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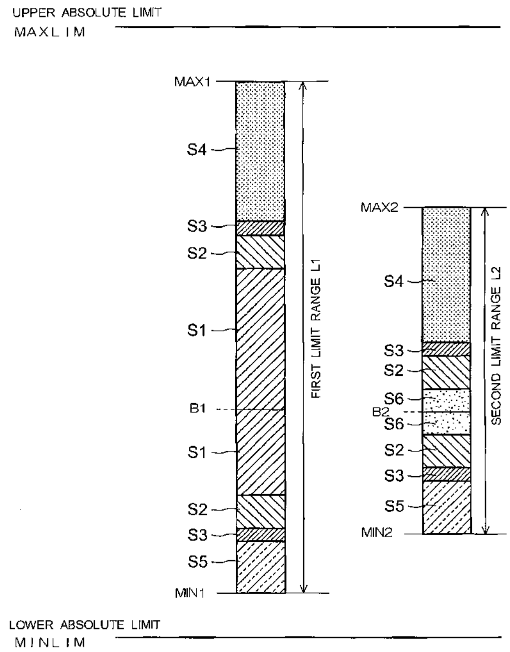
(54) **Fuel injection control system**

(57) To provide a fuel injection control system which properly sets a limit value of an air-fuel ratio feedback correction value, thereby making a good air-fuel ratio feedback control possible.

While a variation rate of an output value of an oxygen sensor (32) is changed from the positive to the negative or from the negative to the positive predetermined times after a power source of a vehicle is turned on, a control unit (C) sets a first limit range (L1) for an air-fuel ratio feedback correction factor (K02) as an upper/lower limit value which have a predetermined upper/lower width, in which the output value of the oxygen sensor (32) detected in a stoicshiometric air-fuel ratio state is a reference value (B1), and which is allowed to be used for calculating a correction injection quantity (T1). After a variation rate of the output value of the oxygen sensor (32) is changed from the positive to the negative or from the negative to the positive predetermined times, the air-fuel ratio feedback correction factor (K02) that is calculated when the variation rate is changed the predetermined times is regarded as a reference value (B2), and a second limit range (L2) which has a predetermined upper/lower width from the reference value (B2) and is narrower than the first limit range (L1) is set.

FIG. 6



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Description

[0001] The present invention relates to a fuel injection control system and, more particularly, to a fuel injection control system which is adapted to perform an air-fuel ratio feedback control based on an air-fuel ratio sensor output.

[0002] In the past, there is known a fuel injection system in which, in order to perform combustion in an internal combustion engine in a region near a theoretical (stoichiometric) air-fuel ratio, a fuel injection quantity is adapted to be feedback-controlled based on an air-fuel ratio which is detected by an air-fuel ratio sensor (an oxygen sensor) provided at an exhaust pipe. When such an air-fuel ratio feedback control is applied, if a feedback correction factor, i.e., a feedback correction amount becomes too large or too small due to any cause, there is a possibility that enriching or enleaning will be excessively performed. Therefore, in order to prevent this, it is conceivable to set a limit value for the air-fuel ratio feedback correction factor. Furthermore, such a fuel injection control system, it is conceivable to perform checking of trouble of the oxygen sensor during operation of the internal combustion engine, in order to continue a good air-fuel ratio feedback control.

[0003] A Patent Literature 1 discloses a fuel injection control system of an internal combustion engine, in which an upper limit value of an air-fuel ratio feedback correction factor is increased at the time of warming-up operation of the engine and returned to a normal upper limit value which corresponds to a stoichiometric air-fuel ratio after the warming-up operation, when the warming-up operation is finished.

[0004] [Patent Literature 1] JP-A No. 2006-37875

[0005] However, in the art which is described in the Patent Literature 1, a limit value of the air-fuel ratio feedback correction factor is increased per warming-up operation and there is a possibility that, if the feedback correction amount becomes too large and too small due to any cause, the warming-up operation will be performed in an excessively enriched or enleaned state. Moreover, when an increased amount of the limit value is determined, consideration of any influence which is exerted upon the air-fuel ratio by a height of a place, at which a vehicle is used, parts accuracy of the vehicle, variation at the time of installing, etc. is not reviewed. Additionally, the art described in the Patent Literature 1 can only periodically perform the trouble checking and can not watch the states of the oxygen sensors always, because the trouble checking is performed by watching an electric current that is produced by applying a reverse voltage to the oxygen sensors. Moreover, if learning of an air-fuel ratio feedback correction factor is adapted to be prohibited when the trouble checking is performed, a possibility occurs which output values of the oxygen sensors just prior to starting to check the trouble will be used for the air-fuel ratio feedback control during the trouble checking and, in the event that the oxygen sensor is out of order just prior to the starting to check the trouble, there is a possibility that a combustion state during the trouble checking will become excessively rich or lean.

[0006] An object of the prevent invention is to provide a fuel injection control system which overcomes the problems of the above-mentioned prior art and in which a good air-fuel ratio feedback control is made possible by correctly setting a limit value for an air-fuel ratio feedback correction value.

[0007] A further object of the present invention is to provide a fuel injection control system which overcomes the problems of the above-mentioned prior art and can always watch a state of an oxygen sensor and perform trouble checking, and makes continuation of a good air-fuel feedback control possible even during trouble checking.

[0008] In order to attain the above object, the present invention has a first characteristic in that a fuel injection control system includes control means (C) which calculate an air-fuel ratio feedback correction factor (KO2) used for a feedback control in order to obtain a target air-fuel ratio, on the basis of an output of an oxygen sensor (32) provided at an exhaust device (15) of an internal combustion engine (E) serving as a drive source of a vehicle, and determines a correction injection quantity (T1) by multiplying a basic injection quantity (T0) by the air-fuel ratio feedback correction factor (K02), wherein, while a variation rate of an output value of the oxygen sensor 32 is changed from the positive to the negative or from the negative to the positive predetermined times after a power source of the vehicle is turned on, the control unit (C) sets a first limit range (L1) for the air-fuel ratio feedback correction factor (K02) as an upper/ lower limit value which have a predetermined upper/lower width, in which the output value of the oxygen sensor (32) detected in a stoicshiometric air-fuel ratio state is a reference value (B1), and which is allowed to be used for calculating the correction injection quantity (T1) and, after a variation rate of the output value of the oxygen sensor (32) is changed from the positive to the negative or from the negative to the positive predetermined times, regards the air-fuel ratio feedback correction factor (K02), calculated when the variation rate is changed the predetermined times, as a reference value (B2), and sets a second limit range (L2) which has a predetermined upper/lower width from the reference value (B2) and is narrower than the first limit range (L1).

[0009] Moreover, the present invention has a second characteristic in that the first limit range (L1) is applied only when the power source of the vehicle is initially turned on and, after the power source is turned on from second time, the second limit range (L2) is applied in which the air-fuel ratio feedback correction factor (K02) at the time of turning the power source off at the last time is made a reference value.

[0010] Moreover, the present invention has a third characteristic in that the control means (C) is configured such that it causes the turning-on of the power source of the vehicle to be memorized in a nonvolatile memory section (40).

[0011] Moreover, the present invention has a fourth characteristic in that the first limit range (L1) is configured by adding a first numeral value (S1) in which an influence that is exerted on the air-fuel ratio by the parts accuracy, variation in assembling, etc. is taken into consideration, a second numeral value (S2) in which an influence that is exerted on the air-fuel ration by an open air temperature is taken into consideration, a third numeral value (S3) in which an influence that is exerted on the air-fuel ratio by an open air pressure is taken into consideration, a fourth numeral value (S4) in which an influence that is exerted on the air-fuel ratio by a height at which the vehicle is used is taken into consideration, and a fifth numeral value (S5) in which an influence that is exerted on the fuel-ratio by a concentration of alcohol in the fuel is taken into consideration, and the second limit range (L2) is configured by excepting the first numeral value (S1) from the first limit range (L1) and adding a sixth numeral value (S6) for setting renewal requirements of the air-fuel ratio feedback correction factor (K02).

[0012] Moreover, the present invention has a fifth characteristic in that the basic injection quantity (T0) is derived from a basic injection quantity map (33) which defines a relationship among a throttle opening (TH) of a throttle valve (21) provided at an intake device (14) of the internal combustion engine (E), the number (NE) of revolution of the internal combustion engine (E), and the basic injection quantity (T0).

[0013] Moreover, the present invention has a sixth characteristic in that, once the second limit range (L2) is applied, a predetermined upper/lower width of the second limit range (L2) is continuously applied even if thereafter renewal of the reference value (B2) is performed.

[0014] Moreover, the present invention has a seventh characteristic in that the renewal of the reference value (B2) is performed in a case where a curve which shows transition of the air-fuel ratio feedback correction factor (K02) is continuously reversed in a deviation width more than a predetermined rate relative to the second limit range (L2) and predetermined times.

[0015] Moreover, the present invention has an eighth characteristic in that an upper absolute limit (MAXLIM) and a lower absolute limit (MINLIM) are previously set for the air-fuel ratio feedback correction factor (K02) and even if the air-fuel ratio feedback correction factor (K02) which exceeds the upper absolute limit (MAXLIM) or is less than the lower absolute limit (MINLIM) is calculated according to the renewal of the basic value (B2), the value is not applied to calculation of the correction injection quantity (T1).

Furthermore, according to a ninth characteristic the control means performs trouble checking of the oxygen sensor (32) when detecting that the output of the oxygen sensor (32) becomes a predetermined state; and during performing of the trouble checking, sets a third limit range (L3) at the time of the trouble that is smaller than the second limit range (L2).

[0016] Moreover, the present invention has a tenth characteristic in that the control means (C) starts to perform the trouble checking of the oxygen sensor (32) if predetermined time passes in a state where an output value of the oxygen sensor (32) is substantially 0V or in a state where the output value of the oxygen sensor (32) is substantially 3V.

[0017] Moreover, the present invention has an eleventh characteristic in that when the trouble checking is started due to the passage of the predetermined time in the state where the output value of the oxygen sensor (32) is substantially 0V, the control means (C) performs fuel injection for the trouble checking and make a judgment of the trouble by detecting change of the output of the oxygen sensor (32) relative to the fuel injection.

[0018] Moreover, the present invention has a twelfth characteristic in that when it is judged by the trouble checking that the oxygen sensor (32) is normal, the control means (C) stops the trouble checking and returns the third limit range (L3) at the time of the trouble to the second limit range (L2).

[0019] Moreover, the present invention has a thirteenth characteristic in that the air-fuel ratio feedback control is performed by a PID control relative to a target output value of the oxygen sensor (32), an upper gain switch threshold (HI) and a lower gain switch threshold (LO) which correspond to a function limit of the oxygen sensor (32) are set for the air-fuel ratio feedback correction factor (K02), and the control means (C) makes a gain of the PID control small when the air-fuel ratio feedback correction factor (K02) exceeds the upper gain switch threshold (HI) or is less than the lower gain switch threshold (LO).

[0020] Moreover, the present invention has a fourteenth characteristic in that the basic injection quantity (T0) is derived from a basic injection quantity map (33) which defines a relationship among a throttle opening (TH) of a throttle valve (21) provided at an intake device (14) of the internal combustion engine (E), the number (NE) of revolution of the internal combustion engine (E), and the basic injection quantity (T0).

[0021] Moreover, the present invention has a fifteenth characteristic in that the normal limit range (L2) has a predetermined upper/lower width from a reference value (Ba), and the limit range (L3) at the time of the trouble is a range in which the reference value (Ba) is maintained, and an upper limit value (MAXa) and lower limit value (MINa) of the second limit range (L2) are each reduced at a predetermined rate.

[0022] Moreover, the present invention has a sixteenth characteristic in that when the control means (C) judges by the trouble checking that the oxygen sensor (32) is out of order, the control means (C) determines the correction injection quantity (T1) by using a predetermined air-fuel ratio feedback correction factor (K02) within the limit range (L3) at the time of the trouble, as an alternative value.

[0023] According to the first characteristic, while the variation rate of the output value of the oxygen sensor is changed from the positive to the negative or from the negative to the positive predetermined times after the power source of the vehicle is turned on, the control means sets the first limit range for the air-fuel ratio feedback correction factor as the upper/lower limit value which have the predetermined upper/lower width, in which the output value of the oxygen sensor is detected in a stoicshiometric air-fuel ratio state is the reference value, and which is allowed to be used for calculating the correction injection quantity and, after the variation rate of the output value of the oxygen sensor is changed from the positive to the negative or from the negative to the positive predetermined times, regards the air-fuel ratio feedback correction factor, calculated when the variation rate is changed the predetermined times, as the reference value, and sets the second limit range which has the predetermined upper/lower width from the reference value and is narrower than the first limit range. Therefore, even if a height of a place, at which the vehicle is used, parts accuracy of the vehicle, variation at the time of installing, etc. exert a considerable influence on the air-fuel ratio, the first limit range that is wider than the second limit range is set, so that even in a condition where a large air-fuel ratio feedback correction factor (correction amount) is necessary, it is possible to suitably operate the internal combustion engine.

