004] Generally, such a drop in the rotation speed of the internal combustion engine is corrected by increasing the fuel supply amount in the above-mentioned integration correction term so that the rotation speed of the internal combustion engine may be returned to a target rotation speed. This integration correction term, however, tends to increase extremely if, for example, load such as semi-clutched state lasts long during idling. If the clutch is disengaged after the integration correction term is thus increased excessively, a prospective correction term due to clutch engagement and the excessive integration correction term may work together to cause a steep rise in the rotation speed of the internal combustion engine. To guard against this, generally, a guard process is executed in calculation of the integration correction term to prevent the integration correction term from becoming excessive.

[0005] If, however, a control range of the integration correction term due to a guard value is narrowed down to prevent a steep rise in the rotation speed as mentioned above, the integration correction term may not be able to change to such an extent as to compensate for large friction which exists at the early stage of the initiation of the internal combustion engine, so that a drop in the rotation speed causes an engine stall, thus preventing stable idling. Accordingly, there is a possibility that the control range for the integration correction term cannot be narrowed down, thereby resulting in insufficient prevention of a steep rise in rotation speed of the internal combustion engine caused by a semi-clutched condition etc.

Disclosure of Invention

[0006] It is the object of the present invention to provide a method for controlling an idling fuel supply amount and an apparatus therefor which can prevent a drop in rotation speed of an internal combustion engine by compensating for friction generated at the early stage of initiation of the internal combustion engine and also which can prevent a steep rise in rotation speed friction which exists an integration correction term in the subsequent control of an idling rotation speed.

[0007] The object is achieved by a method for controlling an idling fuel supply amount according to claim 1.

[0008] According to a method for controlling an idling fuel supply amount according to one embodiment of the present invention, based on a deviation of an actual rotation speed of an internal combustion engine with respect to a target rotation speed during idling thereof, an integration correction term is calculated and then used to correct the fuel supply amount, thus controlling the idling rotation speed of the internal combustion engine. By this method, at the time of and/or immediately after the initiation of the internal combustion engine, prospective correction is conducted on friction which exists at the early stage of the initiation of the internal combustion engine.

[0009] Thus, in contrast to a conventional method, the method of the present invention conducts such prospective correction on a fuel supply amount as to correspond to friction which exists in particular at the early stage of initiation of the internal combustion engine. It is thus possible to bring the actual rotation speed of the internal combustion engine to a target rotation speed before the value of a deviation of the actual rotation speed with respect to the target rotation speed of the internal combustion engine is greatly accumulated in the integration correction term.

[0010] In such a manner, the integration correction term can be prevented from increasing in value, thus narrowing down a range for limiting the integration correction term by utilizing the guard process. It is thus possible to compensate for friction which exists at the early stage of initiation of the internal combustion engine to thereby prevent a drop in the rotation speed thereof and also to prevent a steep rise in the rotation speed caused by the integration correction term in the subsequent control of an idling rotation speed.

[0011] It is to be noted that the concept of the early stage of initiation referred to here covers both the timing of initiation and the timing immediately after initiation. This also applies to the early stage of initiation which will be given below.

[0012] In a preferred method for controlling an idling fuel supply amount, the prospective correction is actually conducted by gradually reducing the value of the prospective correction term which is set at the time of and/or immediately after the initiation of the internal combustion engine. By this prospective correction involving gradual reduction of the prospective correction term value set at the time of and/or immediately after the initiation of the internal combustion engine, friction which exists at the early stage of the initiation thereof is compensated for and then a shock is prevented from occurring when this prospective correction is stopped, thus enabling smoothing the shifting over to the subsequent control on the idling rotation speed.

[0013] In another preferred method for controlling the idling fuel supply amount, a period over which the value of the prospective correction term is held is provided prior to the gradual reduction of this prospective correction term. By thus providing the period over which the prospective correction term value is held, it is possible to effectively suppress an increase in this value at the time of or immediately after the initiation of the internal combustion engine even without extremely enlarging an initial value of the prospective correction term.

[0014] In a further preferred method for controlling the idling fuel supply amount, the prospective correction term is gradually decreased in value as time elapses after the internal combustion engine is initiated or its rotation is started. As a technique for reducing the prospective correction term value gradually, it may be conducted in accordance with the time that has elapsed after the internal combustion engine is initiated or its rotation is started. Since the friction generated at the early stage of the initiation of the internal combustion engine gradually disappears when the internal combustion engine continues to run, the prospective correction term can be reduced in value as time elapses. In such a manner, it is possible to prevent a shock from occurring when the present prospective correction is stopped, thus smoothing the shifting over to the subsequent control on the idling rotation speed.

[0015] In a still further preferred method for controlling the idling fuel supply amount, the prospective correction term is gradually decreased in value in accordance with an accumulated number of rotations of the internal combustion engine after the initiation of the rotation or the initiation of the internal combustion engine. As the internal combustion engine runs, the friction generated at the early stage of the initiation of the internal combustion engine disappears gradually, so that the prospective correction term can be reduced in value based on the number of rotations accumulated as the internal combustion engine runs. In such a manner, it is possible to prevent a shock from occurring when the present prospective correction is stopped, thus smoothing the shifting over to the subsequent control on the idling rotation speed.

[0016] In an additional method for controlling the idling fuel supply amount, the prospective correction term gradually decreases as the temperature of the internal combustion engine rises. The temperature of the internal combustion engine gradually rises as the internal combustion engine continues running after the initiation. Such a pattern of temperature rising is similar to a friction reduction pattern at the early stage of the initiation of the internal combustion engine, while a temperature factor is related to the magnitude of the friction which exists at the early stage of the initiation of the internal combustion engine. It is, therefore, possible to appropriately reduce the value of the prospective correction term based on a rise in the temperature of the internal combustion engine. In such a manner, it is possible to prevent a shock from occurring when the present prospective correction is stopped, thus smoothing the shifting over to the subsequent control on the idling rotation speed.

[0017] Furthermore, preferably the temperature of cooling water of the internal combustion engine is used as the above-mentioned temperature thereof. In this case, based on a rise in the temperature of the cooling water of the internal combustion engine, the prospective correction term can be reduced in value appropriately. In such a manner, it is possible to prevent a shock from occurring when the present prospective correction is stopped, thus smoothing the shifting over to the subsequent control on the idling rotation speed.

[0018] It is to be noted that as the engine temperature a temperature of an engine lubricating oil closely related to the friction may be used in place of the cooling water temperature. In this case also, the prospective correction term can be appropriately reduced in value based on a rise in temperature of the lubricating oil.

[0019] To restart the engine after it is stalled, the prospective correction term is preferably set to a value at the moment of the engine stall to thereby begin to reduce the value of the prospective correction term starting from this value. Upon the engine stall, the friction which had been generated at the early stage of the initiation and decreased by the rotation of the internal combustion engine up to the moment immediately before the engine stalling is scarcely recovered. To restart the engine after being stalled, therefore, the prospective correction term is to take on the value at the moment of engine stalling so that reduction thereof may start from this value. In such a manner, it is possible to set the prospective correction term appropriately, thus further stabilizing control on the idling rotation speed of the internal combustion engine.

[0020] The prospective correction term is preferably switched in accordance with a shifted position of the transmission. Since the magnitude of the friction which exists at the early stage of the initiation of the internal combustion engine changes with the shifted position of the transmission, the magnitude of the prospective correction term is to be switched in accordance with the shifted position of the transmission. In such a manner, it is possible to set the prospective correction term appropriately, thus further stabilizing control on the idling rotation speed of the internal combustion engine.

[0021] The prospective correction term may also be switched in accordance with presence/absence of external load. Since the magnitude of the friction which exists at the early stage of the initiation of the internal combustion engine changes with the presence/absence of external load, the magnitude of the prospective correction term is to be switched in accordance with the presence/absence of external load. In such a manner, it is possible to set the prospective correction term appropriately, thus further stabilizing control on the idling rotation speed of the internal combustion engine.

[0022] The prospective correction term may also be switched in accordance with a kind of external load. Since the magnitude of the friction which exists at the early stage of the initiation of the internal combustion engine changes with the kind of the external load such as an air conditioner or a power steering, the magnitude of the prospective correction term is to be switched in accordance with the kind of the external load. In such a manner, it is possible to set the prospective correction term appropriately, thus further stabilizing control on the idling rotation speed of the internal combustion engine.

[0023] In a method for controlling the idling fuel supply amount of still further embodiment, an integration correction term is calculated on the basis of a deviation of the actual rotation speed of the internal combustion engine with respect to a target rotation speed during idling of the internal combustion engine, so that the guard process is subsequently executed on this integration correction term using an upper-limit and lower-limit guard values and also the integration correction term after the guard process is executed thereon is used to correct the fuel supply amount, thus controlling the idling rotation speed of the internal combustion engine. According to this method, at the time of and/or immediately after the initiation of the internal combustion engine, a control range of the integration correction term between the upper-limit and lower-limit guard values is set wider than that at the time of usual running.

[0024] The control range of the integration correction term in the guard process is particularly set wider than that at the time of usual running at the time of and/or immediately after the initiation of the internal combustion engine. At least at the time of and/or immediately after the initiation of the internal combustion engine, therefore, the value of the deviation of the actual rotation speed with respect to the target rotation speed of the internal combustion engine is allowed to be accumulated greatly in the integration correction term. Only at the time of and/or immediately after the initiation of the internal combustion engine, therefore, the friction which exists at the early stage of the initiation of the internal combustion engine can be compensated for by the integration correction term, thus preventing a drop in rotation speed of the internal combustion engine.

[0025] Furthermore, when the idling rotation speed is controlled subsequently, the control range of the integration correction term is returned to a control range at the time of usual running, so that the magnitude of the integration correction term is inhibited to become excessive, thus preventing a steep rise in rotation speed in the controlling of the idling rotation speed.

[0026] According to the preferred embodiment, in the guard process, the control range of the integration correction term which is set at the time of and/or immediately after the initiation of the internal combustion engine is gradually narrowed down to a control range at the time of usual running. The control range of the integration correction term which is set at the time of and/or immediately after the initiation of the internal combustion engine is thus narrowed down gradually in this guard process. It is, therefore, possible to sufficiently compensate for the friction which exists at the early stage of the initiation of the internal combustion engine using the integration correction term and then restore the control range of the integration correction term at the time of usual running, thus smoothing the shifting over to the subsequent control on the idling rotation speed.

[0027] Furthermore, it is preferred to provide a period over which a width of the integration correction term control range is held before gradual narrowing of the control range of the integration correction term. By thus providing the period over which the width of the integration correction term control range is held, it is possible to give a time margin, at the time of or immediately after the initiation of the internal combustion engine, in which the integration correction term can rise in value sufficiently without widening the control range of the integration correction term extremely. It is thus possible to effectively compensate for the friction which exists at the early stage of the initiation of the internal combustion engine using the integration correction term.

[0028] Furthermore, the control range of the integration correction term can also be narrowed down gradually as time elapses after the internal combustion engine is initiated or its rotation is started. As a technique for reducing gradually the control range of the integration correction term, it may be conducted in accordance with the elapsed time after the internal combustion engine is initiated or its rotation is stared. As the internal combustion engine continues to run, its friction generated at the early stage of the initiation disappears gradually, so that the integration correction term decreases gradually in value. It is, therefore, possible to appropriately narrow down the control range of the integration correction term based on the elapsed time. In such a manner, it is possible to restore the integration correction term control range at the time of usual running, thus smoothing the shifting over to the subsequent control on the idling rotation speed.

[0029] It is preferred to narrow gradually the control range of the integration correction term in accordance with the accumulated number of rotations of the internal combustion engine after it is initiated or its rotation is started. As a technique for narrowing gradually the control range of the integration correction term, it may be conducted in accordance with the accumulated number of rotations of the internal combustion engine after it is initiated or its rotation is started. As the internal combustion engine runs, the friction generated at the early stage of the initiation of the internal combustion engine disappears gradually and, therefore, the integration correction term decreases in value gradually. Therefore, by accumulating the rotations of the internal combustion engine and based on the accumulated number of rotations thereof, the control range of the integration correction term can be narrowed down appropriately. In such a manner, it is possible to restore the integration correction term control range at the time of usual running, thus smoothing the shifting over to the subsequent control on the idling rotation speed.

[0030] It is preferred to narrow gradually the control range of the integration correction term in accordance with a rise in the temperature of the internal combustion engine. As the internal combustion engine continues running after it is initiated, its temperature rises gradually. Such a pattern of temperature rising is similar to a friction reduction pattern at the early stage of the initiation of the internal combustion engine, while a temperature factor is related to the magnitude of the friction which exists at the early stage of the initiation of the internal combustion engine. It is, therefore, possible to appropriately narrow down the control range of the integration correction term based on a rise in temperature of the internal combustion engine. In such a manner, it is possible to restore the integration correction term control range at the time of usual running, thus smoothing the shifting over to the subsequent control on the idling rotation speed.

[0031] The temperature of cooling water of the internal combustion engine is preferably used as the above-mentioned temperature thereof. In this case, the control range of the integration correction term can be narrowed down appropriately based on a rise in the temperature of the cooling water of the internal combustion engine. In such a manner, it is possible to restore the integration correction term control range at the time of usual running, thus smoothing the shifting over to the subsequent control on the idling rotation speed.

[0032] To restart the engine after it is stalled, the integration correction term control range is preferably set to a value at the moment of the engine stalling to thereby start a process to narrow down this range. Upon engine stalling, the friction which had been generated at the early stage of the initiation and decreased by the rotation of the internal combustion engine up to the moment immediately before the engine stalling is scarcely recovered. To restart the engine after being stalled, therefore, a value of the integration correction term control range at the moment of the engine stalling is employed so that the above-mentioned process to narrow down the integration correction term control range may start from this value. In such a manner, it is possible to set the integration correction term control range appropriately, thus further stabilizing control on the idling rotation speed of the internal combustion engine.

[0033] Preferably, the integration correction term control range is switched in accordance with a shifted position of the transmission. Since the magnitude of the friction which exists at the early stage of the initiation of the internal combustion engine changes with the shifted position of the transmission, the integration correction term control range is to be switched in accordance with the shifted position of the transmission. In such a manner, it is possible to set the integration correction term control range appropriately, thus further stabilizing control on the idling rotation speed of the internal combustion engine.

[0034] Preferably, the integration correction term control range is switched in accordance with presence/absence of external load. Since the magnitude of the friction which exists at the early stage of the initiation of the internal combustion engine changes with the presence/absence of such external load as an air conditioner or a power steering, the integration correction term control range is to be switched in accordance with the presence/absence of the external load. In such a manner, it is possible to set the integration correction term control range appropriately, thus further stabilizing control on the idling rotation speed of the internal combustion engine.

[0035] Preferably, the prospective correction term control range is switched in accordance with a kind of the external load. Since the magnitude of the friction which exists at the early stage of the initiation of the internal combustion engine changes with the kind of the external load such as an air conditioner or a power steering, the integration correction term control range is to be switched in accordance with the kind of the external load. In such a manner, it is possible to set the integration correction term control range appropriately, thus further stabilizing control on the idling rotation speed of the internal combustion engine.

[0036] Preferably, the integration correction term control range is set with respect to a learned value of the integration correction term. In this case, it is possible to appropriately guard the integration correction term, which tends to change centering around the learned value. It is thus possible to appropriately set the integration correction term control range, thus further stabilizing control on the idling rotation speed of the internal combustion engine.

[0037] The learned value of the integration correction term may be allowed to be calculated when the integration correction term control range is returned to a range at the time of usual running. In a situation where the integration correction term control range is set wider than that at the time of usual running, the integration correction term changes greatly, so that it is not appropriate to calculate the learned value of the integration correction term because it is liable to generate an error. When, therefore, the integration correction term control range has returned to the range at the time of usual running, the learned value of the integration correction term is allowed to be calculated to thereby suppress the occurrence of an error in the learned value, thus further stabilizing control on the idling rotation speed.

[0038] According to a method for controlling the idling fuel supply amount of still another embodiment, a process of executing prospective correction corresponding to friction which is present at an early stage of initiation of an internal combustion engine and a process of setting an integration correction term control range at the time of and/or immediately after initiation of the internal combustion engine, are carried out. It is thus possible to compensate for the friction which exists at the early stage of the initiation of the internal combustion engine to thereby further improve more markedly the effect of preventing a drop in rotation speed of the internal combustion engine and also a steep rise in rotation speed attributable to the integration correction term in the subsequent control on the idling rotation speed.

[0039] The control range of the integration correction term between the upper-limit and lower-limit guard values is desirably set wider than that at the time of usual running while the prospective correction term exists essentially. By thus making the setting of the prospective correction term and the integration correction term control range correspond to each other, it is possible to more effectively compensate for the friction which exists at the early stage of the initiation of the internal combustion engine and more effectively prevent a steep rise in rotation speed attributable to the subsequent value of the integration correction term.

[0040] Desirably, the control range of the integration correction term between the upper-limit and lower-limit guard values is gradually narrowed down to a range at the time of usual running as working in collaboration with a decrease in value of the prospective correction term. By thus working the prospective correction term and the integration correction term control range in collaboration with each other, it is possible to more effectively compensate for the friction which exists at the early stage of the initiation of the internal combustion engine and also prevent a steep rise in rotation speed attributable to the subsequent value of the integration correction term.

[0041] The internal combustion engine is preferably a diesel engine. In this case, in the diesel engine, it is possible to compensate for the friction which exists at the early stage of initiation to thereby prevent a drop in rotation speed as well as a steep rise in rotation speed attributable to the integration correction term in the subsequent control on the idling rotation speed.

[0042] One embodiment of the present invention provides an apparatus for controlling the idling fuel supply amount. This control apparatus comprises first calculation means (integration correction term calculation means) for calculating an integration correction term based on a deviation of an actual rotation speed of an internal combustion engine with respect to a target rotation speed thereof at the time of idling of the internal combustion engine, setting means for setting a prospective correction term which corresponds to friction which exists at the early stage of initiation of the internal combustion engine at the time of and/or immediately after the initiation of the internal combustion engine, and second calculation means (fuel supply amount calculation means) for calculating the fuel supply amount by correcting a basic fuel amount using correction terms including the integration correction term calculated by the integration correction term calculation means and the prospective correction term set by the setting means.

[0043] The second calculation means calculates the fuel supply amount by correcting the basic fuel amount using correction terms including the integration correction term calculated by the first calculation means and the prospective correction term set by the setting means. Of these terms, the prospective correction term is set as a correction term which corresponds to friction which exists at the early stage of the initiation of the internal combustion engine at the time of and/or immediately after the initiation of the internal combustion engine. It is thus possible to bring an actual rotation speed of the internal combustion engine to a target rotation speed before the value of a deviation of the actual rotation speed with respect to the target rotation speed of the internal combustion engine is greatly accumulated in the integration correction term.

[0044] Therefore, the integration correction term can be prevented from increasing, thus narrowing down a control range of the integration correction term by utilizing the guard process. It is thus possible to compensate for friction which exists at the early stage of initiation of the internal combustion engine to thereby prevent a drop in rotation speed thereof and also to prevent a steep rise in rotation speed attributable to the integration correction term in the subsequent control of an idling rotation speed.

[0045] In a preferred apparatus for controlling an idling fuel supply amount, the setting means gradually reduces a value of the prospective correction term set at the time of and/or immediately after initiation of an internal combustion engine. The setting means can thus gradually reduce the value of the prospective correction term set at the time of and/or immediately after the initiation of the internal combustion engine to compensate for friction which exists at the early stage of the initiation of the internal combustion engine and then prevent a shock which occurs when the present prospective correction is stopped, thus smoothing the shifting over to the subsequent control on the idling rotation speed.

