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(54) **Control apparatus for engine, power unit of saddle-riding type vehicle, saddle-riding type vehicle and method for controlling an engine**

Steuerungsvorrichtung für einen Motor, Antriebsaggregat eines Sattelfahrzeugs, Sattelfahrzeug und Verfahren zur Steuerung eines Motors

Appareil de commande de moteur, unité motrice de véhicule de type à selle, véhicule de type à selle et procédé de commande d'unité de moteur

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EP 2 884 079 B1

Description

[0001] The present invention relates to a control apparatus for an engine, a power unit of a saddle-riding type vehicle, a saddle-riding type vehicle, and a method for controlling an engine.

[0002] JP 3790770 B proposes protection of a sensor that detects an operational state of an engine in a motorcycle or a motor tricycle from a small stone or the like by covering the sensor with a cover.

[0003] Currently, there are examining application of knocking countermeasure control for controlling an engine in a saddle-riding type vehicle to prevent frequent occurrence of knocking, while monitoring occurrence of knocking of the engine.

[0004] To monitor the occurrence of knocking, a knock sensor that detects vibration of the engine can be mounted in the vehicle, and the occurrence of knocking can be determined based on the output of the knock sensor.

[0005] However, the output of the knock sensor may be affected by an external situation such as one where a small stone or the like hits the engine, a crankcase, or the like when the saddle-riding type vehicle is traveling a rough road. Exogenous noise may be mixed in the output of the knock sensor due to the impact of being hit by a small stone or the like, and accurate determination of the occurrence of knocking may be difficult.

[0006] Even if a small stone or the like does not directly hit the knock sensor, the knock sensor is affected by the collision of the small stone or the like when the small stone or the like hits a part that transmits the vibration to the knock sensor. Therefore, the influence of the collision of the small stone or the like cannot be eliminated only by covering with a cover as shown in JP 3790770 B.

[0007] Futhermore US2002/0007818 describes a motorbike knock detection apparatus. The signal is filtered by a low-pass, band-pass filter. Peak is compared with a threshold. US 5,408,863 discloses a generic knock detector for sensing engine noise during a first time period of an engine combustion cycle and during an other time period far from the combustion and providing a different signal. The two signals are the compared to determine the occurrence of knock.

[0008] An object of the present invention is to provide a control apparatus for an engine, a power unit of a saddle-riding type vehicle, a saddle-riding type vehicle, and a method for controlling an engine that can favorably handle knocking even if exogenous noise is mixed in the output of a knock sensor due to collision of a small stone or the like in the saddle-riding type vehicle.

[0009] According to the present invention said object is solved by a control apparatus for an engine having the features of independent claim 1. Moreover, said object is also solved by method for controlling an engine having the features of independent claim 13. Furthermore, said object is solved by a power unit of a saddle-riding type vehicle according to claim 11 and a saddle-riding type vehicle according to claim 12. Preferred embodiments are laid down in the dependent claims.

[0010] A control apparatus for an engine according to an aspect is a control apparatus receiving a detection signal from a knock sensor that detects vibration of the engine mounted in a saddle-riding type vehicle, the control apparatus including: a first acquisition section that acquires a signal output from the knock sensor during a first period during which there is a possibility of occurrence of knocking in one cycle period of the engine; a second acquisition section that acquires a signal output from the knock sensor during a second period which is at least part of a period in the cycle period of the engine excluding the first period and excluding a period during which noise caused by mechanical vibration of the engine is generated; a first control section that determines occurrence of knocking based on the signal acquired by the first acquisition section and that controls the engine to suppress the knocking when knocking occurs; and a second control section that determines generation of exogenous noise caused by an external situation of the saddle-riding type vehicle based on the signal acquired by the second acquisition section and that changes the control of the engine by the first control section based on the determination result.

[0011] A power unit of a saddle-riding type vehicle according to an aspect is a power unit including: an engine mounted in the saddle-riding type vehicle; a knock sensor that detects vibration of the engine; and the control apparatus for the engine according to the aspect of the present teaching.

[0012] A saddle-riding type vehicle according to an aspect includes: an engine at least partially disposed below a seating surface; a knock sensor that detects vibration of the engine; and the control apparatus for the engine according to the aspect of the present teaching.

Advantageous Effects of Invention

[0013] According to the present invention, knocking can be favorably handled even if exogenous noise is mixed in the output of a knock sensor due to collision of a small stone or the like.

Brief Description of Drawings

[0014]

FIG. 1 is an external view showing a saddle-riding type vehicle of Embodiment 1;

FIG. 2 is a block diagram showing an ECU of the saddle-riding type vehicle and a configuration around the ECU of Embodiment 1;

FIG. 3 is a block diagram showing an example of a knock feature extraction circuit of FIG. 2;

FIG. 4 is a flowchart showing a knock determination process executed by the ECU;

FIG. 5 is a diagram describing the knock determination process;

FIG. 6 is a flowchart showing a knocking countermeasure control process executed by the ECU;
FIG. 7 is a computation condition table describing a calculation process of step S66 of FIG. 6;
FIG. 8 is a timing chart describing an example of the knocking countermeasure control process;
FIG. 9 is a diagram describing a detection window showing a signal extraction period of a knock feature extraction circuit;
FIG. 10 is a flowchart showing a first rough road noise determination process executed by the ECU;
FIG. 11 is a flowchart showing a variation of the first rough road noise determination process;
FIG. 12 is a flowchart showing a second rough road noise determination process executed by the ECU;
FIG. 13 is a determination condition table describing a final rough road noise determination process executed by the ECU;
FIG. 14 is a diagram describing a variation of the detection window showing the signal extraction period of the knock feature extraction circuit;
FIG. 15 is a flowchart showing a rough road noise countermeasure control process executed by the ECU;
FIG. 16 is a timing chart describing an example of a rough road noise countermeasure control process;
FIG. 17 is a flowchart showing Variation 1 of the rough road noise countermeasure control process;
FIG. 18 is a flowchart showing Variation 2 of the rough road noise countermeasure control process;
FIG. 19 is a computation condition table describing a knocking countermeasure control process of Embodiment 2;
FIG. 20 is a flowchart showing a rough road noise countermeasure control process of Embodiment 2;
FIG. 21 is a computation condition table describing a knocking countermeasure control process of Embodiment 3; and
FIG. 22 is a flowchart showing a rough road noise countermeasure control process of Embodiment 3.

Description of Embodiments

[0015] Hereinafter, a preferred embodiment will be described in detail with reference to the accompanying drawings.

(Embodiment 1)

[0016] FIG. 1 is an external view showing a saddle-riding type vehicle according to Embodiment 1. FIG. 2 is a block diagram showing an ECU and a configuration around the ECU according to Embodiment 1.

[0017] Saddle-riding type vehicle 1 of the present embodiment is a vehicle on which seat a rider straddles and is, for example, a motorcycle. As shown in FIG. 1, saddle-riding type vehicle 1 includes front wheel 3, rear wheel 4, engine 51 that is an internal combustion engine, power transmission section 52, ECU (Engine Control Unit: corresponding to a control apparatus for an engine) 20, handle bar 6, seat 7 on which the rider sits down, knock sensor 10, and the like. As shown in FIG. 2, saddle-riding type vehicle 1 further includes crank angle sensor 60, ignition unit 40, fuel injection unit 30, and EGR (Exhaust Gas Recirculation) valve 50.

[0018] A power unit of a preferred embodiment is obtained by integrating elements that serve as power sources of saddle-riding type vehicle 1 into a single unit, and the power unit includes engine 51 and ECU 20 among the configuration elements of saddle-riding type vehicle 1. The power unit may include one or both of power transmission section 52 and a power generator.

[0019] Engine 51 is a single-cylinder engine including a single cylinder and is an air-cooled engine. Engine 51 is a four-stroke engine that sequentially repeats an intake stroke, a compression stroke, a combustion stroke, and an exhaust stroke. Engine 51 includes a cylinder head, a cylinder block, a piston, a connecting rod, a crankshaft, and the like. The cylinder head of engine 51 is provided with an intake valve, an exhaust valve, and an ignition plug.

[0020] The piston is disposed in a reciprocatory movable manner in the cylinder and connected to the crankshaft via the connecting rod. The intake valve opens and closes in the intake stroke to take a mixture of air and fuel into the cylinder. The exhaust valve opens and closes in the exhaust stroke to discharge combustion gas. Vibration called valve seating noise is generated when the intake valve closes and when the exhaust valve closes. An air-fuel mixture is combusted in the cylinder when the ignition plug is ignited, and the piston reciprocates to rotationally drive the crankshaft. The air-fuel mixture may be abnormally ignited near the cylinder wall in the course of expansion of the combustion of the air-fuel mixture in the cylinder. Vibration caused by the abnormal ignition is knocking. Vibration caused by the abnormal ignition is knocking.

[0021] Engine 51 is disposed between front wheel 3 and rear wheel 4, and at least part of engine 51 is disposed below the seating surface of seat 7. At least part of the front portion and the bottom portion of engine 51 is exposed to the outside, and the outside air directly hits the part during traveling.

[0022] Power transmission section 52 includes a transmission and a driveshaft as well as a crankcase that houses the transmission, the driveshaft, and a crankshaft. Rotational force of the crankshaft is transmitted to the driveshaft via the transmission and is transmitted from the driveshaft to rear wheel 4 via a chain or the like.

[0023] The cylinder block of engine 51 and the crankcase of power transmission section 52 are connected in an integrated manner, and engine 51 and power transmission section 52 form integrated engine unit 5. Engine 51 and power transmission section 52 are not integrated in some cases.

[0024] ECU 20 is a control apparatus that mainly per-

forms control in relation to the combustion of engine 51. Although it will be described later in detail, ECU 20 executes a knocking determination process of determining whether knocking occurs in engine 51 and a knocking countermeasure control process of realizing efficient combustion of engine 51 within a range of not causing frequent occurrence of knocking. ECU 20 further executes a process of determining the generation of rough road noise and a rough road noise countermeasure control process of changing details of the control of the knocking countermeasure control process when the rough road noise is generated.

[0025] Ignition unit 40 (FIG. 2) includes an ignition plug disposed on the cylinder head and ignites the ignition plug based on a control signal of ECU 20.

[0026] Fuel injection unit 30 (FIG. 2) includes a throttle valve that controls the intake air volume and a fuel injection apparatus that injects and supplies fuel to an intake passage. Fuel injection unit 30 injects fuel to the intake passage at timing and amount based on a control signal of ECU 20. An air-fuel mixture containing air and fuel supplied to the intake passage is supplied into the cylinder of engine 51 when the intake valve is opened.

[0027] EGR valve 50 (FIG. 2) is a valve that recirculates, to the intake passage, part of the combustion gas discharged from the cylinder of engine 51 to an exhaust passage, and EGR valve 50 changes the opening based on a control signal of ECU 20. EGR valve 50 and the control of EGR valve 50 may be omitted.

[0028] Crank angle sensor 60 (FIG. 2) is a sensor that detects the rotation angle of the crankshaft of engine 51, and crank angle sensor 60 outputs a crank angle signal to ECU 20. ECU 20 can count the rotation angle of the crankshaft and the engine speed based on the crank angle signal.

[0029] Knock sensor 10 (FIG. 2) is a vibration detection sensor that detects vibration generated in engine 51 to determine that knocking occurs. Knock sensor 10 includes, for example, a piezoelectric element that receives vibration acceleration generated in engine 51, and knock sensor 10 outputs, from the piezoelectric element, a detection signal indicating AC voltage according to the vibration acceleration. Knock sensor 10 is, for example, a non-resonant sensor in which the gain is flat in a frequency range to be detected. Knock sensor 10 is attached to, for example, the cylinder block of engine 51 and is covered with sensor cover 53. The detection signal of knock sensor 10 is input to ECU 20.

<Details of ECU 20>

[0030] A detailed configuration of ECU 20 will be described.

[0031] As shown in FIG. 2, ECU 20 includes knock feature extraction circuit 21, interface circuit 22, and microcomputer 23. Microcomputer 23 includes knock determination value computation section 231, knock determination section 232, rough road noise determination section 233, ignition timing computation section 234, fuel injection computation section 235, actuator control section 236, and window control section 237.

[0032] Among the configuration elements, knock determination value computation section 231, knock determination section 232, and ignition timing computation section 234 correspond to a first control section that determines the occurrence of knocking and controls engine 51 to suppress knocking. Rough road noise determination section 233 and ignition timing computation section 234 function as a second control section that determines the generation of rough road noise to change the details of the control of engine 51 based on the generation of rough road noise.

[0033] The components of microcomputer 23 may be formed by software executed by a CPU (central processing unit) or may be formed by hardware such as a DSP (digital signal processor).

[0034] Knock feature extraction circuit 21 is a circuit that extracts, from the detection signal of knock sensor 10, signal components for determining knocking and signal components for determining rough road noise with a frequency near knocking. Knock feature extraction circuit 21 extracts the signal components in a signal extraction period designated by a timing signal from window control section 237 and outputs the extracted signal components to knock determination value computation section 231, knock determination section 232, and rough road noise determination section 233. The signal extraction period will be described later.

[0035] FIG. 3 is a block diagram showing an example of knock feature extraction circuit 21.

[0036] As shown in FIG. 3, knock feature extraction circuit 21 mainly includes gain adjustment section 211, filter processing section 212, rectification processing section 213, and peak hold processing section 214.

[0037] Gain adjustment section 211 adjusts the gain of the detection signal of knock sensor 10. The gain is adjusted to, for example, adjust the level of the detection signal that changes according to the engine speed or to adjust the level of the detection signal that changes based on the individual difference of knock sensor 10.

[0038] Filter processing section 212 includes, for example, a band-pass filter circuit and passes more frequency components including more knocking vibration than the other frequency components from the detection signal.

[0039] Rectification processing section 213 rectifies a detection signal of an AC waveform.

[0040] Peak hold processing section 214 holds and outputs the peak voltage of the detection signal in a signal extraction period designated by a timing signal of window control section 237.

[0041] The specific configuration of knock feature extraction circuit 21 is not limited to the example of FIG. 3, and any configuration is possible as long as signal components included in the knocking vibration in a large amount can be extracted in the designated signal extrac-

tion period from the detection signal of knock sensor 10.

[0042] Interface circuit 22 (FIG. 2) adjusts the waveform of the output signal of crank angle sensor 60 and outputs the waveform to microcomputer 23.

[0043] Window control section 237 receives a crank angle signal from crank angle sensor 60 and controls processing timing of each section. Specifically, window control section 237 outputs a timing signal indicating the signal extraction period to knock feature extraction circuit 21. Window control section 237 further outputs a timing signal to knock determination value computation section 231, knock determination section 232, and rough road noise determination section 233 for capturing a signal. The timings will be described later.

[0044] Knock determination value computation section 231 and knock determination section 232 execute a knock determination process described later to determine that knocking occurs. Knock determination section 232 notifies ignition timing computation section 234, fuel injection computation section 235, and actuator control section 236 of the determination result.

[0045] Ignition timing computation section 234 executes a knocking countermeasure control process and a rough road noise countermeasure control process described later to control ignition unit 40.

[0046] Fuel injection computation section 235 executes a knocking countermeasure control process and a rough road noise countermeasure control process described in Embodiment 2 to control fuel injection unit 30. Fuel injection computation section 235 may be omitted in Embodiment 1.

[0047] Actuator control section 236 executes a knocking countermeasure control process and a rough road noise countermeasure control process described in Embodiment 3 to control EGR valve 50. Actuator control section 236 may be omitted in Embodiment 1.

[0048] Rough road noise determination section 233 executes a rough road noise determination process described later to determine the generation of rough road noise. Rough road noise determination section 233 notifies ignition timing computation section 234, fuel injection computation section 235, and actuator control section 236 of the determination result.

<Knock Determination Process>

[0049] The knock determination process executed by knock determination value computation section 231 and knock determination section 232 will be described.

[0050] FIG. 4 is a flowchart showing the knock determination process.

[0051] The knock determination process of FIG. 4 is started at a predetermined timing in one cycle of engine 51 and is repeatedly executed in each cycle of engine 51.

[0052] When the knock determination process is started, knock determination value computation section 231 and knock determination section 232 first acquire an output level of knock feature extraction circuit 21 as a knock vibration detection value based on the timing signal of window control section 237 in step S41. Specifically, microcomputer 23 applies A/D (analog/digital) conversion to the output voltage of knock feature extraction circuit 21, and acquires the digital value after the conversion. The timing of acquiring the knock vibration detection value is a timing just after the elapse of a period (detection window KW of FIG. 9) with a possibility of the occurrence of knocking vibration in one cycle period of engine 51. The knock vibration detection value indicates a signal value extracted in the period by knock feature extraction circuit 21.

[0053] In step S42, knock determination value computation section 231 and knock determination section 232 perform logarithmic conversion of the acquired knock vibration detection value to calculate a logarithmic knock vibration detection value.

[0054] In step S43, knock determination section 232 compares the logarithmic knock vibration detection value with a knock determination threshold (= threshold offset + logarithmic average value) to determine whether the logarithmic knock vibration detection value is larger. The process of step S43 is an example of the process of determining that knocking occurs. The logarithmic average value is a value calculated by knock determination value computation section 231 in step S46. The threshold offset is a value set in advance by experiment or the like.

[0055] As a result of the comparison, if the logarithmic knock vibration detection value is larger, knock determination section 232 holds the determination result indicating the occurrence of knocking in a memory or the like (step S44). The determination result held by knock determination section 232 is output to ignition timing computation section 234, fuel injection computation section 235, and actuator control section 236.

[0056] On the other hand, if the logarithmic knock vibration detection value is smaller, knock determination section 232 holds the determination result indicating no occurrence of knocking in the memory or the like (step S45). The determination result held by knock determination section 232 is output to ignition timing computation section 234, fuel injection computation section 235, and actuator control section 236.

[0057] The processes of steps S44 and S45 can be omitted by switching the determination process of step S43 to the control process in response to the occurrence of knocking.

[0058] In step S46, knock determination value computation section 231 calculates an average value of a plurality of knock vibration detection values acquired in a plurality of past engine cycles and performs logarithmic conversion of the average value to calculate a logarithmic average value. One knock determination process is thus finished.

[0059] FIG. 5 is a diagram describing the knock determination process. The horizontal axis of FIG. 5 indicates the logarithmic knock vibration detection value, and the vertical axis indicates the frequency in the plurality of past

engine cycles.

[0060] As described, the knock vibration detection value is a signal value extracted from the detection signal of knock sensor 10 in the period during which knocking may possibly occur. Therefore, when the logarithmic knock vibration detection values are acquired and calculated over a plurality of engine cycles, the logarithmic knock vibration detection values are distributed in a low range as shown in a histogram of FIG. 5. When knocking occurs less frequently, the logarithmic knock vibration detection value is a higher value compared to the distribution.

[0061] Although the tendency of the distribution of the logarithmic knock vibration detection values does not change much, the absolute value of the range including the distribution of the logarithmic knock vibration detection values is changed by external factors, such as engine speed and individual variations of knock sensor 10.

[0062] Therefore, in the knock determination process of FIG. 4, the logarithmic average value is calculated from the population of the knock vibration detection values acquired over a plurality of engine cycles (step S46), and the threshold offset is added to the logarithmic average value to determine the knock determination threshold (step S43). In the knock determination process of FIG. 4, the magnitudes of the knock determination threshold and the logarithmic knock vibration detection value can be compared (step S43) to determine that knocking occurs by discriminating the knock vibration detection value greater than the normal distribution due to knocking.

[0063] According to the knock determination process, the occurrence of knocking can be accurately determined when abnormal noise, such as rough road noise, is not generated.

<Knocking Countermeasure Control Process>

[0064] The knocking countermeasure control process executed by ignition timing computation section 234 will be described.

[0065] FIG. 6 is a flowchart showing the knocking countermeasure control process. FIG. 7 is a computation condition table describing a calculation process of step S66 of FIG. 6. FIG. 8 is a timing chart describing an example of the knocking countermeasure control process.

[0066] The knocking countermeasure control process is started at a predetermined timing in one cycle of engine 51 and is repeatedly executed in each cycle of engine 51.