[0024] Moreover, the switching from the first limit range to the second limit range is performed by detecting the approaching of a stoicshiometric air-fuel ratio based on the change of the variation rate of the oxygen sensor output value, so that it is possible to prevent the application of the air-fuel ratio feedback correction factor that is not calculated at the time of normalcy of the internal combustion engine. Thereby, it is possible to prevent the occurrence of an excessive rich or lean state and to prevent an operationability of the internal combustion engine and an exhaust gas cleaning capability from deteriorating.

[0025] According to the second characteristic, the first limit range is applied only when the power source of the vehicle is initially turned on and, after the power source is turned on from a second time, the second limit range is applied in which an air-fuel ratio feedback correction factor at the time of turning the power source off is made the reference value. Therefore, it is possible to continuously apply the second limit range once set, reduce a calculation load of the control device, and shorten time until an appropriate air-fuel ratio feedback control is started at the time of re-starting of the engine.

[0026] According to the third characteristic, the control means is configured such that it causes the turning-on of the power source of the vehicle to be memorized in the nonvolatile memory section. Therefore, even if the power source of the vehicle is turned off, it is possible to keep a history of the turning-on of the power source and easily judge application requirements for the second limit range.

[0027] According to the fourth characteristic, the first limit range is configured by adding the first numeral value in which the influence that is exerted on the air-fuel ratio by the parts accuracy, variation in assembling, etc. is taken into consideration, the second numeral value in which the influence that is exerted on the air-fuel ration by the open air temperature is taken into consideration, the third numeral value in which the influence that is exerted on the air-fuel ratio by the open air pressure is taken into consideration, the fourth numeral value in which the influence that is exerted on the air-fuel ratio by the height at which the vehicle is used is taken into consideration, and the fifth numeral value in which the influence that is exerted on the fuel-ratio by the concentration of the alcohol in the fuel is taken into consideration, and the second limit range is configured by excepting the first numeral value from the first limit range and adding the sixth numeral value for setting renewal requirements of the air-fuel ratio feedback correction factor. Therefore, it is possible to allow the application of the air-fuel ratio feedback correction factor, in which the influence of the parts accuracy, the variation in assembling, etc. is taken into consideration at an initial phase, smoothly start the internal combustion engine and, after the variation rate of the output value of the oxygen sensor is changed from the positive to the negative or from the negative to the positive the predetermined times, perform the air-fuel ratio feedback control in a narrow limit range after the influence of the parts accuracy, the variation in assembling, etc. is taken into consideration. Moreover, the sixth numeral value setting the renewal requirements of the air-fuel ratio feedback correction factor is added to the second limit range, so that it is possible to widen the upper/lower width of the limit correspondingly to the renewal requirements of the air-fuel ratio feedback correction factor.

[0028] According to the fifth characteristic, the basic injection quantity is derived from the basic injection quantity map which defines the relationship among the throttle opening of the throttle valve provided at the intake device of the internal combustion engine, the number of revolution of the internal combustion engine, and the basic injection quantity. Therefore, it is possible to find the basic injection quantity without taking a value of an intake pressure and a value of an atmospheric pressure into consideration, and an effective air-fuel ratio feedback control is made possible in a vehicle which does not include an intake pressure sensor and an atmospheric pressure sensor.

[0029] According to the sixth characteristic, once the second limit range is applied, the predetermined upper/lower width of the second limit range is continuously applied even if thereafter the renewal of the reference value is performed, so that it is possible to reduce the calculation load of the control means.

[0030] According to the seventh characteristic, the renewal of the reference value is performed in a case where a curve which shows the transition of the air-fuel ratio feedback correction factor is continuously reversed in the deviation width more than the predetermined rate relative to the second limit range and the predetermined times. Therefore, it is possible to successively perform the renewal according to the transition of the air-fuel ratio feedback correction factor, and it is possible to cause the second limit range to be always located at an appropriate position.

[0031] According to the eighth characteristic, the upper absolute limit and the lower absolute limit are previously set for the air-fuel ratio feedback correction factor and even if the air-fuel ratio feedback correction factor which exceeds the upper absolute limit or is less than the lower absolute limit is calculated according to the renewal of the basic value, the value is not applied to the calculation of the correction injection quantity. Therefore, even if the reference value of the second limit range is renewed, the air-fuel ratio feedback correction factor which exceeds the upper and lower absolute limits is not applied and, it is possible to prevent the occurrence of an excessive rich or lean state.

[0032] According to the eleventh characteristic, at the time of normal operation of the internal combustion engine, the control means sets the second limit range for the air-fuel ratio feedback correction factor, as the an upper/lower value that is allowed to be used for calculation of the correction injection quantity, performs trouble checking of the oxygen sensor when detecting that the output of the oxygen sensor becomes the predetermined state, and during performing of the trouble checking, sets the third limit range at the time of the trouble that is smaller than the second limit range, so that it is possible to quickly detect the trouble of the oxygen sensor by always watching the oxygen sensor output. Moreover, during performing the trouble checking, the fuel injection quantity is calculated using the third limit range at the time of the trouble smaller than the second limit range at the normal time, so that even if the oxygen sensor is out of order at the time of starting the trouble checking, a low-reliable air-fuel ratio feedback correction factor just prior to the trouble checking is not applied during trouble checking, and it is possible to prevent occurrence of an excessive rich or lean state.

[0033] According to the twelfth characteristic, the control means starts to perform the trouble checking if predetermined time passes in the state where the output value of the oxygen sensor is substantially 0V or in the state where the output value of the oxygen sensor is substantially 3V, so that it is possible to quickly progress to the trouble checking on the basis of the output value of the oxygen sensor.

[0034] According to the thirteenth characteristic, when the trouble checking is started due to the passage of the predetermined time in the state where the output value of the oxygen sensor is substantially 0V, the control means performs fuel injection for the trouble checking and make a judgment of the trouble by detecting change of the output of the oxygen sensor relative to the fuel injection, so that it is possible to easily make a judgment of the trouble of the oxygen sensor.

[0035] According to the fourteenth characteristic, when it is judged by the trouble checking that the oxygen sensor is normal, the control means stops the trouble checking and returns the third limit range at the time of the trouble to the second limit range, so that when the oxygen sensor is normal, it is possible to quickly make return to the normal air-fuel ratio feedback control.

[0036] According to the fifteenth characteristic, the air-fuel ratio feedback control is performed by the PID control relative to the target output value of the oxygen sensor, the upper gain switch threshold and the lower gain switch threshold which correspond to the function limit of the oxygen sensor are set for the air-fuel ratio feedback correction factor, and the control means makes the gain of the PID control small when the air-fuel ratio feedback correction factor exceeds the upper gain switch threshold or is less than the lower gain switch threshold, so that the gain of the PID control is made larger at the second time of the normal control thereby to make a high response-speed feedback control possible, and when the air-fuel ratio feedback correction factor is considerably deviated, the gain of the PID control is made small to thereby made the response-speed lower, and if the oxygen sensor is out of order, a low reliable air-fuel ratio feedback correction factor can be prevented from exerting a considerable influence on a combustion state.

[0037] According to the sixteenth characteristic, the basic injection quantity is derived from a basic injection quantity map which defines a relationship among a throttle opening of a throttle valve provided at an intake device of the internal combustion engine, the number of revolution of the internal combustion engine, and the basic injection quantity, so that the basic injection quantity can be found without taking an intake pressure and an atmospheric pressure and an effective air-fuel ratio feedback control is made possible in a vehicle which is not provided with an intake pressure sensor or an atmospheric pressure sensor.

[0038] According to the seventeenth characteristic, the second limit range has a predetermined upper/lower width from the reference value, and the third limit range at the time of the trouble is the range in which the reference value is maintained, and the upper limit value and lower limit value of the second limit range are each reduced at the predetermined rate, so that even in a case where the reference value is successively renewed, it is possible to set, on the basis of the newest reference value, the third limit range at the time of the trouble which correspond to a present combustion sate.

[0039] According to the eighteenth characteristic, when the control means judges by the trouble checking that the oxygen sensor is out of order, the control means determines the correction injection quantity by using the predetermined air-fuel ratio feedback correction factor within the third limit range at the time of the trouble, as an alternative value, so that the air-fuel ratio feedback factor which is too large or too small due to the trouble of the oxygen sensor is not applied and an excessive lean or rich state can be prevented from occurring.

[0040]

Fig. 1 is a view showing an entire structure of an internal combustion engine.

Fig. 2 is a block diagram showing a configuration of a control unit.

Fig. 3 is a map for searching a load region of the engine.

Fig. 4 is a map showing an air-fuel ratio feedback region.

Fig. 5 is a view in which Fig. 4 and Fig. 5 are superposed.

Fig. 6 is a concept view showing a configuration of limits set for an air-fuel ratio feedback correction factor.

Fig. 7 is a graph showing a relationship between an output value of an oxygen sensor and an air-fuel ratio.

Fig. 8 is a graph showing one example of output values of the oxygen sensor.

Fig. 9 is a time chart showing transition of the limit set for the air-fuel ratio feedback correction factor.

Fig. 10 is a graph showing a limit setting process at the time of trouble checking of the oxygen sensor.

Fig. 11 is a time chart showing a relationship among the output value of the oxygen sensor, a control gain of the air-fuel ratio feedback control, and the air-fuel ratio feedback correction factor.

Fig. 12 is a graph showing a relationship between K02 and KBU.

Fig. 13 is a flow chart showing a flow of an oxygen sensor trouble checking process.

[0041] Preferable embodiments of the present invention will be explained in detail with reference to the drawings. Fig. 1 is a block diagram illustrating a structure of a fuel injection control system of an internal combustion engine, according to an embodiment of the present invention. A piston 12 is slidably fitted in a cylinder bore 11 of a water-cooled type internal combustion engine E carried on a motorcycle. An intake device 14 for supplying an air-fuel mixture to a combustion chamber 13 to which a top portion of the piston 12 is faced, and an exhaust device 15 for discharging an exhaust gas from the combustion chamber 13 are connected to a cylinder head 16 of the internal combustion engine E. An intake air path 17 is formed in the intake device 14 and an exhaust gas path 18 is formed in the exhaust device 15. A spark plug 20 whose tip end is faced to the combustion chamber 13 is attached to the cylinder head 16.

[0042] The intake device 14 has a throttle valve 21 openably/closably provided therein for controlling an amount of intake air flowing the intake air path 17, and a fuel injection valve 22 provided thereat on an downstream side relative to the throttle valve 21 for injecting fuel. A bypass path 27 which bypasses the throttle valve 21 is connected to the intake air path 17. An amount of air flowing the bypass path 27 is adjusted by an actuator 28. Moreover, a catalyst converter 25 is interposedly provided at the exhaust device 15.

[0043] A control unit C which serves as control means control timing of ignition by the spark plug 20, a quantity of the fuel injection from the fuel injection valve 22, and operation of the actuator 28. A detection value of a throttle sensor 26 for detecting a throttle opening which is an opening of the throttle valve 21, a detection valve of a revolution number sensor 30 for detecting the number of revolution of a crankshaft 29 coupled to the piston 12, a detection value of a water temperature sensor 31 for detecting a water temperature of an engine cooling water, and a detection value of an oxygen sensor (O_2 sensor) 32 attached to the exhaust device 15 on a downstream side relative to the catalyst converter 25 for detecting a concentration of residual oxygen in the exhaust gas flowing the exhaust gas path 18 are inputted to the control unit C.

[0044] Fig. 2 is a block diagram illustrating a configuration of the control unit C. Among the control unit C, a section which controls the injection quantity of the fuel injection valve 22 is provided with basic injection quantity detecting means 34 setting a basic fuel injection quantity for obtaining a target air-fuel ratio, while referring to a basic injection quantity map 33 on the basis of the number of revolution obtained by the revolution number sensor 30 and the throttle opening obtained by the throttle sensor 26, air-fuel ratio feedback correction factor calculating means 35 calculating a feedback correction factor K02 for causing an air-fuel ratio to approach the target air-fuel ratio on the basis of the oxygen concentration obtained by the oxygen sensor 32, correction means 36 correcting the basic fuel injection quantity on the basis of a correction amount obtained by the feedback correction factor calculating means 35, and final fuel injection time calculating means 37 determining fuel injection time corresponding to a final fuel injection quantity obtained by the correction means 36. Thereby, the control unit C can obtain the fuel injection quantity without being based on an intake pressure and an atmospheric pressure.