[0046] In another preferred apparatus for controlling the idling fuel supply amount, a period over which the value of the prospective correction term is held is provided prior to the gradual reduction of the prospective correction term. In this case, it is possible to effectively suppress an increase in value of the integration correction term at the time of or immediately after the initiation of the internal combustion engine even without extremely enlarging an initial value of the prospective correction term.

[0047] Furthermore, the setting means may execute a process to reduce the value of the prospective correction term gradually as time elapses after the internal combustion engine starts running or is initiated. The friction which exists at the early stage of the initiation of the internal combustion engine disappears gradually as the internal combustion engine continues running, so that the setting means can appropriately reduce the value of the prospective correction term based on the elapsing of time. It is, therefore, possible to prevent a shock which occurs when the setting means reduces the value of the prospective correction term, thus smoothing the shifting over to the subsequent control on the idling rotation speed.

[0048] The setting means may reduce the value of the prospective correction term gradually in accordance with an accumulated number of rotations of the internal combustion engine after it starts running or is initiated. In this case, the friction which exists at the early stage of the initiation of the internal combustion engine disappears gradually as the internal combustion runs, so that the setting means can appropriately reduce the value of the prospective correction term if based on the accumulated number of rotations of the internal combustion engine. It is thus possible to prevent a shock from occurring when the setting means reduces the value of the prospective correction term, thus smoothing the shifting over to the subsequent control on the idling rotation speed.

[0049] In the preferred idling fuel supply amount control apparatus, the setting means gradually reduces the prospective correction term in accordance with a rise in the temperature of the internal combustion engine. As the internal combustion engine continues running after being initiated, the temperature thereof rises gradually. Such a pattern of temperature rising is similar to a friction reduction pattern at the early stage of the initiation of the internal combustion engine, while a temperature factor is related to the magnitude of the friction which exists at the early stage of the initiation of the internal combustion engine. It is, therefore, possible to appropriately reduce the value of the prospective correction term based on a rise in temperature of the internal combustion engine. In such a manner, it is possible to prevent a shock from occurring when the value of the prospective correction term is reduced by the setting means, thus smoothing the shifting over to the subsequent control on the idling rotation speed.

[0050] The setting means can employ a temperature of cooling water of the internal combustion engine as the temperature thereof. It is, therefore, possible to appropriately reduce the value of the prospective correction term based on a rise in the temperature of the cooling water of the internal combustion engine. In such a manner, it is possible to prevent a shock from occurring when the value of the prospective correction term is reduced by the setting means, thus smoothing the shifting over to the subsequent control on the idling rotation speed.

[0051] In a preferable idling fuel supply amount controlling apparatus, when restarting an engine after the engine has stalled, the setting means sets the prospective correction terms to values at the time when the engine has stalled, and starts the reduction from the values. In a case where the engine has stalled, reduced friction which had been produced by rotation of an internal combustion engine up to immediately prior to its stall, is scarcely recovered in a start-up early stage of the engine. Therefore, when restarting the engine after having stalled, the setting means adopts the values of the prospective correction terms at the time of the engine stall, and the above-described reduction is started from the values. As a result, the setting means can set the prospective correction terms appropriately, and an idling engine speed control of the internal combustion engine can further be stabilized.

[0052] Since the magnitude of friction in a start-up early stage of an internal combustion engine is changed by shift positions of a transmission, the setting means may also be constituted such that the magnitude of the prospective correction terms are switched by the shift positions of the transmission. As a result, the setting means can set the prospective correction terms appropriately, and an idling engine speed control of the internal combustion engine can further be stabilized.

[0053] Since the magnitude of friction in a start-up early stage of an internal combustion engine is changed by the presence or absence of external loads such as an air conditioner or a power steering, the setting means may also be constituted in a manner to switch the magnitude of the prospective correction terms by the presence or absence of external loads. As a result, the setting means can set the prospective correction terms appropriately, and an idling engine speed control of the internal combustion engine can further be stabilized.

[0054] Since the magnitude of friction in a start-up early stage of an internal combustion engine is changed by the types of external loads such as an air conditioner or a power steering, the setting means may also be constituted such that the magnitude of the prospective correction terms are switched by the types of the external loads. As a result, the setting means can set the prospective correction terms appropriately, and an idling engine speed control of the internal combustion engine can further be stabilized.

[0055] The idling fuel supply amount control apparatus of the preferred embodiment comprises first calculation means for calculating an integration correction term based on a deviation of an actual rotation speed of an internal combustion engine with respect to a target rotation speed thereof at the time of idling of the internal combustion engine to thereby execute the guard process on the integration correction term using upper-limit and lower-limit guard values and also set a control range of the integration correction term between the upper-limit and lower-limit guard values at the time of and/or immediately after initiation of the internal combustion engine wider than the control range at the time of usual running and second calculation means for calculating a fuel supply amount by correcting a basic fuel amount using correction terms including the integration correction term calculated by the first calculation means.

[0056] Thus, the first calculation means sets the control range of the integration correction term at the time of and/or immediately after initiation of the internal combustion engine wider than the control range at the time of usual running. At least at the time of and/or immediately after the initiation of the internal combustion engine, therefore, the value of the deviation of the actual rotation speed with respect to the target rotation speed of the internal combustion engine is allowed to be accumulated in the integration correction term greatly. Only at the time of and/or immediately after the initiation of the internal combustion engine, therefore, the friction which exists at the early stage of the initiation of the internal combustion engine can be compensated for by the integration correction term calculated by the first calculation means, thus preventing a drop in rotation speed of the internal combustion engine.

[0057] Furthermore, when the idling rotation speed is controlled subsequently, the first calculation means can inhibit the value of the integration correction term from becoming excessive to recover a width of the integration correction term control range at the time of usual running, thus preventing a steep rise in rotation speed in the controlling of the idling rotation speed.

[0058] In the guard process, the first calculation means may gradually narrow down the control range of the integration correction term set at the time of and/or immediately after the initiation of the internal combustion engine to the control range at the time of usual running. Then, the first calculation means can sufficiently compensate for the friction which exists at the early stage of the initiation of the internal combustion engine using the integration correction term and then recover the integration correction term control range at the time of usual running, thus smoothing the shifting over to the subsequent control on the idling rotation speed.

[0059] The first calculation means may have a period over which the width of the control range of the integration correction term is held prior to gradual narrowing down of the integration correction term. Then, it is possible to give a time margin, at the time of or immediately after the initiation of the internal combustion engine, in which the integration correction term is allowed to rise in value sufficiently without widening the control range of the integration correction term extremely. It is thus possible to effectively compensate for the friction which exists at the early stage of the initiation of the internal combustion engine using the integration correction term.

[0060] The first calculation means may execute the process to gradually narrow down the control range of the integration correction term in accordance with the elapsed time after the internal combustion engine is initiated or its running is started. As the internal combustion engine continues running, the friction generated at the early stage of the initiation of the internal combustion engine disappears gradually, so that the value of the integration correction term is also reduced gradually. The first calculation means, therefore, can appropriately narrow down the integration correction term control range based on the elapsing of time. It is thus possible for the first calculation means to recover an integration correction term control range at the time of usual running, thus smoothing the shifting over to the subsequent control on the idling rotation speed.

[0061] The first calculation means may execute the process to gradually narrow down the control range of the integration correction term in accordance with an accumulated number of rotations of the internal combustion engine after it is initiated or its rotation is started. As the internal combustion engine continues running, the friction generated at the early stage of the initiation of the internal combustion engine disappears gradually, so that the value of the integration correction term is reduced gradually. The first calculation means, therefore, can appropriately narrow down the integration correction term control range based on the accumulated number of rotations of the internal combustion engine. It is thus possible for the first calculation means to recover the integration correction term control range at the time of usual running, thus smoothing the shifting over to the subsequent control on the idling rotation speed.

[0062] The first calculation means may gradually narrow down the control range of the integration correction term in accordance with a rise in the temperature of the internal combustion engine. As the internal combustion engine continues running after being initiated, its temperature rises gradually. Such a pattern of temperature rising is similar to a friction reduction pattern at the early stage of the initiation of the internal combustion engine, while a temperature factor is related to the magnitude of the friction which exists at the early stage of the initiation of the internal combustion engine. The first calculation means, therefore, can appropriately narrow down the control range of the integration correction term based on a rise in the temperature of the internal combustion engine. In such a manner, it is possible for the first calculation means to restore the integration correction term control range at the time of usual running, thus smoothing the shifting over to the subsequent control on the idling rotation speed.

[0063] The first calculation means can use the temperature of cooling water of the internal combustion engine as that of the internal combustion engine. The first calculation means, therefore, can appropriately narrow down the control range of the integration correction term based on the rise of the temperature of the cooling water of the internal combustion engine. It is thus possible for the first calculation means to recover the integration correction term control range at the time of usual running, thus smoothing the shifting over to the subsequent control on the idling rotation speed.

[0064] When the engine is restarted after being stalled, the first calculation means may set the control range to a value at the time of engine stalling for the integration correction term to then start a process to gradually narrow down the control range from that value. Upon engine stalling, the friction which had been generated at the early stage of the initiation and decreased by the rotation of the internal combustion engine up to the moment immediately before the engine stalling is scarcely recovered. To restart the engine after being stalled, therefore, the first calculation means uses the value of the integration correction term control range at the time of engine stalling described above so that reduction of the integration correction term control range may start from this value. In such a manner, it is possible for the first calculation means to set the prospective correction term appropriately, thus further stabilizing control on the idling rotation speed of the internal combustion engine.

[0065] The first calculation means may switch the integration correction term control range in accordance with a shifted position of the transmission. Since the magnitude of the friction which exists at the early stage of the initiation of the internal combustion engine changes with the shifted position of the transmission, the first calculation means is to switch the integration correction term control range in accordance with the shifted position of the transmission. In such a manner, it is possible for the first calculation means to set the integration correction term control range appropriately, thus further stabilizing control on the idling rotation speed of the internal combustion engine.

[0066] The first calculation means may switch the integration correction term control range in accordance with the presence/absence of external load. Since the magnitude of the friction which exists at the early stage of the initiation of the internal combustion engine changes with the presence/absence of external load, the first calculation means is to switch the integration correction term control range in accordance with the presence/absence of external load. In such a manner, it is possible for the first calculation means to set the integration correction term control range appropriately, thus further stabilizing control on the idling rotation speed of the internal combustion engine.

[0067] The first calculation means may also switch the integration correction term control range in accordance with the kind of external load. Since the magnitude of the friction which exists at the early stage of the initiation of the internal combustion engine changes with the kind of the external load such as an air conditioner or a power steering, the first calculation means is to switch the integration correction term control range in accordance with the kind of the external load. In such a manner, it is possible for the first calculation means to set the integration correction term control range appropriately, thus further stabilizing control on the idling rotation speed of the internal combustion engine.

[0068] The first calculation means may set the integration correction term control range using a learned value of the integration correction term as a reference. In this case, it is possible to appropriately guard the integration correction term, the value of which tends to change centering around the learned value. In such a manner, it is possible for the first calculation means to set the integration correction term control range appropriately, thus further stabilizing control on the idling rotation speed of the internal combustion engine.

[0069] A preferred idling fuel supply amount control apparatus may be provided with integration correction term learning means which calculates a learned value of the integration correction term when the integration correction term control range set by the first calculation means has returned to a range value at the time of usual running.

[0070] Since the value of the integration correction term fluctuates greatly in such a situation where the value of the integration correction term control range is set wider than that at the time of usual running, it is not appropriate for the integration correction term learning means to calculate a learned value of the integration correction term because it is liable to generate an error. Thus, the integration correction term learning means is to perform calculation of the learned value of the integration correction term when the integration correction term set by the first calculation means has returned to a control range value at the time of usual running. It is thus possible to suppress the erring of the learned value, thus further stabilizing control on the idling rotation speed.

[0071] The idling fuel supply amount control apparatus of another embodiment comprises setting means for setting a value of the prospective correction term which corresponds to friction which exists at the early stage of the initiation of the internal combustion engine at the time of and/or immediately after the initiation of the internal combustion engine and first calculation means for calculating a value of the integration correction term based on a deviation of an actual rotation speed of the internal combustion engine with respect to a target rotation speed thereof at the time of idling of the internal combustion engine to thereby execute the guard process on the integration correction term using upper-limit and lower-limit guard values and also set the control range of the integration correction term between the upper-limit and lower-limit guard values at the time of and/or immediately after initiation of the internal combustion engine wider than the control range at the time of usual running. It is thus possible to compensate for the friction which exists at the early stage of the initiation of the internal combustion engine to thereby further improve the effect of more effectively preventing a drop in rotation speed of the internal combustion engine and also a steep rise in rotation speed attributable to the integration correction term in the subsequent control on the idling rotation speed.

[0072] The first calculation means may set the control range of the integration correction term between the upper-limit and lower-limit guard values wider than that at the time of usual running while the prospective correction term exists essentially. In this case, the first calculation means makes an expansion in integration correction term control range correspond to a set condition of the prospective correction term. It is thus possible to more effectively compensate for the friction which exists at the early stage of the initiation of the internal combustion engine and more effectively prevent a steep rise in rotation speed attributable to the subsequent value of the integration correction term.

[0073] Preferably, the first calculation means gradually narrows down the control range of the integration correction term between the upper-limit and lower-limit guard values down to a range at the time of usual running as worked in collaboration with a decrease in value of the prospective correction term. In this case, the first calculation means works in collaboration with the prospective correction term and the integration correction term control range with each other. It is thus possible to more effectively compensate for the friction which exists at the early stage of the initiation of the internal combustion engine and also prevent a steep rise in rotation speed attributable to the subsequent value of the integration correction term.

[0074] Preferably, the idling fuel supply amount control apparatus is applied to a diesel engine. In this case, in the diesel engine, it is possible to compensate for the friction which exists at the early stage of initiation to thereby prevent a drop in rotation speed as well as a steep rise in rotation speed attributable to the integration correction term in the subsequent control on the idling rotation speed.

[0075] A method for controlling an idling fuel supply amount, wherein an integration correction term is calculated based on a deviation of an actual rotation speed of an internal combustion engine with respect to a target rotation speed of said internal combustion engine when said internal combustion engine is idling, and wherein said integration correction term is used to correct a fuel supply amount, thus controlling the idling rotation speed of said internal combustion engine, the method being characterized in that:

conducting prospective correction corresponding to friction which exists at an early initiation stage of said internal combustion engine on said fuel supply amount at an early stage of and/or immediately after initiation of said internal combustion engine.

[0076] The method for controlling an idling fuel supply amount, characterized in that said prospective correction is conducted by gradually reducing a prospective correction term set at the early stage of and/or immediately after the initiation of said internal combustion engine.

[0077] The method for controlling an idling fuel supply amount, characterized in that a period over which a value of said prospective correction term is held is provided prior to gradual reduction of said prospective correction term.

[0078] The method for controlling an idling fuel supply amount, characterized in that said prospective correction term is reduced gradually in accordance with the elapsed time after said internal combustion engine has started to run or been initiated.

[0079] The method for controlling an idling fuel supply amount, characterized in that said prospective correction term is reduced gradually in accordance with an accumulated number of rotations of said internal combustion engine after said internal combustion engine has started to run or been initiated.

[0080] The method for controlling an idling fuel supply amount, characterized in that said prospective correction term is reduced gradually in accordance with a rise in the temperature of said internal combustion engine.

[0081] The method for controlling an idling fuel supply amount, characterized in that the temperature of said internal combustion engine is a temperature of cooling water of said internal combustion engine.

[0082] The method for controlling an idling fuel supply amount, characterized in that at the time of restart after an engine stall, said prospective correction term is set at the value at the time of the engine stall to start said reduction from said value.

[0083] The method for controlling an idling fuel supply amount, characterized in that said prospective correction term is switched in accordance with a shifted position of a transmission.

[0084] The method for controlling an idling fuel supply amount, characterized in that said prospective correction term is switched in accordance with the presence/absence of external load.

[0085] The method for controlling an idling fuel supply amount, characterized in that said prospective correction term is switched in accordance with a kind of external load.

[0086] A method for controlling an idling fuel supply amount, wherien an integration correction term is calculated based on a deviation of an actual rotation speed of an internal combustion engine with respect to a target rotation speed of said internal combustion engine when said internal combustion engine is idling, wherein a guard process is executed on said integration correction term using an upper limit guard value and a lower limit guard value, and wherein a fuel supply amount is corrected using the integration correction term after said guard process is executed, thus controlling an idling rotation speed of said internal combustion engine, the method being characterized in that:

> setting a control range of the integration correction term between said upper limit guard value and said lower limit guard value wider than the control range at the time of usual running at an early stage of and/or immediately after initiation of said internal combustion engine.

[0087] The method for controlling an idling fuel supply amount, characterized in that, in said guard process, a control range of said integration correction term which is set at the time of and/or immediately after the initiation of the internal combustion engine is gradually narrowed down to the control range at the time of usual running.

[0088] The method for controlling an idling fuel supply amount, characterized in that a period over which a width of the integration correction term control range is held is provided prior to gradual narrowing down of said integration correction term control range.

[0089] The method for controlling an idling fuel supply amount, characterized in that said integration correction term control range is narrowed down gradually in accordance with the elapsed time after said internal combustion engine has started to run or been initiated.

[0090] The method for controlling an idling fuel supply amount, characterized in that said integration correction term control range is narrowed down gradually in accordance with an accumulated number of rotations of said internal combustion engine after said internal combustion engine has started to run or been initiated.

[0091] The method for controlling an idling fuel supply amount, characterized in that said integration correction term control range is narrowed down gradually in accordance with a rise in the temperature of said internal combustion engine.

[0092] The method for controlling an idling fuel supply amount, characterized in that the temperature of said internal combustion engine is a temperature of cooling water of said internal combustion engine.

[0093] The method for controlling an idling fuel supply amount, characterized in that at the time of restart after an engine stall, said integration correction term control range is set at a range at the time of the engine stall, so that said gradual narrowing down process starts from said range.

[0094] The method for controlling an idling fuel supply amount, characterized in that said integration correction term control range is switched in accordance with a shifted position of a transmission.

[0095] The method for controlling an idling fuel supply amount, characterized in that said integration correction term control range is switched in accordance with the presence/absence of external load.

[0096] The method for controlling an idling fuel supply amount, characterized in that said integration correction term control range is switched in accordance with a kind of external load.

[0097] The method for controlling an idling fuel supply amount, characterized in that said integration correction term control range is set using a learned value of said integration correction term as a reference position.

[0098] The method for controlling an idling fuel supply amount, characterized in that calculation of the learned value of said integration correction term is allowed when said integration correction term control range is returned to the range at the time of usual running.

[0099] A method for controlling an idling fuel supply amount, wherein an integration correction term is calculated based on a deviation of an actual rotation speed of an internal combustion engine with respect to a target rotation speed of said internal combustion engine when said internal combustion engine is idling, wherein a guard process is executed on said integration correction term using an upper limit guard value and a lower limit guard value, and wherein a fuel supply amount is corrected using the integration correction term after said guard process is executed, thus controlling an idling rotation speed of said internal combustion engine, the method being characterized in that:

> executing two processes at the time of and/or immediately after initiation of said internal combustion engine, wherein one of the two processes is a process for conducting, on a fuel supply amount, prospective correction which corresponds to friction which exists at an early initiation stage of said internal combustion engine, and

wherein the other one of the two processes is a process for setting the integration correction term control range between said upper limit guard value and said lower limit guard value wider than the control range at the time of usual running are both executed.

[0100] The method for controlling an idling fuel supply amount, characterized in that the integration correction term control range between said upper limit guard value and said lower limit guard value is set wider than the range at the time of usual running while said prospective correction term is present essentially.

[0101] The method for controlling an idling fuel supply amount, characterized in that said integration correction term control range between said upper limit guard value and said lower limit guard value is narrowed down gradually toward the range at the time of usual running as worked with reduction of said prospective correction term.