[0067] As shown in FIG. 8, the knocking countermeasure control process is a process of correcting the ignition timing from reference ignition timing based on the determination of the occurrence of knocking.

[0068] Specifically, as shown in FIG. 8, the ignition timing is retarded by a certain amount (hereinafter, called "knock determination retard amount") if it is determined that knocking occurs. If a period without the determination of the occurrence of knocking continues for a predetermined period (hereinafter, called "reset cycle C"), the ignition timing is advanced by an advance amount (hereinafter, called "reset advance amount") smaller than the knock determination retard amount.

[0069] The reference ignition timing is a standard ignition timing determined based on the number of revolutions of engine 51 and the like.

[0070] When the knocking countermeasure control process of FIG. 6 is started, ignition timing computation section 234 first determines whether a cycle counter that counts the engine cycle indicates the reset cycle C (termination cycle of period C of FIG. 8) in step S61.

[0071] If the result of the determination is affirmative, ignition timing computation section 234 holds the determination result indicating that it is the reset timing in the memory or the like in step S62.

[0072] Ignition timing computation section 234 clears the cycle counter in step S64.

[0073] On the other hand, if the determination result of step S61 is negative, ignition timing computation section 234 holds the determination result indicating that it is not the reset timing in the memory or the like in step S63.

[0074] The processes of steps S62 and S63 can be omitted by immediately switching the determination process of step S61 to the control process according to the determination result.

[0075] Ignition timing computation section 234 increments the cycle counter in step S65.

[0076] In step S66, ignition timing computation section 234 calculates an ignition timing correction value according to computation condition table 70 (see FIG. 7). The computation condition is determined from the determination result of knocking held in the memory or the like in the knock determination process of FIG. 4 and from the determination result indicating whether it is the reset timing held in the memory or the like in step S62 or S63 of FIG. 6.

[0077] More specifically, if it is determined that it is the reset timing and that knocking occurs, ignition timing computation section 234 calculates the ignition timing correction value by "last cycle correction value - knock determination retard amount + reset advance amount" as shown in field (1) of FIG. 7. As a result of the calculation, the ignition timing is retarded by "knock determination retard amount - reset advance amount" (see cycle C1 of FIG. 8) in the cycle in which it is determined that knocking occurs, and frequent occurrence of knocking is prevented.

[0078] As shown in field (2) of FIG. 7, if it is determined that it is the reset timing and that no knocking occurs, ignition timing computation section 234 calculates the ignition timing correction value by "last cycle correction value + reset advance amount". As a result of the calculation, the ignition timing gradually advances in the cycles in which no knocking occurs for a while (cycles C2, C3, C4, and C5 of FIG. 8), and engine 51 is combusted more efficiently.

[0079] As shown in field (3) of FIG. 7, if it is determined that it is not the reset timing and that knocking occurs,

ignition timing computation section 234 calculates the ignition timing correction value by "last cycle correction value - knock determination retard amount". As a result of the calculation, the ignition timing is retarded by "knock determination retard amount" without a delay if it is determined that knocking occurs, and frequent occurrence of knocking is prevented (see cycle N1 of FIG. 8).

[0080] As shown in field (4) of FIG. 7, if it is determined that it is not the reset timing and that no knocking occurs, ignition timing computation section 234 sets the ignition timing correction value to the same value as the correction value of the last cycle and does not change the ignition timing correction value.

[0081] Once the ignition timing correction value is calculated, ignition timing computation section 234 outputs a timing signal to ignition unit 40 at a timing reflecting the correction value to ignite the ignition plug.

[0082] A maximum value and a minimum value of the ignition timing correction amount may be set in the calculation process of the ignition timing correction value of FIG. 6 (step S66) to prevent the ignition timing from exceeding the appropriate range. The maximum value may be set if the ignition timing correction amount exceeds the maximum value, and the minimum value may be set if the ignition timing correction amount is below the minimum value.

[0083] According to the knock determination process (FIG. 4) and the knocking countermeasure control process (FIG. 6), the ignition timing is retarded without a delay if it is determined that knocking occurs as shown in FIG. 8, and frequent occurrence of knocking is prevented afterward. The ignition timing is gradually advanced if it is determined that no knocking occurs. According to the control, the ignition timing is controlled near the knocking limit, and the fuel efficiency and the output characteristics of engine 51 are fully improved.

<Rough Road Noise and Detection Window>

[0084] The rough road noise that may be mixed in the output of knock sensor 10 and the detection window for knock feature extraction circuit 21 (FIG. 2) to extract a signal will be described.

[0085] When saddle-riding type vehicle 1 travels a rough road, such as a gravel road, a bounced stone may hit engine 51 or the crankcase of power transmission section 52. The vibration may be transmitted to knock sensor 10 and may be mixed as exogenous noise (will be called "rough road noise") in the detection output of knock sensor 10. If the rough road noise includes components close to the frequency of knocking vibration, knock determination value computation section 231 and knock determination section 232 may not be able to accurately determine that knocking occurs.

[0086] For example, when the strength of the rough road noise is high, knock determination value computation section 231 and knock determination section 232 may erroneously determine the rough road noise as knocking.

[0087] When a large amount of small rough road noise is mixed, a large error is generated in the distribution of the logarithmic knock vibration extraction value of FIG. 5, and a large error is included in the knock determination threshold (FIG. 5) calculated by knock determination value computation section 231. When the knock determination threshold is set higher than the normal value, it is difficult for knock determination value computation section 231 and knock determination section 232 to determine relatively small knocking as knocking.

[0088] FIG. 9 is a diagram describing a detection window indicating a signal extraction period of the knock feature extraction circuit. FIG. 9 illustrates an example of a detection signal waveform of knock sensor 10 in one cycle period (-360° to 360°) of engine 51. The horizontal axis of the waveform chart of FIG. 9 indicates the crank angle, in which the top dead center is 0°. The vertical axis indicates the signal strength of the detection signal. The top dead center denotes a compression top dead center in which the piston compresses the air-fuel mixture in the cylinder to the maximum extent.

[0089] In the present embodiment, knock feature extraction circuit 21 (FIG. 2) extracts signals in detection windows KW, NW1, and NW2 shown in FIG. 9 to determine the rough road noise along with the vibration signal of knocking. Window control section 237 (FIG. 2) outputs timing signals for peak hold processing section 214 to execute the peak hold process according to detection windows KW, NW1, and NW2.

[0090] Detection window KW corresponds to a first period with a possibility of the occurrence of knocking. For example, detection window KW is set to a period from before the top dead center to 60°±5° which is the end of the expansion of the combustion in the cylinder.

[0091] Detection window NW1 corresponds to a second period that does not overlap with detection windows KW and NW2 and in which the vibration of engine 51 is smaller than in the generation period of the mechanical vibration of engine 51. For example, detection window NW1 is set to a period with the generation of a little vibration in the exhaust stroke. For example, detection window NW1 can be set to a period other than the seating period of the exhaust valve in the exhaust stroke.

[0092] Detection window NW2 corresponds to a third period in which the mechanical vibration of engine 51 is generated. For example, detection window NW2 is set to a period in which the valve seating noise of the discharge valve is generated.

[0093] Knock determination value computation section 231 and knock determination section 232 (FIG. 2) acquire the signal extracted in detection window KW to determine that knocking occurs as described above. Knock determination value computation section 231 and knock determination section 232 acquire the signal based on the timing signal of window control section 237.

[0094] Meanwhile, rough road noise determination section 233 acquires the signals extracted in detection

windows NW1 and NW2 to determine the generation of the rough road noise. Rough road noise determination section 233 acquires the signals based on the timing signals of window control section 237. Rough road noise determination section 233 executes two types of rough road noise determination processes described below, based on the acquired signals.

[0095] The configuration of acquiring the signal of detection window KW in knock feature extraction circuit 21, window control section 237, knock determination value computation section 231, and knock determination section 232 corresponds to a first acquisition section. The configuration of acquiring the signal of detection window NW1 in knock feature extraction circuit 21, window control section 237, and rough road noise determination section 233 corresponds to a second acquisition section, and the configuration of capturing the signal of detection window NW2 corresponds to a third acquisition section.

<First Rough Road Noise Determination Process>

[0096] FIG. 10 is a flowchart of a first rough road noise determination process.

[0097] The first rough road noise determination process is started at a predetermined timing in one cycle of engine 51 and is repeatedly executed in each cycle of engine 51.

[0098] When the first rough road noise determination process is started, rough road noise determination section 233 acquires a signal level (hereinafter, called "rough road noise detection value") extracted in detection window NW1 in step S101. Specifically, microcomputer 23 applies A/D conversion to the output voltage of knock feature extraction circuit 21 at a designated timing, and acquires the digital value after the conversion.

[0099] In step S102, rough road noise determination section 233 determines whether the acquired rough road noise detection value is greater than a rough road noise threshold. The process of step S102 is an example of a process of determining the generation of rough road noise as exogenous noise. The rough road noise threshold is a value calculated in step S106.

[0100] If the result of the determination is affirmative, rough road noise determination section 233 holds the determination result indicating that rough road noise state (1) is generated, in a memory or the like in step S103. Rough road noise state (1) denotes that the rough road noise is generated less frequently. The reason will be described later.

[0101] On the other hand, if the result of the determination is negative, rough road noise determination section 233 holds the determination result indicating that rough road noise state (1) is not generated, in the memory or the like in step S104.

[0102] In step S105, rough road noise determination section 233 calculates an average value of the rough road noise detection values from the population of a plurality of rough road noise detection values acquired in a plurality of past cycles.

[0103] In step S106, rough road noise determination section 233 uses the average value of the rough road noise detection values to calculate a threshold (hereinafter, called rough road noise threshold) for determining the generation of the rough road noise state. For example, rough road noise determination section 233 calculates the rough road noise threshold by "average value of rough road noise detection values × coefficient set in advance by experiment or the like".

[0104] As described, the rough road noise detection value is a signal value extracted in the period with a little vibration in the engine cycle (period of detection window NW1). Therefore, in a situation that the rough road noise is generated less frequently, the rough road noise detection values are distributed in a low level range when the rough road noise detection values are acquired over a plurality of engine cycles. In this case, when the rough road noise is generated, the rough road noise detection value is a value higher than the distribution.

[0105] Although the tendency of the distribution of the rough road noise detection values does not change much, the absolute value of the distribution range is changed by external factors, such as engine speed and individual variations of knock sensor 10.

[0106] Therefore, in the rough road noise determination process of FIG. 10, the average value is calculated from the population of the rough road noise detection values acquired over a plurality of engine cycles (step S105), and the average value is multiplied by the coefficient to determine the rough road noise threshold (step S106). The rough road noise detection value and the rough road noise threshold can be compared to determine the generation of the rough road noise in the situation that the rough road noise is generated less frequently.

[0107] The processes of steps S102, S105, and S106 function as a statistical processing section that determines the degree of dispersion of the rough road noise detection values.

[0108] FIG. 11 is a flowchart showing a variation of the first rough road noise determination process.

[0109] The first rough road noise determination process of FIG. 10 can be changed as shown in FIG. 11. More specifically, the comparison of the rough road noise detection value and the rough road noise threshold of FIG. 10 is equivalent to the comparison of a standard deviation of the rough road noise detection values in the population and a predetermined threshold. Therefore, as shown in FIG. 11, rough road noise determination section 233 calculates the standard deviation of the acquired rough road noise detection values (step S112) and compares the calculated value with the rough road noise setting threshold determined in advance by a test or the like (step S113). As a result, rough road noise determination section 233 can determine whether or not the rough road noise is generated in the situation that the rough road noise is generated less frequently, as in the process of

FIG. 10. Processes of steps S111, S114, and S115 are the same as the processes of steps S101, S103, and S104 of FIG. 10.

[0110] The process of step S112 functions as a statistical processing section that calculates the degree of dispersion of the rough road noise detection values.

[0111] As described, the first rough road noise determination process can accurately determine the generation of the rough road noise in the situation that the rough road noise is generated less frequently. On the other hand, many values for rough road noise generation state are included in the population of the rough road noise detection values when the rough road noise is frequently generated, and accurate determination of the rough road noise is difficult in the first rough road noise determination process. For example, accurate determination of the generation of the rough road noise is difficult in the first rough road noise determination process when the amount of the rough road noise gradually increases, when the volume of the rough road noise gradually increases, or when these are combined.

[0112] Therefore, rough road noise determination section 233 executes a second rough road noise determination process described below, in conjunction with the first rough road noise determination process.

<Second Rough Road Noise Determination Process>

[0113] FIG. 12 is a flowchart showing the second rough road noise determination process.

[0114] The second rough road noise determination process is started at a predetermined timing in one cycle of engine 51 and is repeatedly executed in each cycle of engine 51.

[0115] When the second rough road noise determination process is started, rough road noise determination section 233 acquires the signal level (hereinafter, called "mechanical vibration noise detection value") extracted in detection window NW2 (FIG. 9) in step S121. Specifically, microcomputer 23 applies A/D conversion to the output voltage of knock feature extraction circuit 21 at a designated timing, and acquires the digital value after the conversion.

[0116] In step S122, rough road noise determination section 233 calculates an average value (corresponding to a second statistic) of the population of the mechanical vibration noise detection values acquired in a plurality of past cycles.

[0117] In step S123, rough road noise determination section 233 acquires the rough road noise detection value extracted in detection window NW1. The acquisition process of the data may be executed in common with the process of step S101 of FIG. 10.

[0118] In step S124, rough road noise determination section 233 calculates an average value (corresponding to a first statistic) of the population of the rough road noise detection values acquired in a plurality of past cycles.

[0119] In step S125, rough road noise determination section 233 weights the average value of the rough road noise detection values and the average value of the mechanical vibration noise detection values by predetermined coefficients and compares the weighted values. The process of step S125 is an example of a process of determining the generation of the rough road noise. The coefficients are values set in advance by experiment or the like to allow appropriate determination of the rough road noise.

[0120] The processes of steps S122 and S124 function as a statistical processing section that calculates statistical information.

[0121] As a result of the comparison, if "average value of rough road noise detection values $\times$ coefficient" is greater, rough road noise determination section 233 stores the determination result indicating the generation of rough road noise state (2) in the memory or the like in step S126. Rough road noise state (2) denotes a state that the rough road noise is frequently generated.

[0122] On the other hand, if "average value of rough road noise detection values $\times$ coefficient" is greater, rough road noise determination section 233 stores the determination result indicating that rough road noise state (2) is not generated in the memory or the like in step S127.

[0123] The second rough road noise determination process is thus finished.

[0124] In the situation that the rough road noise is frequently generated, the signal values of detection window NW1 with a little vibration during the ordinary time include many large signal values of rough road noise, and the average value is large. On the other hand, the signal values extracted in the period of detection window NW2, in which the mechanical noise is generated every time, mostly include components of large mechanical noise, and the average value is not significantly changed from the situation without the generation of the rough road noise.

[0125] Therefore, the average values can be compared in the second rough road noise determination process to determine whether there is a situation that the rough road noise is frequently generated.

<Final Rough Road Noise Determination Process>

[0126] A final rough road noise determination process executed by rough road noise determination section 233 will be described.

[0127] FIG. 13 is a determination condition table describing the final rough road noise determination process.

[0128] Rough road noise determination section 233 executes the final rough road noise determination process in each cycle of engine 51, for example.

[0129] Rough road noise determination section 233 makes final determination of whether or not the rough road noise is generated based on the determination result of the first rough road noise determination process and the determination result of the second rough road

noise determination process according to the determination condition table of FIG. 13.

[0130] More specifically, rough road noise determination section 233 makes a final determination that the rough road noise is generated if at least one of the determination result of the first rough road noise determination process and the determination result of the second rough road noise determination process is a determination result indicating the generation.

[0131] Rough road noise determination section 233 holds the final determination result and notifies ignition timing computation section 234 and the like of the result.

<Variation of Detection Window>

[0132] A variation of the detection window used to determine the rough road noise will be described.

[0133] FIG. 14 is a diagram describing a variation of the detection window indicating the signal extraction period of the knock feature extraction circuit.

[0134] The signals used to determine the rough road noise are not limited to detection window NW1 or NW2 described above, and other periods with similar conditions of the generation of vibration may also be arranged.

[0135] If there are a plurality of periods with a little vibration during the ordinary time, a plurality of detection windows NW1 and NW3 may be set in the plurality of periods as shown in FIG. 14. Detection window NW3 corresponds to a period in the intake stroke.

[0136] In this case, rough road noise detection values acquired in both of detection windows NW1 and NW3 may be used to execute the first rough road noise determination process. An independent first rough road noise determination process may be executed for each of the rough road noise detection values acquired in detection windows NW1 and NW3.

[0137] Similarly, if there are a plurality of periods in which the mechanical vibration of engine 51 is constantly generated, a plurality of detection windows NW2 and NW4 may be arranged in the plurality of periods as shown in FIG. 14. Detection window NW4 corresponds to a period in which the valve seating noise of the intake valve is generated.

[0138] In this case, the mechanical vibration noise detection values acquired in both of detection windows NW2 and NW4 may be used to execute the second rough road noise determination process. An independent second rough road noise determination process may be executed for each of the mechanical vibration noise detection values acquired in detection windows NW2 and NW4. If part of the period just before or just after detection windows KW, NW1, NW2, NW3, and NW4 is a period with a little vibration, the period may be expanded by including the part of the period. The period with a little vibration is a period in which only vibration smaller than the mechanical vibration and the knocking vibration is generated. Parts of the periods of detection windows KW, NW1, NW2, NW3, and NW4 may overlap each other if only a little vibration is generated in the parts of the periods.

<Rough Road Noise Countermeasure Control Process>

[0139] The rough road noise countermeasure control process executed by ignition timing computation section 234 will be described.

[0140] FIG. 15 is a flowchart of the rough road noise countermeasure control process. FIG. 16 is a timing chart describing an example of the rough road noise countermeasure control process. FIG. 16 illustrates an example that the control operation of the ignition timing of the knocking countermeasure control process is switched by the rough road noise countermeasure control process.

[0141] The rough road noise countermeasure control process is started at, for example, a predetermined timing in one cycle of engine 51 and is repeatedly executed in each cycle of engine 51. Ignition timing computation section 234 executes the rough road noise countermeasure control process in parallel with the knocking countermeasure control process.

[0142] When the rough road noise countermeasure control process is started, ignition timing computation section 234 determines whether the final determination result notified by rough road noise determination section 233 indicates "generated" in step S151.

[0143] If the result of the determination indicates "generated," ignition timing computation section 234 changes the reset cycle to long cycle D for rough road noise generation state in step S152. The reset cycle is a cycle when the ignition timing is gradually advanced, which is described in FIGS. 6 and 7.

[0144] As shown in FIG. 16, the change to the reset cycle D reduces the advance speed of the ignition timing based on the determination indicating that knocking is not generated in the knocking countermeasure control process.

[0145] Ignition timing computation section 234 resets timer T in step S154 and advances the process to step S156.

[0146] On the other hand, if the result of the determination in step S151 indicates "not generated," ignition timing computation section 234 determines in step S153 whether predetermined time ST has passed while the final determination of the rough road noise remains "not generated," based on the value of timer T. Predetermined time ST is a time significantly longer than the reset cycle.

[0147] As a result of the determination, if predetermined time ST has not passed, ignition timing computation section 234 advances the process to step S156.

[0148] On the other hand, if predetermined time ST has passed, ignition timing computation section 234 restores the reset cycle to cycle C for rough road noise non-generation state in step S155 and advances the process to step S156.

[0149] As shown in FIG. 16, the change to reset cycle C restores the original advance speed of the ignition tim-

ing based on the determination indicating that knocking is not generated in the knocking countermeasure control process.

[0150] In step S156, ECU 20 increments timer T and ends one rough road noise countermeasure control process.

[0151] The rough road noise countermeasure control reduces the advance speed of the ignition timing even if the occurrence of knocking is missed due to a little reduction in the determination accuracy of the occurrence of knocking caused by the generation of the rough road noise. This can avoid frequent occurrence of knocking afterward.