[0045] The feedback correction factor calculating means 35 includes rich/lean judging means 38 judging a degree of rich/lean of the exhaust gas on the basis of the oxygen concentration detected by the oxygen sensor 32, and parameter calculating means 39 correcting the feedback correction factor K02 and the basic fuel injection quantity T0 on the basis of a judgment result of the rich/lean judging means 38. The parameter calculating means 39 causes a parameter to be memorized in a nonvolatile memory section 40 such as EPROM or a flash memory at a predetermined cycle, and inputs the parameter from the nonvolatile memory section 40 when an ignition key is turned on (at the time of starting the system).

[0046] The parameter calculating means 39 calculates an integral correction factor KT for air-fuel ratio control according to the detection value of the oxygen sensor 32, by a calculation equation: KT=KO2 × KBU, on the basis of the air-fuel feedback correction factor K02 periodically memorized in the nonvolatile memory section 40 and a correction factor KBU corresponding to time-passage change. The correction factor KBU corresponding to time passage change is set per engine load while learning so as to change according to time passage change, such as deterioration of the internal combustion engine E, and memorized in the nonvolatile memory section 40 at a predetermined cycle, its value is maintained even after a power source of the vehicle is turned off (system stopping) and is inputted at the time of system starting next time.

[0047] The air-fuel ratio feedback correction factor K02 is a variable which is temporarily used per predetermined cycle when the air-fuel ratio feedback control is performed. Basically, the feedback control is performed based on the air-fuel ratio feedback correction factor K02, thus causing the air-fuel ratio to approach the target air-fuel ratio. The air-fuel ratio feedback correction factor K02 is set based on the judgment result by the rich/lean judging means 38.

[0048] The parameter calculating means 39 calculates, in a plurality of air-fuel ratio feedback regions, the correction factor KBU corresponding to time passage change, every air-fuel ratio feedback regions, based on the number of the engine revolution NE and the throttle opening TH, calculates the integral correction factor KT using this correction factor KBU corresponding to time passage change, and controls, in load regions of the engine other than the air-fuel ratio feedback regions, the fuel injection quantity, using a learning value of a feedback region adjacent the load region.

[0049] Fig. 3 is a map for searching the load regions of the engine. The control unit C searches where the load regions are present, on the basis of the number NE of revolution of the engine and the throttle opening TH. In this drawing, a set lower limit throttle opening TH02L, a set upper limit throttle opening THO2H, and a plurality of set throttle openings THFB0, THFB1, THFB2, THFB3 between the set lower and upper limit throttle openings TH02L, TH02H are previously set so as to become larger according to increase in the number NE of revolution of the engine and so as to become THO2L<THFB0<THFB1<THFB2<THFB3<THO2H. Solid lines which are indicative of the respective set throttle openings TH02L, THFB0, THFB1, THFB2, THFB3, TH02H show boundary values which are applied to when the throttle opening TH is increased, and broken lines which are adjacent the solid lines show values for giving a hysteresis when they cut across a boundary toward a reduced side.

[0050] Fig. 4 is a map illustrating the air-fuel ratio feedback region. The air-fuel ratio feedback region which is shown by oblique lines is a region which is defined by a set lower limit revolution number NLOP, a set upper limit revolution number NHOP, an idle region upper limit revolution number NTH02, the set lower limit throttle opening TH02L, and the set upper limit throttle opening TH02H. The idle region upper limit revolution number NTH02L is shown with its value on an increased side of the number of the engine NE being indicated by a solid line and with its value on a reduced side of the number of the engine NE being indicated by a broken line. Moreover, the set lower limit throttle opening TH02L and the set upper limit throttle opening TH02H are shown with their values on an increased side of the throttle opening TH being indicated by solid lines and with their values on a reduced side of the throttle opening TH being indicated by broken lines, and they are each set to have the hysteresis.

[0051] Fig. 5 is a view in which the regions defined in Figs. 3 and 4 are superposed. In this drawing, a plurality of load regions which include the plurality of air-fuel ratio feedback regions are set based on the number NE of revolution of the engine and the throttle opening TH. In this embodiment, six air-fuel ratio feedback regions are shown by Nos. "1" to "6" and regions other than the air-fuel ratio feedback regions are shown by Nos. "0", and "7" to "11".

[0052] Boundaries among the plurality of load regions shown in Fig. 5 are set to have systeresises. The air-fuel ratio feedback regions indicated by "1" to "6" are set in such a manner that smaller the throttle opening TH becomes, narrower the air-fuel ratio feedback regions become. When an operation condition of the engine is in an air-fuel ratio feedback, it is detected that it is present in any of the respective air-fuel ratio feedback regions "1" to "6", KBU1-KBU6 which respectively correspond to them are selected and, in the load regions "0" and "7"-"11" of the engine other than the air-fuel ratio feedback regions, the fuel injection quantity is controlled by using KBU1-KBU6 of the air-fuel ratio feedback regions adjacent the load regions.

[0053] The basic injection quantity calculating means 34 calculates the basic fuel injection quantity T0 on the basis of the basic injection quantity map 33. In the correction means 36, the correction fuel injection quantity T1 is found as (T0×KT). The final fuel injection time calculating means 37 finds the fuel injection time corresponding to the correction fuel injection quantity T1. The control unit C controls the quantity of the fuel injection from the fuel injection valve 22 which has performed the learning control for causing the air-fuel ratio based on the detection value of the oxygen sensor 32 to approach the target air-fuel ratio.

[0054] Now, when predetermined time passes in a state where the value of K02 is constant, regarding KBU, KBU1-6 are selected from the map shown in Fig. 5, and the selected KBUx is multiplied by the value of K02 at that time to new KBUx' (KBUx'=KO2×KBUx). When KBUx is renewed to KBUx', the value of K02 is returned to a reference (1.0). Namely, each time the predetermined time passes in the state where the value of K02 is constant, KBUx is renewed to KBUx', KBUx" (=KO2×KBUx')···. While KBUx', KBUx" ···become values equal to the integral correction factor KT at the time of respective renewals, KT=KO2×KBU as described above, so that the value of KT is varied according to the variation of K02 until KBU is next renewed.

[0055] Referring to a graph shown in Fig. 12, a relationship between the above-mentioned K02 and KBU will be concretely explained. In the air-fuel ratio feedback control according to this embodiment, if the correction amount for obtaining the stoichiometric air-fuel ratio is increased, K02 correspondingly becomes a large value but should be set to a value near 1.0 in view of calculation process. Thus, in this embodiment, if the predetermined time passes in the case where the value of K02 is constant, the value of KBU is adapted to be renewed in order to cause the value of K02 to be returned to 1.0.

[0056] In an example shown in Fig. 12, K02 commences to increase from 1.0 at time t1 according to lowering of the oxygen sensor output. Next, the increase of K02 stops at 1.2 at time t2 according to approaching V1 in which the air-fuel ratio becomes a stoichiometric state. Then, KBUx is renewed to KBUx' (1.2=1.2×1.0) at time t3 according to continuation of predetermined time Ta during which K02 is constant, whereby K02 is reduced to 1.0.

[0057] Moreover, in the example shown in Fig. 12, K02 commences to again increase from 1.0 at time t4 according to the lowering of the oxygen sensor output. Next, the increase of K02 stops at 1.2 at time t5 according to convergence of the air-fuel ratio to the stoichiometric state. Then, at time t6, KBUx' is renewed to KBUx'' (1.44=1.2×1.2) according to continuation of predetermined time Tb, whereby K02 is again reduced to 1.0. A renewal value of KBUx is kept, whereby it is functioned as the correction factor corresponding to time-passage change, in which the value of K02 falls in an appropriate range. Incidentally, it is possible to arbitrarily set the predetermined time Ta, Tb.

[0058] The control unit C sets the basic fuel injection quantity for causing the air-fuel ratio to become the target air-fuel ratio, based on the throttle opening and the engine revolution number, and controls the fuel injection quantity without being based on the intake pressure and the atmospheric pressure, by multiplying the basic fuel injection quantity T0 by the feedback correction factor K02 set according to the detection value of the oxygen sensor 32, and the correction factor KBU corresponding to time-passage change, which is set per engine load, while learning so as to vary according to time-passage change of the internal combustion engine E.

[0059] Thereby, it becomes unnecessary to use an intake pressure sensor and an atmospheric pressure sensor in the fuel injection control system, making the cost down of the system and reduction of the number of parts possible. Particularly, in a region of a low throttle opening, it is possible to perform the air-fuel ratio control taking into consideration of friction change of the internal combustion engine E, and deterioration of the engine such as change of an intake amount due to adhering of soot to the throttle valve 21. Moreover, the property of output deviation of the throttle sensor 26 shows a high tendency to depend upon the throttle opening and, even if the output deviation is increased in a region of a high throttle opening, it is possible to set an appropriate air-fuel ratio.

[0060] In the air-fuel ratio feedback region, the control unit C performs the fuel injection control using the air-fuel ratio feedback correction factor K02 and the correction factor KBU corresponding to time-passage change. Moreover, the air-fuel ratio feedback region is set in such a manner that smaller the throttle opening becomes, narrower the air-fuel ratio feedback region becomes, so that more appropriate air-fuel ratio control can be performed by performing a fine learning control in a low throttle opening region which is easy to be subjected to an influence of deterioration of a bypass valve, etc.

[0061] Incidentally, when the air-fuel ratio feedback control is applied, if the air-fuel ratio feedback correction factor K02, i.e., the feedback correction amount becomes too large or too small due to any cause, there is a possibility that enriching or enleaning will be excessively performed, so that, in order to prevent this, it is conceivable to set a limit value for the air-fuel ratio feedback correction factor K02. On the other hand, the intake pressure sensor and the atmospheric pressure sensor are omitted, so that in a fuel injection control system which is adapted to also compensate for a correction amount of the fuel injection quantity which corresponds to the intake pressure and the atmospheric pressure, by the air-fuel ratio feedback control, the necessity of increasing the limit for the air-fuel ratio feedback correction amount is raised in order that appropriate stoichiometric combustion can be performed, for example, even when the vehicle is used at a high ground exceeding 2000m.

[0062] Moreover, when the limit for the correction amount is set to a value in which an influence exerted upon the air-fuel ratio by parts accuracy of the vehicle, variation at the time of installing, etc. is taken into consideration, even if the vehicle is in various states, it is possible to perform the appropriate stoichiometric combustion by applying a feedback correction amount according to this.

[0063] The present invention is characterized in that the setting of the limit is devised in such a manner that both, namely, an advantage of setting the limit for the air-fuel ratio feedback correction amount and an advantage of increasing the limit are satisfied at the same time. Concretely, when the internal combustion engine (engine) is initially started, the limit for the air-fuel ratio feedback correction amount is widely set, and after the initial engine starting, when a variation region of the air-fuel ratio feedback correction factor K02 which is estimated thereafter is learned, the limit is narrowed.

[0064] Fig. 6 is a concept view illustrating a configuration of the limit set for the air-fuel ratio feedback correction factor K02. An illustrated graph on the left side shows a first limit range L1 which is applied to when the engine of the vehicle is initially started. On the other hand, an illustrated graph on the right side shows a second limit range L2 (normal limit range) which is applied to when predetermined conditions are satisfied after the power source of the vehicle is initially turned on and the engine is then started.

[0065] The first limit range L1 and the second limit range L2 are ranges, in which the air-fuel ratio feedback correction factor K02 for causing the air-fuel ratio at the time of engine driving to approach the stoicshiometric air-fuel ratio is allowed by any value during the engine driving, in other word, upper and lower limit values of the air-fuel ratio feedback correction factor K02 which are allowed to be used for calculating the correction injection quantity. An upper/lower width which is consisted of the upper and lower limit values MAX2, MIN2 of the second limit range L2 is set so as to be smaller than an upper/lower width which is consisted of the upper and lower limit values MAX1, MIN1 of the first limit range L1. The first limit range L1 is set so as to be a limit in which good operation state of the engine cannot be anticipated with an application range of the air-fuel ratio feedback correction factor K02, namely, is set so as to be smaller than upper and lower absolute limits MAXLIM, MINLIM and larger than the second limit range L2.

[0066] Incidentally, whether or not the starting of the engine is initially performed is judged based on whether or not a starting history remains in the nonvolatile memory section 40 in the control unit C. This starting history can be set, for example, in such a manner that tests of a finished vehicle in a factory, etc. are excluded from it and it is recorded when an engine is initially started after the vehicle is received by a dealer. In this embodiment, after the vehicle is received by the dealer, a battery is connected to the vehicle, a power source of the vehicle is initially turned on and, when the engine is started, the first limit range L1 is adapted to be applied to. Once the first limit range L1 is switched to the second limit range L2, thereafter the second limit range L2 is continuously applied and the first limit range L1 is not applied again.