[0102] The method for controlling an idling fuel supply amount, characterized in that said internal combustion engine is configured as a diesel engine.

[0103] An idling fuel supply amount control apparatus, being characterized in that the apparatus controls the idling rotation speed of an internal combustion engine by comprising:

first calculation means for calculating an integration correction term based on a deviation of an actual rotation speed of an internal combustion engine with respect to a target rotation speed of said internal combustion engine at the time of idling of said internal combustion engine; setting means for setting a prospective correction term which corresponds to friction which exists at an early initiation stage of said internal combustion engine at the time of and/or immediately after the initiation of said internal combustion engine; and

second calculation means for calculating a fuel supply amount by correcting a basic fuel amount using correction terms including the integration correction term calculated by said first calculation means and the prospective correction term set by said setting means.

[0104] The idling fuel supply amount control apparatus, characterized in that said setting means gradually reduces the prospective correction term set at the time of and/or immediately after the initiation of said internal combustion engine.

[0105] The idling fuel supply amount control apparatus, characterized in that said setting means provides a period over which a value of the prospective correction term is held prior to gradual reduction of said prospective correction term.

[0106] The idling fuel supply amount control apparatus, characterized in that said setting means reduces said prospective correction term gradually in accordance with the elapsed time after said internal combustion engine starts running or is initiated.

[0107] The idling fuel supply amount control apparatus, characterized in that said setting means reduces said prospective correction term gradually in accordance with an accumulated number of rotations of said internal combustion engine after said internal combustion engine starts running or is initiated.

[0108] The idling fuel supply amount control apparatus, characterized in that said setting means reduces said prospective correction term gradually in accordance with a rise in temperature of said internal combustion engine.

[0109] The idling fuel supply amount control apparatus, characterized in that said setting means uses a temperature of cooling water of said internal combustion engine as the temperature of said internal combustion engine.

[0110] The idling fuel supply amount control apparatus, characterized in that, when said engine is restarted after an engine stall, said setting means sets said prospective correction term at a value of the engine stall to start said reduction starting from said value.

[0111] The idling fuel supply amount control apparatus, characterized in that said setting means switches said prospective correction term in accordance with a shifted position of a transmission.

[0112] The idling fuel supply amount control apparatus, characterized in that said setting means switches said prospective correction term in accordance with the presence/absence of external load.

[0113] The idling fuel supply amount control apparatus, characterized in that said setting means switches said prospective correction term in accordance with a kind of external load.

[0114] An idling fuel supply amount control apparatus, being characterized in that the apparatus controls the idling rotation speed of an internal combustion engine by comprising:

first calculation means for calculating an integration correction term based on a deviation of an actual rotation speed of said internal combustion engine with respect to a target rotation speed of said internal combustion engine at the time of idling of said internal combustion engine to execute a guard process on said integration correction term using an upper limit guard value and a lower limit guard value and also for setting a control range of the integration correction term between said upper limit guard value and said lower limit guard value wider than the control range at the time of usual running at the time of and/or immediately after initiation of said internal combustion engine; and

second calculation means for calculating a fuel supply amount by correcting a basic fuel amount using correction terms including the integration correction term calculated by said first calculation means.

[0115] The idling fuel supply amount control apparatus, characterized in that, in said guard process, said first calculation means gradually narrows down a control range of said integration correction term, which range is set at the time of and/or immediately after initiation of said internal combustion engine, to the range at the time of usual running.

[0116] The idling fuel supply amount control apparatus, characterized in that said first calculation means provides a period over which a width of said integration correction term control range is held prior to gradual narrowing down of said integration correction term.

[0117] The idling fuel supply amount control apparatus, characterized in that said first calculation means narrows down said integration correction term control range gradually in accordance with the elapsed time after said internal combustion engine starts running or is initiated.

[0118] The idling fuel supply amount control apparatus, characterized in that said first calculation means narrows down said integration correction term control range gradually in accordance with an accumulated number of rotations of said internal combustion engine after said internal combustion engine starts running or is initiated.

[0119] The idling fuel supply amount control apparatus, characterized in that said first calculation means narrows down said integration correction term control range gradually in accordance with a rise in the temperature of said internal combustion engine.

[0120] The idling fuel supply amount control apparatus, characterized in that said first calculation means uses the temperature of cooling water of said internal combustion engine as the temperature of said internal combustion engine.

[0121] The idling fuel supply amount control apparatus, characterized in that when engine is restarted after being stalled, said first calculation means sets said integration correction term control range to the range at the time of the engine stall to start gradually the narrowing-down process from said range.

[0122] The idling fuel supply amount control apparatus, characterized in that said first calculation means switches said integration correction term control range in accordance with a shifted position of a transmission.

[0123] The idling fuel supply amount control apparatus, characterized in that said first calculation means switches said integration correction term control range in accordance with the presence/absence of external load.

[0124] The idling fuel supply amount control apparatus, characterized in that said first calculation means switches said integration correction term control range in accordance with a kind of external load.

[0125] The idling fuel supply amount control apparatus, characterized in that said first calculation means sets said integration correction term control range using a learned value of said integration correction term as a reference.

[0126] The idling fuel supply amount control apparatus, characterized by integration correction term learning means for executing the calculation of a learned value of said integration correction term when said integration correction term control range set by said first calculation means is returned to the range at the time of usual running.

[0127] An idling fuel supply amount control apparatus, being characterized in that the apparatus controls the idling rotation speed of an internal combustion engine by comprising:

first calculation means for calculating an integration correction term based on a deviation of an actual rotation speed of said internal combustion engine with respect to a target rotation speed of said internal combustion engine at the time of idling of said internal combustion engine to execute a guard process on said integration correction term using an upper limit guard value and a lower limit guard value and also for setting a control range of the integration correction term between said upper limit guard value and said lower limit guard value wider than the control range at the time of usual running at the time of and/or immediately after initiation of said internal combustion engine;

setting means for setting the prospective correction term which corresponds to friction which exists at an early initiation stage of said internal combustion engine at the time of and/or immediately after the initiation of said internal combustion engine; and

second calculation means for calculating a fuel supply amount by correcting a basic fuel amount using correction terms including the integration correction term calculated by said first calculation means and the prospective correction term set in said setting means.

[0128] The idling fuel supply amount control apparatus, characterized in that said integration correction term control range between said upper limit guard value and said lower limit guard value is set wider than the range at the time of usual running while said prospective correction term is present essentially.

[0129] The idling fuel supply amount control apparatus, characterized in that said first calculation means gradually narrows down the integration correction term control range between said upper limit guard value and said lower limit guard value toward the range at the time of usual running as worked in collaboration with reduction of said prospective correction term by said setting means.

[0130] The idling fuel supply amount control apparatus, characterized in that said internal combustion engine is configured as a diesel engine.

[0131] The method for controlling an idling fuel supply amount, characterized in that, in addition to prospective correction corresponding to the friction generated at the early initiation stage of said internal combustion engine, cold correction is conducted on the fuel supply amount for reflecting a degree of an influence of the friction owing to a temperature of said internal combustion engine on fuel injection amount.

[0132] The method for controlling an idling fuel supply amount, characterized in that, in addition to prospective correction corresponding to the friction generated at the early initiation stage of said internal combustion engine, electric load correction is conducted on a fuel injection amount for reflecting a degree of power amount used in a vehicle on the fuel injection amount.

[0133] The method for controlling an idling fuel supply amount, characterized in that, in addition to prospective correction corresponding to the friction generated at the early initiation stage of said internal combustion engine, correction is conducted on a fuel injection amount for reflecting load of an air conditioner of a vehicle on the fuel injection amount.

[0134] The method for controlling an idling fuel supply amount, characterized in that, in addition to prospective correction corresponding to the friction generated at the early initiation stage of said internal combustion engine, correction is conducted on a fuel injection amount for reflecting load of a power steering of a vehicle on the fuel injection amount.

[0135] The method for controlling an idling fuel supply amount, characterized in that said setting means sets a cold correction term to reflect a degree of an influence of friction owing to a temperature of said internal combustion engine on a fuel injection amount and adds said cold correction term to said prospective correction term.

[0136] The method for controlling an idling fuel supply amount, characterized in that said setting means sets an electric load correction term to reflect a degree of power amount used in a vehicle on a fuel injection amount and adds said electric load correction term to said prospective correction term.

[0137] The method for controlling an idling fuel supply amount, characterized in that said setting means sets a correction term to reflect load of an air conditioner of a vehicle on a fuel injection amount and adds said correction term to said prospective correction term.

[0138] The method for controlling an idling fuel supply amount, characterized in that said setting means sets a correction term to reflect load of a power steering of a vehicle on a fuel injection amount and adds said correction term to said prospective correction term.

BRIEF DESCRIPTION OF THE DRAWINGS

[0139]

Fig. 1 is a schematic configuration diagram for showing a pressure-accumulation type diesel engine and a control system thereof according to a first embodiment;

Fig. 2 is a flowchart of control process of fuel injection amount executed by an ECU according to the first embodiment;

Fig. 3 is a map configuration diagram used to calculate governor injection amounts tQGOV1 and tQGOV2 based on an engine rotation speed NE and an acceleration pedal depression degree ACCP used in a control process of the fuel injection amount;

Fig. 4 is a flowchart of ISC control process executed by the ECU according to the first embodiment;

Fig. 5 is a flowchart of a calculation process of a learned integration correction term value QIXM according to the first embodiment;

Fig. 6 is a flowchart of a guard process of an integration correction term QII according to the first embodiment;

Fig. 7 is a flowchart of a calculation process of an ISC prospective correction term according to the first embodiment;

Fig. 8 is a map configuration diagram used in a calculation process of an early initiation-stage prospective correction term QIPAS and that of the ISC prospective correction term;

Fig. 9 is a map configuration diagram used in a calculation process of the ISC prospective correction term;

Fig. 10 is a flowchart of a calculation process of the early initiation-stage prospective term QIPAS executed by the ECU according to the first embodiment;

Fig. 11 is a flowchart of a post-initiation counting process of a timer counter Ts according to the first embodiment;

Fig. 12 is a timing chart for showing one example of the process according to the first embodiment;

Fig. 13 is a timing chart for showing another example of the process according to the first embodiment;

Fig. 14 is a flowchart of a guard value setting process executed by the ECU according to a second embodiment;

Fig. 15 is a flowchart of a calculation process of a learned integration correction term value according to the second embodiment;

Fig. 16 is a timing chart for showing one example of the process according to the second embodiment; and

Fig. 17 is a timing chart for showing another example of the process according to the second embodiment.

BEST MODE FOR CARRYING OUT THE INVENTION

First Embodiment

[0140] Fig. 1 is a schematic configuration diagram for showing a pressure-accumulation type diesel engine (common-rail type diesel engine) 1 and a control system thereof according to a first embodiment. The present diesel engine 1 is an internal combustion engine mounted on a vehicle to drive it.

[0141] The diesel engine 1 is provided with a plurality of cylinders #1, #2, #3, and #4 (four cylinders are used in this embodiment, but only one cylinder is shown), a combustion chamber of each of cylinders #1 to #4 is provided with an injector 2. The timing for and the amount of injecting a fuel to each of cylinders #1 to #4 of the diesel engine 1 from the injector 2 are controlled by turning ON/OFF an electromagnetic valve 3 for controlling of the injection.

[0142] The injector 2 is connected to a common rail 4, which serves as a pressure accumulation tube common to all the cylinders in such a configuration that when the injection controlling electromagnetic valve 3 is opened, the fuel in the common rail 4 is injected into the combustion chambers of cylinders #1 to #4 from the injector 2. The common rail 4 accumulates therein a relatively high pressure which corresponds to a fuel injection pressure. To achieve this accumulation pressure, the common rail 4 is connected via a supply piping 5 to a discharge port 6a of a supply pump 6. Furthermore, a check valve 7 is provided in the supply piping 5. The existence of the check valve 7 permits the fuel to be supplied from the supply pump 6 to the common rail 4 and regulates it from counter-flowing from the common rail 4 to the supply pump 6.

[0143] The supply pump 6 is connected via a suction port 6b to a fuel tank 8, and a filter 9 is provided between the suction port 6b and the fuel tank 8. The supply pump 6 intakes the fuel from the fuel tank 8 through the filter 9. Furthermore, at the same time, the supply pump 6 causes a plunger to reciprocate using a cam, not shown, synchronized with the rotation of the diesel engine 1 to thereby increase the fuel pressure to a desired level, thus supplying the high-pressure fuel to the common rail 4.

[0144] Furthermore, near the discharge port 6a of the supply pump 6, a pressure control valve 10 is provided. The pressure control valve 10 is provided to control the pressure (that is, injection pressure) of the fuel discharged toward the common rail 4 from the discharge port 6a. When the pressure control valve 10 is opened, a surplus fuel not discharged from the discharge port 6a is returned through a return port 6c provided in the supply pump 6 via a return piping 11 into the fuel tank 8.

[0145] To the combustion chamber of the diesel engine 1, an intake passage 13 and an exhaust passage 14 are both connected. The combustion chamber of the diesel engine 1 has a glow plug 18 arranged therein. The glow plug 18 turns red hot when a current flows through a glow relay 18a immediately before the initiation of the diesel engine 1, to which glow plug 18 is then applied part of injected fuel, thus promoting ignition and combustion of the fuel in the present initiation assisting apparatus.

[0146] The diesel engine 1 is provided with the following various kinds of sensors etc. to detect the running state of the diesel engine 1 in the first embodiment. That is, near an accelerator pedal 19, an acceleration sensor 20 is provided to detect an acceleration pedal depression degree ACCP. Furthermore, the intake passage 13 is provided with an intake air amount sensor 22 to detect a sucked air amount GN of an air flowing through the intake passage 13. A cylinder block of the diesel engine 1 is provided with a water temperature sensor 24 to detect the temperature (cooling water temperature THW) of engine cooling water.

[0147] Furthermore, the return piping 11 is provided with the fuel temperature sensor 26 to detect the temperature of a fuel. Furthermore, the common rail 4 is provided with a fuel pressure sensor 27 to detect a pressure (injection pressure PC) of fuel in the common rail 4.

[0148] In the first embodiment, an NE sensor (engine rotation speed sensor) 28 is provided near a pulser (not shown) provided on a crank shaft (not shown) of the diesel engine 1. Furthermore, the rotation of the crank shaft is transmitted through a timing belt etc. over to a cam shaft (not shown), which acts to open/close an intake valve 31 and an exhaust valve 32. The cam shaft is designed to rotate at half the rotation speed of the crank shaft. Near a pulser (not shown) provided on the cam shaft, a G sensor (acceleration sensor) 29 is provided. In the configuration of the first embodiment, respective pulse signals output from these sensors 28 and 29 are used to calculate the engine rotation speed NE, the crank angle CA, and the top dead center (TDC) of each of cylinders #1-#4.

[0149] Furthermore, an output shaft of a transmission, not shown, is provided with a vehicle speed sensor 30 to detect the vehicle speed SPD based on a rotation speed of the output shaft.

[0150] Furthermore, there are provided an air conditioner switch 34 to turn ON/OFF an air conditioner which is driven in rotary by the output power of the diesel engine 1, a power steering switch 36 to indicate whether a power steering which is driven utilizing an operating oil pressure transmitted from a hydraulic pump which is driven in rotary by the output power of the diesel engine 1, a generated alternator power amount control circuit 38 provided to an alternator to regulate generated power of the alternator, a neutral switch 40 to indicate that a range position of an automatic transmission is neutral, an idling upgrading switch 42 to be turned ON/OFF when manually switching from an ordinary idling state to an upgraded idling state or vice versa, a starter switch 43 to detect the operating state of a starter, etc.

[0151] In the first embodiment, there is provided an electronic control unit (ECU) 44 to conduct various kinds of control on the diesel engine 1, which ECU 44 executes a process to control the diesel engine 1 such as control over fuel injection amount. The ECU 44 is provided with the central processing unit (CPU), a read only memory (ROM) which stores various kinds of programs or later-described maps and data, a random access memory (RAM) which temporarily stores an operation result by the CPU, a back-up RAM which backs up the operation result and the data stored beforehand, and a timer counter as well as an input interface and an output interface. These members are all connected with each other through a bus.

[0152] The above-mentioned acceleration sensor 20, the intake air amount sensor 22, the water temperature sensor 24, the fuel temperature sensor 26, the fuel pressure sensor 27, and the generated alternator power control circuit 38 are connected to the input interface via a buffer, a multiplexer and an A/D converter respectively (neither shown). Furthermore, the NE sensor 28, the G sensor 29, and the vehicle speed sensor 30 are connected to the input interface through a waveform shaping circuit (not shown). Furthermore, the air conditioner switch 34, the power steering switch 36, the neutral switch 40, the idling upgrading switch 42, and the starter switch 43 are directly connected to the input interface. The CPU receives signals from the above-mentioned sensors through the input interface.

[0153] Furthermore, the electromagnetic valve 3, the pressure control valve 10 and the glow relay 18a are connected to the output interface via their respective drive circuits (not shown). The CPU conducts control and performs operations based on a value received through the interface to thereby control the electromagnetic valve 3, the pressure control valve 10, and the glow relay 18a appropriately through the output interface.

[0154] The following will describe the fuel injection amount control process executed by the ECU 44 based on the flowchart of Fig. 2. The present routine is executed by interruption for each injection process, that is, for each crank angle of 180 degrees because the diesel engine 1 is of a four-cylinder type. It is to be noted that each process content and the corresponding step are represented by "S---".

[0155] When the control process of the fuel injection amount starts, first the process reads the running state of the diesel engine 1, that is, in this case, the engine rotation speed NE obtained from a signal sent from the NE sensor 28, the acceleration pedal depression degree ACCP obtained from a signal sent from the acceleration sensor 20, the integration correction term QII, ISC prospective load correction term QIPB, and ISC prospective rotation speed correction term QIPNT calculated by the later-described ISC (idling rotation speed control) process, into a work area provided in the RAM of the ECU 44 (S110).

[0156] Next, the idling governor injection amount tQGOV1 and the traveling governor injection amount tQGOV2 is calculated from a map of Fig. 3, where their relationships with respect to the engine rotation speed NE and the acceleration pedal depression degree ACCP are set (S120). It is to be noted that as can be seen from Fig. 3, the idling governor injection amount tQGOV1, which is given in a broken line in Fig. 3, indicates an injection amount in a low rotation speed range of engine, that is when an automobile is mainly in the idling rotation state. The traveling governor injection amount tQGOV2, which is given in a solid line in Fig. 3, indicates an injection amount in a high rotation speed range of engine, that is, when the automobile is mainly in the traveling state.

[0157] Next, a sum of the idling governor injection amount tQGOV1, the integration correction term QII, the ISC prospective load correction term QIPB, and the prospective rotation speed correction term QIPNT is compared with a sum of the traveling governor injection amount tQGOV2 and the ISC prospective load correction term QIPB to select the larger of the two as a governor injection amount QGOV (S130). As can be seen from Fig. 3, therefore, in the low rotation speed range of the engine 1, that is, when the engine 1 is mainly in the idling rotation state, the sum of the idling governor injection amount tQGOV1, the integration correction amount QII, the ISC prospective load correction term QIPB, and the ISC prospective rotation speed correction term QIPNT tends to be selected as the governor injection amount QGOV. On the other hand, in the high rotation speed range of the engine 1, that is, when the automobile is mainly traveling, the sum of the traveling governor injection amount tQGOV2 and the ISC prospective load correction term QIPB tends to be selected as the above-mentioned governor injection amount QGOV.

[0158] Next, a maximum injection amount QFULL (S140) is calculated. It is to be noted that the maximum injection amount QFULL refers to an upper limit of a fuel amount that is to be supplied to the combustion chamber and provides a limit value to inhibit a rapid increase in the amount of smoke discharged from the combustion chamber, excessive torque, etc.