[0152] The rough road noise countermeasure control process in Embodiment 1 can be changed as in Variations 1 and 2 to be described next.

[0153] FIG. 17 is a flowchart showing Variation 1 of the rough road noise countermeasure control process.

[0154] The example of FIG. 17 is an example in which a method of switching the reset advance amount of the ignition timing to a small value and to the original value according to the situation of generation of the rough road noise (steps S172 and S175) is adopted as a method of adjusting the advance speed of the ignition timing.

[0155] FIG. 18 is a flowchart showing Variation 2 of the rough road noise countermeasure control process.

[0156] The example of FIG. 18 is an example in which the threshold offset that is a parameter for determining the knock determination threshold is switched to a small value when it is determined that the rough road noise is generated (step S182) to thereby avoid determining that knocking is not generated when knocking actually occurs. If the rough road noise is not generated for a predetermined period, the threshold offset is restored to the original value (S185).

[0157] Knock determination value computation section 231 executes the rough road noise countermeasure control process of FIG. 18. In this case, knock determination value computation section 231 is notified of the final rough road determination result of rough road noise determination section 233.

[0158] Other steps in FIGS. 17 and 18 are the same processes as the corresponding steps of FIG. 15, and the description will not be repeated.

[0159] According to the rough road noise countermeasure control process of the present embodiment, a malfunction of the knocking countermeasure control process and frequent occurrence of knocking can be avoided even if exogenous noise is mixed in the output signal of knock sensor 10 due to collision of a small stone or the like during travelling on a rough road or the like.

(Embodiment 2)

[0160] In Embodiment 2, a method of adjusting the fuel injection quantity is adopted as the knocking countermeasure control process and the rough road noise countermeasure control process, instead of adjusting the ignition timing as in Embodiment 1.

[0161] Fuel injection computation section 235 can drive the fuel injection apparatus of fuel injection unit 30 to bring the air-fuel ratio of the air-fuel mixture close to an optimal value to thereby improve the fuel efficiency and the output characteristics. On the other hand, when knocking occurs, the fuel injection apparatus of fuel injection unit 30 can be driven to increase the ratio of the fuel to thereby reduce the temperature of the combustion chamber to suppress the occurrence of knocking.

[0162] Hereinafter, parts different from Embodiment 1 will be mainly described.

<Knocking Countermeasure Control Process>

[0163] FIG. 19 is a computation condition table describing a knocking countermeasure control process of Embodiment 2.

[0164] In FIG. 19, "fuel injection quantity correction value" denotes an amount of adjustment from a standard fuel injection quantity determined based on the engine speed, the amount of rotation of the throttle handle, and the like. "Knock determination increase" denotes an increase in the fuel injection quantity when it is determined that knocking occurs. "Reset decrease" denotes a decrease in the fuel injection quantity when the reset cycle has passed without the determination of the occurrence of knocking.

[0165] In Embodiment 2, fuel injection computation section 235 executes the knocking countermeasure control process of FIG. 6. In step S66 of the knocking countermeasure control process (FIG. 6), fuel injection computation section 235 computes the correction value of the fuel injection quantity according to computation condition table 72 of FIG. 19.

[0166] For example, if it is determined that it is the reset timing and that knocking occurs as shown in field (1) of FIG. 19, fuel injection computation section 235 calculates the fuel injection quantity correction value by "last cycle correction value + knock determination increase ? reset decrease."

[0167] As shown in field (2) of FIG. 19, if it is determined that it is the reset timing and that knocking is not generated, fuel injection computation section 235 calculates the fuel injection quantity correction value by "last cycle correction value ? reset decrease."

[0168] As shown in field (3) of FIG. 19, if it is determined that it is not the reset timing and that knocking occurs, fuel injection computation section 235 calculates the fuel injection quantity correction value by "last cycle correction value + knock determination increase."

[0169] As shown in field (4) of FIG. 19, if it is determined that it is not the reset timing and that knocking is not generated, fuel injection computation section 235 sets the fuel injection quantity to the same value as the last correction value and does not change the fuel injection quantity correction value.

[0170] Once the fuel injection quantity correction value

is calculated, fuel injection computation section 235 drives the fuel injection apparatus of fuel injection unit 30 to inject the fuel in an amount corrected by the fuel injection quantity correction value from the standard fuel injection quantity.

[0171] According to the knocking countermeasure control process, the fuel injection quantity is increased without delay when knocking is detected, and frequent occurrence of knocking is prevented afterward. The fuel injection quantity is gradually reduced when knocking is not detected. According to the controls, the fuel injection quantity is controlled near the knocking limit, and the fuel efficiency and the output characteristics of engine 51 are improved.

[0172] In the calculation process of the fuel injection quantity correction value, a maximum value and a minimum value of the fuel injection quantity correction amount may be set to prevent the fuel injection quantity from exceeding the appropriate range. The maximum value may be set when the fuel injection quantity correction amount exceeds the maximum value, and the minimum value may be set when the fuel injection quantity correction amount is below the minimum value.

<Rough Road Noise Countermeasure Control Process>

[0173] FIG. 20 is a flowchart of a rough road noise countermeasure control process of Embodiment 2.

[0174] The rough road noise countermeasure control process is started at, for example, a predetermined timing in one cycle of engine 51 and is repeatedly executed in each cycle of engine 51. Fuel injection computation section 235 executes the rough road noise countermeasure control process in parallel with the knocking countermeasure control process.

[0175] When the rough road noise countermeasure control process is started, fuel injection computation section 235 determines whether the final determination result notified by rough road noise determination section 233 indicates "generated" in step S201.

[0176] If the result of determination indicates "generated," fuel injection computation section 235 changes the reset decrease of the fuel injection quantity to a small value for rough road noise generation state in step S202. As a result, the speed of decrease in the fuel injection quantity based on the determination indicating that knocking is not generated is reduced in the knocking countermeasure control.

[0177] Fuel injection computation section 235 resets timer T in step S204 and advances the process to step S206.

[0178] On the other hand, if the result of determination of step S201 indicates "not generated," fuel injection computation section 235 determines whether predetermined time ST has passed while the final determination of the rough road noise remains "not generated," based on the value of timer T in step S203.

[0179] As a result of the determination, if predetermined time ST has not passed, fuel injection computation section 235 advances the process to step S206.

[0180] On the other hand, if predetermined time ST has passed, fuel injection computation section 235 restores the reset decrease of the fuel injection quantity to the value for rough road noise non-generation state in step S205 and advances the process to step S206. As a result of the process of step S205, the original speed of decrease in the fuel injection quantity based on the determination indicating that knocking is not generated is restored in the knocking countermeasure control.

[0181] In step S206, ECU 20 increments timer T and ends one rough road noise countermeasure control process.

[0182] The rough road noise countermeasure control reduces the speed of decrease in the fuel injection quantity even if the occurrence of knocking is missed due to a little reduction in the determination accuracy of the occurrence of knocking caused by the generation of the rough road noise. This can avoid frequent occurrence of knocking afterward.

(Embodiment 3)

[0183] In Embodiment 3, a method of adjusting the amount of EGR gas (hereinafter, called amount of EGR) included in the air-fuel mixture is adopted as the knocking countermeasure control process and the rough road noise countermeasure control process, instead of adjusting the ignition timing as in Embodiment 1.

[0184] Actuator control section 236 can change the opening of EGR valve 50 to adjust the amount of EGR to thereby reduce the generation of nitrogen oxide (NOx) and to improve the fuel consumption rate. When knocking occurs, the amount of EGR can be increased to reduce the combustion temperature of the air-fuel mixture to suppress the occurrence of knocking.

[0185] Hereinafter, parts different from Embodiment 1 will be mainly described.

<Knocking Countermeasure Control Process>

[0186] FIG. 21 is a computation condition table describing a knocking countermeasure control process of Embodiment 3.

[0187] In FIG. 21, "EGR amount correction value" denotes an adjustment value from the standard amount of EGR determined based on the engine speed and the like. "Knock determination increase" denotes an increase in the amount of EGR when it is determined that knocking occurs. "Reset decrease" denotes a decrease in the amount of EGR when the reset cycle has passed without the determination of the occurrence of knocking.

[0188] In Embodiment 3, actuator control section 236 executes the knocking countermeasure control process of FIG. 6. Actuator control section 236 computes the correction value of the amount of EGR according to computation condition table 73 of FIG. 21 in step S66 of the

knocking countermeasure control process (FIG. 6).

[0189] For example, if it is determined that it is the reset timing and that knocking occurs as shown in field (1) of FIG. 21, actuator control section 236 calculates the EGR amount correction value by "last cycle correction value + knock determination increase - reset decrease."

[0190] As shown in field (2) of FIG. 21, if it is determined that it is the reset timing and that knocking is not generated, actuator control section 236 calculates the EGR amount correction value by "last cycle correction value - reset decrease."

[0191] As shown in field (3) of FIG. 21, if it is determined that it is not the reset timing and that knocking occurs, actuator control section 236 calculates the EGR amount correction value by "last cycle correction value + knock determination increase".

[0192] As shown in field (4) of FIG. 21, if it is determined that it is not the reset timing and that knocking is not generated, actuator control section 236 sets the amount of EGR to the same value as the last correction value and does not change the EGR amount correction value.

[0193] Once the EGR amount correction value is calculated, actuator control section 236 drives EGR valve 50 to recirculate the combustion gas in the corrected amount of EGR.

[0194] According to the knocking countermeasure control process, the amount of EGR is increased without delay when it is determined that knocking occurs, and frequent occurrence of knocking is prevented afterward. The amount of EGR is gradually reduced when it is determined that knocking is not generated. According to the controls, the amount of EGR is controlled near the knocking limit, and the fuel efficiency and the output characteristics of engine 51 are improved.

[0195] In the calculation process of the EGR amount correction value, a maximum value and a minimum value of the EGR correction amount may be set to prevent the amount of EGR from exceeding the appropriate range. The maximum value may be set if the EGR correction amount exceeds the maximum value, and the minimum value may be set if the EGR correction amount is below the minimum value.

<Rough Road Noise Countermeasure Control Process>

[0196] FIG. 22 is a flowchart of the rough road noise countermeasure control process of Embodiment 3.

[0197] The rough road noise countermeasure control process is started at, for example, a predetermined timing in one cycle of engine 51 and is repeatedly executed in each cycle of engine 51. Actuator control section 236 executes the rough road noise countermeasure control process in parallel with the knocking countermeasure control process.

[0198] When the rough road noise countermeasure control process is started, actuator control section 236 determines whether the final determination result notified by rough road noise determination section 233 indicates "generated" in step S221.

[0199] If the result of the determination indicates "generated", actuator control section 236 changes the reset decrease of the amount of EGR to a small value for rough road noise generation state in step S222. As a result, the speed of decrease in the amount of EGR based on the determination indicating that knocking is not generated is reduced in the knocking countermeasure control.

[0200] Actuator control section 236 resets timer T in step S224 and advances the process to step S226.

[0201] On the other hand, if the result of the determination of step S221 indicates "not generated," actuator control section 236 determines whether predetermined time ST has passed while the final determination of the rough road noise remains "not generated" based on the value of timer T in step S223. Predetermined time ST is time significantly longer than the reset cycle.

[0202] As a result of the determination, if predetermined time ST has not passed, actuator control section 236 advances the process to step S226.

[0203] On the other hand, if predetermined time ST has passed, actuator control section 236 restores the reset decrease of the amount of EGR to the value for rough road noise non-generation state in step S225 and advances the process to step S226. As a result of the process of step S225, the speed of decrease in the amount of EGR based on the determination indicating that knocking is not generated is restored to the original value in the knocking countermeasure control.

[0204] In step S226, ECU 20 increments timer T and ends one rough road noise countermeasure control process.

[0205] The rough road noise countermeasure control reduces the speed of decrease in the amount of EGR even if the occurrence of knocking is missed due to a little reduction in the determination accuracy of the occurrence of knocking caused by the generation of the rough road noise. This can avoid frequent occurrence of knocking afterward.

[0206] According to ECU 20, the power unit, and saddle-riding type vehicle 1 of the present embodiment, rough road noise can be detected even if the rough road noise is mixed in the output of the knock sensor when a small stone or the like hits engine 51 or the crankcase of power transmission section 52. The rough road noise countermeasure control process switches details of the knocking countermeasure control process when rough road noise is detected. This can avoid frequent occurrence of knocking even if the determination accuracy of the occurrence of knocking is reduced a little due to the generation of the rough road noise.

[0207] Each preferred embodiment have been described.

[0208] The configurations and the methods specifically described in the embodiments can be appropriately changed.

[0209] For example, the saddle-riding type vehicle according to the present teaching is not limited to the mo-

torcycle of the type shown in FIG. 1, and the saddle-riding type vehicle also includes a scooter-type vehicle in which the knees can be kept together. The number of wheels of the saddle-riding type vehicle according to the present teaching is not limited to two, and the number of wheels may be three, four, for example, as long as the vehicle is a saddle-riding type.

[0210] Although a four-stroke air-cooled engine is adopted as the engine in the example described in the embodiments, the engine may be a two-stroke engine, and the present teaching can also be applied to a water-cooled engine.

[0211] A non-resonant sensor is adopted as the knock sensor in the example described in the embodiments. However, a resonant knock sensor in which the detection level of the resonance frequency band is high may be adopted. In this case, the resonance frequency band can be set to a band similar to the pass-band of filter processing section 212 of the embodiments, and filter processing section 212 can be omitted.

[0212] The control parameters (ignition timing, fuel injection quantity, amount of EGR, or the like) are changed to continue the knocking countermeasure control process when it is determined that the rough road noise is generated in the example described in the embodiments. However, the control parameters (ignition timing, fuel injection quantity, amount of EGR, or the like) may be saved in stable regions to prevent the occurrence of knocking in advance when it is determined that the rough road noise is generated, regardless of whether the determination result indicates that knocking occurs or not.

[0213] The knocking countermeasure control process and the rough road noise countermeasure control process may be combinations of the processes of Embodiments 1 to 3.

[0214] The configurations of acquiring the signal of the knock sensor in the specific period in one cycle period of the engine are formed by hardware in the first acquisition section, the second acquisition section, and the third acquisition section in the example illustrated in the embodiments. However, the configurations may be formed by software. The configuration of determining the occurrence of knocking and controlling the combustion of the engine based on the determination result is mainly realized by software in the first control section in the mode illustrated in the embodiments. The configuration of determining the generation of the rough road noise and changing the details of the combustion control of the engine based on the determination result is mainly realized by software in the second control section in the illustrated mode. However, the first control section and the second control section may be realized by hardware by using, for example, a digital signal processor, a sequencer, or the like.

[0215] In the example described in the embodiments, one ECU 20 includes the configuration of acquiring the detection signal of knock sensor 10 in the specific period, the configuration of determining the occurrence of knocking, the configuration of controlling engine 51 to suppress knocking when knocking occurs, the configuration of determining the generation of the rough road noise, and the configuration of changing the details of the control of engine 51 based on the determination result of the generation of the rough road noise. However, one or a plurality of the configurations may be separated from each other and connected by signal lines or the like.

[0216] According to the present teaching, the "determination of occurrence of knocking" includes various modes. For example, the determination of the occurrence of knocking includes a mode of determining that knocking occurs from the detection signal of the knock sensor. The determination of the occurrence of knocking includes a mode of determining that no knocking occurs from the detection signal of the knock sensor. The method for determining that knocking occurs includes a mode of comparing the value obtained by processing the detection signal of the knock sensor with a reference value experimentally defined as a value indicating the occurrence of knocking. A value calculated by an experimentally defined method as a value indicating the occurrence of knocking may be used as the reference value. The method for determining that knocking occurs further includes a mode of determining that knocking occurs if the value obtained by processing the detection signal of the knock sensor is greater than the reference value. The method for determining that knocking occurs also includes a mode of determining that no knocking occurs if the value obtained by processing the detection signal of the knock sensor is smaller than the reference value.

[0217] According to the present teaching, the "determination of generation of exogenous noise" includes various modes. For example, the determination of the generation of exogenous noise includes a mode of determining that exogenous noise is generated, a mode of determining that exogenous noise is not generated, and a mode of making both of these determinations. The method for determining that exogenous noise is generated includes a mode of comparing the value obtained by processing the detection signal of the knock sensor with a reference value experimentally defined in advance as a value indicating the generation of exogenous noise. A value calculated in advance by an experimentally defined method as a value indicating the generation of exogenous noise may be used as the reference value. The method for determining that exogenous noise is generated further includes a mode of determining that exogenous noise is generated if the value obtained by processing the detection signal of the knock sensor is greater than the reference value. The method for determining that exogenous noise is generated also includes a mode of determining that exogenous noise is not generated if the value obtained by processing the detection signal of the knock sensor is smaller than the reference value.

Industrial Applicability

[0218] The present teaching can be used for, for example, a saddle-riding type vehicle such as a motorcycle, a power unit of the saddle-riding type vehicle, and an ECU.

Reference Signs List

[0219]

1	Saddle-riding type vehicle
3	Front wheel
4	Rear wheel
5	Engine unit
7	Seat
10	Knock sensor
20	ECU
21	Knock feature extraction circuit
23	Microcomputer
30	Fuel injection unit
40	Ignition unit
50	EGR valve
51	Engine
52	Power transmission section
60	Crank angle sensor
214	Peak hold processing section
231	Knock determination value computation section
232	Knock determination section
233	Rough road noise determination section
234	Ignition timing computation section
235	Fuel injection computation section
236	Actuator control section
237	Window control section

Claims

1. A control apparatus for an engine (51) adapted to receive a detection signal from a knock sensor (10) adapted to detect vibration of the engine (51) mounted in a saddle-riding type vehicle, the control apparatus comprising:

a first acquisition section (232) adapted to acquire a signal output from the knock sensor (10) during a first period during which there is a possibility of occurrence of knocking in one cycle period of the engine (51);
a second acquisition section (233) adapted to acquire a signal output from the knock sensor (10) during a second period which is at least part of a period in the cycle period of the engine (51) excluding the first period and excluding a period during which noise caused by mechanical vibration of the engine (51) is generated;
characterized by
a first control section (234) adapted to determine occurrence of knocking based on the signal acquired by the first acquisition section (232) and adapted to control the engine (51) to suppress the knocking when knocking occurs; and
a second control section (233,234) adapted to determine generation of exogenous noise caused by an external situation of the saddle-riding type vehicle based on the signal acquired by the second acquisition section (233) and adapted to change the control of the engine (51) performed by the first control section (234) based on the determination result.

2. A control apparatus for the engine (51) according to claim 1, further comprising a third acquisition section adapted to acquire a signal output from the knock sensor (10) during a third period overlapping with the period during which the mechanical vibration is generated in the cycle period of the engine (51), wherein the second control section (233,234) is adapted to determine generation of the exogenous noise based on the signal acquired by the second acquisition section (233) and the signal acquired by the third acquisition section.

3. A control apparatus for the engine (51) according to claim 1, wherein:

the second control section (233,234) includes a statistical processing section adapted to calculate statistical information of the signal acquired by the second acquisition section (233); and
the second control section (233,234) is adapted to determine generation of the exogenous noise based on the statistical information.

4. A control apparatus for the engine (51) according to claim 3, wherein the statistical processing section is adapted to calculate, as the statistical information, a degree of dispersion of signal levels acquired by the second acquisition section (233).

5. A control apparatus for the engine (51) according to claim 2, wherein:

the second control section (233,234) includes a statistical processing section adapted to calculate statistical information of the signals acquired by the second acquisition section (233) and the third acquisition section; and
the second control section (233,234) is adapted to determine generation of the exogenous noise based on the statistical information.

6. A control apparatus for the engine (51) according to claim 5, wherein:

the statistical processing section is adapted to

calculate a first statistic and a second statistic as the statistical information, the first statistic being obtained by averaging a plurality of signal levels acquired in a plurality of cycle periods by the second acquisition section (233), the second statistic being obtained by averaging a plurality of signal levels acquired in a plurality of cycle periods by the third acquisition section; and
the second control section (233,234) is adapted to determine generation of the exogenous noise based on a relationship between the first statistic and the second statistic.