[0067] The first limit range L1 has a predetermined upper/lower width as a reference B1 of the output value of the oxygen sensor 32 which is detected in the stoichiometric air-fuel ratio state, and is configured by adding a first numeral value S1 in which an influence that is exerted on the air-fuel ratio by the parts accuracy, variation in assembling, etc. is taken into consideration, a second numeral value S2 in which an influence that is exerted on the air-fuel ration by an open air temperature is taken into consideration, a third numeral value S3 in which an influence that is exerted on the air-fuel ratio by an open air pressure is taken into consideration, a fourth numeral value S4 in which an influence that is exerted on the air-fuel ratio by a height at which the vehicle is used is taken into consideration, and a fifth numeral value S5 in which an influence that is exerted on the fuel-ratio by a concentration of alcohol in the fuel is taken into consideration.

[0068] On the other hand, the second limit range L2 is configured by reducing the first numeral value S1 from the first limit range and adding a sixth numeral value S6 which sets renewal requirements of the air-fuel ratio feedback correction factor K02. Thereby, it is possible widen the upper/lower width of the limit correspondingly to the renewal requirements of the air-fuel ratio feedback correction factor.

[0069] In this embodiment, after the power source of the vehicle is turned on and the engine is started, if a variation rate of the output value of the oxygen sensor 32 is varied from the positive to the negative or from the negative to the positive predetermined times (for example, three times), the first limit range L1 is switched to the second limit range L2.

[0070] Fig. 7 is a graph illustrating a relationship between the output value of the oxygen sensor 32 and the air-fuel ratio. Moreover, Fig. 8 is a graph illustrating one example of the output values of the oxygen sensor 32. As shown in Fig. 7, the oxygen sensor 32 according to this embodiment exhibits a step-shaped output in a border of the theoretical (stoichiometric) air-fuel ratio state. Thereby, when a combustion state approaches the stoichiometric air-fuel ratio λs after the starting of the engine, the output value of the oxygen sensor 32 outputting a predetermined voltage Vs at the time of the stoichiometric air-fuel ratio tends to converge to a predetermined voltage Vs while reducing its deviation width, as shown in Fig. 8. At this time, the change of the variation rate of the output value of the oxygen sensor 32 from the positive to the negative or from the negative to the positive is regarded as "reverse of the output value" and it is possible to count the number of the reverse. In this embodiment, it is judged that the reverse of the output value of the oxygen sensor 32 is performed three times at time ts after the starting of the engine, whereby it is possible to switch the first limit range L1 to the second limit range L2.

[0071] Fig. 9 is a time chart which illustrates a transition of the limit set for the air-fuel ratio feedback correction factor K02. At the time t1, the power source of the vehicle is turn on in order to start the engine, and the application of the first limit range L1 is started. Thereby, even if the height of the place, at which the vehicle is used, the parts accuracy of the vehicle, the variation at the time of installing, etc. significantly exert the influences on the air-fuel ratio, the first limit range which is wider than the second limit range is set, so that it is possible to suitably operate the internal combustion engine using the large air-fuel ratio feedback correction factor K02.

[0072] Next, when the engine is started and it is detected that the output value of the oxygen sensor 32 is reversed three times at the time t2, the application of the second limit range consisted of the upper and lower limit values MAX2, MIN2 as a reference value B2 based on the air-fuel ratio feedback correction factor K02 at that time is started. Thereafter, a reference value which defines a shown position of the second limit range L2 in a vertical direction is renewed each time the renewal requirements are satisfied. Namely, the upper/lower width of the second limit range L2 is also invariable after the renewal of the reference value and only moves in the shown vertical direction each time the reference value is renewed.

[0073] The renewal of the reference value after the shifting to the second limit range L2 is performed in a case where a curve (not shown) which shows the transition of the air-fuel ratio feedback correction factor K02 is continuously reversed in a deviation width more than a predetermined rate (for example, more than 6%) and predetermined times (for example, three times). The sixth numeral value S6 is set as an allowance width of the renewal requirements of the reference value. In this drawing, at the time t3, the first renewal of the reference value is performed and the reference value becomes B3 from B2. Incidentally, in the time chart, the reference values are connected to each other by broken lines for sake of explanation but the reference values are invariable until the next renewal time and, for example, the reference value B2 is applied without being varied until the renewal time at the time t3.

[0074] At the time t4, the renewal requirements are satisfied and the second renewal of the reference value is performed. In this renewal, the upper and lower limit values of the second limit range L2 become MAX4, MIN4 as the reference value is renewed to B4 from B3. In this case, the upper limit value MAX4 exceeds the upper absolute limit MAXLIM. However, even if the air-fuel ratio feedback correction factor K02 which exceeds the upper absolute limit MAXLIM is calculated, its value is used for calculating of the correction injection quantity T1.

[0075] At the time t5, the renewal requirements are satisfied and the third renewal of the reference value is performed. In this renewal, the upper and lower limit values of the second limit range L2 become MAX5, MIN5 according to the renewal of the reference value to B5 from B4. Thereafter, at the time t6, the power source of the vehicle is turned off.

[0076] Then, if the power source of the vehicle is again turned on at the time t7, the reference value B5 which has been memorized in the nonvolatile memory section 40 from the time t5 is retrieved and the second limit range L2 which is consisted of the upper and lower limit values MAX5, MIN5 based on the reference value B5 is set.

[0077] Fig. 10 is a graph which shows a process for setting the limit at the time of checking the trouble of the oxygen sensor 32. The fuel injection control system according to this embodiment is configured in such a manner that it is shifted to a trouble checking mode if it is detected that the output value of the oxygen sensor 32 is not normal, and performs the trouble checking of the oxygen sensor 32. It is configured in such a manner that, when it is shifted to the trouble checking mode, in lieu of the second limit range L2 having been continuously applied, it applies a third limit range L3 (limit range at the trouble time) whose upper/lower width is smaller than the second limit range L2.

[0078] The oxygen sensor 32 according to this embodiment is configured so as to be capable of outputting substantially 0-3V which is within a small deviation range (for example, 0.6-1.5V) around an output value (for example, 1V) corresponding to the stoicshiometric air-fuel ratio at the time of normal operation during performing of the normal feedback control.

[0079] This embodiment is configured such that it is switched over to the trouble checking mode from a normal mode, if a sensor output of substantially 3V continues at predetermined time or a sensor output of substantially 0V continues at the predetermined time. In the case where the sensor output of substantially 3v continues at the predetermined time, it is switched over to the trouble checking mode and it is judged that the oxygen sensor 32 is out of order at that time. On the other hand, in the case where the sensor output of substantially 0V continues at the predetermined time, the fuel injection quantity is increased by a predetermined quantity after switching over to the trouble checking mode, and the trouble checking is performed by detecting whether or not variation of the output value that corresponds to the increased quantity occurs. For example, in a case where, when the engine is in a high revolution and high load state and the substantially 0V is outputted, even if the fuel injection quantity is increased, the output value is not varied, it is judged that the oxygen sensor 32 is out of order.

[0080] A graph (a) shows a relationship between the second limit range L2 and the third limit range L3. The second limit range L2 that has been continuously applied to from the time t1 is replaced with the third limit range L3 by rushing into the trouble checking mode at the time t2. The third limit range L3 is a range in which an upper limit value MAXa and a lower limit value MINa of the second limit range L2 are reduced at predetermined rates while keeping a reference value Ba and made an upper limit value MAXb and a lower limit value MINb.

[0081] A graph (b) shows a relationship between the air-fuel ratio feedback correction factor K02 and the limit ranges. In the example of this drawing, since the shifting to the trouble checking mode is performed at the time t2 during rising of K02, so that K02 is kept at the upper limit value MAXb of the third limit range L3 from the time t2. Thereby, even if the calculation value of K02 becomes an abnormal value due to the trouble of the oxygen sensor 32, a value that is applied for calculation of the correction injection quantity T1 during the rushing into the trouble checking mode does not exceed the upper limit value MAXb and the lower limit value MINb. Therefore, excessive enleaning or enriching is prevented from occurring during the trouble checking.

[0082] In a case where, as a result of a trouble checking process in the trouble checking mode, it is judged that the oxygen sensor 32 is out of order, an appropriate air-fuel feedback factor K02 within the third limit range L3 is applied as an alternative value and a warning can be provided by any warning means which is provided at a meter device, etc. of the vehicle. On the other hand, in a case where it is judge that the oxygen sensor 32 is normal, the trouble checking mode is shifted to the normal mode and the third limit range L3 is returned to the second limit range L2.

[0083] Referring now to a flow chart of Fig. 13, the flow of the oxygen sensor trouble checking process is cleared. In step S1, the output of the oxygen sensor 32 is detected and, in step S2, it is judged whether or not the output of substantially 3V or the output of substantially 0V continues over the predetermined time. If the positive judgment is made in step S2, the process progresses to step S3 in which the shifting of the trouble checking mode from the normal mode is performed. On the other hand, if the negative judgment is made in step S2, the process is returned to step S1.

[0084] In subsequent step S4, shifting of the third limit range (limit range at the time of trouble) L3 from the second limit range (limit range at the time of normalcy) L2 is performed according to the shifting to the trouble checking mode. Then, in step S5, whether or not shifting to the trouble checking mode is performed due to the output of substantially 0V and the increase of the fuel injection quantity is performed if the positive judgment is made. In step S7, whether or not variation of the output of the oxygen sensor 32 occurs is judged, and the process progresses to step S8 if the negative judgment is made. Moreover, if the negative judgment is made in step S5, namely, if it is judged that the shifting to the trouble checking mode is performed due to the output of substantially 3V, the process skips the steps S6, S7 and progresses to S8. In step S8, it is judged that the oxygen sensor 32 is out of order, an alternative value is applied to K02, and a series of controls is finished. This alternative value can be made a predetermined value which corresponds to the appropriate value within the third limit range or the stoicshiometric air-fuel ratio.

[0085] Moreover, if the positive judgment is made in step S7, namely, if the output of the oxygen sensor 32 is varied relative to the increase of the injection quantity, the process progresses to step S9 in which it is judged that the oxygen sensor is normal, the trouble checking mode is returned to the normal mode, and the series of controls is finished.

[0086] Fig. 11 is a time chart which shows a relationship among the output value of the oxygen sensor 32, a control gain of the air-fuel ratio feedback control, and the air-fuel ratio feedback correction factor. In the fuel injection control system according to this embodiment, if the calculation value of the air-fuel ratio feedback correction factor K02 exceeds a predetermined value during the air-fuel ratio control, a large PID control gain that is applied at the time of normalcy is adapted to be replaced with a small PID control gain.

[0087] In the example of this drawing, an output voltage of the oxygen sensor 32 exceeds Va at the time t1 and the feedback correction factor K02 starts to rise toward an upper gain switch threshold HI according to this. Then, at the time t2, the air-fuel ratio correction factor K02 arrives at the upper gain switch threshold HI, and the control gain is switched to a smaller value.

[0088] If the control gain becomes small, a speed of response of the feedback correction factor K02 relative to the output value of the oxygen sensor 32 is lowered and it is possible to reduce an influence that is exerted upon the feedback correction factor K02, for example, even if the oxygen sensor 32 is out of order and outputs an abnormal output value. Namely, at the time of the normal control, the large control gain is applied, thus making the feedback control of a high response speed possible and, if the air-fuel ratio feedback correction factor is too large or too small, the control gain is made small, to thereby lower the response speed, and it is possible to prevent a low reliable air-fuel ratio feedback correction factor K02 from exerting upon the combustion state if the oxygen sensor is out of order.

[0089] Incidentally, the switching of the control gain is performed also in the case where the air-fuel ratio feedback correction factor K02 is less than a lower gain switch threshold L0. The upper gain switch threshold HI and the lower gain switch threshold LO are each set to a value corresponding to a function limit of the oxygen sensor 32. When the output value of the oxygen sensor 32 satisfies the requirements for rushing into the trouble checking mode, the process progresses to the trouble checking mode.

[0090] Incidentally, the configuration of the control unit, the structure and form of the oxygen sensor, the setting widths of the first and second limit ranges, etc. are not limited to those of the above embodiment and various modifications are made possible. While the case where the fuel injection control system according to the present invention is applied to the motorcycle is not limited, it can be applied to various vehicles, such as saddle-ride type three-wheeled/four-wheeled vehicles, general purpose engines, etc.