[0159] Next, of the maximum injection amount QFULL and the governor injection amount QGOV, the smaller is selected as final injection amount QFIN (S150). Then, an injection amount instructing value (value in terms of time) TSP that corresponds to the final injection amount QFIN (S160) is calculated and the injection amount instructing value is output (S170), thus ending the present routine temporarily. When the injection amount instructing value TSP is thus output, the driving of the electromagnetic valve 3 of the injector 2 is controlled, thus injecting the fuel.

[0160] Fig. 4 indicates a flowchart of ISC (idling rotation speed control) routine. This routine is executed by interruption for each injection process when the engine is idling.

[0161] When the present routine starts, the acceleration pedal depression degree ACCP obtained from the signal of the acceleration sensor 20, the cooling water temperature THW obtained from the signal of the water temperature sensor 24, the engine rotation speed NE obtained from the signal of the NE sensor 28, the vehicle speed SPD obtained from the signal of the vehicle speed sensor 30, the ON/OFF state obtained from the power steering switch 36, an alternator control duty DU obtained from the generated alternator power amount control circuit 38, etc. into the work area provided in the RAM of the ECU44 (S210).

[0162] Then, whether the engine is idling currently is decided (S220). If, for example, such conditions are all satisfied that the acceleration pedal depression degree ACCP is not more than a predetermined opening degree of a mostly full-closed state and the vehicle speed SPD = 0 km/h, whether the engine is in the idling state is decided.

[0163] If the non-idling state is detected ("NO" in

S220), the present routine is terminated temporarily. If the idling state is detected ("YES" in S220), then an appropriate target idling rotation speed NETRG that corresponds to the ON/OFF state of the air conditioner, the ON/OFF state of the power steering, electric load appearing in the alternator control duty DU, and the cooling water temperature THW is set (S230). This setting is made on the basis of the map and data stored in the ROM of the ECU44. Specifically, if the air conditioner and the power steering is in the ON state, the electric load is high, and the cooling water temperature THW is low, the setting is made so that the target idling rotation speed NETRG is at a higher value.

[0164] Next, the deviation NEDL of the actual engine rotation speed NE with respect to the target idling rotation speed NETRG is calculated by the following equation 1 (S240):

NEDL QIXM(i-1)

where QIXM(i-1) refers to a learned integration correction term value QIXM obtained in the previous control period for each of the setting conditions at the time of idling such as the presence/absence or the kind of external load including the air conditioner or the ON/OFF state of the idling upgrading switch 42. It is to be noted that the above-mentioned Equation 3 is not to hold true if the idling state in the current control period is different from that in the previous control period owing to switch-over in external load, etc.

[0165] If both Equations 2 and 3 hold true ("YES" in S271), the learned integration correction term value QIXM (i) in the current control period is calculated by the following equation 4 (S272). QIXM(i) <- QIXM(i-1) + IQIIMDL where the increased and updated value IQIIMDL provides a constant for gradually increasing the learned integration correction term value QIXM(i-1) of the previous control period.

[0166] If at least one of the Equations 2 and 3 does not hold true ("NO" in S271), whether the decreasing/updating conditions of the learned integration correction term value QIXM are satisfied is determined (S273). The decreasing/updating conditions are to be satisfied when the following equations 5 and 6 hold true.

"[Eq. 5]" NE $\geq$ NETRG

"[Eq. 6]" QII(i) < QIXM(i-1)

[0167] It is to be noted that the Equation 6 is not to hold true if the idling state in the previous control period of the idling state is different from that in the current control period of the idling state owing to switch-over of the external load, etc.

[0168] If both Equations 5 and 6 hold true ("YES" in S273), the learned integration correction term value QIXM(i) in the current control period is calculated by the following

equation 7 (S274): QIXM(i) QIXM(i) + QIIGMX

The equation 8 indicates that the integration correction term QII(i) calculated as previously described is above the upper limit of the control range of the integration correction term. If equation 8 is satisfied ("YES" in S291), the upper limit of the integration correction term control range is set in the integration correction term QII(i) as indicated by the following equation 9 (S292).

QII(i) <- QIXM(i) + QIIGMX

[0169] Then, the guard process (Fig. 6) of the present integration correction term QII is exited.

[0170] If the equation 8 is not satisfied ("NO" in S291), on the other hand, whether the integration correction term QII(i) in the current period satisfies a relationship of the following equation 10 is determined (S293)

"[Eq. 10]" QII(i) < QIXM(i) - QIIGMN

[0171] The equation 10 indicates that the integration correction term QII(i) calculated as previously described is below the lower limit of the integration correction term control range. If the equation 10 is satisfied ("YES" in S293), the lower limit value of the integration correction term control range is set for the integration correction term QII(i) in this period as indicated by the following equation 11 (S294). QII(i) CQIPOF ("YES" in S620), the early initiation-stage prospective correction term QIPAS is calculated by the following equation 12 (S640).

QIPAS <-

QIPASB - (Ts - CQIPOF) x QIPASDL

[0172] In this equation, the decrease width QIPASDL gives the value of a rate at which the early initiation-stage prospective correction term QIPAS is decreased as time elapses in the autonomous running condition.

[0173] Next, whether the early initiation-stage prospective correction term QIPAS is set negative is determined (S650). If QIPAS $\geq$ 0 ("NO" in S650), then the early initiation-stage prospective correction term QIPAS calculation process is exited temporarily.

[0174] If QIPAS < 0 ("YES" in S650), on the other hand, "0" is set as the early initiation-stage prospective correction term QIPAS (S650) and the early initiation-stage prospective correction term QIPAS calculation process is exited temporarily. Hereinafter, as far as the power of the ECU44 is ON, the early initiation-stage prospective correction term QIPAS is kept at 0 (zero).

[0175] That is, after the engine 1 is initiated, the early initiation-stage prospective correction term QIPAS stays in a constant state for a while, and then gradually decreases by repeating the process in step 640 to disappear substantially in the end.

[0176] The following will describe the counting process of the timer counter Ts. A flowchart of the counting process of the timer counter Ts is shown in Fig. 11. This counting process of the timer counter Ts is executed repeatedly not only at the time of idling but also every predetermined short period of time by interruption.

[0177] When the present routine is started, first whether it is the first process after power of the ECU44 is turned on (S710). If it is the first process ("YES" in S710), the timer counter Ts is cleared to "0" (S720). Otherwise ("NO" in S710), the value of the timer counter Ts is kept at the current value.

[0178] In the case where it is after step S720 or decided to be "NO" in step S710, whether the engine 1 is running autonomously is determined (S730).

[0179] If it is not running autonomously ("NO" in step S730), that is, the engine 1 is stopped or, even if it has run once, the starter switch 43 is in the ON state or it is stalled, then the present routine is terminated temporarily.

[0180] If the engine 1 is running autonomously ("YES" in step S730), the timer counter Ts performs counting as indicated by the following equation 13 (S740). Ts TMX ("YES" in S750), the upper limit value at the timer counter Ts is set (S760). Then, the present routine is terminated temporarily.

[0181] Therefore, when the engine 1 is running autonomously, the timer counter Ts performs counting and, if the upper limit value TMX is reached, the value is held constant at the value of TMX. Furthermore, if the engine 1 in the autonomous running state is stopped temporarily owing to engine stalling etc. ("NO" in S730), the value of the timer counter Ts is kept at a value at the time of engine stalling. If it is restarted and starts autonomous running, the timer counter Ts starts performing counting from the value kept upon engine stalling.

[0182] An example of process according to the first embodiment is shown in the timing chart of Fig. 12.

[0183] The starter operates at time t1 to cause the engine 1 to start running. Then, the engine 1 is initiated to turn OFF the starter (time t2). Then, the engine 1 starts running autonomously (time t2 or later). At the time t2 the timer counter Ts starts performing counting. Until the value of the timer counter Ts exceeds the early initiation-stage prospective correction term holding time CQIPOF, however, the early initiation-stage prospective correction term QIPAS is held at a value of QIPASB already set upon initiation.

[0184] Then, when the value of the timer counter Ts exceeds the early initiation-stage prospective correction term holding time CQIPOF (time t3), the early initiation-stage prospective correction term QIPAS gradually reduces in value and, finally, to "0" to thereby disappears substantially (time t4).

[0185] In such a manner, the load owing to the heavy friction that occurs at the early stage of the initiation of the engine 1 is compensated for by the early initiation-stage prospective correction term QIPAS, so that the integration correction term QII will not increase greatly as indicated by a solid line. If the early initiation-stage prospective correction term QIPAS is not provided, the integration correction term QII changes greatly as indicated by a dash and dotted line. This makes it impossible to set the upper limit guard value QIIGMX at a low level as in the case of the present embodiment.

[0186] Fig. 13 shows a timing chart in the case where the engine is stalled after being initiated. The starter is turned ON at time t11 and switched from the ON state to the OFF state at time t12. Accordingly, as in the case of Fig. 12 described above, the timer counter Ts starts to perform counting (time t12 or later), when the holding time CQIPOF of the early initiation-stage prospective correction term has elapsed, the early initiation-stage prospective correction term QIPAS starts decreasing in value (time t13 or later).

[0187] If the engine is stalled at time t14, however, the timer counter Ts stops counting, accompanying which the early initiation-stage prospective correction term QIPAS stops decrementing in value (time t14 or later). At the same time, the timer counter Ts and the early initiation-stage prospective correction term QIPAS are held at their respective current values.

[0188] Then, when the engine 1 starts running autonomously owing to the subsequent switch-over from the ON state to the OFF state of the starter (time t15 to time t16), the timer counter Ts starts performing counting again from the value held at the time of engine stalling, accompanying which the early initiation-stage prospective correction term QIPAS also starts decreasing in value from the value held at the time of engine stalling (time t16 or later).

[0189] In the above-mentioned first embodiment, steps S240 to S260 of the ISC process (Fig. 4) correspond to the process as the integration correction term calculation means, the calculation process (Fig. 10) of the early initiation-stage prospective correction term QIPAS and the counting process (Fig. 11) of the timer counter Ts correspond to the process as the early initiation-stage prospective correction term setting means, and steps S120 and S130 of the fuel injection amount control process (Fig. 2) correspond to the process as the fuel supply amount calculation means.

[0190] The above-mentioned first embodiment gives the following effects.

(1) In the first embodiment, as mentioned above, in particular, the early initiation-stage prospective correction term QIPAS is provided to conduct such prospective correction on fuel injection amount as to

correspond to friction that exists at the early stage of the initiation of the engine 1. Accordingly, it is possible to bring the engine rotation speed NE near a target idling rotation speed NETRG before a deviation of an actual engine rotation speed NE with respect to the target idling rotation speed NETRG is greatly accumulated in the integration correction term QII.

In such a manner, the integration correction term QII can be inhibited from becoming large in value, thus narrowing down the integration correction term control range by use of the guard process. According to the first embodiment, in particular, the upper limit guard value QIIGMX can be reduced.

Accordingly, it is possible to compensate for friction which exists at the early stage of the initiation of the engine to thereby prevent a drop in engine rotation speed NE and also effectively prevent the integration correction term QII from becoming excessive in value owing to a semi-clutched condition. It is thus possible to prevent a steep rise in engine rotation speed in control of the idling rotation speed.

(2) The early initiation-stage prospective correction term QIPAS is set at the time of initiation, kept constant for some lapse of time, and then decreased gradually. It is decreased with lapse of time, according to the first embodiment.

As the engine continues running, the friction which exists at the early stage of the initiation of the engine disappears gradually. By reducing the early initiation-stage prospective correction term QIPAS based on the elapsing of time, therefore, essential correction by use of the early initiation-stage prospective correction term QIPAS can be stopped without a shock, thus smoothing the shifting over to the subsequent control on the idling rotation speed.

Furthermore, until the holding time CQIPOF of the early initiation-stage prospective correction term elapses, the value of the early initiation-stage prospective correction term QIPAS remains unchanged, so that the integration correction term QII can be effectively inhibited from becoming large in value immediately after the engine 1 is initiated even without setting an extremely large initial value of the early initiation-stage prospective correction term QIPAS.

(3) If the engine is stalled, the friction which had been generated at the early stage of the initiation and decreased by the rotation of the engine 1 up to the moment immediately before the engine stalling is scarcely recovered. To restart the engine after being stalled, therefore, the early initiation-stage prospective correction term QIPAS is set at the value at the moment of engine installing so that the process may start from this value. In such a manner, it is possible to set the early initiation-stage prospective correction term QIPAS appropriately, thus further stabilizing control on the idling rotation speed.

(4) The magnitude of the friction which exists at the early stage of the initiation of the engine changes with a shifted position of the transmission and the temperature of the engine. Therefore, the reference value QIPASB, which is an initial value of the early initiation-stage prospective correction term QIPAS, is switched in accordance with the shifted position of the transmission and the temperature of the cooling water THW. In such a manner, it is possible to set the early initiation-stage prospective correction term QIPAS appropriately, thus further stabilizing control on the idling rotation speed of the internal combustion engine.

(5) In the guard process (Fig. 6) of the integration correction term QII, the integration correction term control range is set using the upper limit guard value QIIGMX and the lower limit guard value QIIGMN with respect to the learned integration correction term value QIXM as a reference. Thus, this makes it possible to appropriately guard the integration correction term QII, which tends to fluctuate centering around the learned integration correction term value QIXM. In such a manner, it is possible to set the integration correction term control range appropriately, thus further stabilizing control on the idling rotation speed.

Second Embodiment

[0191] Different from the above-mentioned first embodiment, in the second embodiment, no calculation is conducted for the early initiation-stage prospective correction term QIPAS shown in Fig. 10. Therefore, in step 510 of the ISC prospective correction term calculation process (Fig. 7), the process sums up the cold correction term QIPBCL, the electric load correction term QIPBDF, the air conditioner correction term QIPBAC, and the power steering correction term QIPBPS to give the load correction term QIPB.

[0192] Furthermore, step S280 of the ISC process (Fig. 4) is not executed and, instead, the guard value setting process as shown in Fig. 14 is independently executed. Furthermore, the present embodiment differs from the above-mentioned first embodiment in that it executes the calculation process of the learned integration correction term value QIXM shown in Fig. 15 in place of the calculation process (Fig. 5) of the learned integration correction term value QIXM. The other components are the same as those of the above-mentioned first embodiment unless otherwise described.

[0193] The guard value setting process (Fig. 14) is described as follows. The present routine is repeatedly executed for each constant short period of time.

[0194] First, whether the value of the timer counter Ts has passed over the early initiation-stage guard holding time CQIGOF (S810) is determined. As this early initiation-stage guard holding time CQIGOF, a value which corresponds to, for example, 1 to 10 seconds or so is set.

[0195] If Ts ≤ CQIGOF ("NO" in S810), then an initial upper limit guard value QIIGMXS is set as the upper limit guard value QIIGMX (S820). The initial upper limit guard value QIIGMXS is set beforehand at such a value that the integration correction term QII can accommodate such friction as to exist at the early stage of the initiation of the engine.

[0196] Next, as the lower limit guard value QIIGMN, an initial lower limit guard value QIIGMNS is set (S830). The initial lower limit guard value QIIGMNS is set beforehand at such a value that the engine may not be stalled by an excessive reduction in value of the integration correction term QII owing to some reason at the initial stage of the initiation of the engine.

[0197] Then, the present routine is terminated temporarily. As long as Ts ≤ CQIGOF ("NO" in S810), therefore, a relationship of the upper limit guard value QIIGMX = QIIGMXS is held (S820), while at the same time a relationship of the lower limit guard value QIIGMN = QIIGMNS is held (S830).

[0198] When the timer counter Ts continues to perform counting to provide a relationship of Ts > CQIGOF ("YES" in S810), the upper limit guard value QIIGMX is calculated by the following equation 14 (S840).

QIIGMX <- QIIGMXS - (Ts - CQIGOF) x QIGMXDL

[0199] In this equation, the decrease width QIGMXDL gives a set value of a rate at which the upper limit guard value QIIGMX is decreased in accordance with the autonomous running condition.

[0200] Next, whether the thus calculated upper limit guard value QIIGMX is smaller than an ordinary-time upper limit guard value QIIGMXB is determined (S850). If QIIGMX < QIIGMXB ("YES" in S850), a value of the ordinary-time upper limit guard value QIIGMXB is set as the upper limit guard value QIIGMX (S860). If QIIGMX ≥ QIIGMXB ("NO" in S850), on the other hand, the value calculated in step S840 is held as the value of the upper limit guard value QIIGMX.

[0201] When having passed through step S860 or decided "NO" in step S850, the lower limit guard value QIIGMN is calculated by the following equation 15 (S870).

QIIGMN <- QIIGMNS - (Ts - CQIGOF) x QIGMNDL

[0202] In this equation, the decrease width QIGMNDL gives a set value of a rate at which the lower limit guard value QIIGMN is decreased in accordance with the autonomous running time.

[0203] Next, whether the thus calculated lower limit guard value QIIGMN is smaller than an ordinary-time lower limit guard value QIIGMNB is determined (S880). If QIIGMN < QIIGMNB ("YES" in S880), a value of the ordinary-time lower limit guard value QIIGMNB as the lower limit guard value QIIGMN is set (S890). If QIIGMN ≥ QIIGMNB ("NO" in S880), on the other hand, a value calculated in step S870 is held as the value of the lower limit guard value QIIGMN.

[0204] When having passed through step S890 or decided "NO" in step S880, the present routine is terminated temporarily.

[0205] The following will describe the calculation process (Fig. 15) of the learned integration correction term value QIXM. It is to be noted that in the present embodiment, the process of steps S911 through S915 is the same as that of steps S271 through S275 of the calculation process (Fig. 5) of the learned integration correction term value QIXM in the above-mentioned first embodiment.

[0206] Upon start of the present routine, first whether the upper limit guard value QIIGMX has reached the ordinary-time upper limit guard value QIIGMXB is determined and, at the same time, whether the lower limit guard value QIIGMN has reached the ordinary-time lower limit guard value QIIGMNB is determined (S910). If QIIGMX NOTEQUAL QIIGMXB and/or QIIGMN NOTEQUAL QIIGMNB ("NO" in S910), the learned integration correction term value QIXM is held unchanged by setting the learned integration correction term value QIXM (i-1) in the previous control period as the learned integration correction term value QIXM (i) in the current control period (S915). It is to be noted that the previous control period and the current control period are in different idling states owing to switch-over of the external load, the most recent learned integration correction term value QIXM in the same idling state as that of the current control period is set as the learned integration correction term value QIXM (i) in the current control period.

[0207] If QIIGMX = QIIGMXB and QIIGMN = QIIGMNB ("YES" in S910), on the other hand, the process is started in step S911, which is followed by the calculation processes (S911 to S915) of the learned integration correction term value QIXM to change the learned integration correction term value QIXM to an appropriate value as mentioned above in the description of the first embodiment.

[0208] One example of the process according to the second embodiment is shown in a timing chart of Fig. 16.

[0209] The starter operates at time t21 to cause the engine 1 to start running. Then, the engine 1 is initiated to turn OFF the starter (time t22). Then, the engine 1 starts running autonomously (starting from time t22). At the time t22 the timer counter Ts starts to perform counting. Until the value of the timer counter Ts passes over the early initiation-stage guard holding time CQIGOF, however, the upper limit guard value QIIGMX is held at a value of the initial upper limit guard value QIIGMXS already set upon initiation, and the lower limit guard value QIIGMN is held at a value of the initial lower limit guard value QIIGMNS already set upon initiation.

[0210] Then, when the value of the timer counter Ts has passed over the early initiation-stage guard holding time CQIGOF (time t23), the upper limit guard value QIIGMX and the lower limit guard value QIIGMN decrease gradually to be finally equal to the ordinary-time upper limit guard value QIIGMXB (time t25) and the ordinary-time lower limit guard value QIIGMNB (time t24) respectively.