7. A control apparatus for the engine (51) according to claim 1, wherein the second control section (233,234) is adapted to change a control parameter of the engine (51) in a direction for suppressing the occurrence of knocking when it is determined that exogenous noise is generated.

8. A control apparatus for the engine (51) according to claim 7, wherein:

the first control section (234) is adapted to perform advance control for advancing a combustion timing of the engine (51) in a stepwise manner when determination indicating that knocking occurs is absent continuously; and
the second control section (233,234) is adapted to reduce speed of advancing the combustion timing in the advance control when it is determined that the exogenous noise is generated.

9. A control apparatus for the engine (51) according to claim 7, wherein:

processing by the first control section (234) includes a process of comparing the signal level acquired by the first acquisition section (232) with a threshold to determine occurrence of knocking; and
the second control section (233,234) is adapted to change a determination method of the threshold when it is determined that exogenous noise is generated.

10. A control apparatus for the engine (51) according to claim 7, wherein the second control section (233,234) is adapted to switch the control of the engine (51) to control for suppressing knocking regardless of the determination result of knocking when it is determined that exogenous noise is generated.

11. A power unit of a saddle-riding type vehicle, the power unit comprising:

an engine (51) mounted in the saddle-riding type vehicle;
a knock sensor (10) adapted to detect vibration of the engine (51); and
the control apparatus for the engine (51) according to at least one of the claims 1 to 10.

12. A saddle-riding type vehicle comprising:

an engine (51) at least partially disposed below a seating surface;
a knock sensor (10) adapted to detect vibration of the engine (51); and
the control apparatus for the engine (51) according to at least one of the claims 1 to 10.

13. A method for controlling an engine (51) with a knock sensor (10) detecting vibration of the engine (51) mounted in a saddle-riding type vehicle, comprising the steps of:

acquiring a signal output from the knock sensor (10) during a first period during which there is a possibility of occurrence of knocking in one cycle period of the engine (51);
acquiring a signal output from the knock sensor (10) during a second period which is at least part of a period in the cycle period of the engine (51) excluding the first period and excluding a period during which noise caused by mechanical vibration of the engine (51) is generated;
characterized by
determining occurrence of knocking based on the acquired signal output from the knock sensor (10) during the first period and controlling the engine (51) to suppress the knocking when knocking occurs; and
determining generation of exogenous noise caused by an external situation of the saddle-riding type vehicle based on the acquired signal output from the knock sensor (10) during the second period and changing the control of the engine (51) performed on bases of signal output from the knock sensor (10) during the first period based on the determination result.

14. A method for controlling an engine (51) according to claim 13, further comprising:

acquiring a signal output from the knock sensor (10) during a third period overlapping with the period during which the mechanical vibration is generated in the cycle period of the engine (51),
determining generation of the exogenous noise based on the acquired signal output from the knock sensor (10) during the second period and the acquired signal output from the knock sensor (10) during a third period, and/or
calculating statistical information of the acquired signal output from the knock sensor (10) during

the second period; and
determining generation of the exogenous noise based on the statistical information.

15. A method for controlling an engine (51) according to at least one of the claims 13 or 14, further comprising:
changing a control parameter of the engine (51) in a direction for suppressing the occurrence of knocking when it is determined that exogenous noise is generated, and/or
performing advance control for advancing a combustion timing of the engine (51) in a stepwise manner when determination indicating that knocking occurs is absent continuously; and
reducing speed of advancing the combustion timing in the advance control when it is determined that the exogenous noise is generated, and/or
comparing the signal level acquired from the knock sensor (10) during the first period with a threshold to determine occurrence of knocking; and
changing a determination method of the threshold when it is determined that exogenous noise is generated, and/or
switching the control of the engine (51) to control for suppressing knocking regardless of the determination result of knocking when it is determined that exogenous noise is generated.

Patentansprüche

1. Ein Steuerapparat für einen Motor (51) angepasst, um ein Erfassungssignal von einem Klopfsensor (10) zu empfangen, der angepasst ist, Vibrationen des Motors (51), montiert in einem Sattel-Reit-Typ-Fahrzeug zu erfassen, der Steuerapparat umfasst:

einen ersten Übernahmeabschnitt (232), der angepasst ist, um einen Signal-Ausgang von dem Klopfsensor (10) zu übernehmen, während einer ersten Periode, während der eine Möglichkeit des Auftretens von Klopfen in einer Ein-Zyklus-Periode des Motors (51) besteht;
einen zweiten Übernahmeabschnitt (233), der angepasst ist, um einen Signal-Ausgang von dem Klopfsensor zu übernehmen, während einer zweiten Periode, die zumindest Teil einer Periode in der Zyklus-Periode des Motors (51) ist, welche die erste Periode ausschließt und eine Periode ausschließt, in welcher Rauschen, bewirkt durch mechanische Vibrationen des Motors (51), erzeugt ist;
gekennzeichnet durch
einen ersten Steuerabschnitt (234), der angepasst ist, um das Auftreten von Klopfen auf Grundlage des Signals, übernommen **durch** den ersten Übernahmeabschnittt (232), zu bestimmen und angepasst ist, den Motor zu steuern, um das Klopfen zu unterdrücken, wenn klopfen auftritt; und
einen zweiten Steuerabschnitt (233, 234), der angepasst ist, um Erzeugung von Fremd-Rauschen, bewirkt **durch** eine äußere Situation des Sattel-Reit-Typ-Fahrzeugs zu bestimmen, auf Grundlage des Signals, übernommen **durch** den zweiten Übernahmeabschnitt (233), und angepasst ist, die Steuerung des Motors (51), durchgeführt **durch** den ersten Steuerabschnitt (234), auf Grundlage des Bestimmungs-Ergebnisses zu ändern.

2. Ein Steuerapparat für den Motor (51) gemäß Anspruch 1, der weiterhin umfasst, einen dritten Übernahmeabschnitt, der angepasst ist, einen Signal-Ausgang von dem Klopfsensor (10) während einer dritten Periode zu übernehmen, die mit der Periode überlappt, während der die mechanische Vibration in der Zyklus-Periode des Motors (51) erzeugt ist, wobei der zweite Steuerabschnitt (233, 234) angepasst ist, um Erzeugung von Fremd-Rauschen auf Grundlage des Signals, übernommen durch den zweiten Übernahmeabschnitt (233), und des Signals, übernommen durch den dritten Übernahmeabschnitt, zu bestimmen.

3. Ein Steuerapparat für den Motor (51) gemäß Anspruch 1, wobei:

der zweite Steuerabschnitt (233, 234) einen statistischen Verarbeitungsabschnitt beinhaltet, der angepasst ist, statistische Informationen des Signals, übernommen durch den zweiten Übernahmeabschnitt (233), zu berechnen; und
der zweite Steuerabschnitt (233, 234) ist angepasst, um Erzeugung des Fremd-Rauschens auf Grundlage der statistischen Information zu bestimmen.

4. Ein Steuerapparat für den Motor (51) gemäß Anspruch 3, wobei der statistische Verarbeitungsabschnitt angepasst ist zur Berechnung, als die statistische Information, ein Grad der Verteilung von Signal-Pegeln, übernommen durch den zweiten Übernahmeabschnitt (233).

5. Ein Steuerungsapparat für den Motor (51) gemäß Anspruch 2, wobei der zweite Steuerabschnitt (233, 234) einen statistischen Verarbeitungsabschnitt beinhaltet, der angepasst ist, um statistische Informationen des Signals, übernommen durch den zweiten Übernahmeabschnitt (233) und den dritten Übernahmeabschnitt, zu berechnen; und
der zweite Steuerabschnitt (233, 234) ist angepasst, um Erzeugen von Fremd-Rauschen auf Grundlage der statistischen Information zu bestimmen.

6. Ein Steuerungsapparat für den Motor (51) gemäß Anspruch 5, wobei:

der statistische Verarbeitungsabschnitt angepasst ist, eine erste Statistik und eine zweite Statistik als die statistische Information zu berechnen, die erste Statistik ist erhalten durch Mittelung einer Mehrzahl von Signal-Pegeln, übernommen in einer Mehrzahl von Zyklus-Perioden durch den zweiten Übernahmeabschnitt (233), die zweite Statistik ist erhalten durch Mittelung einer Mehrzahl von Signal-Pegeln, übernommen in einer Mehrzahl von Zyklus-Perioden durch den dritten Übernahmeabschnitt; und
der zweite Steuerabschnitt (233, 234) ist angepasst, um Erzeugung von Fremd-Rauschen auf Grundlage einer Beziehung zwischen der ersten Statistik und der zweiten Statistik zu bestimmen.

7. Ein Steuerungsapparat für den Motor (51) gemäß Anspruch 1, wobei der zweite Steuerabschnitt (233, 234) angepasst ist, um einen Steuer-Parameter des Motors (51) in einer Richtung zur Unterdrückung des Auftretens von Klopfen zu ändern, wenn bestimmt ist, dass Fremd-Rauschen erzeugt ist.

8. Ein Steuerungsapparat für den Motor (51) gemäß Anspruch 7, wobei:

der erste Steuerabschnitt (234) angepasst ist, um eine Vor-Steuerung zu einer Voreilung einer Verbrennungszeit des Motors (51) in einer stufenweise durchzuführen, wenn Bestimmung anzeigt, dass Klopfen auftritt, kontinuierlich abwesent ist; und
der zweite Steuerabschnitt (233, 234) ist angepasst, um eine Geschwindigkeit der Voreilung der Verbrennungszeit in der Vor-Steuerung zu reduzieren, wenn bestimmt ist, dass das Fremd-Rauschen erzeugt ist.

9. Ein Steuerungsapparat für den Motor (51) gemäß Anspruch 7, wobei:

Verarbeiten durch den ersten Steuerabschnitt (234) beinhaltet einem Prozess des Vergleichens der Signal-Pegel, übernommen durch den ersten Übernahmeabschnitt (233), mit einem Grenzwert, um Auftreten von Klopfen zu bestimmen; und
der zweite Steuerabschnitt (233, 234) ist angepasst, um ein Bestimmungsverfahren des Grenzwertes zu ändern, wenn bestimmt ist, dass Fremd-Rauschen erzeugt ist.

10. Ein Steuerungsapparat für den Motor (51) gemäß Anspruch 7, wobei der zweite Steuerabschnitt (233, 234) angepasst ist, um die Steuerung des Motors (51) zur Steuerung zur Unterdrückung des Klopfens zu schalten, ungeachtet des Bestimmungs-Ergebnisses des Klopfens, wenn bestimmt ist, dass Fremd-Rauschen erzeugt ist.

11. Eine Leistungseinheit für ein Sattel-Reit-Typ-Fahrzeug, die Leistungseinheit umfasst:

einen Motor (51), montiert in dem Sattel-Reit-Typ-Fahrzeug;
einen Klopfsensor (10), angepasst, um Vibrationen des Motors (51) zu erfassen; und
den Steuerapparat für den Motor (51) gemäß zumindest einem der Ansprüche 1 bis 10.

12. Ein Sattel-Reit-Typ-Fahrzeug, das umfasst:

einen Motor (51), der zumindest teilweise unter einer Sitzfläche positioniert ist;
einen Klopfsensor (10), angepasst um Vibrationen des Motors (51) zu erfassen; und
den Steuerapparat für den Motor (51) gemäß zumindest einem der Ansprüche 1 bis 10.

13. Ein Verfahren zur Steuerung eines Motors (51) mit einem Klopfsensor (10), der Vibrationen des Motors (51) erfasst, montiert in einem Sattel-Reit-Typ-Fahrzeug, das die Schritte umfasst:

Übernehmen eines Signal-Ausgangs von dem Klopfsensor (10), während einer ersten Periode, während der eine Möglichkeit des Auftretens von Klopfen in einer Zyklus-Periode des Motors (51) ist;
Übernehmen eines Signal-Ausgangs von dem Klopfsensor (10) während einer zweiten Periode, die zumindest ein Teil einer Periode ist, in der Zyklus-Periode des Motors (51), welche die erste Periode ausschließt, und eine Periode ausschließt, während der Rauschen, bewirkt durch mechanische Vibrationen des Motors (51), erzeugt ist;
gekennzeichnet durch
Bestimmen Auftreten von Klopfen auf Grundlage des übernommenen Signal-Ausgangs von dem Klopfsensor (10) während der ersten Periode und Steuern des Motors (51), um Klopfen zu unterdrücken, wenn Klopfen auftritt; und
Bestimmen von Erzeugen von Fremd-Rauschen, bewirkt **durch** eine externe Situation des Sattel-Reit-Typ-Fahrzeugs, auf Grundlage des übernommenen Signal-Ausgangs von dem Klopfsensor (10), während der zweiten Periode, und Ändern der Steuerung des Motors (51), durchgeführt auf Grundlage des Signal-Ausgangs von dem Klopfsensor (10), während der ersten Periode, auf der Grundlage des Bestimmungs-Ergebnisses.

14. Ein Verfahren zur Steuerung eines Motors (51) gemäß Anspruch 13, das weiterhin umfasst:

Übernehmen eines Signal-Ausgangs von dem Klopfsensor (10) während einer dritten Periode, die mit der Periode überlappt, während der die mechanische Vibration erzeugt ist, in der Zyklus-Periode des Motors (51),
Bestimmen der Erzeugung von Fremd-Rauschen auf Grundlage des übernommenen Signal-Ausgangs von dem Klopfsensor (10) während der zweiten Periode und des übernommenen Signal-Ausgangs von dem Klopfsensor (10), während einer dritten Periode; und / oder
Berechnen statistischer Informationen des übernommenen Signal-Ausgangs von dem Klopfsensor (10) während der zweiten Periode; und
Bestimmen Erzeugung von Fremd-Rauschen auf Grundlage der statistischen Information.

15. Ein Verfahren zur Steuerung eines Motors (51) gemäß zumindest einem der Ansprüche 13 oder 14, das weiterhin umfasst: Ändern eines Steuer-Parameters des Motors (51) in einer Richtung zur Unterdrückung des Auftretens von Klopfen, wenn bestimmt ist, das Fremd-Rauschen erzeugt ist; und / oder
Durchführen einer Vor-Steuerung zur Voreilung einer Verbrennungszeit des Motors (51) in einer stufenweise, wenn die Bestimmung anzeigt, dass Klopfen auftritt, kontinuierlich abwesend ist; und
Reduzieren der Geschwindigkeit der Voreilung der Verbrennungszeit in der Vor-Steuerung, wenn bestimmt ist, dass das Fremd-Rauschen erzeugt ist; und / oder Vergleichen des Signal-Pegels, übernommen von dem Klopfsensor (10) während der ersten Periode, mit einem Grenzwert, um Auftreten von Klopfen zu bestimmen; Ändern eines Bestimmungsverfahrens für den Grenzwert, wenn bestimmt ist, das Fremd-Rauschen erzeugt ist, und / oder
Schalten der Steuerung des Motors (51) zur Steuerung zur Unterdrückung von Klopfen, ungeachtet des Bestimmungs-Ergebnisses des Klopfens, wenn bestimmt ist, das Fremd-Rauschen erzeugt ist.

Revendications

1. Appareil de commande pour moteur (51), conçu pour recevoir un signal de détection d'un détecteur de cliquetis (10) conçu pour détecter les vibrations du moteur (51) monté dans un véhicule de type à selle, l'appareil de commande comprenant :

une première section d'acquisition (232) conçue pour acquérir un signal délivré en sortie par le détecteur de cliquetis (10) pendant une première période durant laquelle un cliquetis risque de se produire dans une période de cycle du moteur (51) ;
une deuxième section d'acquisition (233) conçue pour acquérir un signal délivré en sortie par le détecteur de cliquetis (10) pendant une deuxième période qui fait au moins parti d'une période de la période de cycle du moteur (51), à l'exclusion de la première période et à l'exclusion d'une période durant laquelle un bruit causé par les vibrations mécaniques du moteur (51) est généré ;
caractérisé par
une première section de commande (234) conçue pour déterminer la survenue d'un cliquetis sur la base du signal acquis par la première section d'acquisition (232) et conçue pour commander le moteur (51) pour éliminer le cliquetis lorsque celui-ci se produit; et
une seconde section de commande (233, 234) conçue pour déterminer la génération d'un bruit exogène causé par une situation extérieure du véhicule de type à selle sur la base du signal acquis par la deuxième section d'acquisition (233) et conçue pour modifier la commande du moteur (51) réalisée par la première section de commande (234) en fonction du résultat de la détermination.

2. Appareil de commande pour moteur (51) selon la revendication 1, comprenant, en outre, une troisième section d'acquisition conçue pour acquérir un signal délivré en sortie par le détecteur de cliquetis (10) pendant une troisième période chevauchant la période durant laquelle les vibrations mécaniques sont générées dans la période de cycle du moteur (51), la seconde section de commande (233, 234) étant conçue pour déterminer la génération du bruit exogène sur la base du signal acquis par la deuxième section d'acquisition (233) et du signal acquis par la troisième section d'acquisition.

3. Appareil de commande pour moteur (51) selon la revendication 1 :

la seconde section de commande (233, 234) incluant une section de traitement statistique conçue pour calculer des informations statistiques du signal acquis par la deuxième section d'acquisition (233) ; et
la seconde section de commande (233, 234) étant conçue pour déterminer la génération du bruit exogène sur la base des informations statistiques.

4. Appareil de commande pour moteur (51) selon la revendication 3, la section de traitement statistique étant conçue pour calculer, en tant qu'informations

statistiques, un degré de dispersion des niveaux des signaux acquis par la deuxième section d'acquisition (233).

5. Appareil de commande pour moteur (51) selon la revendication 2 :

la seconde section de commande (233, 234) incluant une section de traitement statistique conçue pour calculer des informations statistiques des signaux acquis par la deuxième section d'acquisition (233) et la troisième section d'acquisition ; et
la seconde section de commande (233, 234) étant conçue pour déterminer la génération du bruit exogène sur la base des informations statistiques.

6. Appareil de commande pour moteur (51) selon la revendication 5 :

la section de traitement statistique étant conçue pour calculer une première statistique et une seconde statistique en tant qu'informations statistiques, la première statistique étant obtenue en faisant la moyenne d'une pluralité de niveaux de signaux acquis dans une pluralité de périodes de cycle par la deuxième section d'acquisition (233), la seconde statistique étant obtenue en faisant la moyenne d'une pluralité de niveaux de signaux acquis dans une pluralité de périodes de cycle par la troisième section d'acquisition ; et
la seconde section de commande (233, 234) étant conçue pour déterminer la génération du bruit exogène en fonction d'une relation entre la première statistique et la seconde statistique.

7. Appareil de commande pour moteur (51) selon la revendication 1 :

la seconde section de commande (233, 234) étant conçue pour modifier un paramètre de commande du moteur (51) dans un sens visant à supprimer la survenue d'un cliquetis lorsque la génération d'un bruit exogène est déterminée.

8. Appareil de commande pour moteur (51) selon la revendication 7 :

la première section de commande (234) étant conçue pour exécuter une commande d'avance pour avancer un minutage de combustion du moteur (51) de manière graduelle lorsqu'une détermination indique une absence continue de survenue d'un cliquetis ; et
la seconde section de commande (233, 234) étant conçue pour réduire la vitesse d'avance du minutage de combustion dans la commande d'avance lorsque la génération du bruit exogène est déterminée.

9. Appareil de commande pour moteur (51) selon la revendication 7 :

le traitement par la première section de commande (234) incluant un processus de comparaison du niveau du signal acquis par la première section d'acquisition (232) avec un seuil pour déterminer la survenue d'un cliquetis ; et
la seconde section de commande (233, 234) étant conçue pour modifier une méthode de détermination du seuil lorsque la génération d'un bruit exogène est déterminée.

10. Appareil de commande pour moteur (51) selon la revendication 7 :

la seconde section de commande (233, 234) étant conçue pour commuter la commande du moteur (51) et passer en commande visant à supprimer le cliquetis quel que soit le résultat de la détermination de cliquetis lorsque la génération d'un bruit exogène est déterminée.