Reference Signs List

[0091]

14··· Intake device,
15··· Exhaust device,
21··· Throttle valve,
22··· Fuel injection valve,
26··· Throttle sensor,
30··· Revolution number sensor,
32··· Oxygen sensor,
33··· Basic injection quantity map,
34··· Basic injection quantity calculating means,
35··· Feedback correction factor calculating means,
36··· Correction means,
37··· Final fuel injection time calculating means,
E··· Internal combustion engine (Engine),
C··· Control unit (Control means),
KO2··· Air-fuel ratio feedback correction factor,
L1··· First limit range,
L2··· Second limit range (Normal limit range),
L3··· Third limit range (Limit range at the time of trou-

ble),

S1-S6··· First numeral value to sixth numeral value

Claims

1. A fuel injection control system comprising:

control means (C) which calculate an air-fuel ratio feedback correction factor (K02) used for a feedback control in order to obtain a target air-fuel ratio, on the basis of an output of an oxygen sensor (32) provided at an exhaust device (15) of an internal combustion engine (E) serving as a drive source of a vehicle, and determines a correction injection quantity (T1) by multiplying a basic injection quantity (T0) by the air-fuel ratio feedback correction factor (K02),
wherein: while a variation rate of an output value of the oxygen sensor (32) is changed from the positive to the negative or from the negative to the positive predetermined times after a power source of the vehicle is turned on, the control unit (C) sets a first limit range (L1) for the air-fuel ratio feedback correction factor (K02) as an upper/lower limit value which have a predetermined upper/lower width, in which the output value of the oxygen sensor (32) detected in a stoicshiometric air-fuel ratio state is a reference value (B1), and which is allowed to be used for calculating the correction injection quantity (T1); and
after a variation rate of the output value of the oxygen sensor (32) is changed from the positive to the negative or from the negative to the positive predetermined times, regards the air-fuel ratio feedback correction factor (K02), calculated when the variation rate is changed the predetermined times, as a reference value (B2), and sets a second limit range (L2) which has a predetermined upper/lower width from the reference value (B2) and is narrower than the first limit range (L1).

2. The fuel injection control system according to claim 1,
wherein: the first limit range (L1) is applied only when the power source of the vehicle is initially turned on; and
after the power source is turned on from a second time, the second limit range (L2) is applied in which the air-fuel ratio feedback correction factor (K02) at the time of turning the power source off at the last time is made a reference value.

3. The fuel injection control system according to claim 2,
wherein the control means (C) is configured such that it causes the turning-on of the power source of the vehicle to be memorized in a nonvolatile memory section (40).

4. The fuel injection control system according to any of claims 1 to 3,
wherein: the first limit range (L1) is configured by adding a first numeral value (S1) in which an influence that is exerted on the air-fuel ratio by the parts accuracy, variation in assembling, etc. is taken into consideration, a second numeral value (S2) in which an influence that is exerted on the air-fuel ration by an open air temperature is taken into consideration, a third numeral value (S3) in which an influence that is exerted on the air-fuel ratio by an open air pressure is taken into consideration, a fourth numeral value (S4) in which an influence that is exerted on the air-fuel ratio by a height at which the vehicle is used is taken into consideration, and a fifth numeral value (S5) in which an influence that is exerted on the fuel-ratio by a concentration of alcohol in the fuel is taken into consideration; and
the second limit range (L2) is configured by excepting the first numeral value (S1) from the first limit range (L1) and adding a sixth numeral value (S6) for setting renewal requirements of the air-fuel ratio feedback correction factor (K02).

5. The fuel injection control system according to any of claims 1 to 4, wherein the basic injection quantity (T0) is derived from a basic injection quantity map (33) which defines a relationship among a throttle opening (TH) of a throttle valve (21) provided at an intake device (14) of the internal combustion engine (E), the number (NE) of revolution of the internal combustion engine (E), and the basic injection quantity (T0).

6. The fuel injection control system according to any of claims 1 to 5, wherein once the second limit range (L2) is applied, a predetermined upper/lower width of the second limit range (L2) is continuously applied even if thereafter renewal of the reference value (B2) is performed.

7. The fuel injection control system according to claim 6,
wherein the renewal of the reference value (B2) is performed in a case where a curve which shows transition of the air-fuel ratio feedback correction factor (K02) is continuously reversed in a deviation width more than a predetermined rate relative to the second limit range (L2) and predetermined times.

8. The fuel injection control system according to claim 7, wherein an upper absolute limit (MAXLIM) and a lower absolute limit (MINLIM) are previously set for the air-fuel ratio feedback correction factor (K02) and even if the air-fuel ratio feedback correction factor (K02) which exceeds the upper absolute limit (MAXLIM) or is less than the lower absolute limit (MINLIM) is calculated according to the renewal of the basic value (B2), the value is not applied to calculation of the correction injection quantity (T1).

9. A fuel injection control system according to any of claims 1 to 8,
wherein the control means (C) performs trouble checking of the oxygen sensor (32) when detecting that the output of the oxygen sensor (32) becomes a predetermined state; and
during performing of the trouble checking, sets a third limit range (L3) at the time of the trouble that is smaller than the second limit range (L2).

10. The fuel injection control system according to claim 9, wherein the control means (C) starts to perform the trouble checking of the oxygen sensor (32) if predetermined time passes in a state where an output value of the oxygen sensor (32) is substantially 0V or in a state where the output value of the oxygen sensor (32) is substantially 3V.

11. The fuel injection control system according to claim 10, wherein when the trouble checking is started due to the passage of the predetermined time in the state where the output value of the oxygen sensor (32) is substantially 0V, the control means (C) performs fuel injection for the trouble checking and make a judgement of the trouble by detecting change of the output of the oxygen sensor (32) relative to the fuel injection.

12. The fuel injection control system according to any of claims 9 to 11, wherein when it is judged by the trouble checking that the oxygen sensor (32) is normal, the control means (C) stops the trouble checking and returns the third limit range (L3) at the time of the trouble to the second limit range (L2).

13. The fuel injection control system according to any of claims 9 to 12,
wherein: the air-fuel ratio feedback control is performed by a PID control relative to a target output value of the oxygen sensor (32);
an upper gain switch threshold (HI) and a lower gain switch threshold (LO) which correspond to a function limit of the oxygen sensor (32) are set for the air-fuel ratio feedback correction factor (K02); and
the control means (C) makes a gain of the PID control small when the air-fuel ratio feedback correction factor (K02) exceeds the upper gain switch threshold (HI) or is less than the lower gain switch threshold (LO).

14. The fuel injection control system according to any of claims 9 to 13, wherein the basic injection quantity (T0) is derived from a basic injection quantity map (33) which defines a relationship among a throttle opening (TH) of a throttle valve (21) provided at an intake device (14) of the internal combustion engine (E), the number (NE) of revolution of the internal combustion engine (E), and the basic injection quantity (T0).

15. The fuel injection control system according to any of claims 9 to 14, wherein the second limit range (L2) has a predetermined upper/lower width from a reference value (Ba), and the limit range (L3) at the time of the trouble is a range in which the reference value (Ba) is maintained, and an upper limit value (MAXa) and lower limit value (MINa) of the second limit range (L2) are each reduced at a predetermined rate.

16. The fuel injection control system according to any of claims 9 to 15, wherein when the control means (C) judges by the trouble checking that the oxygen sensor (32) is out of order, the control means (C) determines the correction injection quantity (T1) by using a predetermined air-fuel ratio feedback correction factor (K02) within the third limit range (L3) at the time of the trouble, as an alternative value.

FIG. 1

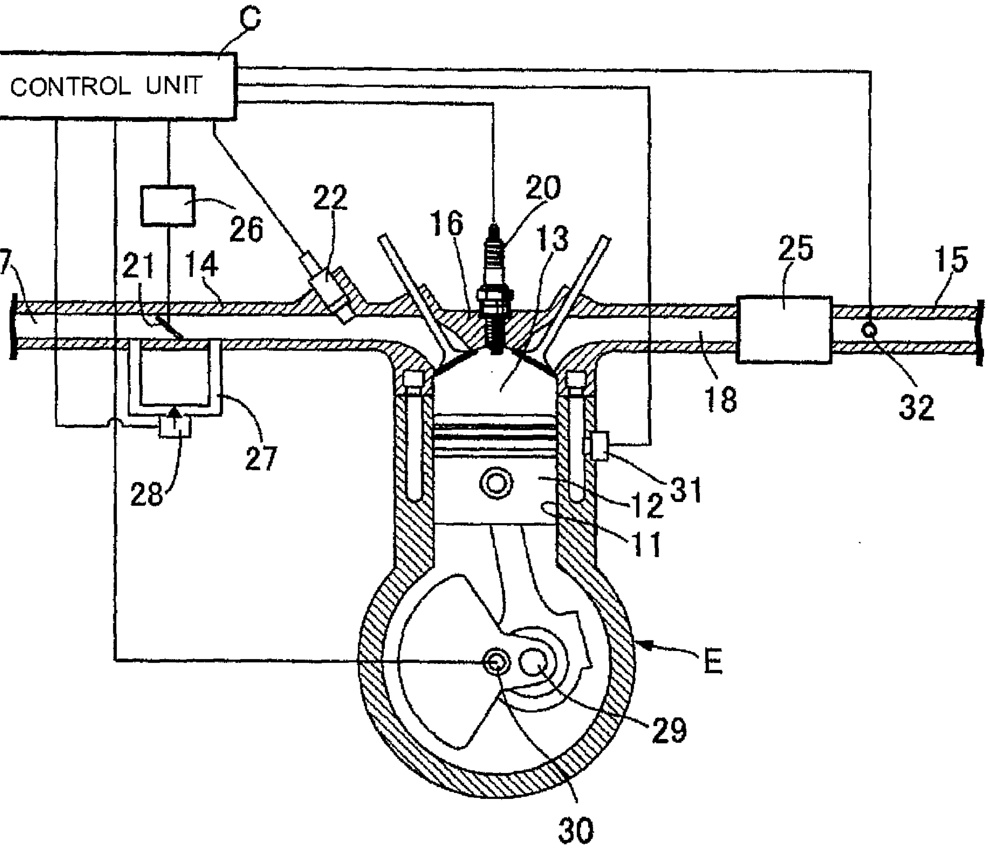

C
CONTROL UNIT
20
22
16
13
26
25
15
17
21
14
18
32
27
31
28
12
11
E
29
30

FIG. 2

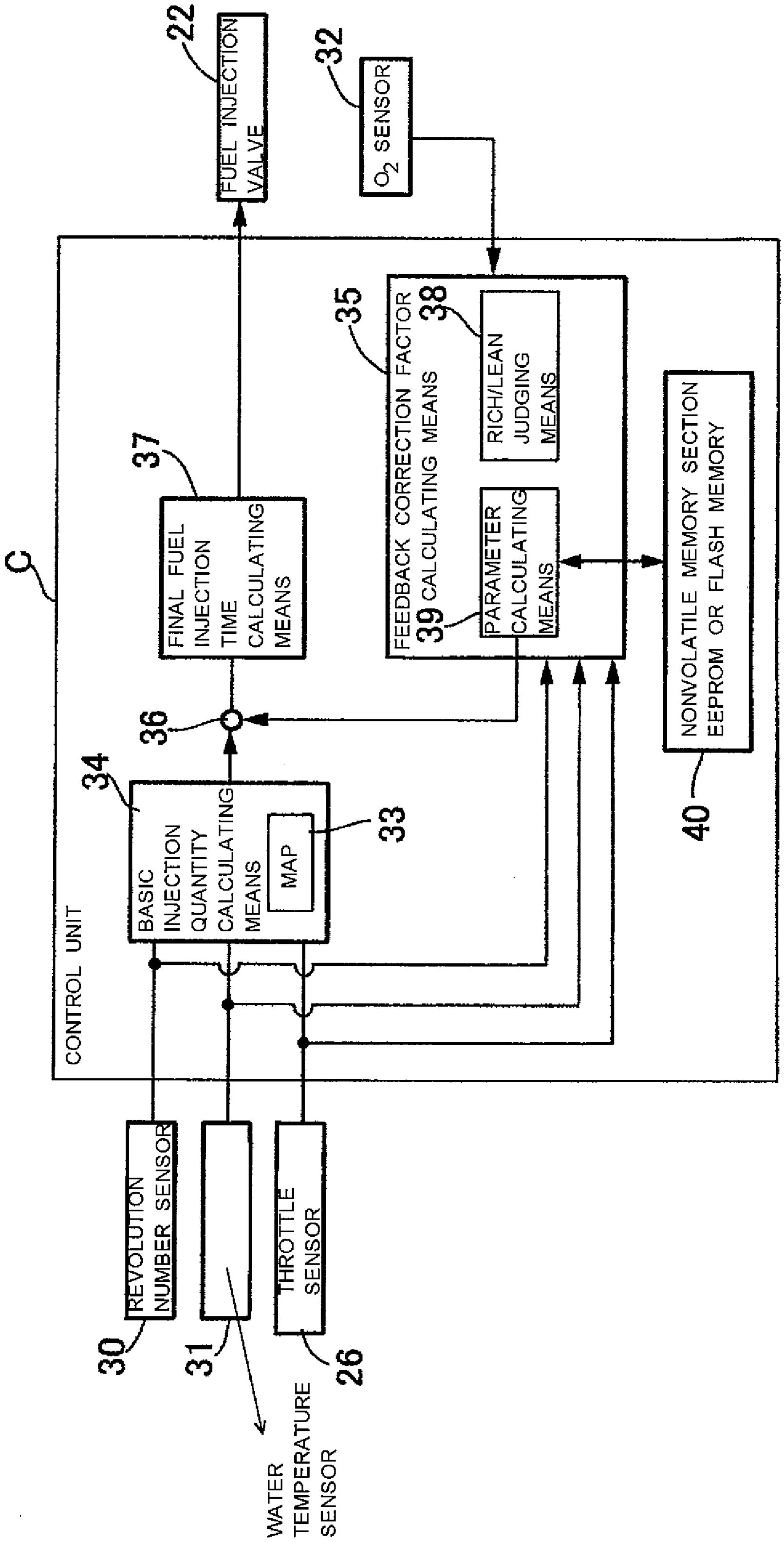

FUEL INJECTION VALVE
22
O2 SENSOR
32
C
CONTROL UNIT
FEEDBACK CORRECTION FACTOR CALCULATING MEANS
35
RICH/LEAN JUDGING MEANS
38
PARAMETER CALCULATING MEANS
39
FINAL FUEL INJECTION TIME CALCULATING MEANS
37
36
BASIC INJECTION QUANTITY CALCULATING MEANS
34
MAP
33
NONVOLATILE MEMORY SECTION EEPROM OR FLASH MEMORY
40
REVOLUTION NUMBER SENSOR
30
31
WATER TEMPERATURE SENSOR
THROTTLE SENSOR
26