[0211] To accommodate such a possible significant increase in value of the integration correction term QII as to be required to compensate for load of heavy friction that occurs at the early stage of the initiation of the engine 1, the guard value, especially, the upper limit guard value QIIGMX is temporarily set large at the time of and immediately after the initiation. Accordingly, it is possible to sufficiently compensate for the friction which occurs at the early stage of the initiation in terms of fuel injection amount.

[0212] Then, to go along with a drop in the friction at the time of early stage of the initiation, both the upper limit guard value QIIGMX and the lower limit guard value QIIGMN are reduced so that they may finally become the ordinary-time upper limit guard value QIIGMXB and the ordinary-time lower limit guard value QIIGMNB respectively. Neither the upper limit guard value QIIGMX nor the lower limit guard value QIIGMN, therefore, continues being large in value.

[0213] Fig. 17 shows a case where the engine is stalled after being initiated. The starter is turned ON at time t31 and turned OFF at time t32 to cause, as described with reference to Fig. 16, the timer counter Ts to start to perform counting (time t32 or later), thus starting decreasing the upper limit guard value QIIGMX and the lower limit guard value QIIGMN after the early initiation-stage guard holding time CQIGOF has elapsed (time t33 or later).

[0214] If the engine is stalled at time t34, however, the timer counter Ts is stopped in counting, accompanying which the upper limit guard value QIIGMX and the lower limit guard value QIIGMN are also stopped in decrementing (time t34 or later). At this time, the timer counter Ts and the upper limit and lower limit guard values QIIGMX and QIIGMN are held at their respective current values.

[0215] Then, when the engine 1 starts running autonomously owing to the subsequent switch-over from the ON state to the OFF state of the starter (time t35 to time t36), the timer counter Ts restarts to perform counting from the value held at the time of engine stalling, accompanying which the upper limit guard value QIIGMX and the lower limit guard value QIIGMN also begin to be decremented again starting from the respective values held at the time of engine stalling (time t36 or later). Finally, the upper limit guard value QIIGMX equals the ordinary-time upper limit guard value QIIGMXB (time t38) and the lower limit guard value QIIGMN equals the ordinary-time lower limit guard value QIIGMNB (time t37).

[0216] In the above-mentioned second embodiment, steps S240 to S270 and S290 of the ISC process (Fig. 4), the guard value setting process (Fig. 14), and the counting process (Fig. 11) of the timer counter Ts correspond to the process as the integration correction term calculation means, steps S120 and S130 of the fuel injection amount control process (Fig. 2) corresponds to the process as the fuel supply amount calculation means, and the calculation process (Fig. 15) of the learned integration correction term value QIXM corresponds to the process as the learned integration correction term means.

[0217] The above-mentioned second embodiment gives the following effects.

(1) At the time of and immediately after the initiation of the engine 1, the control range of the integration correction term, that is, a distance between the upper-limit guard value QIIGMX and the lower-limit guard value QIIGMN is set wider than that at the time of usual running. In particular, the upper limit guard value QIIGMX is set large. Accordingly, at the time of or immediately after the initiation of the engine 1, the value of a deviation of an actual engine rotation speed NE with respect to a target idling rotation speed NETRG is allowed to be accumulated greatly in the integration correction term QII greatly. Only at the time of and immediately after the initiation, therefore, the friction which exists at the early stage of the initiation of the engine can be compensated for by the integration correction term QII, thus preventing a drop in rotation speed of the engine NE.

Furthermore, when the idling rotation speed is controlled subsequently, the control range of the integration correction term is returned to a control range at the time of usual running, so that the magnitude of the integration correction term QII is inhibited from becoming excessive, thus preventing a steep rise in rotation speed in the controlling of the idling rotation speed.

(2) The control range of the integration correction term is narrowed down gradually by reducing the upper limit guard value QIIGMX and the lower limit guard value QIIGMN gradually as time elapses after their values have been held as they are for a while. Specifically, the integration correction term QII is reduced in value gradually because the friction generated at the early stage of the initiation of the engine disappears gradually as the engine 1 continues running. By narrowing down the integration correction term control range gradually as time elapses, therefore, an integration correction term control range at the time of usual running can be restored, thus smoothing the shifting over to the subsequent control on the idling rotation speed.

Furthermore, by providing a period over which a width of the integration correction term control range is held at the early stage, it is possible to give a time margin, at the time of or immediately after the initiation of the internal combustion engine, in which the integration correction term QII can rise in value sufficiently without widening the control range of the integration correction term extremely. It is thus possible to effectively compensate for the friction which exists at the early stage of the initiation of the engine using the integration correction term QII.

(3) In a situation where the integration correction term control range is set wider than that at the time of usual running, the integration correction term QII changes greatly. Therefore, it is not appropriate to calculate the learned integration correction term value QIXM because it is liable to generate an error. Therefore, if the integration correction term control range is yet to return to the range at the time of usual running, calculation of the learned value integration correction term value QIXM is inhibited and, when the range at the time of usual running is restored, the calculation of the learned integration correction term value QIXM is permitted. In such a manner, it is possible to effectively suppress the occurrence of an error in the learned integration correction term value QIXM, thus further stabilizing control on the idling rotation speed.

(4) Upon engine stalling, the friction which had been generated at the early stage of the initiation and decreased due to the rotation of the engine 1 up to the moment immediately before the engine stalling is scarcely recovered, so that the integration correction term QII needs also to remain large in value. To restart the engine after it is stalled, therefore, the integration correction term control range is to be set at a width at the time of engine stalling so that the process may start in this state. In such a manner, it is possible to set the integration correction term control range appropriately, thus further stabilizing control on the idling rotation speed of the internal combustion engine.

(5) As in the case of the above-mentioned first embodiment, the integration correction term control range can be set appropriately, thus further stabilizing control on the idling rotation speed.

Other Embodiments

[0218] The above-mentioned first and second embodiments may be combined in configuration. That is, the calculation process of the early initiation-stage prospective correction term QIPAS (Fig. 10) of the above-mentioned first embodiment is to be executed in a configuration of the above-mentioned second embodiment so that the early initiation-stage prospective correction term QIPAS may be calculated and added to the load correction term QIPB. At the same time, the same values will be used for the early initiation-stage guard holding time CQIGOF and the early initiation-stage prospective correction term holding time CQIPOF used, for example, in the guard value setting process (Fig. 14). Furthermore, the decrease width QIPASDL in the above-mentioned equation 12, the decrease width QIGMXDL in the above-mentioned equation 14 and the decrease width QIGMNDL in the above-mentioned equation 15 are set so that the timing at which the early initiation-stage prospective correction term QIPAS becomes "0", the timing at which the upper limit guard value QIIGMX becomes the ordinary-time upper limit guard value QIIGMXB, and the timing at which the lower limit guard value QIIGMN becomes the ordinary-time lower limit guard value QIIGMNB may occur roughly simultaneously.

[0219] In such a configuration, there are provided an extension of the application of the early initiation-stage prospective correction term QIPAS and an expansion of the integration correction term control range at the time of or immediately after the initiation, so that subsequently, the early initiation-stage prospective correction term QIPAS disappears as related with the reduction in the integration correction term control range. This makes it possible to sufficiently compensate for, in the integration correction term QII, the friction generated at the early stage of the initiation even if it has not sufficiently been compensated for by the value of the early initiation-stage prospective correction term QIPAS at the time of or immediately after the initiation. It is, therefore, possible to further stabilize control on the idling rotation speed.

[0220] Although the early initiation-stage prospective correction term QIPAS of the above-mentioned first embodiment and the guard values QIIGMX and QIIGMN of the above-mentioned second embodiment have been set in accordance with the value of the timer counter Ts, they may be set according to the accumulated number of rotations of the engine rotation speed NE. This is because the early initiation-stage friction attenuates gradually as the engine runs upon or after the initiation thereof. Furthermore, the early initiation-stage prospective correction term QIPAS and the guard values QIIGMX and QIIGMN may be set in accordance with a rise in cooling water temperature THW. The cooling water temperature THW rises gradually as the engine continues running after being initiated. This is because such a temperature rising pattern is similar to a decrease pattern of the friction generated at the early stage of the initiation of the engine and also such a temperature factor is involved in the magnitude of the friction generated at the early initiation stage of the engine.

[0221] Although in the above-mentioned embodiments, the timer counter Ts has started to perform counting at a timing that the engine 1 had completely started to run autonomously after switch-over from the ON state to the OFF state of the starter, the timer counter

Ts may be adapted to start to perform counting at a timing that the running of the engine 1 had been started by the starter. Furthermore, the timer counter Ts may be adapted to perform counting when the rotation speed exceeds a reference rotation speed even if the starter is in the ON state.

[0222] Although in the above-mentioned first embodiment, the reference value QIPASB of the early initiation-stage prospective correction term has been set in accordance with the shifted position of the automatic transmission and the cooling water temperature THW, it may be set otherwise, for example, according to the kind or the presence/absence of the external load such as the air conditioner or the power steering.

[0223] Although in the above-mentioned second embodiment, a fixed value has been used as the initial upper limit guard value QIIGMXS and the initial lower limit guard value QIIGMNS, they may be set according to the shifted position of the automatic transmission or the cooling water temperature THW or to the kind or the presence/absence of the external load such as the air conditioner or the power steering.

[0224] An integration correction term is calculated on the basis of a deviation of an actual rotation speed with respect to a target rotation speed of an internal combustion engine when the internal combustion engine is idling and used to correct a fuel supply amount, thus controlling an idling rotation speed of the internal combustion engine. At the time of and/or immediately after initiation of the internal combustion engine, prospective correction in accordance with friction which exists at an early initiation stage of the internal combustion engine is conducted on the fuel supply amount.

Claims

1. A method for controlling an idling fuel supply amount, wherien an integration correction term is calculated based on a deviation of an actual rotation speed of an internal combustion engine with respect to a target rotation speed of said internal combustion engine when said internal combustion engine is idling, wherein a guard process is executed on said integration correction term using an upper limit guard value and a lower limit guard value, and wherein a fuel supply amount is corrected using the integration correction term after said guard process is executed, thus controlling an idling rotation speed of said internal combustion engine, the method being **characterized in that**:

setting a control range of the integration correction term between said upper limit guard value and said lower limit guard value wider than the control range at the time of usual running at an early stage of and/or immediately after initiation of said internal combustion engine.

2. The method for controlling an idling fuel supply amount according to claim 1, **characterized in that**, in said guard process, a control range of said integration correction term which is set at the time of and/or immediately after the initiation of the internal combustion engine is gradually narrowed down to the control range at the time of usual running.

3. The method for controlling an idling fuel supply amount according to claim 2, **characterized in that** a period over which a width of the integration correction term control range is held is provided prior to gradual narrowing down of said integration correction term control range.

4. The method for controlling an idling fuel supply amount according to claim 2 or 3, **characterized in that** said integration correction term control range is narrowed down gradually in accordance with the elapsed time after said internal combustion engine has started to run or been initiated.

5. The method for controlling an idling fuel supply amount according to claim 2 or 3, **characterized in that** said integration correction term control range is narrowed down gradually in accordance with an accumulated number of rotations of said internal combustion engine after said internal combustion engine has started to run or been initiated.

6. The method for controlling an idling fuel supply amount according to claim 2 or 3, **characterized in that** said integration correction term control range is narrowed down gradually in accordance with a rise in the temperature of said internal combustion engine.

7. The method for controlling an idling fuel supply amount according to claim 6, **characterized in that** the temperature of said internal combustion engine is a temperature of cooling water of said internal combustion engine.

8. The method for controlling an idling fuel supply amount according to any one of claims 2to 7, **characterized in that** at the time of restart after an engine stall, said integration correction term control range is set at a range at the time of the engine stall, so that said gradual narrowing down process starts from said range.

9. The method for controlling an idling fuel supply amount according to any one of claims 1 to 8, **characterized in that** said integration correction term control range is switched in accordance with a shifted position of a transmission.

10. The method for controlling an idling fuel supply amount according to any one of claims 1 to 8, **characterized in that** said integration correction term control range is switched in accordance with the presence/absence of external load.

11. The method for controlling an idling fuel supply amount according to any one of claims 1 to 8, **characterized in that** said integration correction term control range is switched in accordance with a kind of external load.

12. The method for controlling an idling fuel supply amount according to any one of claims 1 to 11, **characterized in that** said integration correction term control range is set using a learned value of said integration correction term as a reference position.

13. The method for controlling an idling fuel supply amount according to any one of claims 1 to 12, **characterized in that** calculation of the learned value of said integration correction term is allowed when said integration correction term control range is returned to the range at the time of usual running.

Fig.1

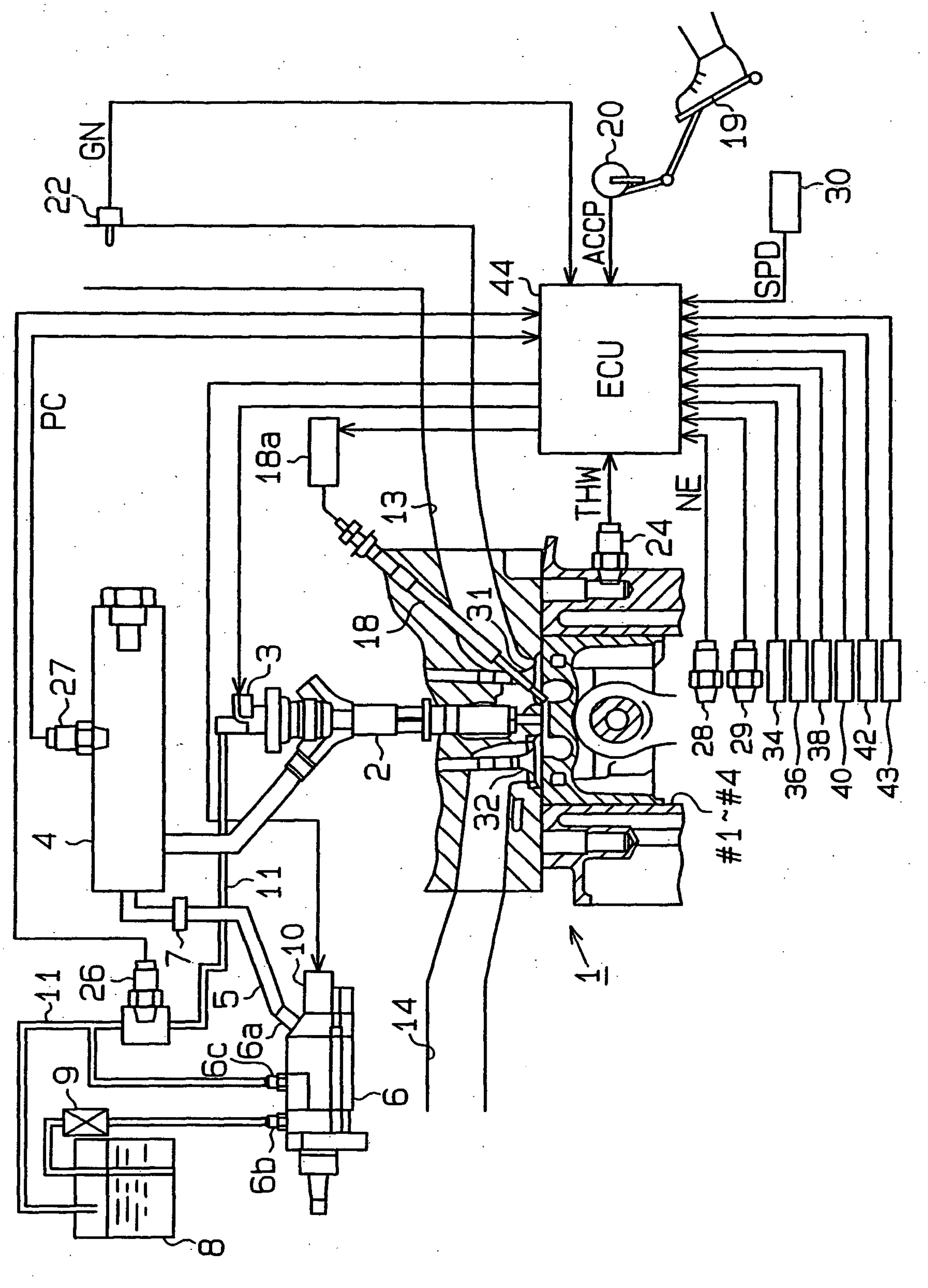

ECU
PC
GN
ACCP
SPD
THW
NE
44
22
20
19
30
18a
13
18
31
24
27
3
2
4
28
29
34
36
38
40
42
43
32
#1~#4
11
7
10
26
5
6a
6c
6
9
6b
8
14
1