11. Unité de puissance d'un véhicule de type à selle, l'unité de puissance comprenant :

un moteur (51) monté dans le véhicule de type à selle ;
un détecteur de cliquetis (10) conçu pour détecter les vibrations du moteur (51); et
l'appareil de commande pour moteur (51) selon au moins une des revendications 1 à 10.

12. Véhicule de type à selle, comprenant :

un moteur (51) disposé au moins en partie sous une surface d'assise ;
un détecteur de cliquetis (10) conçu pour détecter les vibrations du moteur (51); et
l'appareil de commande pour moteur (51) selon au moins une des revendications 1 à 10.

13. Procédé de commande d'un moteur (51) avec un détecteur de cliquetis (10) détectant les vibrations du moteur (51) monté dans un véhicule de type à selle, comprenant les étapes consistant à :

acquérir un signal délivré en sortie par le détecteur de cliquetis (10) pendant une première période durant laquelle un cliquetis risque de se produire dans une période de cycle du moteur (51) ;
acquérir un signal délivré en sortie par le détecteur de cliquetis (10) pendant une deuxième pé-

riode qui fait au moins partie d'une période de la période de cycle du moteur (51), à l'exclusion de la première période et à l'exclusion d'une période durant laquelle un bruit causé par les vibrations mécaniques du moteur (51) est généré ;

caractérisé par

la détermination de la survenue d'un cliquetis sur la base du signal acquis à la sortie du détecteur de cliquetis (10) pendant la première période et la commande du moteur (51) pour supprimer le cliquetis lorsque celui-ci se produit ; et

la détermination de la génération d'un bruit exogène causé par une situation extérieure du véhicule de type à selle sur la base du signal acquis à la sortie du détecteur de cliquetis (10) pendant la deuxième période, et la modification de la commande du moteur (51) réalisée sur la base du signal délivré en sortie par le détecteur de cliquetis (10) pendant la première période en fonction du résultat de la détermination.

14. Procédé de commande d'un moteur (51) selon la revendication 13, comprenant, en outre :

l'acquisition d'un signal délivré en sortie par le détecteur de cliquetis (10) pendant une troisième période chevauchant la période durant laquelle les vibrations mécaniques sont générées dans la période de cycle du moteur (51),

la détermination de la génération du bruit exogène sur la base du signal acquis à la sortie du détecteur de cliquetis (10) pendant la deuxième période et du signal acquis à la sortie du détecteur de cliquetis (10) pendant une troisième période, et/ou

le calcul d'informations statistiques du signal acquis à la sortie du détecteur de cliquetis (10) pendant la deuxième période ; et

la détermination de la génération du bruit exogène sur la base des informations statistiques.

15. Procédé de commande d'un moteur (51) selon au moins une des revendications 13 ou 14, comprenant, en outre :

la modification d'un paramètre de commande du moteur (51) dans un sens visant à supprimer la survenue d'un cliquetis lorsque la génération d'un bruit exogène est déterminée, et/ou

l'exécution d'une commande d'avance pour avancer un minutage de combustion du moteur (51) de manière graduelle lorsqu'une détermination indique une absence continue de survenue d'un cliquetis ; et

la réduction de la vitesse d'avance du minutage de combustion dans la commande d'avance lorsque la génération d'un bruit exogène est déterminée, et/ou

la comparaison du niveau du signal acquis à la sortie du détecteur de cliquetis (10) pendant la première période avec un seuil pour déterminer la survenue d'un cliquetis ; et

la modification d'un procédé de détermination du seuil lorsque la génération d'un bruit exogène est déterminée, et/ou

la commutation de la commande du moteur (51) pour passer en commande visant à supprimer le cliquetis quel que soit le résultat de la détermination de cliquetis lorsque la génération d'un bruit exogène est déterminée.

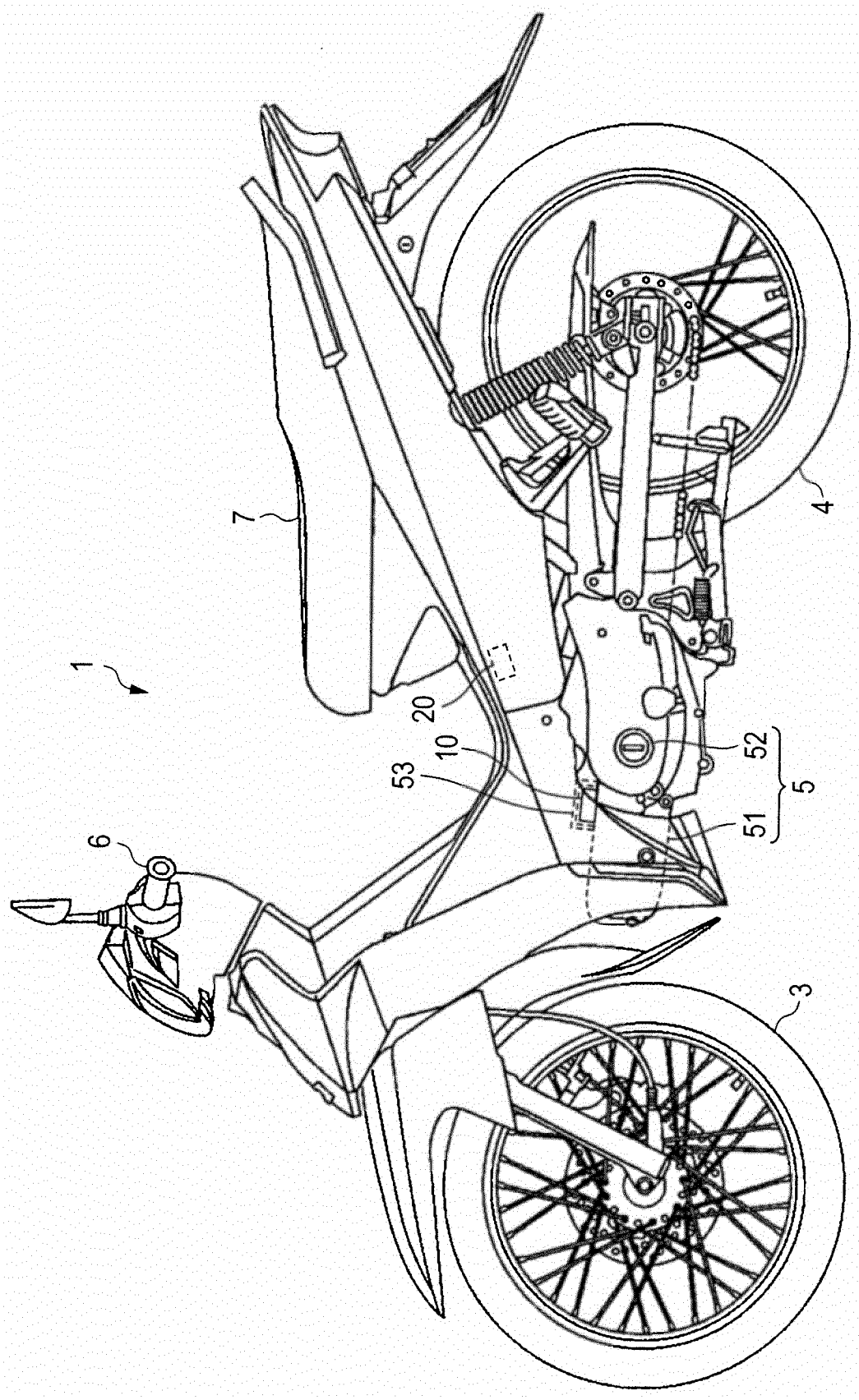


FIG. 1

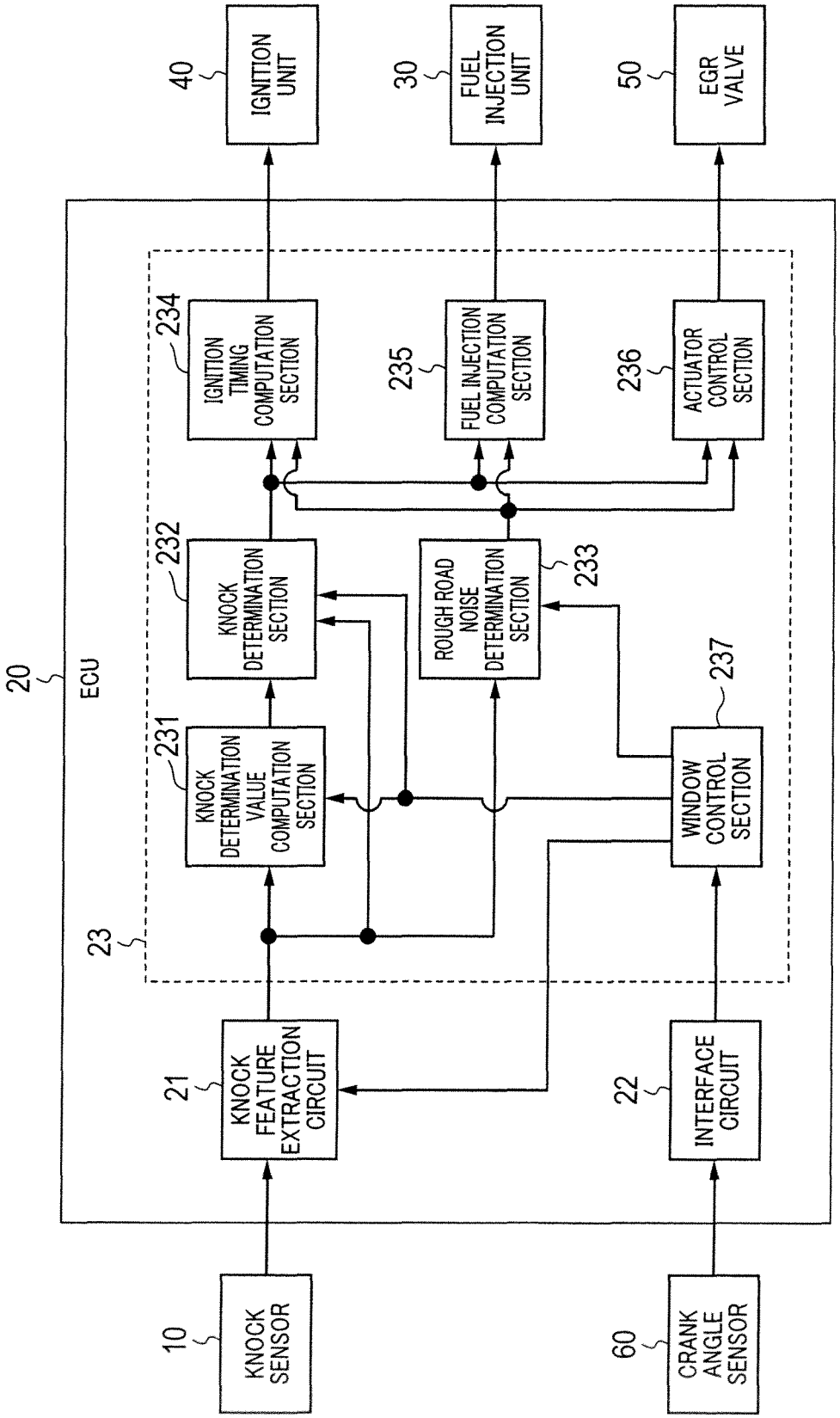

40
IGNITION UNIT
30
FUEL INJECTION UNIT
50
EGR VALVE
20
ECU
234
IGNITION TIMING COMPUTATION SECTION
235
FUEL INJECTION COMPUTATION SECTION
236
ACTUATOR CONTROL SECTION
232
KNOCK DETERMINATION SECTION
233
ROUGH ROAD NOISE DETERMINATION SECTION
231
KNOCK DETERMINATION VALUE COMPUTATION SECTION
237
WINDOW CONTROL SECTION
23
21
KNOCK FEATURE EXTRACTION CIRCUIT
22
INTERFACE CIRCUIT
10
KNOCK SENSOR
60
CRANK ANGLE SENSOR

FIG. 2

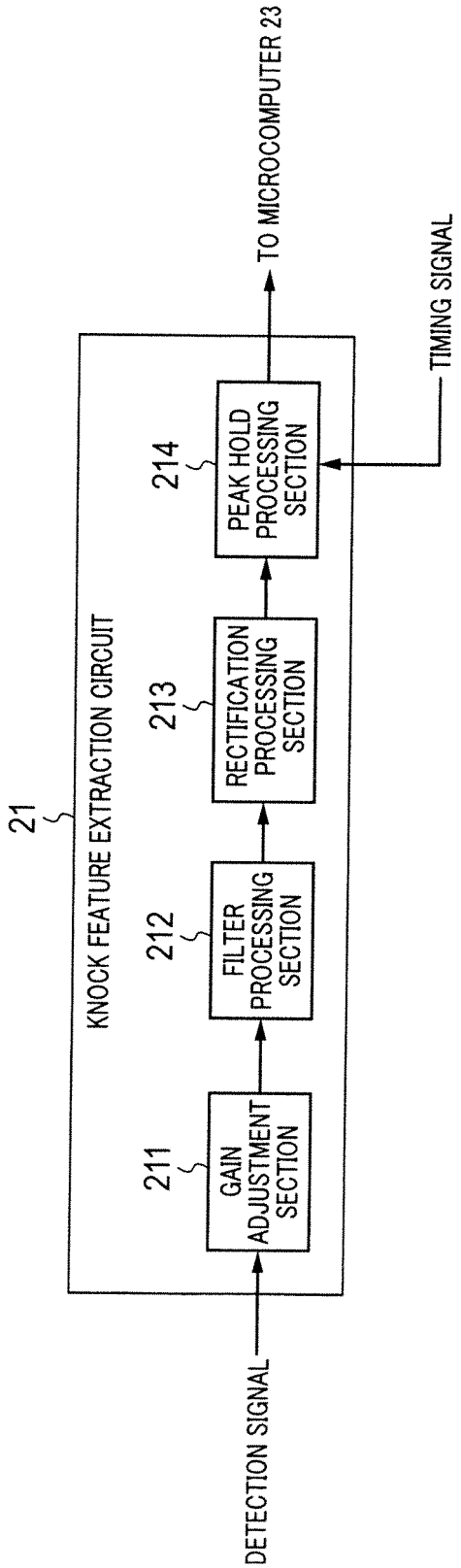

21
KNOCK FEATURE EXTRACTION CIRCUIT
211
GAIN ADJUSTMENT SECTION
212
FILTER PROCESSING SECTION
213
RECTIFICATION PROCESSING SECTION
214
PEAK HOLD PROCESSING SECTION
DETECTION SIGNAL
TIMING SIGNAL
TO MICROCOMPUTER 23

FIG. 3

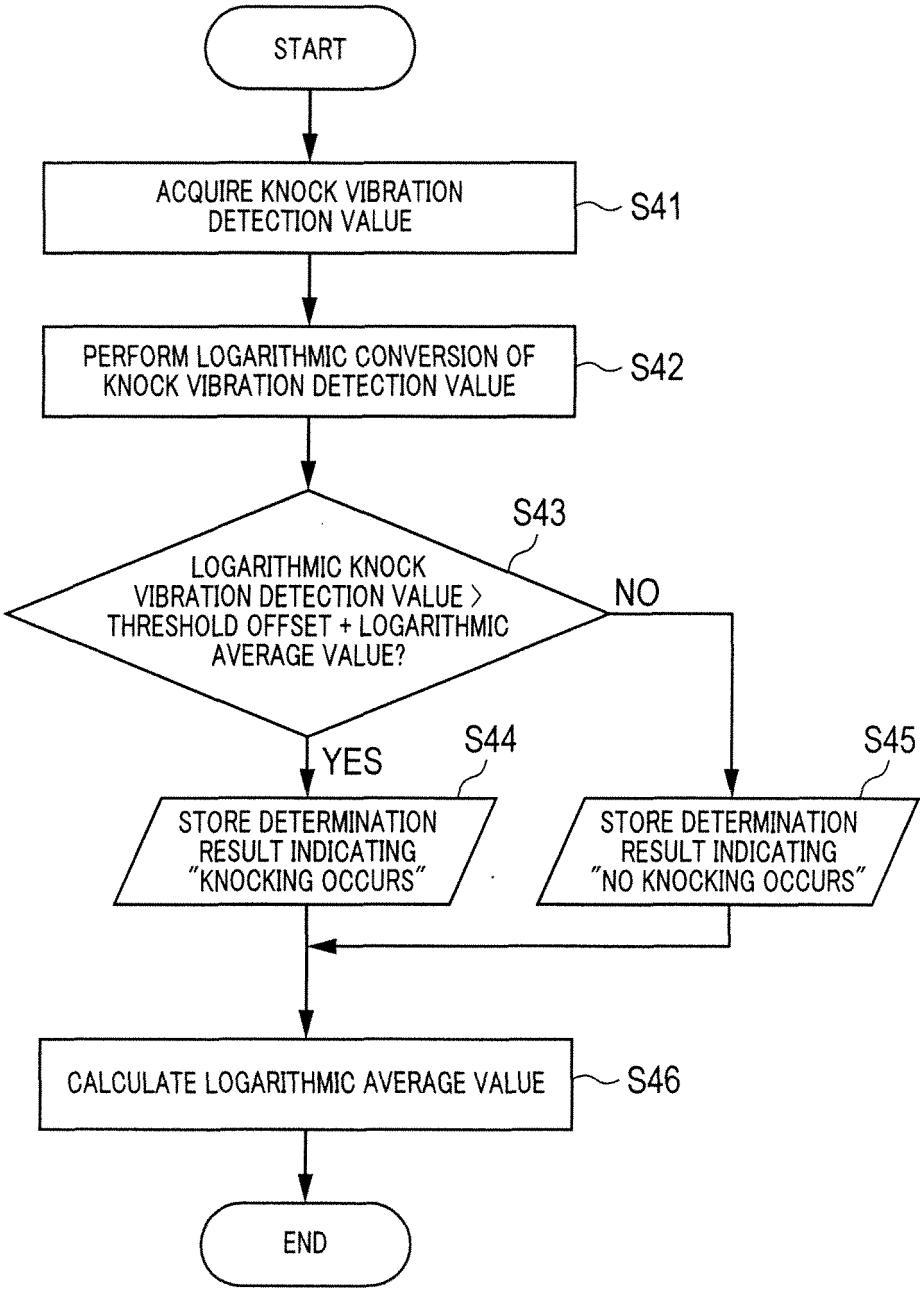

START
ACQUIRE KNOCK VIBRATION DETECTION VALUE
S41
PERFORM LOGARITHMIC CONVERSION OF KNOCK VIBRATION DETECTION VALUE
S42
S43
LOGARITHMIC KNOCK VIBRATION DETECTION VALUE > THRESHOLD OFFSET + LOGARITHMIC AVERAGE VALUE?
NO
YES
S44
STORE DETERMINATION RESULT INDICATING "KNOCKING OCCURS"
S45
STORE DETERMINATION RESULT INDICATING "NO KNOCKING OCCURS"
CALCULATE LOGARITHMIC AVERAGE VALUE
S46
END