FIG. 3

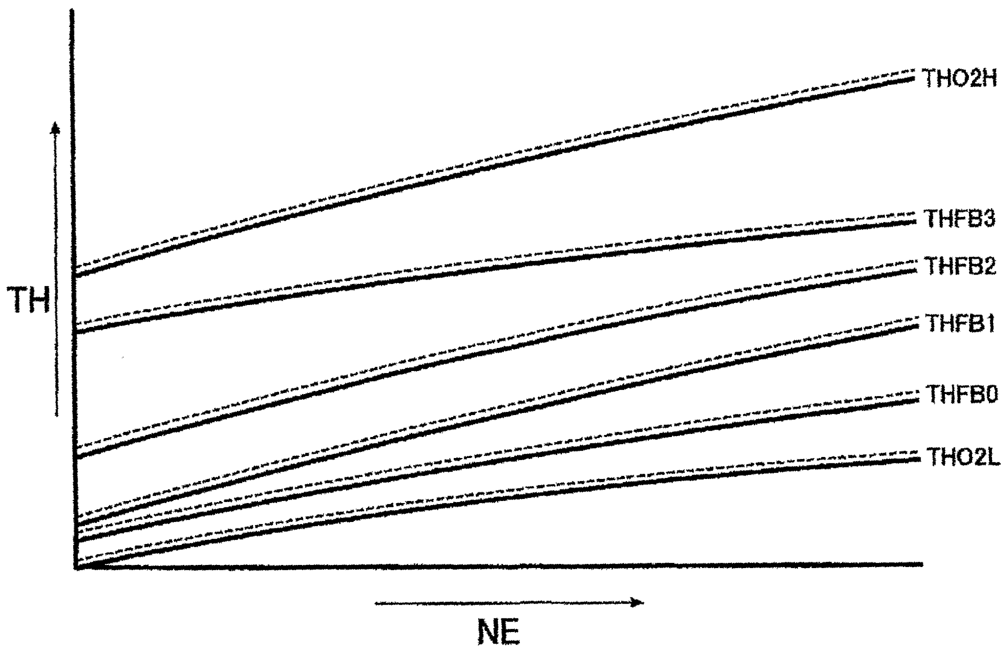

THO2H
THFB3
THFB2
THFB1
THFB0
THO2L
TH
NE

FIG. 4

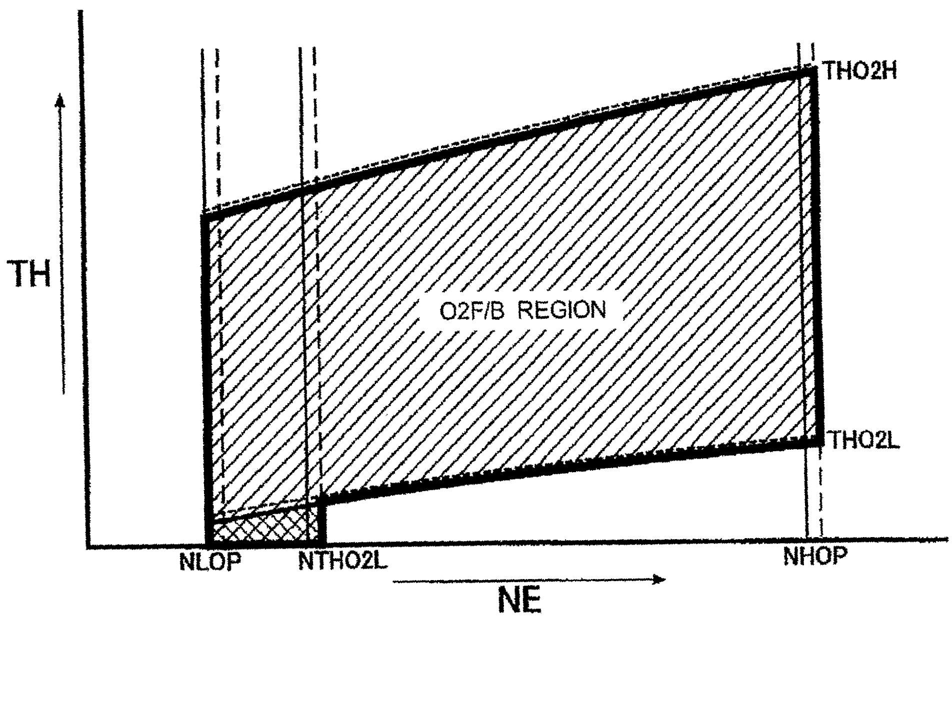

THO2H
TH
O2F/B REGION
THO2L
NLOP
NTHO2L
NHOP
NE

FIG. 5

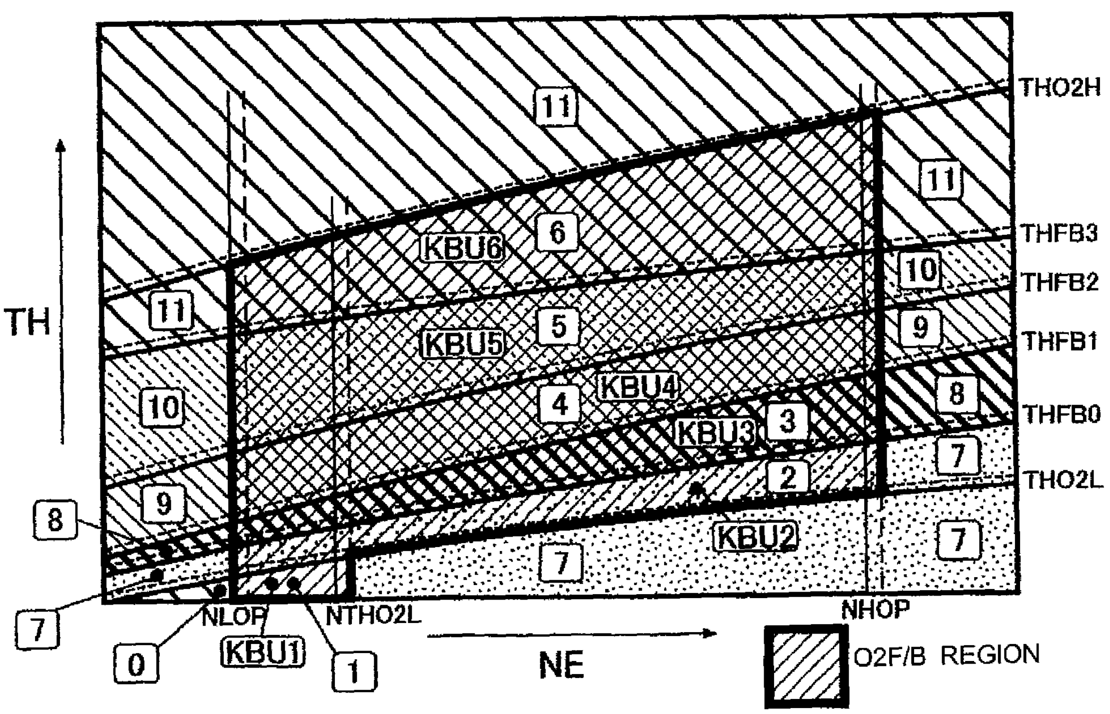

11
11
6
KBU6
THO2H
THFB3
10
THFB2
11
KBU5
5
9
THFB1
TH
10
4
KBU4
8
THFB0
KBU3
3
7
2
THO2L
9
8
KBU2
7
7
7
NLOP
NTHO2L
NHOP
7
0
KBU1
1
NE
O2F/B REGION

FIG. 6

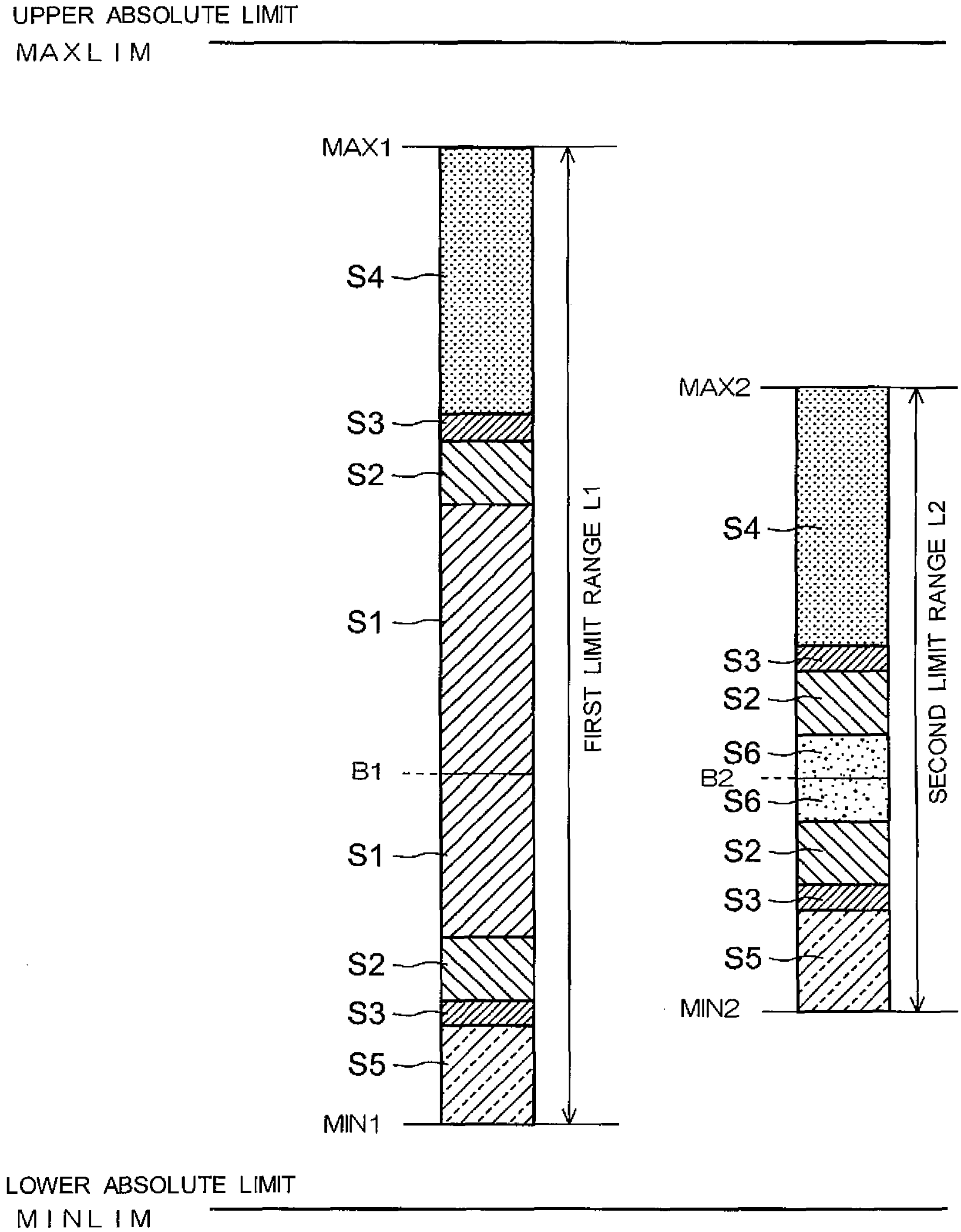

UPPER ABSOLUTE LIMIT
MAXLIM
MAX1
S4
S3
S2
S1
B1
S1
S2
S3
S5
MIN1
FIRST LIMIT RANGE L1
MAX2
S4
S3
S2
S6
B2
S6
S2
S3
S5
MIN2
SECOND LIMIT RANGE L2
LOWER ABSOLUTE LIMIT
MINLIM