Fig.2

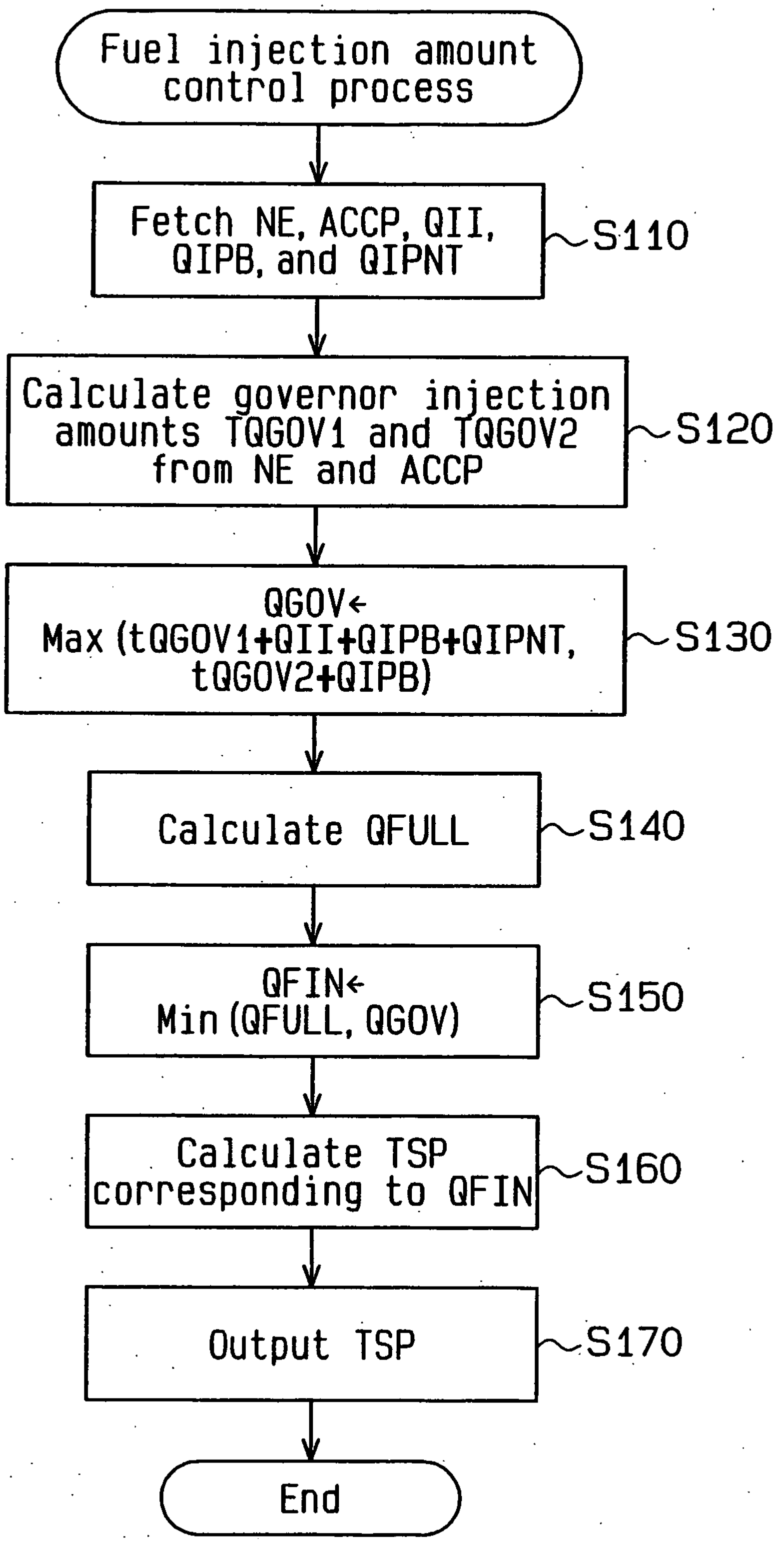
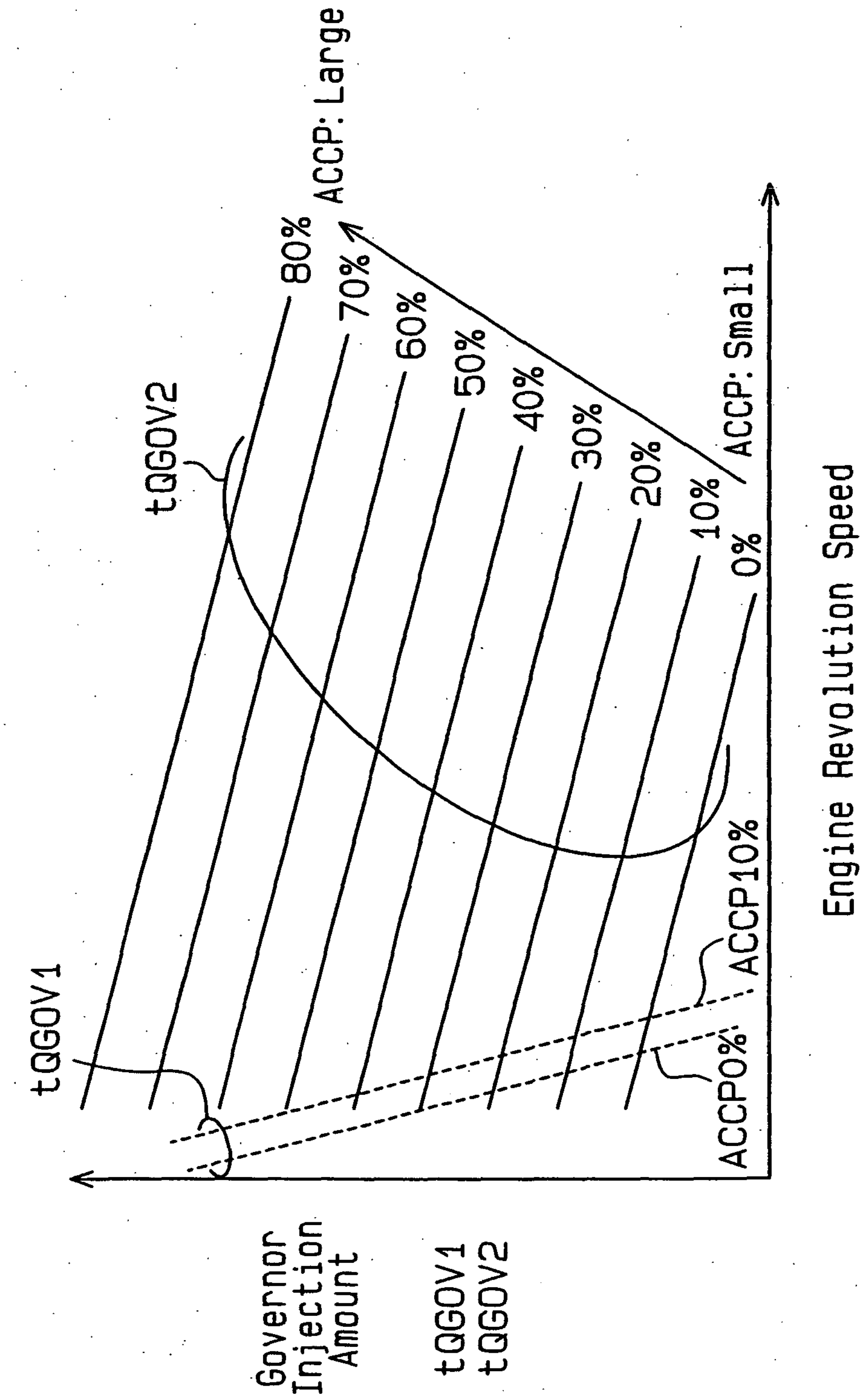

Fuel injection amount control process
Fetch NE, ACCP, QII, QIPB, and QIPNT
S110
Calculate governor injection amounts TQGOV1 and TQGOV2 from NE and ACCP
S120
QGOV← Max (tQGOV1+QII+QIPB+QIPNT, tQGOV2+QIPB)
S130
Calculate QFULL
S140
QFIN← Min (QFULL, QGOV)
S150
Calculate TSP corresponding to QFIN
S160
Output TSP
S170
End

Fig.3



ACCP: Large
ACCP: Small
80%
70%
60%
50%
40%
30%
20%
10%
0%
tQGOV2
tQGOV1
ACCP10%
ACCP0%
Engine Revolution Speed
Governor Injection Amount
tQGOV1
tQGOV2

Fig.4

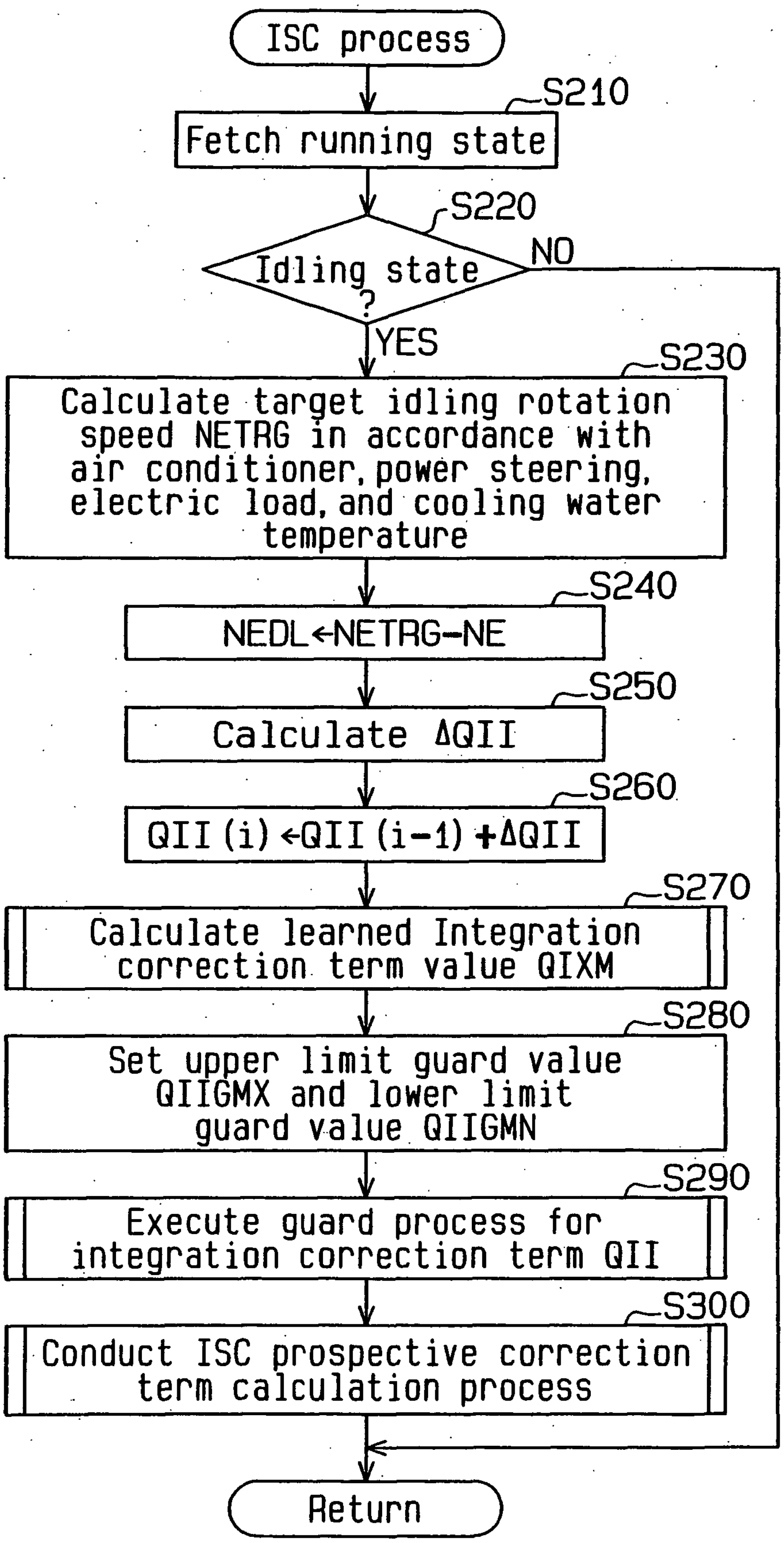

ISC process
S210
Fetch running state
S220
Idling state ?
NO
YES
S230
Calculate target idling rotation speed NETRG in accordance with air conditioner, power steering, electric load, and cooling water temperature
S240
NEDL←NETRG−NE
S250
Calculate ΔQII
S260
QII (i) ←QII (i−1) +ΔQII
S270
Calculate learned Integration correction term value QIXM
S280
Set upper limit guard value QIIGMX and lower limit guard value QIIGMN
S290
Execute guard process for integration correction term QII
S300
Conduct ISC prospective correction term calculation process
Return

Fig.5

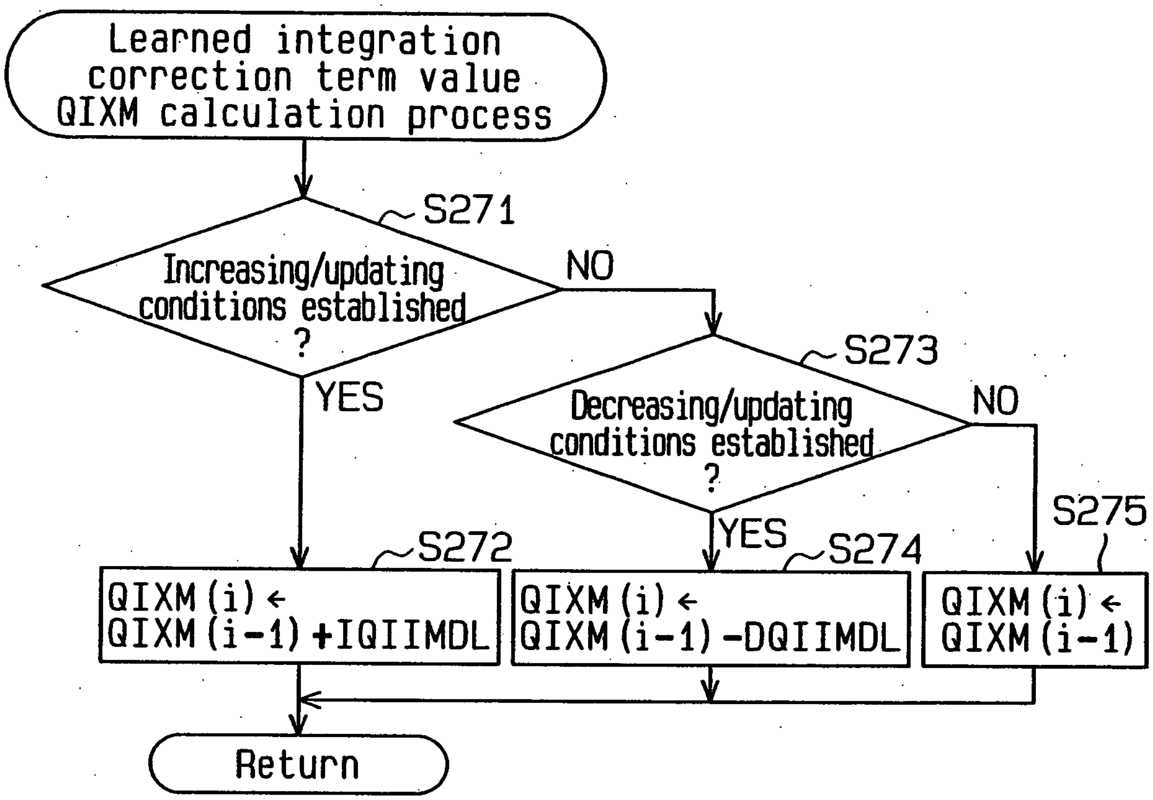

Learned integration correction term value QIXM calculation process
S271
Increasing/updating conditions established ?
NO
YES
S273
Decreasing/updating conditions established ?
NO
YES
S272
QIXM (i) ← QIXM (i-1) +IQIIMDL
S274
QIXM (i) ← QIXM (i-1) -DQIIMDL
S275
QIXM (i) ← QIXM (i-1)
Return

Fig.6

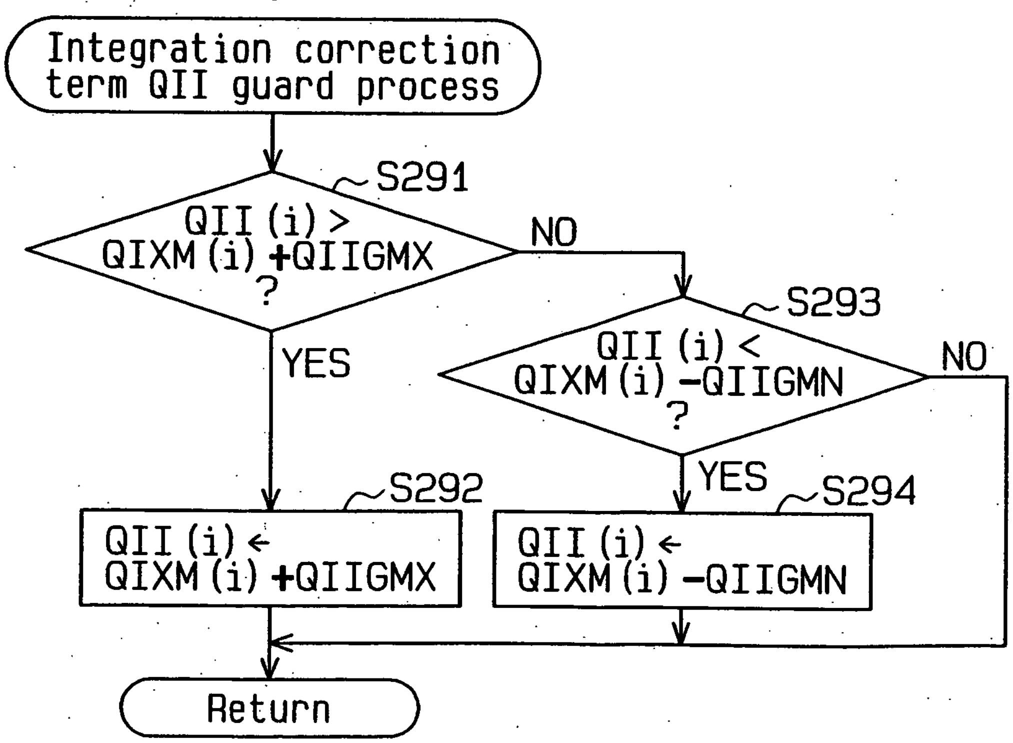

Integration correction term QII guard process
S291
QII (i) > QIXM (i) +QIIGMX ?
NO
YES
S293
QII (i) < QIXM (i) -QIIGMN ?
NO
YES
S292
QII (i) ← QIXM (i) +QIIGMX
S294
QII (i) ← QIXM (i) -QIIGMN
Return

Fig.7

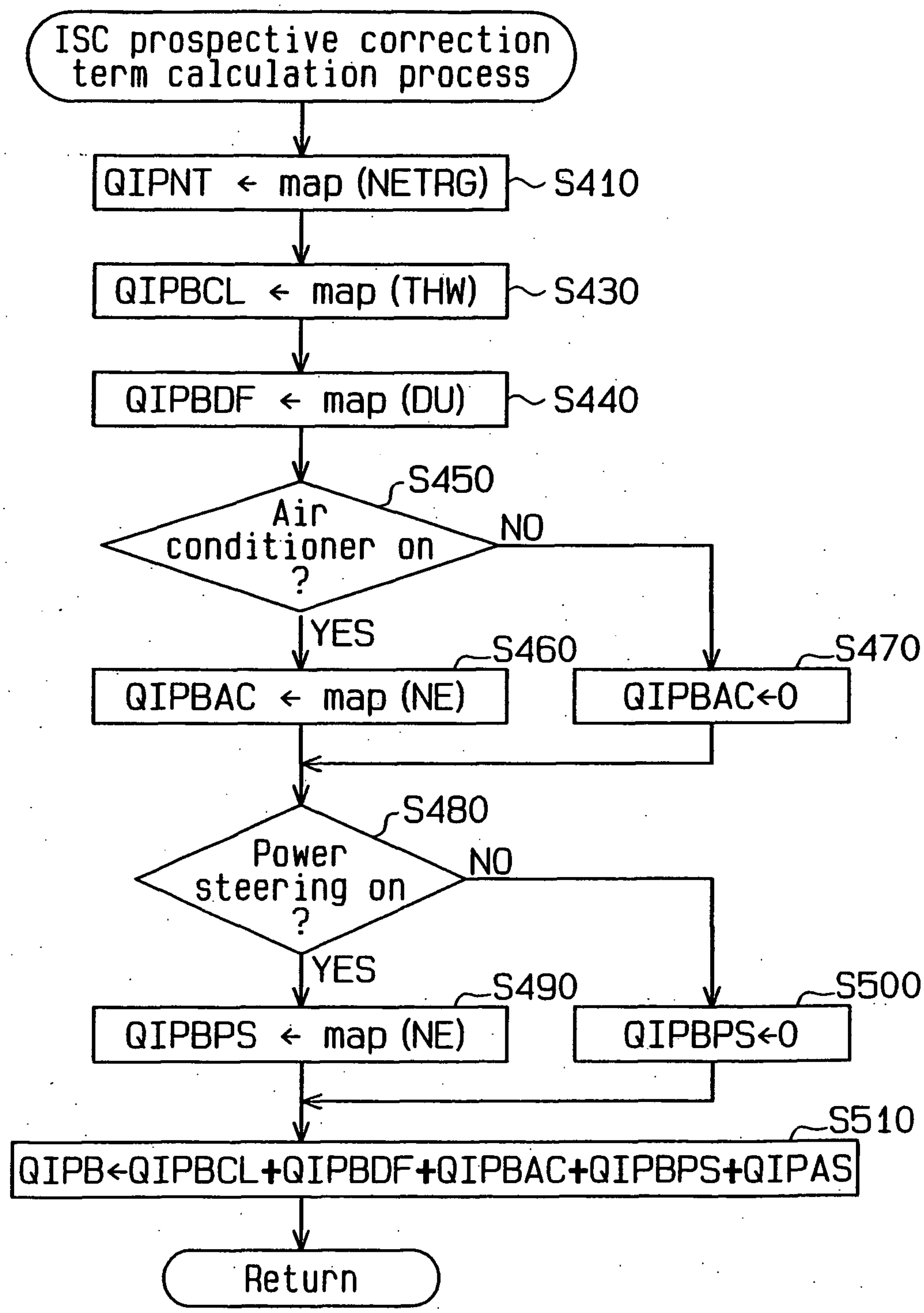

ISC prospective correction term calculation process
QIPNT ← map (NETRG)
S410
QIPBCL ← map (THW)
S430
QIPBDF ← map (DU)
S440
S450
Air conditioner on ?
NO
YES
S460
S470
QIPBAC ← map (NE)
QIPBAC←0
S480
Power steering on ?
NO
YES
S490
S500
QIPBPS ← map (NE)
QIPBPS←0
S510
QIPB←QIPBCL+QIPBDF+QIPBAC+QIPBPS+QIPAS
Return