FIG. 4

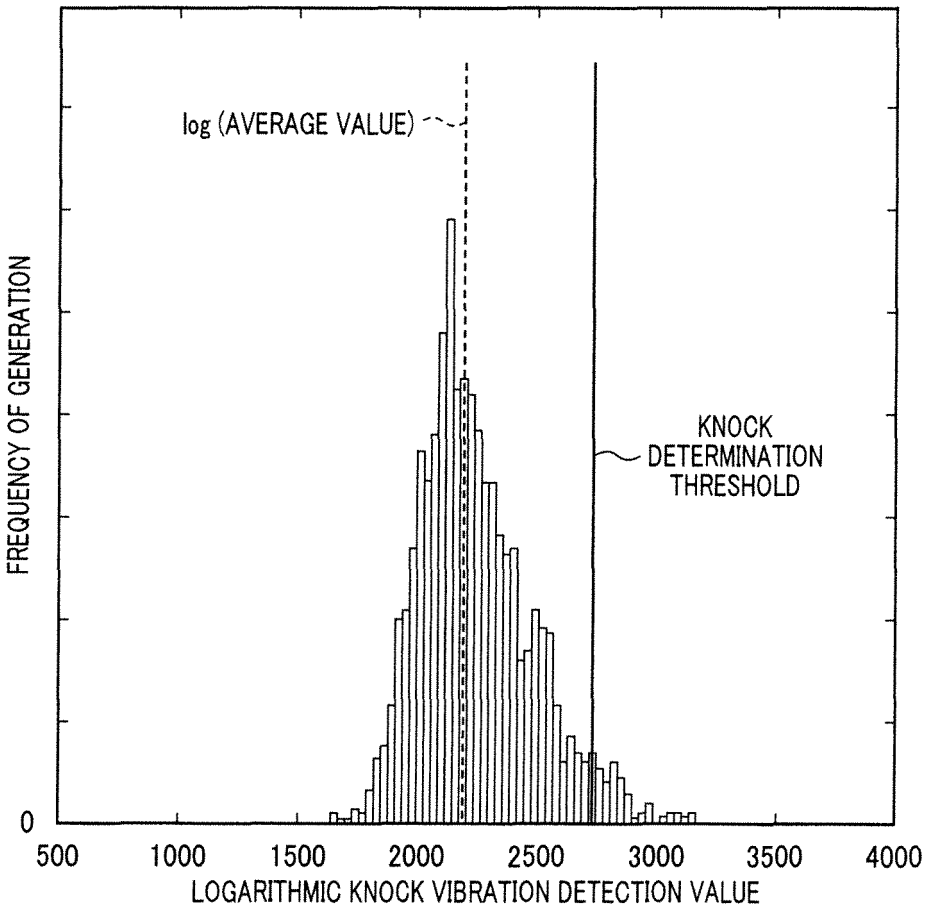

log (AVERAGE VALUE)
KNOCK
DETERMINATION
THRESHOLD
FREQUENCY OF GENERATION
0
500
1000
1500
2000
2500
3000
3500
4000
LOGARITHMIC KNOCK VIBRATION DETECTION VALUE

FIG. 5

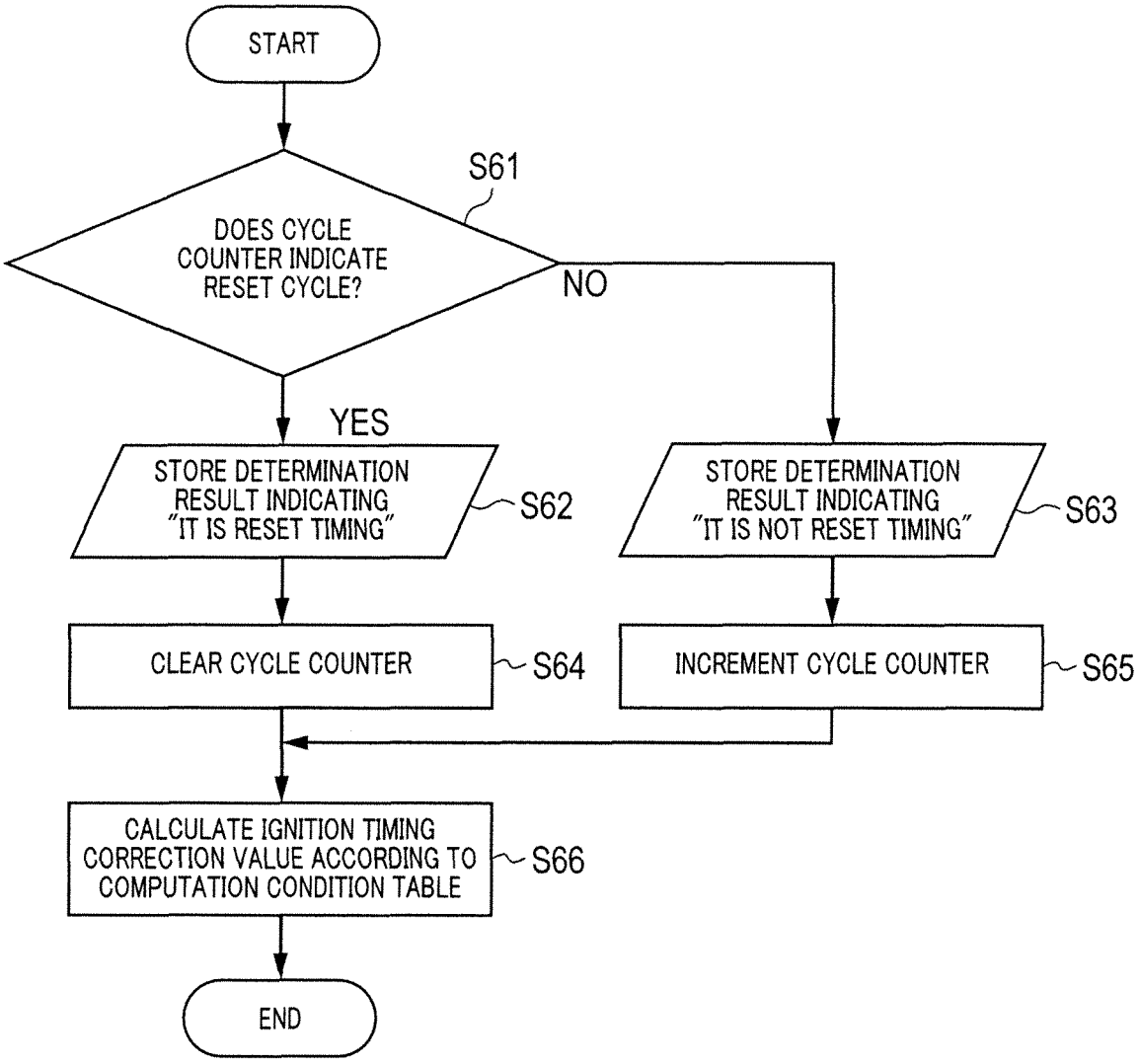

START
S61
DOES CYCLE COUNTER INDICATE RESET CYCLE?
NO
YES
STORE DETERMINATION RESULT INDICATING "IT IS RESET TIMING"
S62
STORE DETERMINATION RESULT INDICATING "IT IS NOT RESET TIMING"
S63
CLEAR CYCLE COUNTER
S64
INCREMENT CYCLE COUNTER
S65
CALCULATE IGNITION TIMING CORRECTION VALUE ACCORDING TO COMPUTATION CONDITION TABLE
S66
END

FIG. 6

70

	IT IS RESET TIMING	IT IS NOT RESET TIMING
KNOCKING OCCURS	(1) IGNITION TIMING CORRECTION VALUE = LAST CYCLE CORRECTION VALUE – KNOCK DETERMINATION RETARD AMOUNT + RESET ADVANCE AMOUNT	(3) IGNITION TIMING CORRECTION VALUE = LAST CYCLE CORRECTION VALUE – KNOCK DETERMINATION RETARD AMOUNT
NO KNOCKING OCCURS	(2) IGNITION TIMING CORRECTION VALUE = LAST CYCLE CORRECTION VALUE + RESET ADVANCE AMOUNT	(4) IGNITION TIMING CORRECTION VALUE = LAST CYCLE CORRECTION VALUE

FIG. 7

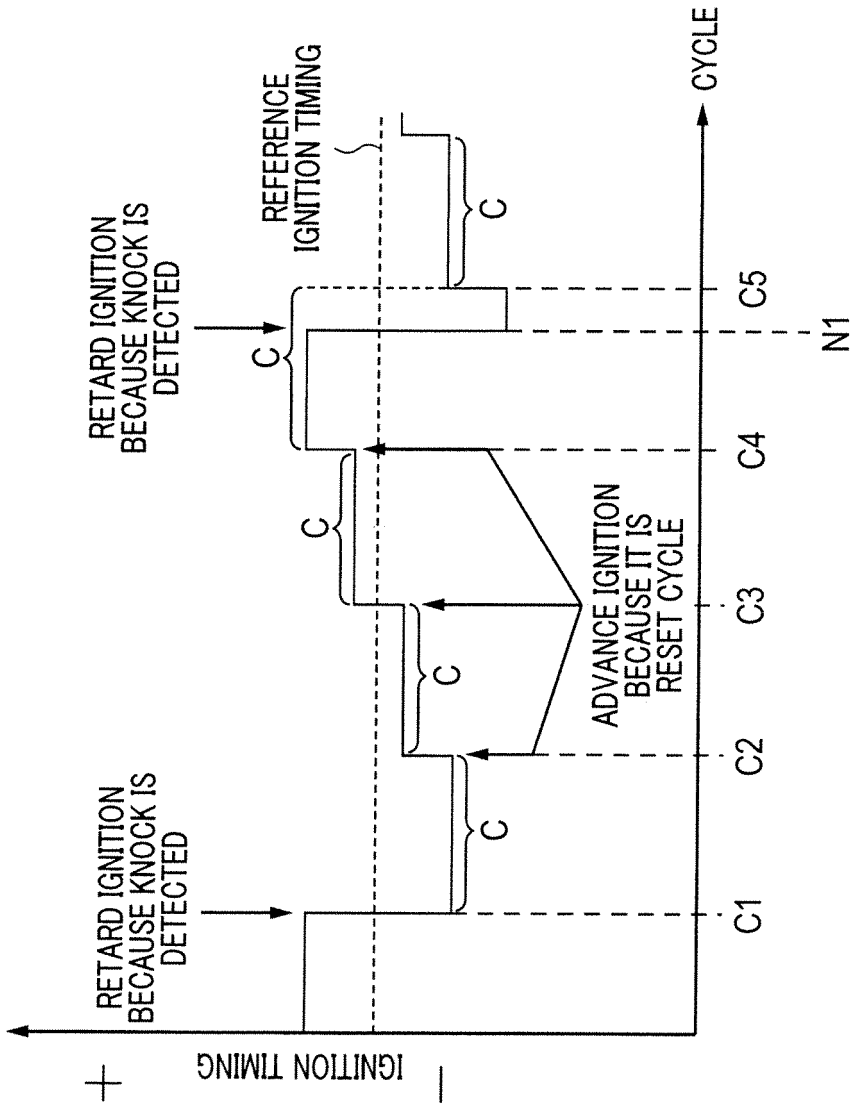

IGNITION TIMING
+
-
CYCLE
C1
C2
C3
C4
C5
N1
C
RETARD IGNITION BECAUSE KNOCK IS DETECTED
RETARD IGNITION BECAUSE KNOCK IS DETECTED
REFERENCE IGNITION TIMING
ADVANCE IGNITION BECAUSE IT IS RESET CYCLE

FIG. 8

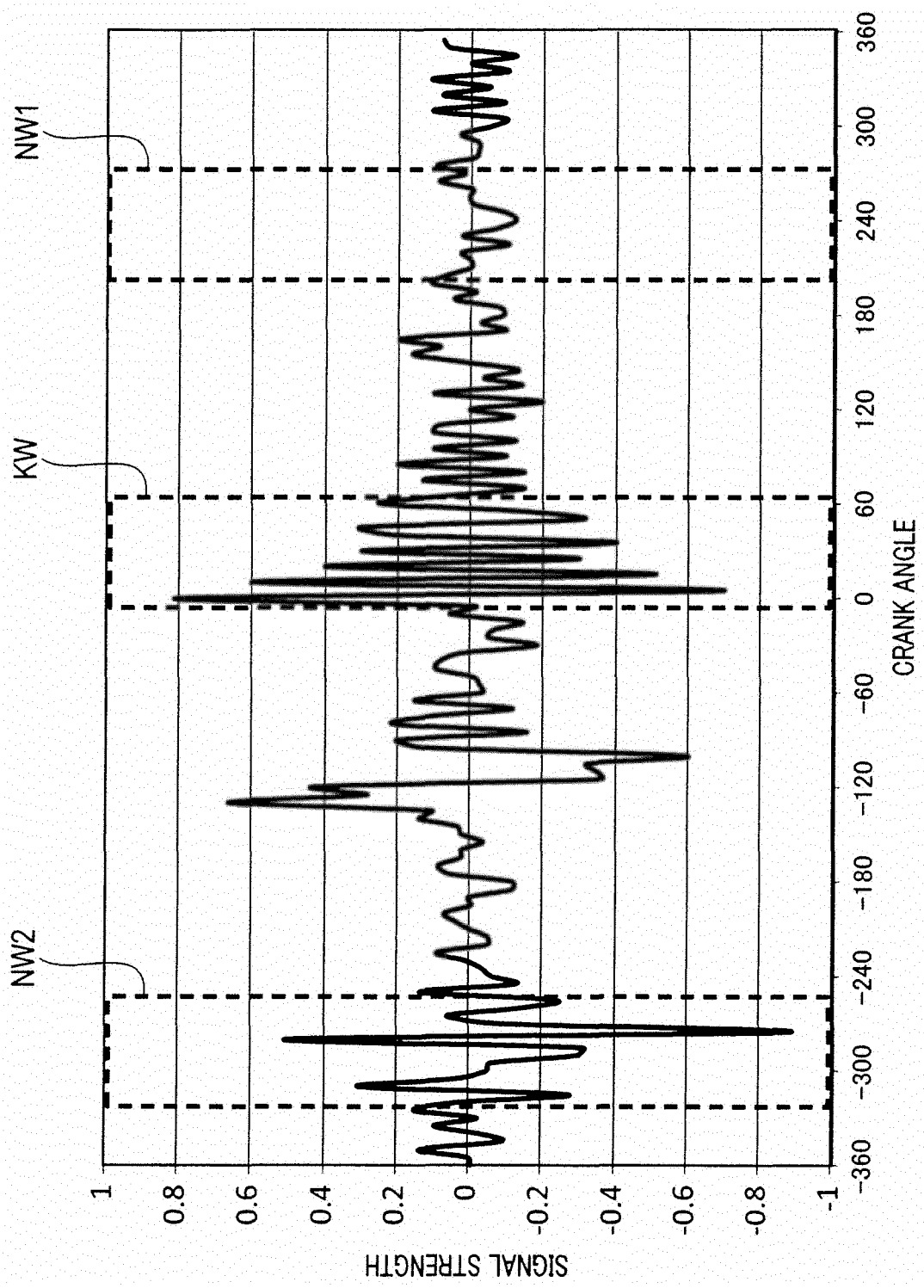

NW1
KW
NW2
SIGNAL STRENGTH
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-360
-300
-240
-180
-120
-60
0
60
120
180
240
300
360
CRANK ANGLE

FIG. 9

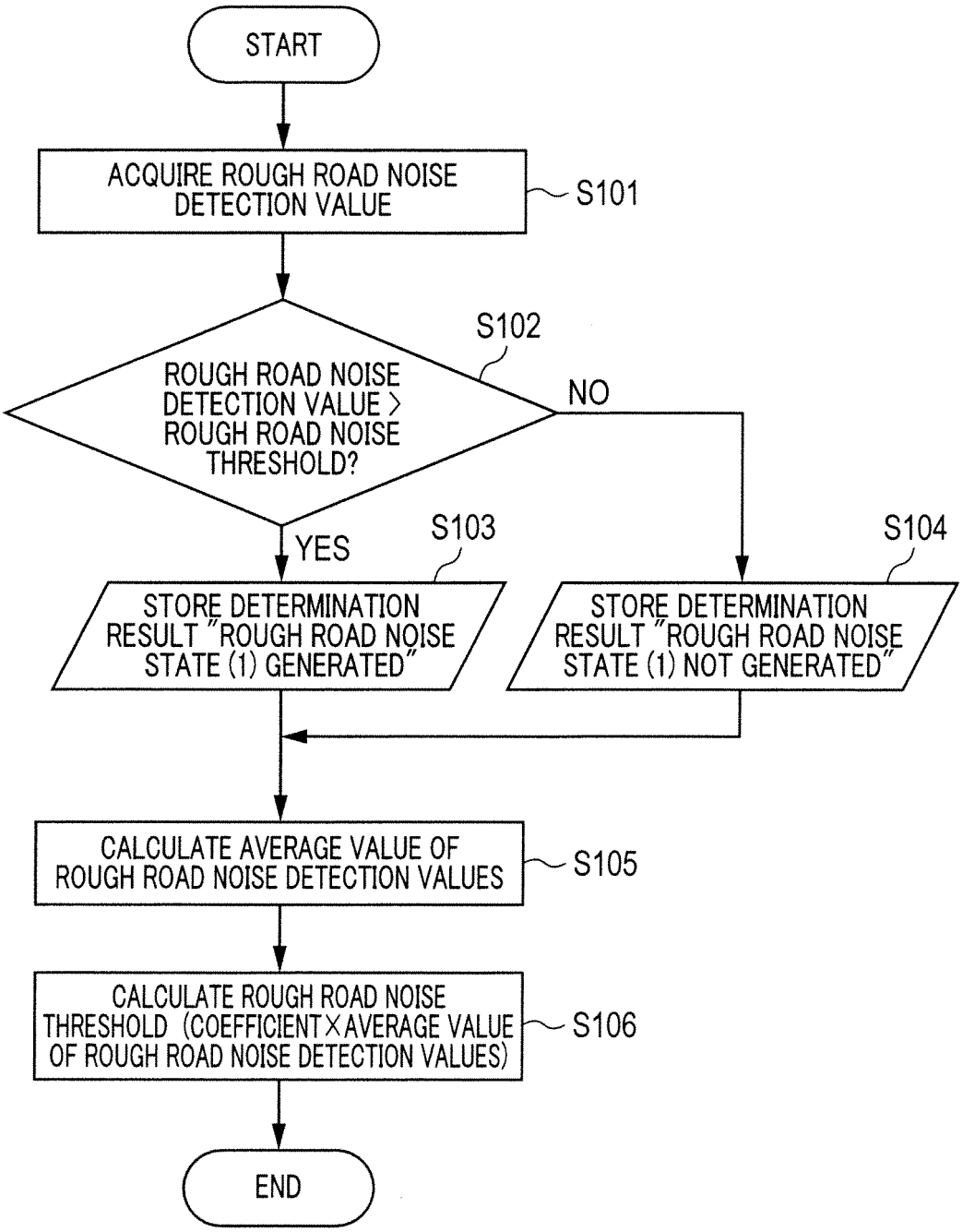

START
ACQUIRE ROUGH ROAD NOISE DETECTION VALUE
S101
S102
ROUGH ROAD NOISE DETECTION VALUE > ROUGH ROAD NOISE THRESHOLD?
NO
YES
S103
S104
STORE DETERMINATION RESULT "ROUGH ROAD NOISE STATE (1) GENERATED"
STORE DETERMINATION RESULT "ROUGH ROAD NOISE STATE (1) NOT GENERATED"
CALCULATE AVERAGE VALUE OF ROUGH ROAD NOISE DETECTION VALUES
S105
CALCULATE ROUGH ROAD NOISE THRESHOLD (COEFFICIENT×AVERAGE VALUE OF ROUGH ROAD NOISE DETECTION VALUES)
S106
END