FIG. 7

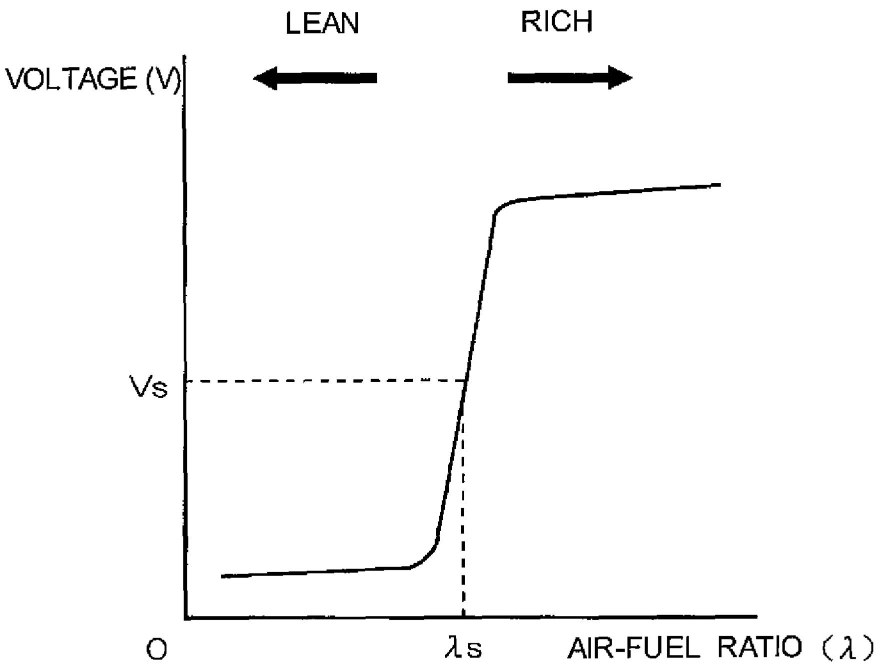

LEAN
RICH
VOLTAGE (V)
Vs
O
λs
AIR-FUEL RATIO (λ)

FIG. 8

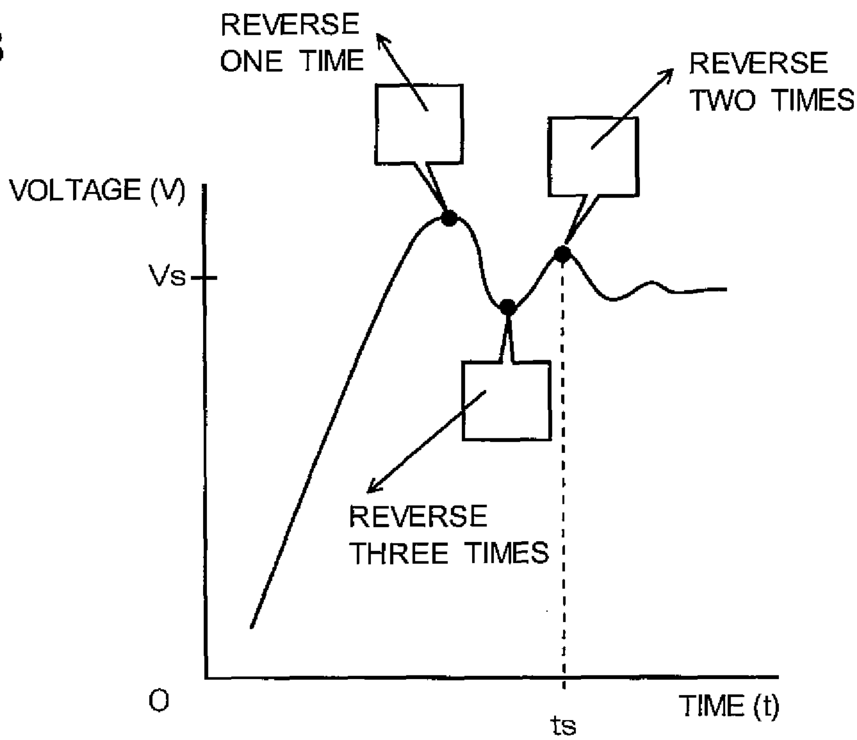

REVERSE
ONE TIME
REVERSE
TWO TIMES
VOLTAGE (V)
Vs
REVERSE
THREE TIMES
O
ts
TIME (t)

FIG. 9

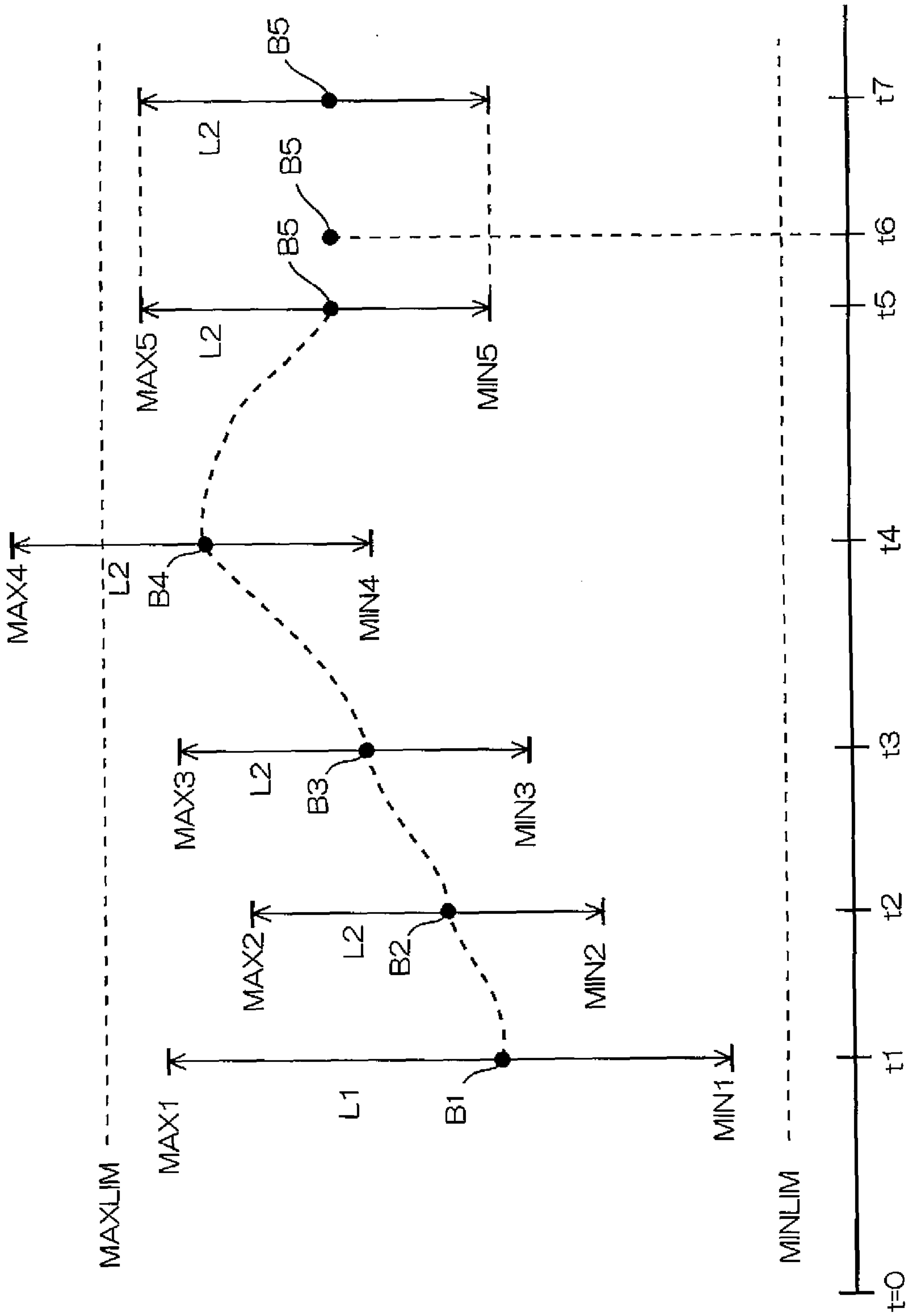

MAXLIM
MINLIM
MAX1
MIN1
L1
B1
MAX2
MIN2
L2
B2
MAX3
MIN3
L2
B3
MAX4
MIN4
L2
B4
MAX5
MIN5
L2
B5
B5
B5
L2
t=O
t1
t2
t3
t4
t5
t6
t7

FIG. 10

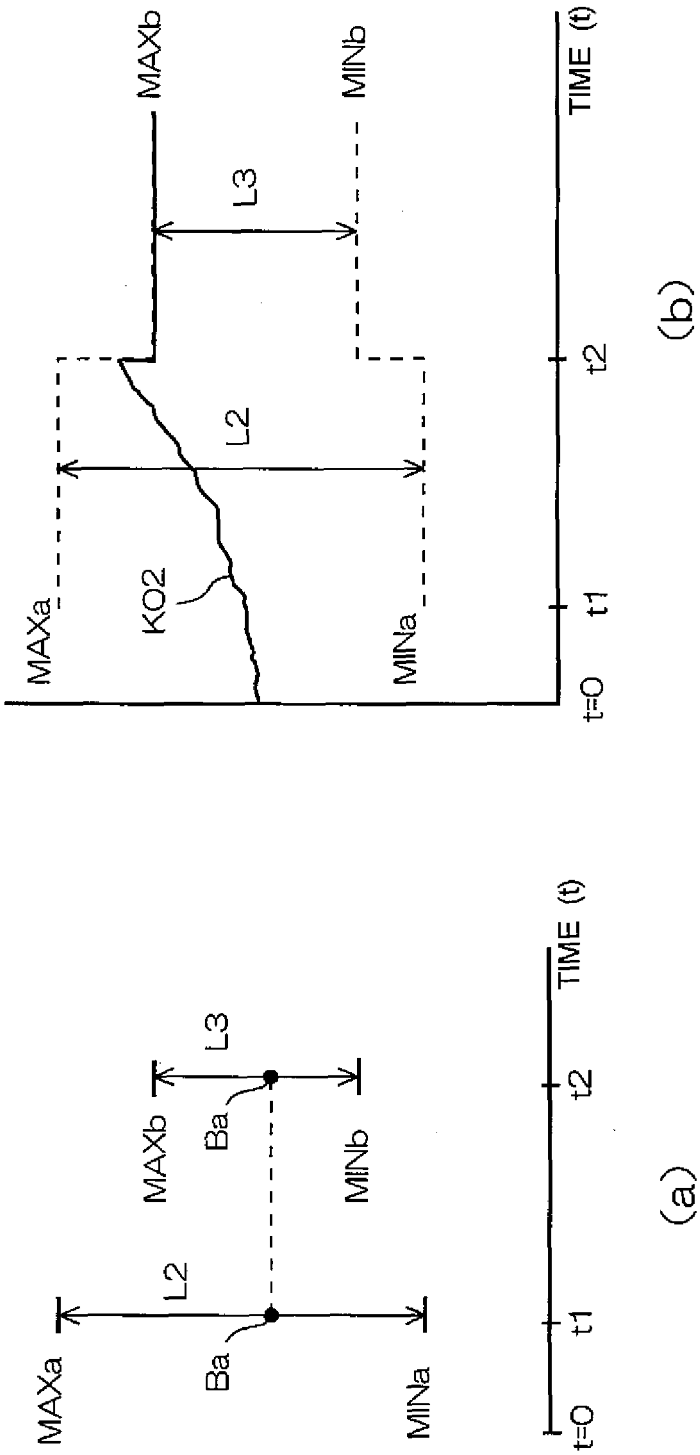

MAXb
MINb
TIME (t)
L3
L2
MAXa
KO2
MINa
t=O
t1
t2
(b)
MAXa
Ba
MINa
L2
MAXb
Ba
MINb
L3
TIME (t)
t=O
t1
t2
(a)