Fig.8(A)

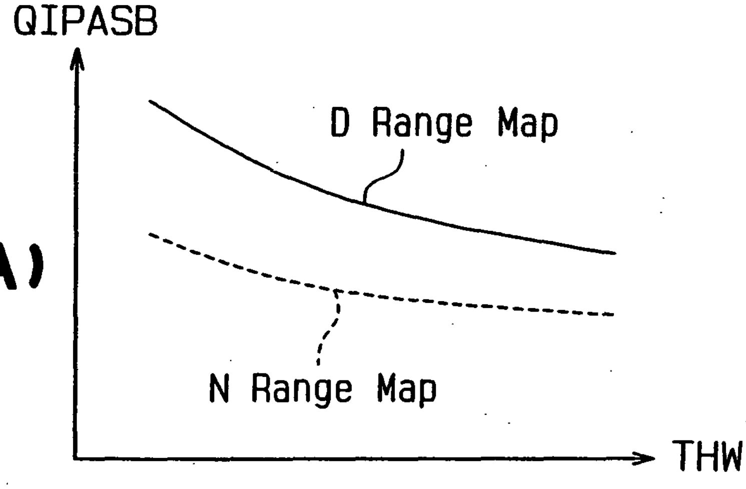


Fig.8(B)

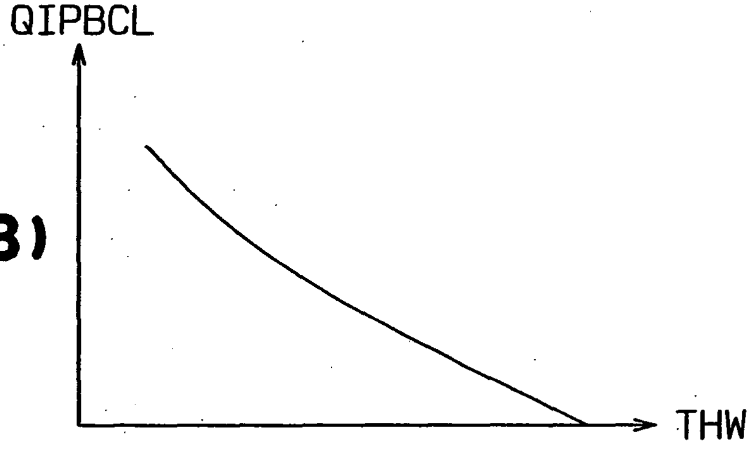


Fig.8(C)

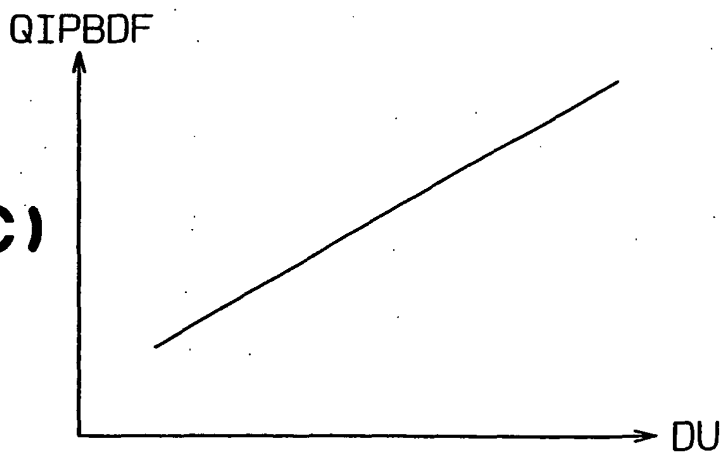


Fig.9(A)

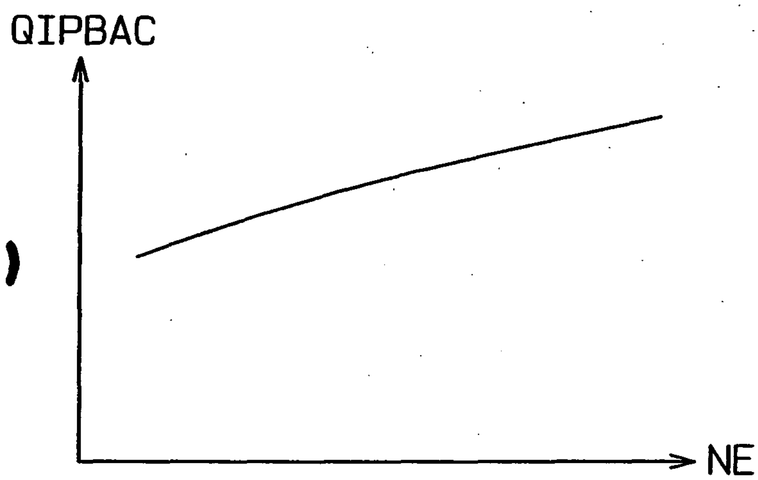


Fig.9(B)

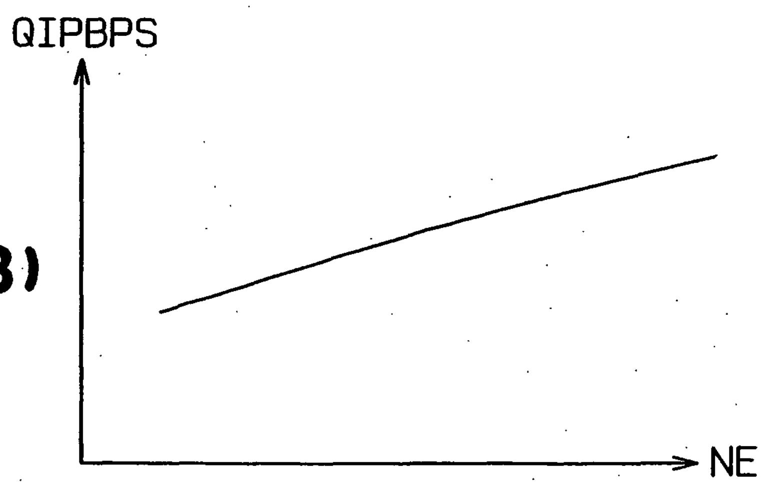


Fig.10

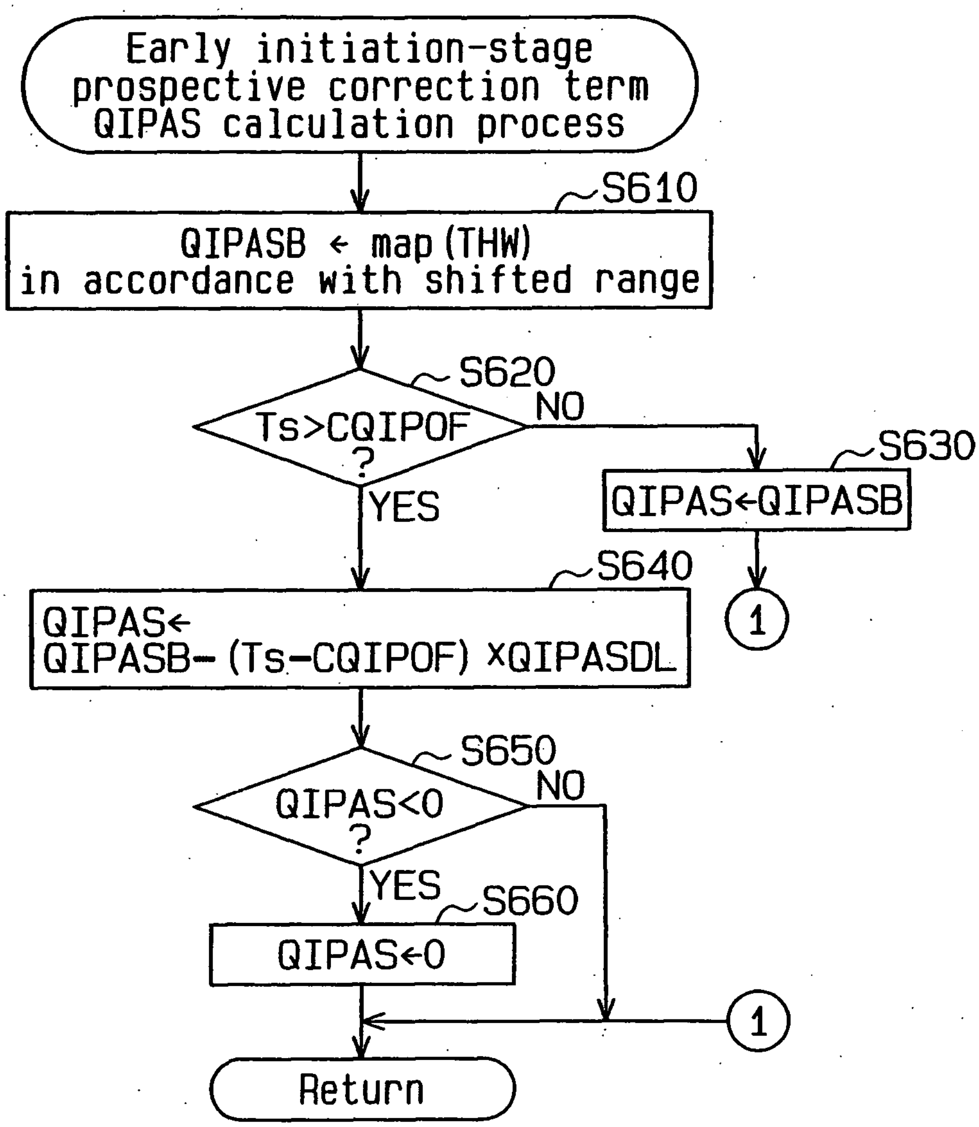

Early initiation-stage prospective correction term QIPAS calculation process
S610
QIPASB ← map (THW) in accordance with shifted range
S620
Ts>CQIPOF ?
NO
YES
S630
QIPAS←QIPASB
1
S640
QIPAS← QIPASB− (Ts−CQIPOF) ×QIPASDL
S650
QIPAS<0 ?
NO
YES
S660
QIPAS←0
1
Return

Fig.11

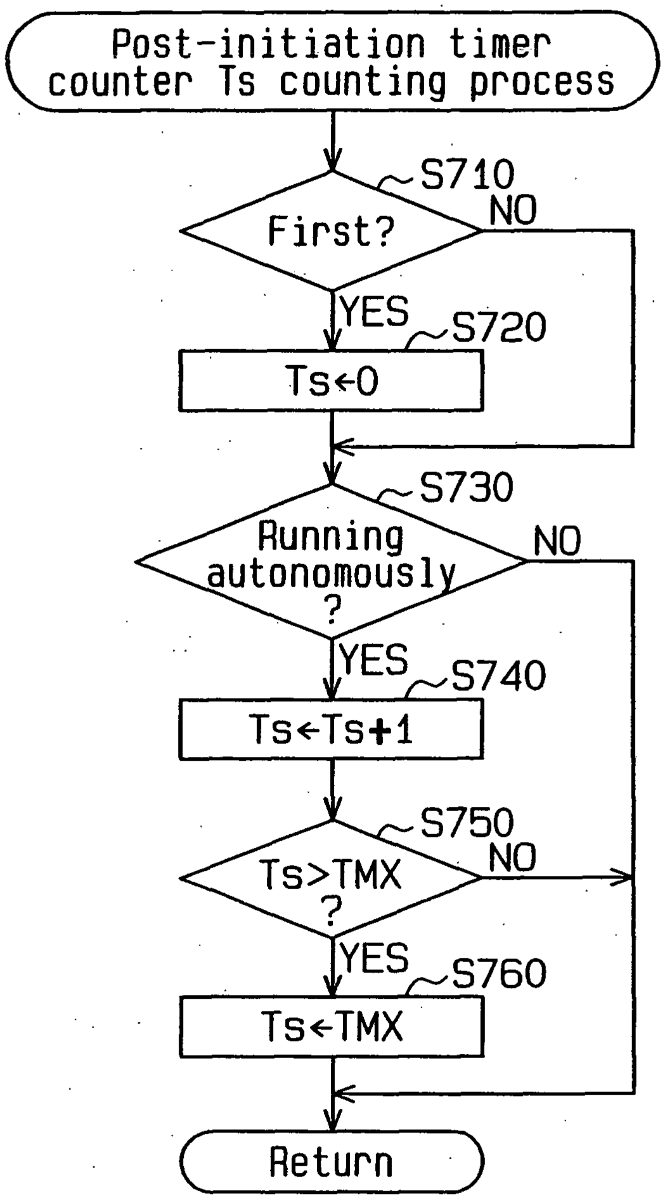

Post-initiation timer counter Ts counting process
S710
First?
NO
YES
S720
Ts←0
S730
Running autonomously ?
NO
YES
S740
Ts←Ts+1
S750
Ts>TMX ?
NO
YES
S760
Ts←TMX
Return

Fig.12

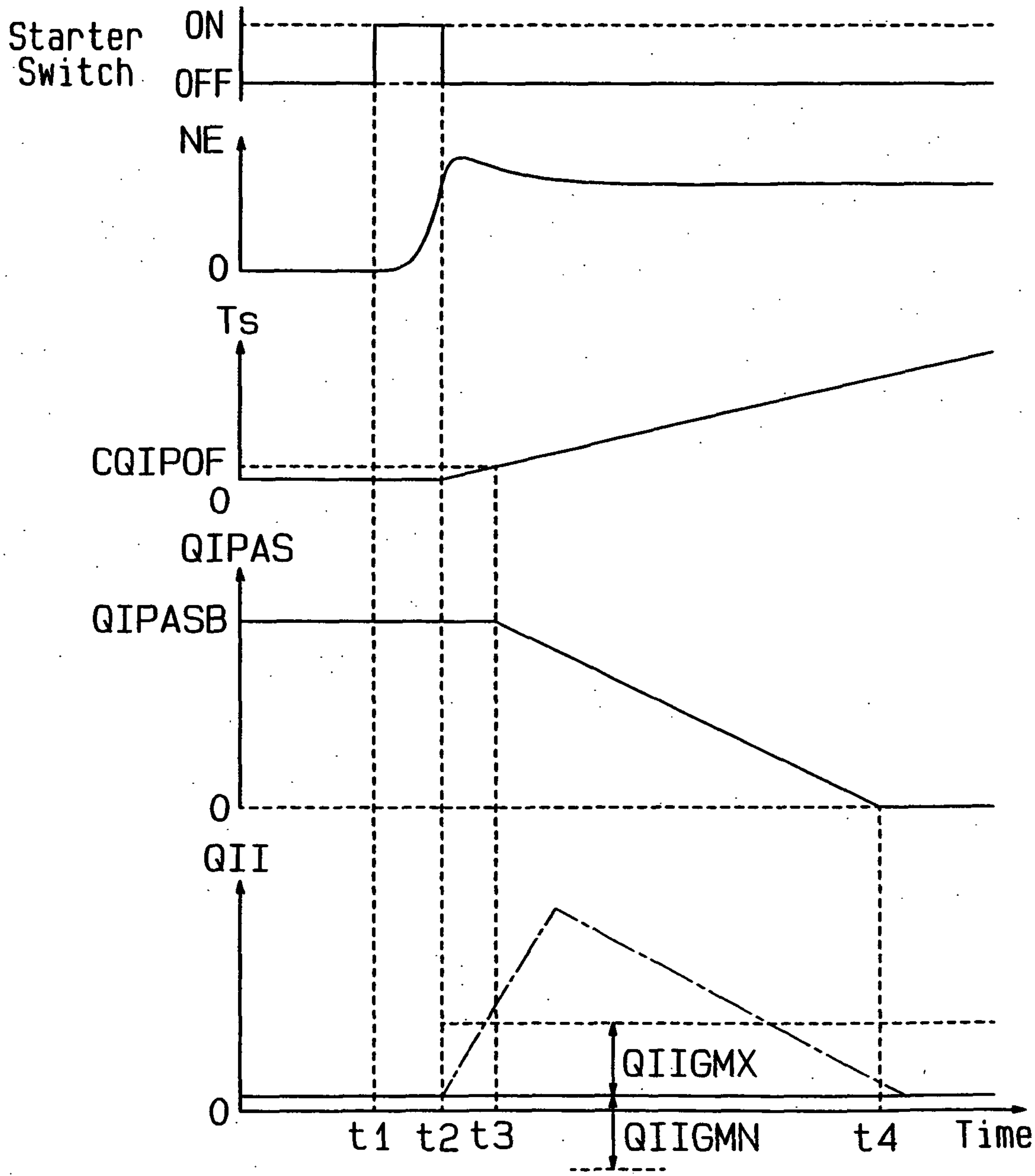

Starter Switch
ON
OFF
NE
0
Ts
CQIPOF
0
QIPAS
QIPASB
0
QII
QIIGMX
0
t1
t2
t3
QIIGMN
t4
Time

Fig.13

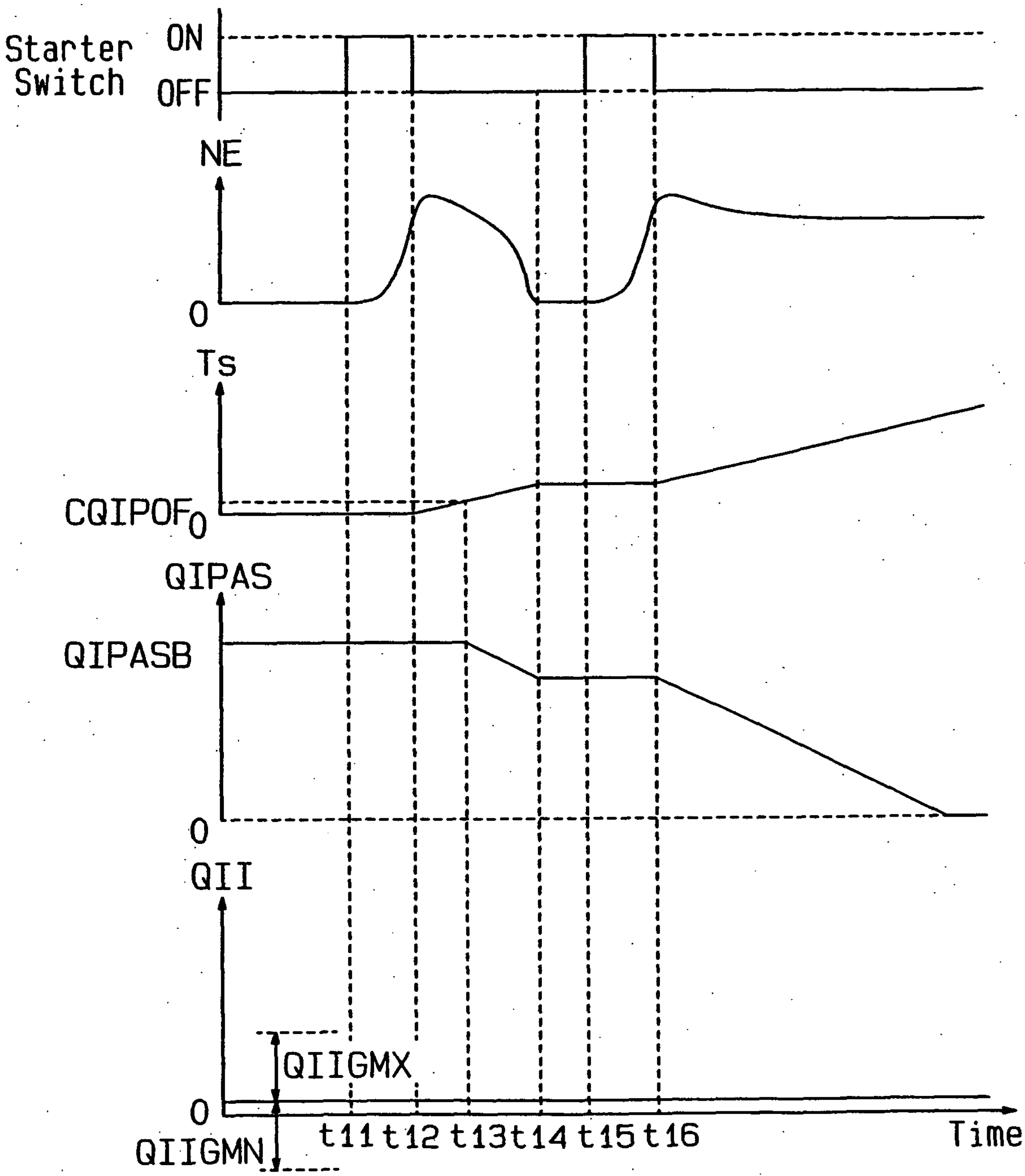

Starter Switch
ON
OFF
NE
0
Ts
CQIPOF
0
QIPAS
QIPASB
0
QII
QIIGMX
0
QIIGMN
t11
t12
t13
t14
t15
t16
Time