FIG. 10

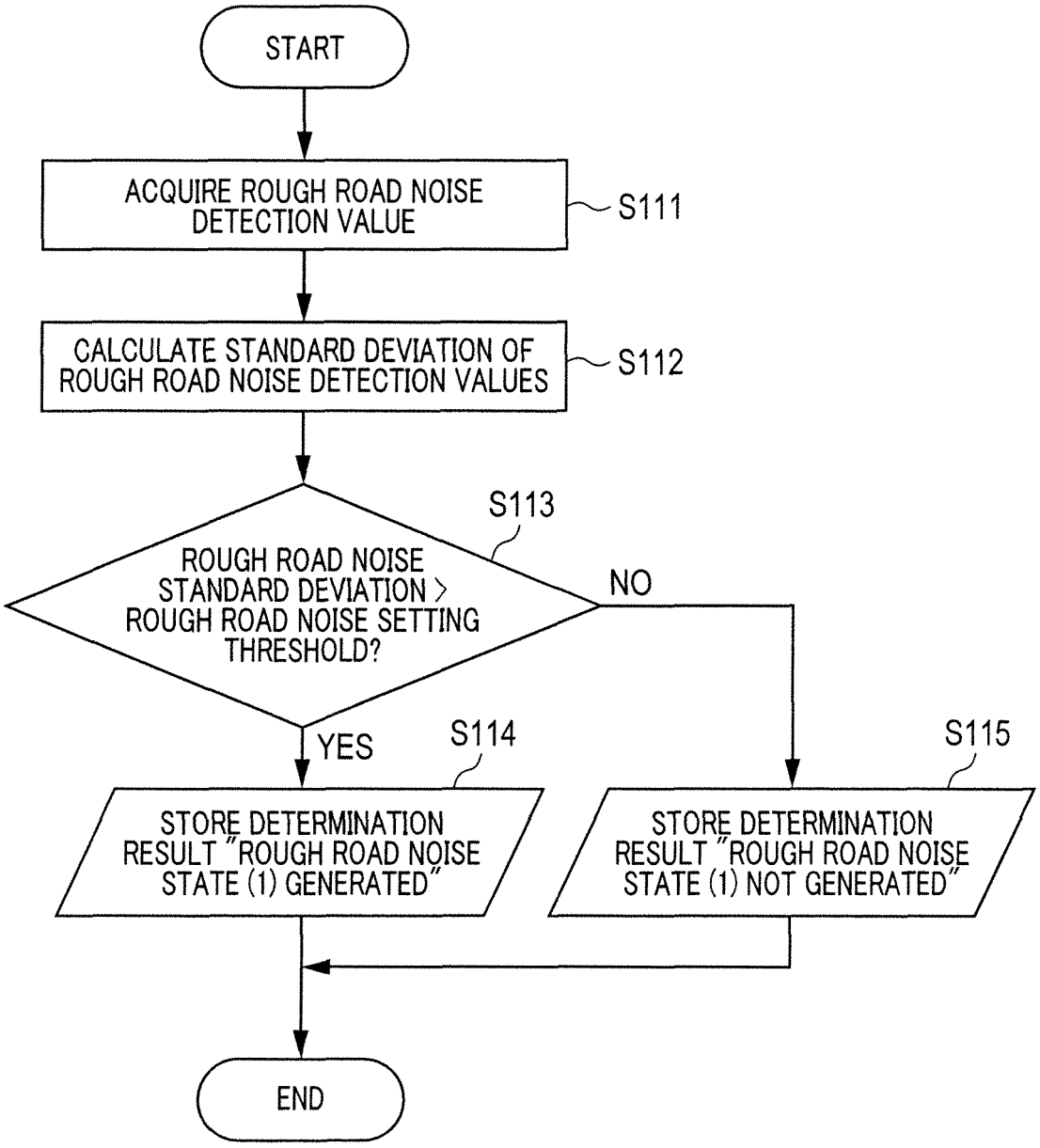

START
ACQUIRE ROUGH ROAD NOISE DETECTION VALUE
S111
CALCULATE STANDARD DEVIATION OF ROUGH ROAD NOISE DETECTION VALUES
S112
S113
ROUGH ROAD NOISE STANDARD DEVIATION > ROUGH ROAD NOISE SETTING THRESHOLD?
NO
YES
S114
STORE DETERMINATION RESULT "ROUGH ROAD NOISE STATE (1) GENERATED"
S115
STORE DETERMINATION RESULT "ROUGH ROAD NOISE STATE (1) NOT GENERATED"
END

FIG. 11

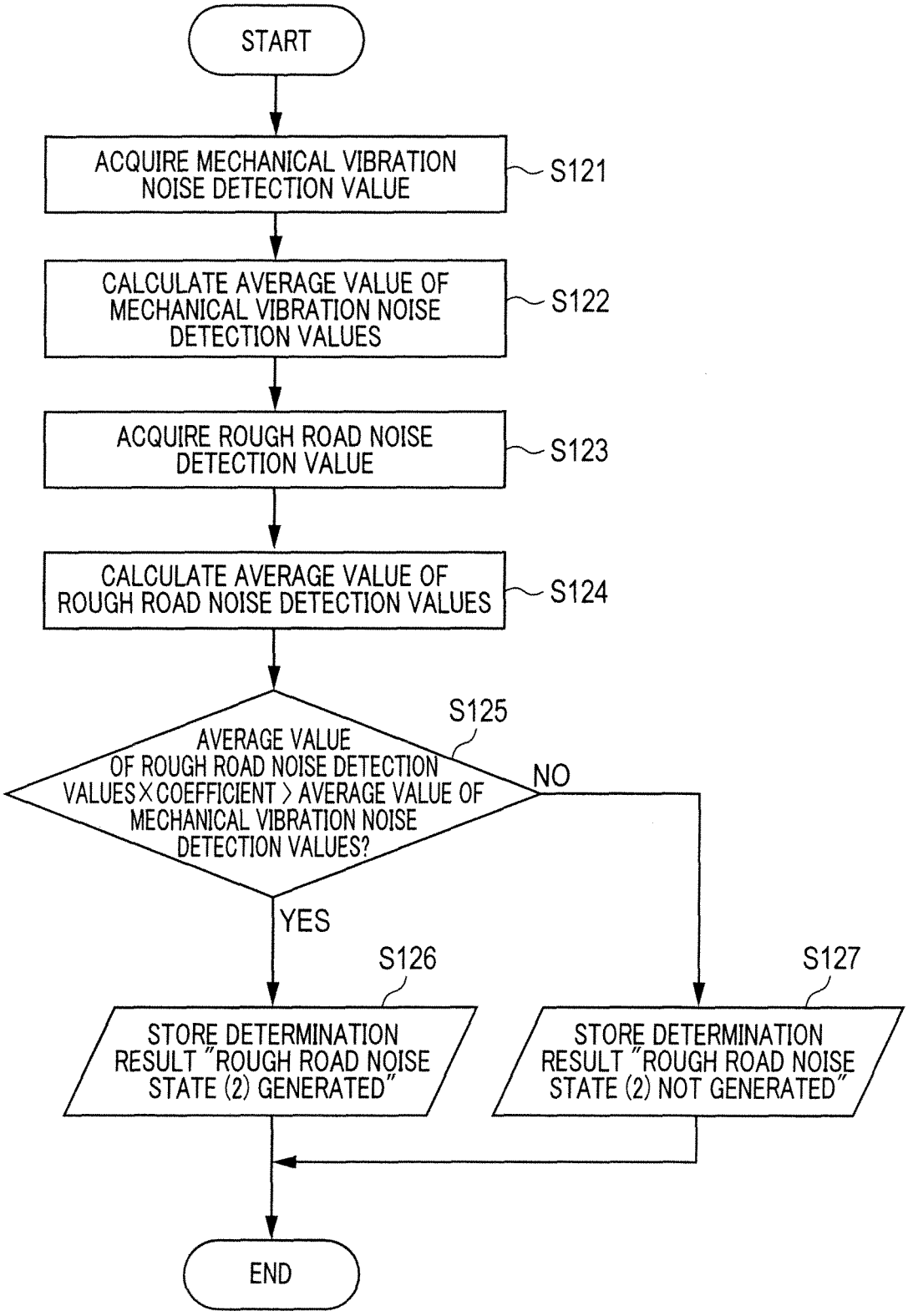

START
ACQUIRE MECHANICAL VIBRATION NOISE DETECTION VALUE
S121
CALCULATE AVERAGE VALUE OF MECHANICAL VIBRATION NOISE DETECTION VALUES
S122
ACQUIRE ROUGH ROAD NOISE DETECTION VALUE
S123
CALCULATE AVERAGE VALUE OF ROUGH ROAD NOISE DETECTION VALUES
S124
S125
AVERAGE VALUE OF ROUGH ROAD NOISE DETECTION VALUES × COEFFICIENT > AVERAGE VALUE OF MECHANICAL VIBRATION NOISE DETECTION VALUES?
NO
YES
S126
STORE DETERMINATION RESULT "ROUGH ROAD NOISE STATE (2) GENERATED"
S127
STORE DETERMINATION RESULT "ROUGH ROAD NOISE STATE (2) NOT GENERATED"
END

FIG. 12

71

FINAL ROUGH ROAD NOISE DETERMINATION TABLE		
	ROUGH ROAD NOISE STATE (2) GENERATED	ROUGH ROAD NOISE STATE (2) NOT GENERATED
ROUGH ROAD NOISE STATE (1) GENERATED	GENERATED	GENERATED
ROUGH ROAD NOISE STATE (1) NOT GENERATED	GENERATED	NOT GENERATED

FIG. 13

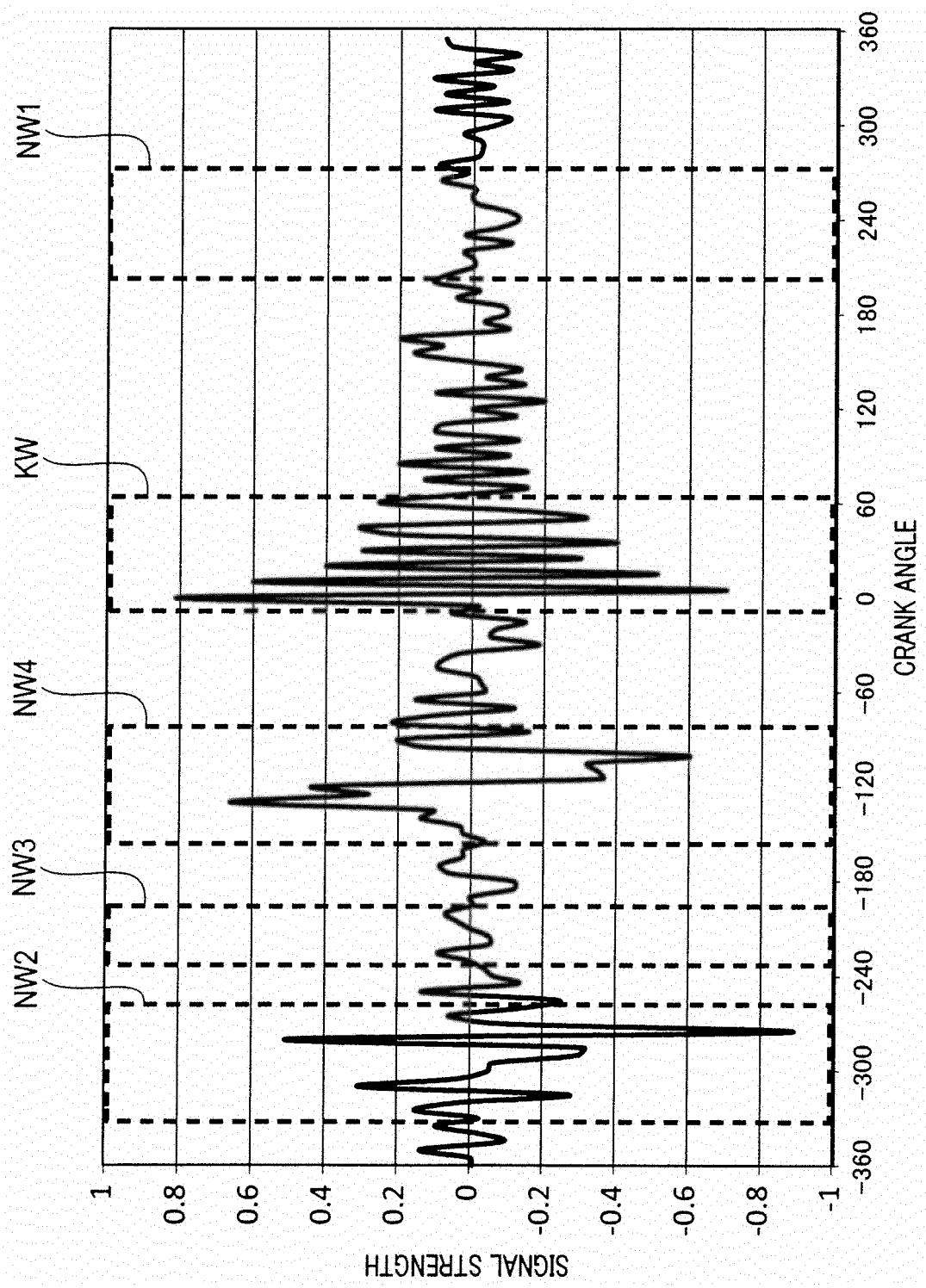

NW1
KW
NW4
NW3
NW2
SIGNAL STRENGTH
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
CRANK ANGLE
360
300
240
180
120
60
0
−60
−120
−180
−240
−300
−360

FIG. 14

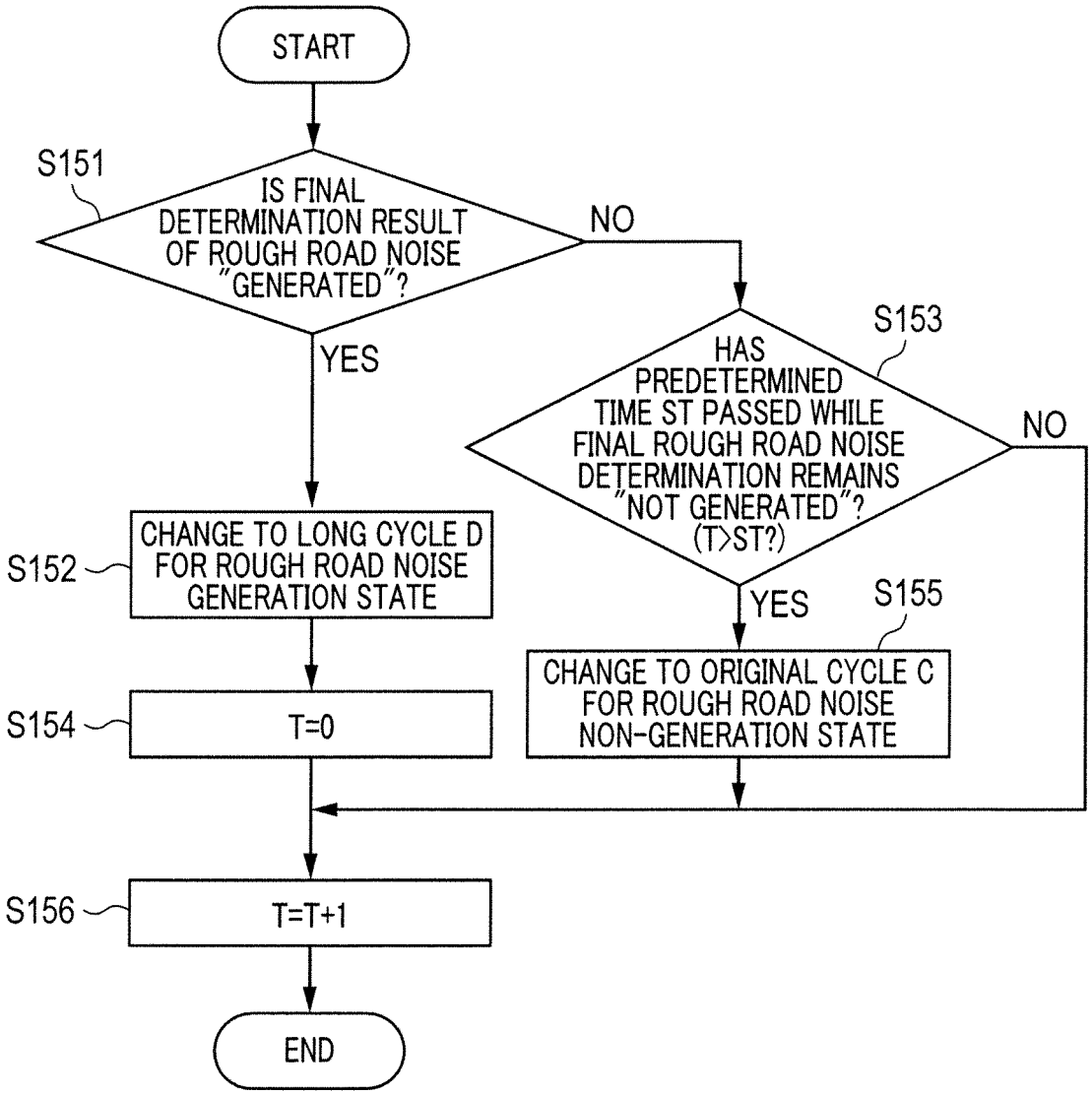

START
S151
IS FINAL DETERMINATION RESULT OF ROUGH ROAD NOISE "GENERATED"?
NO
YES
S153
HAS PREDETERMINED TIME ST PASSED WHILE FINAL ROUGH ROAD NOISE DETERMINATION REMAINS "NOT GENERATED"? (T>ST?)
NO
YES
S152
CHANGE TO LONG CYCLE D FOR ROUGH ROAD NOISE GENERATION STATE
S155
CHANGE TO ORIGINAL CYCLE C FOR ROUGH ROAD NOISE NON-GENERATION STATE
S154
T=0
S156
T=T+1
END

FIG. 15

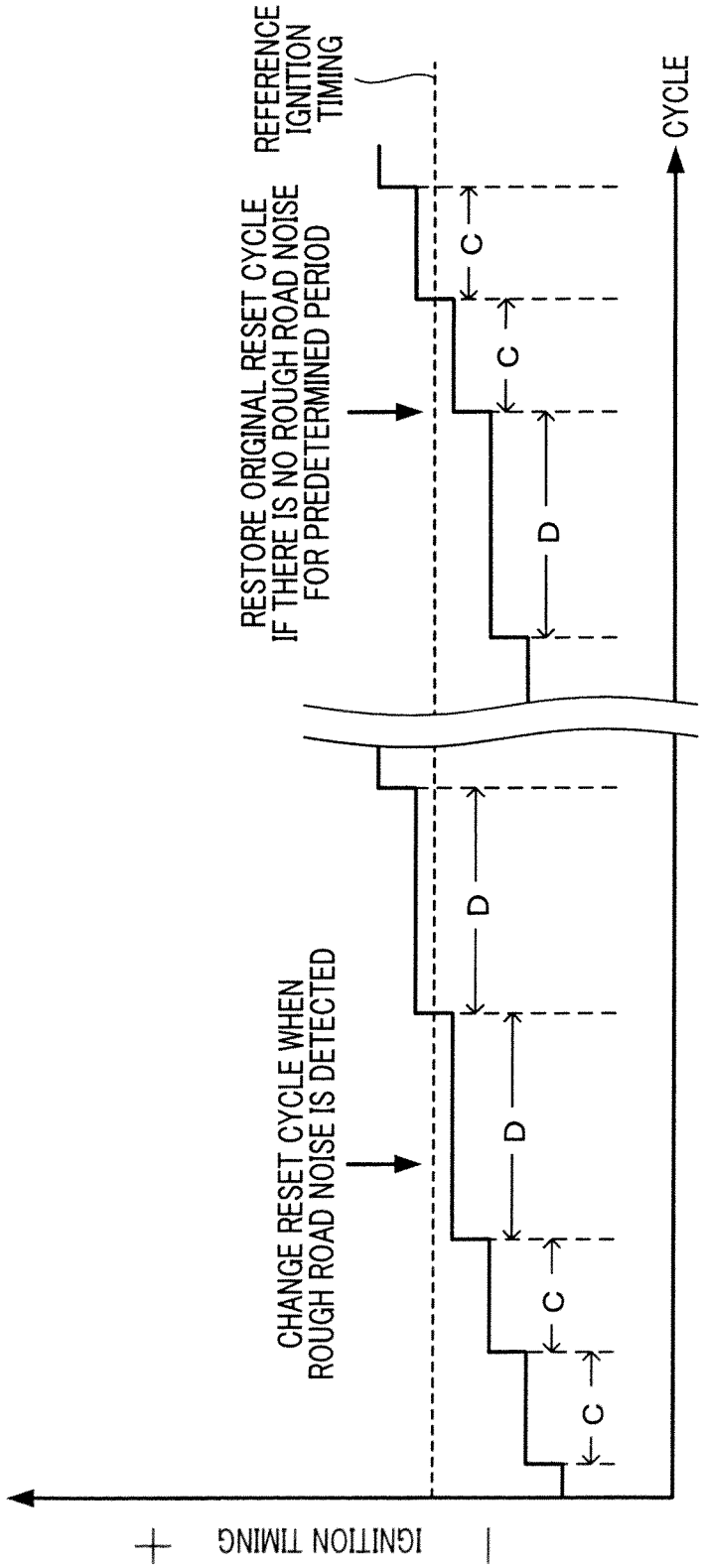

REFERENCE IGNITION TIMING
CYCLE
RESTORE ORIGINAL RESET CYCLE IF THERE IS NO ROUGH ROAD NOISE FOR PREDETERMINED PERIOD
CHANGE RESET CYCLE WHEN ROUGH ROAD NOISE IS DETECTED
C
C
D
D
D
C
C
+
IGNITION TIMING
-