FIG. 11

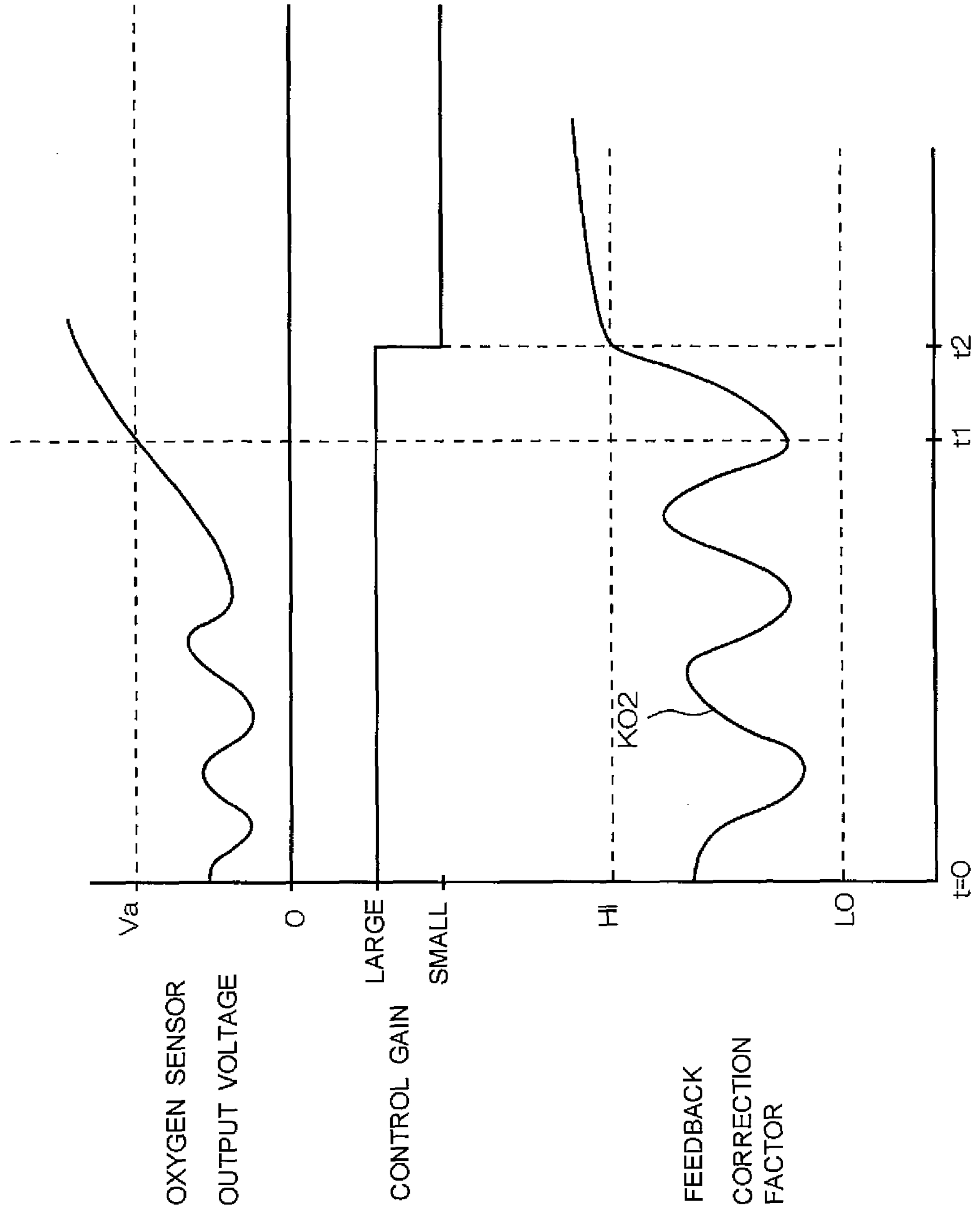
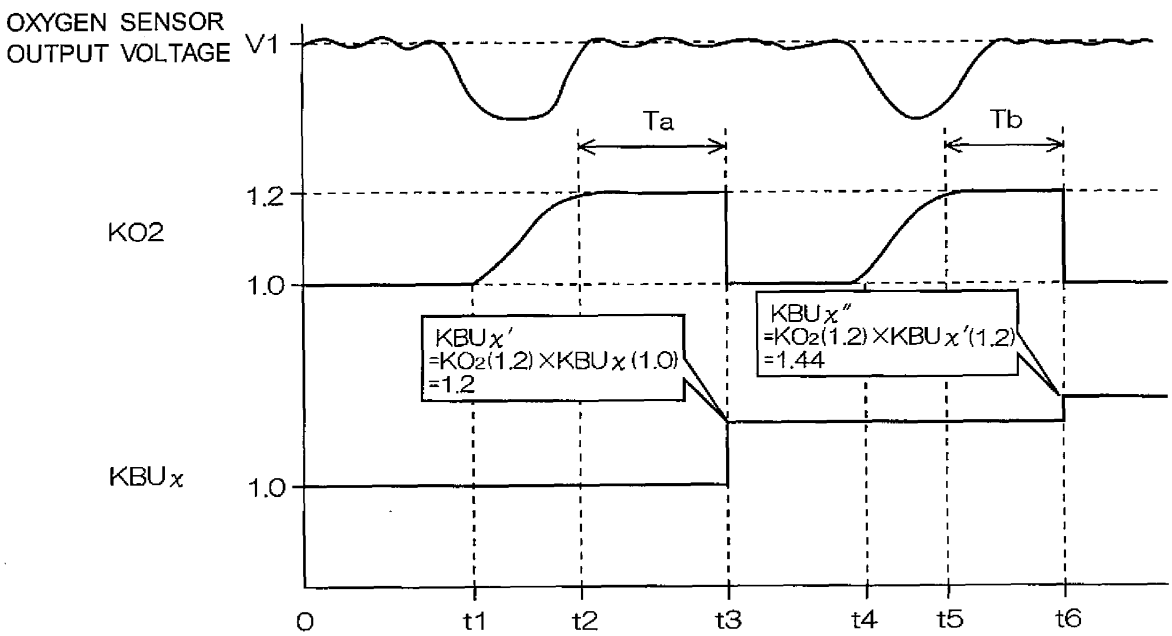
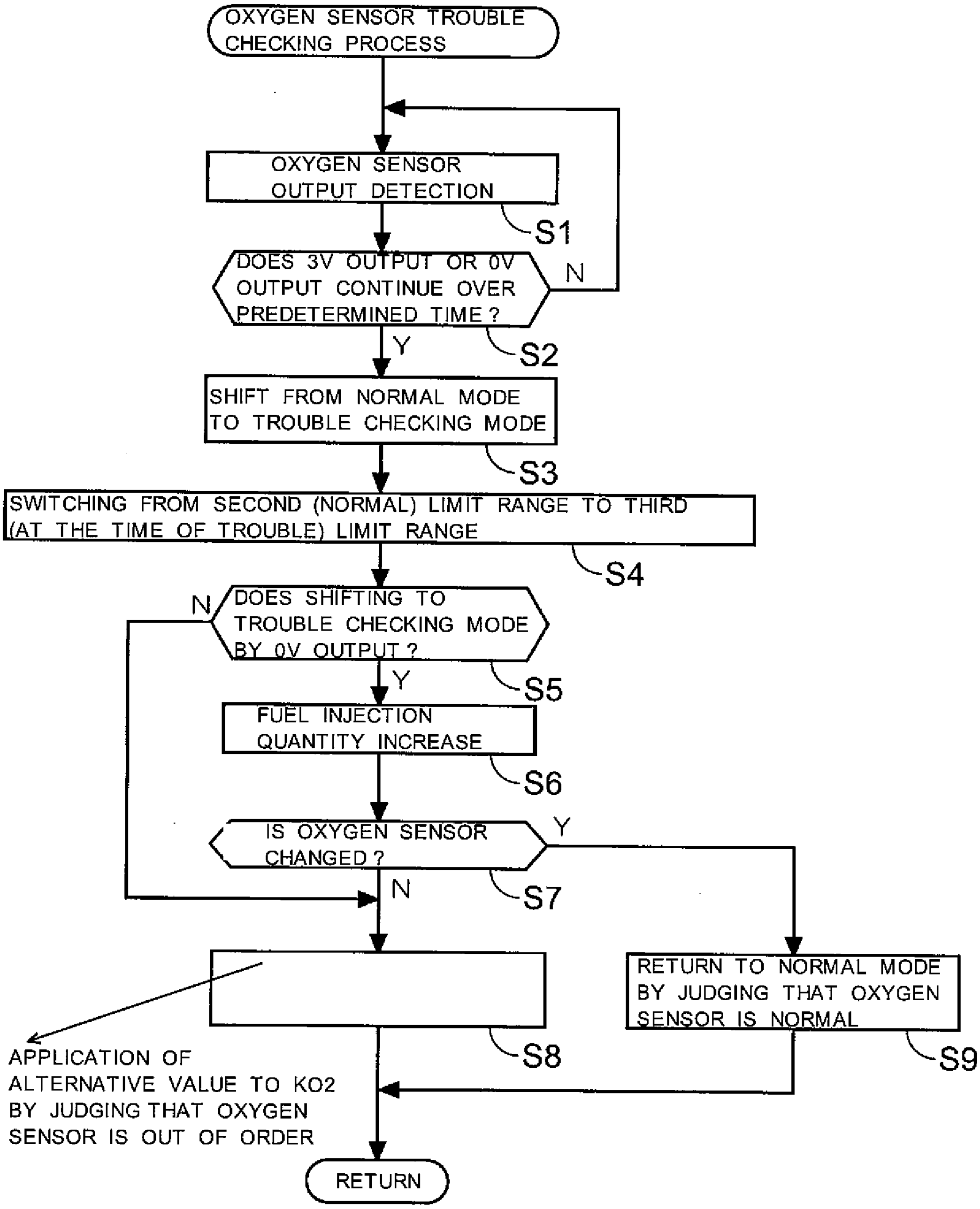

OXYGEN SENSOR
OUTPUT VOLTAGE
Va
O
CONTROL GAIN
LARGE
SMALL
FEEDBACK
CORRECTION
FACTOR
HI
LO
KO2
t=O
t1
t2

FIG. 12


OXYGEN SENSOR
OUTPUT VOLTAGE
V1
Ta
Tb
1.2
KO2
1.0
KBUx'
=KO2(1.2)×KBUx(1.0)
=1.2
KBUx"
=KO2(1.2)×KBUx'(1.2)
=1.44
KBUx
1.0
0
t1
t2
t3
t4
t5
t6

【FIG. 1 3】


OXYGEN SENSOR TROUBLE CHECKING PROCESS
OXYGEN SENSOR OUTPUT DETECTION
S1
DOES 3V OUTPUT OR 0V OUTPUT CONTINUE OVER PREDETERMINED TIME ?
N
Y
S2
SHIFT FROM NORMAL MODE TO TROUBLE CHECKING MODE
S3
SWITCHING FROM SECOND (NORMAL) LIMIT RANGE TO THIRD (AT THE TIME OF TROUBLE) LIMIT RANGE
S4
DOES SHIFTING TO TROUBLE CHECKING MODE BY 0V OUTPUT ?
N
Y
S5
FUEL INJECTION QUANTITY INCREASE
S6
IS OXYGEN SENSOR CHANGED ?
Y
N
S7
RETURN TO NORMAL MODE BY JUDGING THAT OXYGEN SENSOR IS NORMAL
S8
S9
APPLICATION OF ALTERNATIVE VALUE TO KO2 BY JUDGING THAT OXYGEN SENSOR IS OUT OF ORDER
RETURN

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EUROPEAN SEARCH REPORT

Application Number
EP 11 16 6845

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A,D	JP 2006 037875 A (NISSAN MOTOR) 9 February 2006 (2006-02-09) * abstract * -----	1-16	INV. F02D41/14 F02D41/22 F02D41/06
A	FR 2 923 864 A1 (RENAULT SAS [FR]) 22 May 2009 (2009-05-22) * the whole document * -----	1-16	
A	DE 10 2008 043124 A1 (BOSCH GMBH ROBERT [DE]) 29 April 2010 (2010-04-29) * the whole document * -----	1-16	
A	DE 10 2008 000567 A1 (BOSCH GMBH ROBERT [DE]) 10 September 2009 (2009-09-10) * the whole document * -----	1-16	
			TECHNICAL FIELDS SEARCHED (IPC)
			F02D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	27 September 2011	Calabrese, Nunziante

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27-09-2011

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2006037875 A	09-02-2006	NONE	
FR 2923864 A1	22-05-2009	AT 507383 T	15-05-2011
		EP 2215344 A2	11-08-2010
		WO 2009068777 A2	04-06-2009
		JP 2011503440 A	27-01-2011
		KR 20100106407 A	01-10-2010
		US 2010313641 A1	16-12-2010
DE 102008043124 A1	29-04-2010	NONE	
DE 102008000567 A1	10-09-2009	CN 101960128 A	26-01-2011
		EP 2263001 A1	22-12-2010
		WO 2009109421 A1	11-09-2009

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- JP 2006037875 A **[0004]**