Fig.14

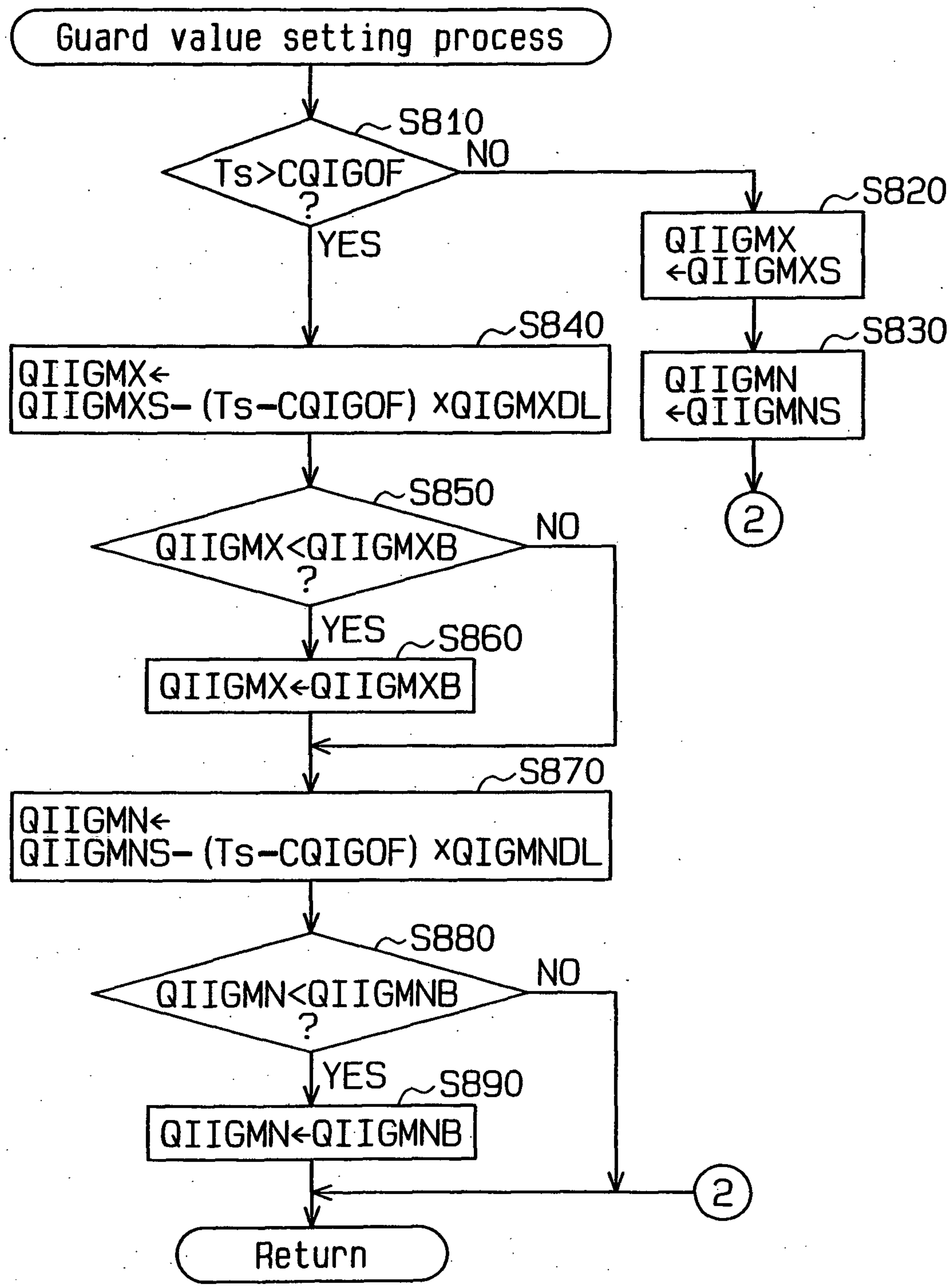

Guard value setting process
S810
Ts>CQIGOF ?
NO
YES
S820
QIIGMX ←QIIGMXS
S830
QIIGMN ←QIIGMNS
2
S840
QIIGMX←
QIIGMXS-(Ts-CQIGOF) ×QIGMXDL
S850
QIIGMX<QIIGMXB ?
NO
YES
S860
QIIGMX←QIIGMXB
S870
QIIGMN←
QIIGMNS-(Ts-CQIGOF) ×QIGMNDL
S880
QIIGMN<QIIGMNB ?
NO
YES
S890
QIIGMN←QIIGMNB
2
Return

Fig.15

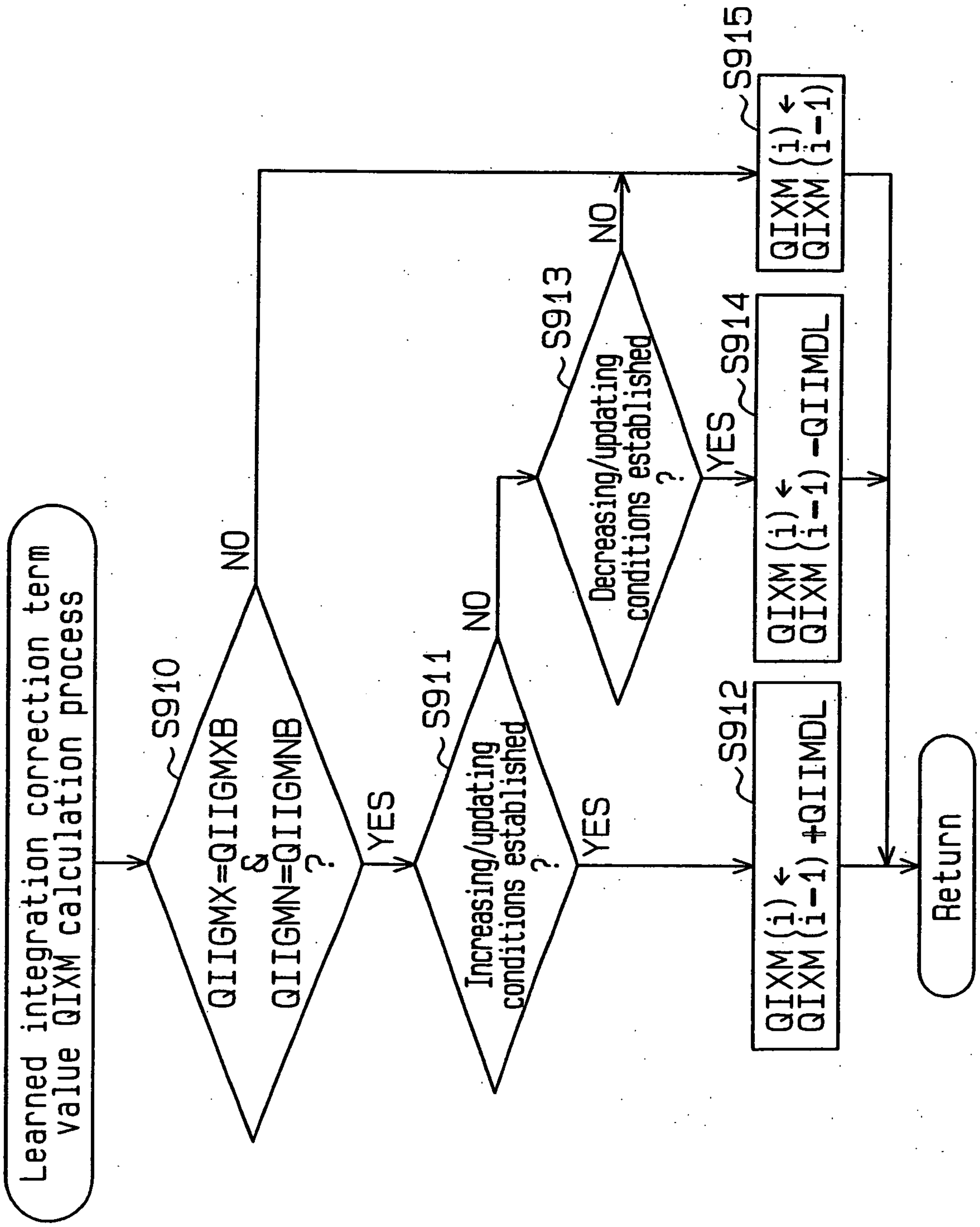

Learned integration correction term value QIXM calculation process
S910
QIIGMX=QIIGMXB & QIIGMN=QIIGMNB ?
YES
NO
S911
Increasing/updating conditions established ?
YES
NO
S912
QIXM(i) ← QIXM(i−1) +QIIMDL
S913
Decreasing/updating conditions established ?
YES
NO
S914
QIXM(i) ← QIXM(i−1) −QIIMDL
S915
QIXM(i) ← QIXM(i−1)
Return

Fig.16

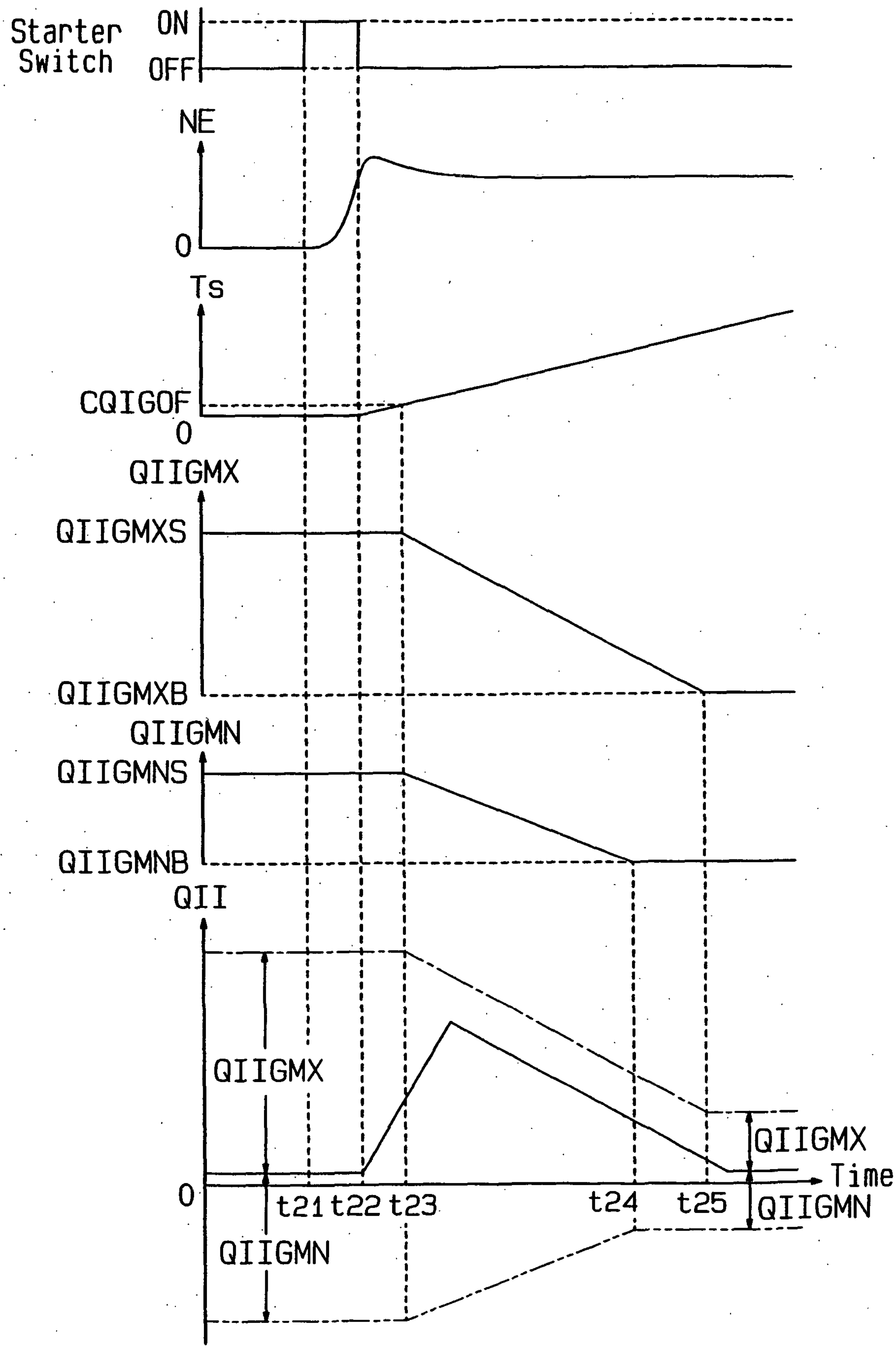
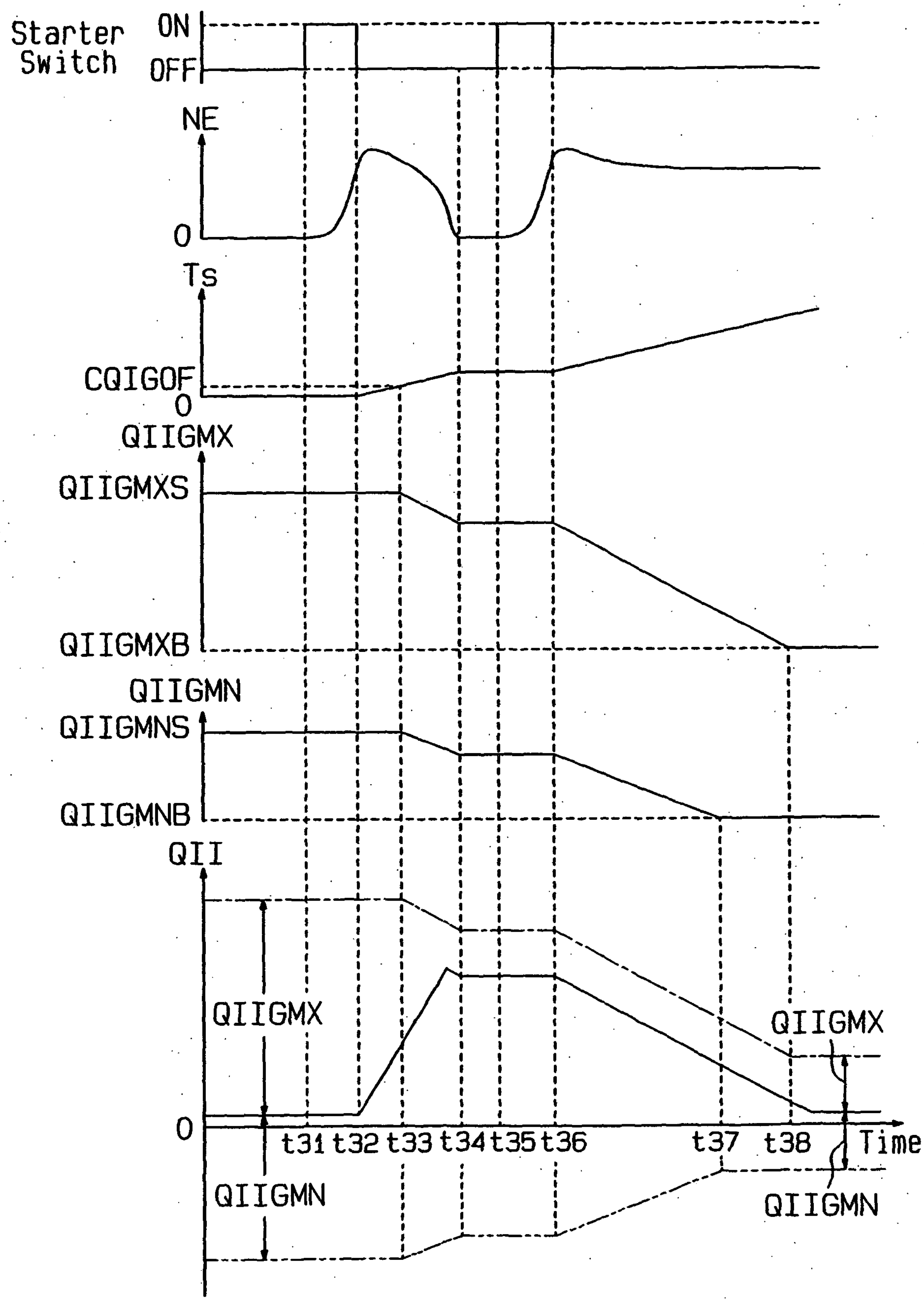

Starter Switch
ON
OFF
NE
0
Ts
CQIGOF
0
QIIGMX
QIIGMXS
QIIGMXB
QIIGMN
QIIGMNS
QIIGMNB
QII
QIIGMX
0
t21 t22 t23
t24
t25
QIIGMX
Time
QIIGMN
QIIGMN

Fig.17



Starter Switch
ON
OFF
NE
0
Ts
CQIGOF
0
QIIGMX
QIIGMXS
QIIGMXB
QIIGMN
QIIGMNS
QIIGMNB
QII
QIIGMX
0
QIIGMN
t31 t32 t33 t34 t35 t36
t37 t38
Time
QIIGMX
QIIGMN

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 05 00 8644

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	US 5 722 368 A (SAKAI SHOICHI) 3 March 1998 (1998-03-03) * the whole document * -----	1-13	F02D41/16 F02D41/06
A	PATENT ABSTRACTS OF JAPAN vol. 008, no. 244 (M-337), 9 November 1984 (1984-11-09) & JP 59 122761 A (TOYOTA JIDOSHA KK), 16 July 1984 (1984-07-16) * abstract * -----	1-13	
A	PATENT ABSTRACTS OF JAPAN vol. 009, no. 073 (M-368), 3 April 1985 (1985-04-03) & JP 59 203849 A (TOYOTA JIDOSHA KK), 19 November 1984 (1984-11-19) * abstract * -----	1-13	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)
F02D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	23 May 2005	Calabrese, N

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 05 00 8644

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

23-05-2005

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5722368 A	03-03-1998	JP 3265496 B2	11-03-2002
		JP 9264179 A	07-10-1997
		DE 19713107 A1	30-10-1997
JP 59122761 A	16-07-1984	JP 1759630 C	20-05-1993
		JP 4045660 B	27-07-1992
JP 59203849 A	19-11-1984	JP 2012257 C	02-02-1996
		JP 7033797 B	12-04-1995

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82