FIG. 16

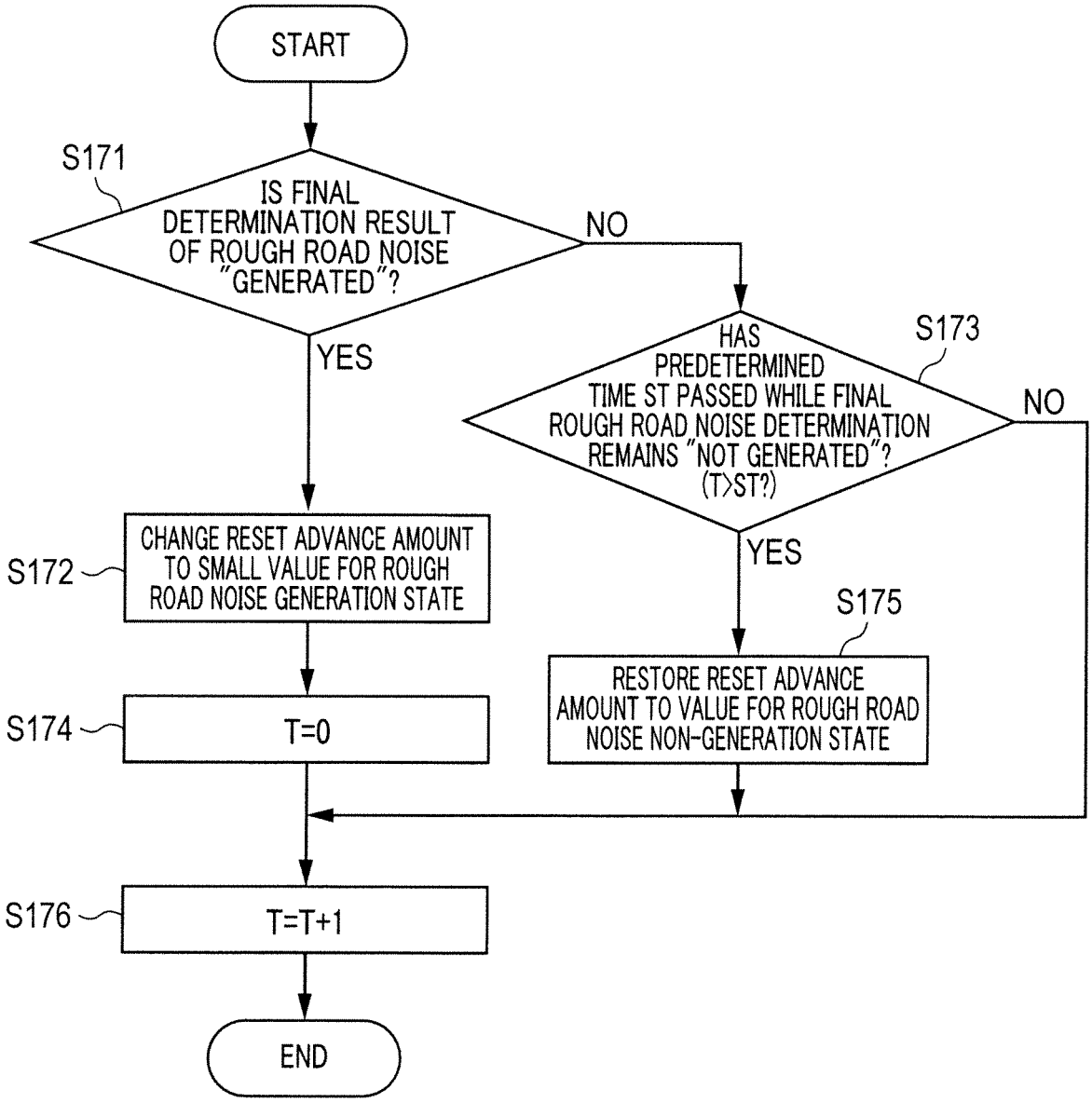

START
S171
IS FINAL DETERMINATION RESULT OF ROUGH ROAD NOISE "GENERATED"?
NO
YES
S173
HAS PREDETERMINED TIME ST PASSED WHILE FINAL ROUGH ROAD NOISE DETERMINATION REMAINS "NOT GENERATED"? (T>ST?)
NO
YES
S172
CHANGE RESET ADVANCE AMOUNT TO SMALL VALUE FOR ROUGH ROAD NOISE GENERATION STATE
S175
RESTORE RESET ADVANCE AMOUNT TO VALUE FOR ROUGH ROAD NOISE NON-GENERATION STATE
S174
T=0
S176
T=T+1
END

FIG. 17

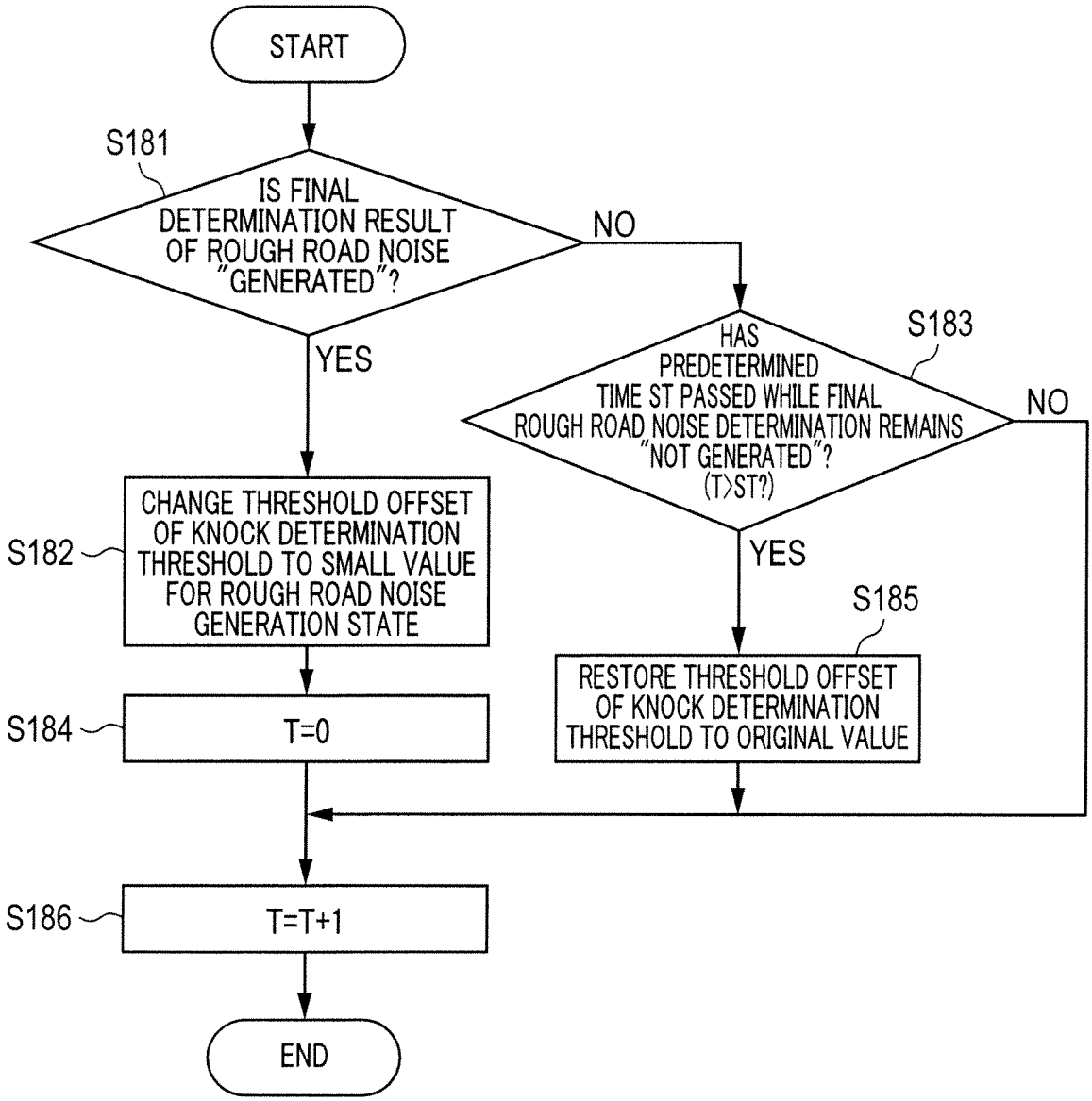

START
S181
IS FINAL DETERMINATION RESULT OF ROUGH ROAD NOISE "GENERATED"?
NO
YES
S183
HAS PREDETERMINED TIME ST PASSED WHILE FINAL ROUGH ROAD NOISE DETERMINATION REMAINS "NOT GENERATED"? (T>ST?)
NO
YES
S182
CHANGE THRESHOLD OFFSET OF KNOCK DETERMINATION THRESHOLD TO SMALL VALUE FOR ROUGH ROAD NOISE GENERATION STATE
S185
RESTORE THRESHOLD OFFSET OF KNOCK DETERMINATION THRESHOLD TO ORIGINAL VALUE
S184
T=0
S186
T=T+1
END

FIG. 18

72

	IT IS RESET TIMING	IT IS NOT RESET TIMING
KNOCKING OCCURS	(1) FUEL INJECTION QUANTITY CORRECTION VALUE = LAST CYCLE CORRECTION VALUE + KNOCK DETERMINATION INCREASE – RESET DECREASE	(3) FUEL INJECTION QUANTITY CORRECTION VALUE = LAST CYCLE CORRECTION VALUE + KNOCK DETERMINATION INCREASE
NO KNOCKING OCCURS	(2) FUEL INJECTION QUANTITY CORRECTION VALUE = LAST CYCLE CORRECTION VALUE – RESET DECREASE	(4) FUEL INJECTION QUANTITY CORRECTION VALUE = LAST CYCLE CORRECTION VALUE

FIG. 19

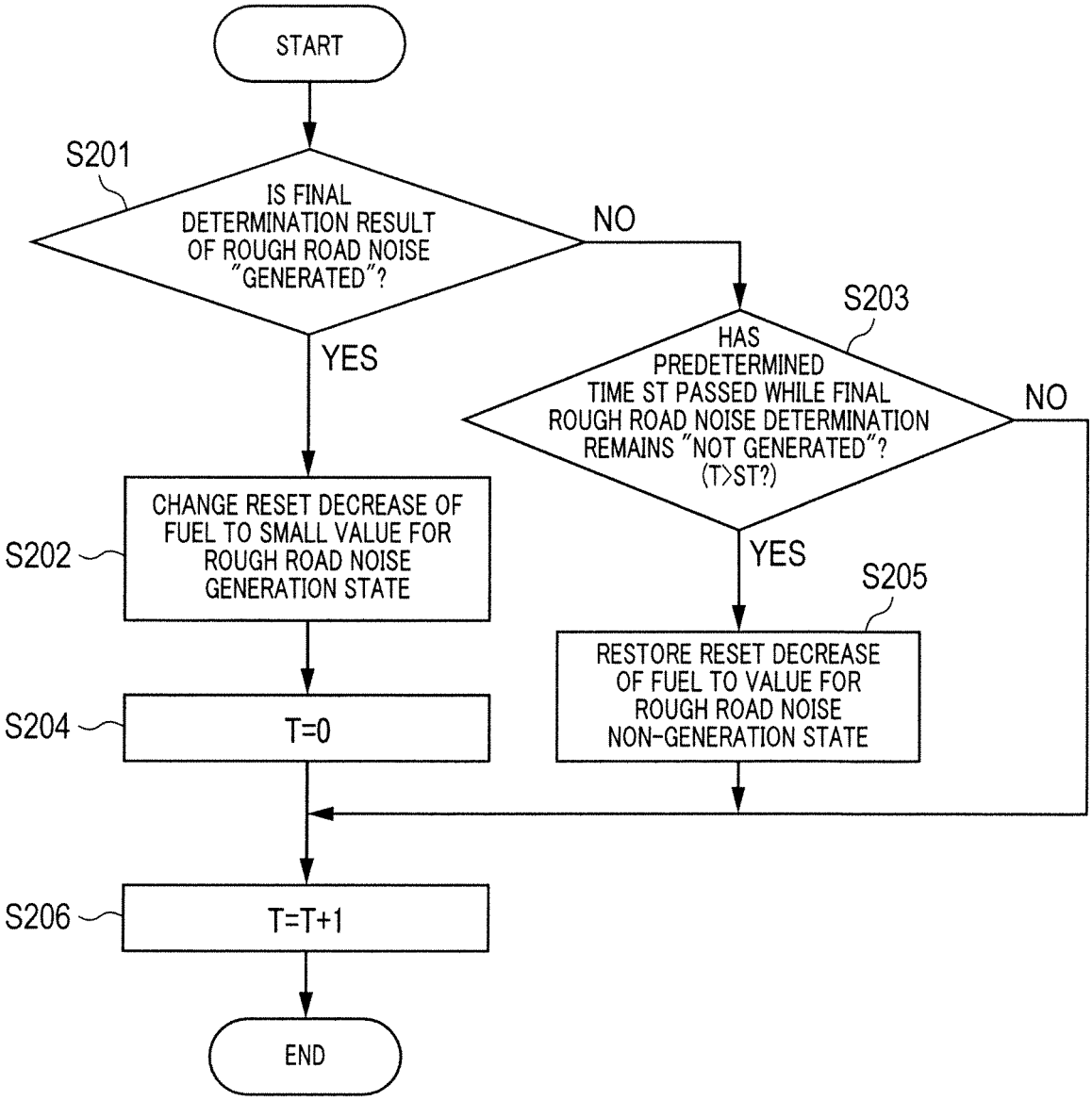

START
S201
IS FINAL DETERMINATION RESULT OF ROUGH ROAD NOISE "GENERATED"?
NO
YES
S203
HAS PREDETERMINED TIME ST PASSED WHILE FINAL ROUGH ROAD NOISE DETERMINATION REMAINS "NOT GENERATED"? (T>ST?)
NO
YES
S202
CHANGE RESET DECREASE OF FUEL TO SMALL VALUE FOR ROUGH ROAD NOISE GENERATION STATE
S205
RESTORE RESET DECREASE OF FUEL TO VALUE FOR ROUGH ROAD NOISE NON-GENERATION STATE
S204
T=0
S206
T=T+1
END

FIG. 20

73

	IT IS RESET TIMING	IT IS NOT RESET TIMING
KNOCKING OCCURS	(1) EGR AMOUNT CORRECTION VALUE = LAST CYCLE CORRECTION VALUE + KNOCK DETERMINATION INCREASE − RESET DECREASE	(3) EGR AMOUNT CORRECTION VALUE = LAST CYCLE CORRECTION VALUE + KNOCK DETERMINATION INCREASE
NO KNOCKING OCCURS	(2) EGR AMOUNT CORRECTION VALUE = LAST CYCLE CORRECTION VALUE − RESET DECREASE	(4) EGR AMOUNT CORRECTION VALUE = LAST CYCLE CORRECTION VALUE

FIG. 21

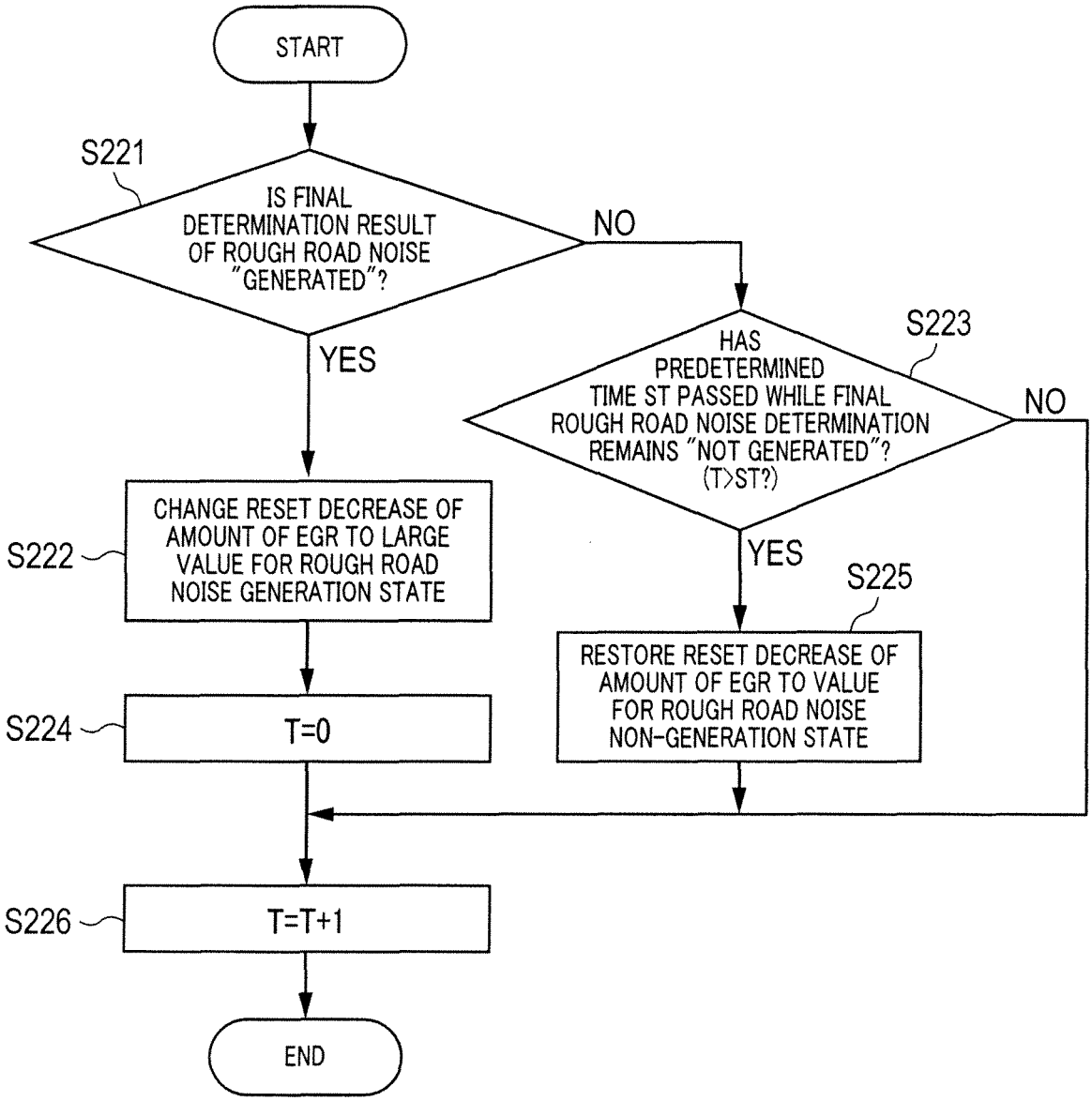

START
S221
IS FINAL DETERMINATION RESULT OF ROUGH ROAD NOISE "GENERATED"?
NO
YES
S223
HAS PREDETERMINED TIME ST PASSED WHILE FINAL ROUGH ROAD NOISE DETERMINATION REMAINS "NOT GENERATED"? (T>ST?)
NO
YES
S222
CHANGE RESET DECREASE OF AMOUNT OF EGR TO LARGE VALUE FOR ROUGH ROAD NOISE GENERATION STATE
S225
RESTORE RESET DECREASE OF AMOUNT OF EGR TO VALUE FOR ROUGH ROAD NOISE NON-GENERATION STATE
S224
T=0
S226
T=T+1
END

FIG. 22

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 3790770 B **[0002] [0006]**
- US 20020007818 A **[0007]**
- US 5408863 A **[0007]**