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(54) **Fuel injection apparatus designed to diagnose failure in injection fuel into each cylinder of diesel engine**

Kraftstoffeinspritzvorrichtung zur Fehlerdiagnose einer Einspritzung in jedem Zylinder eines Dieselmotors

Dispositif d'injection de carburant pour diagnostiquer une défaillance de l'injection dans chaque cylindre d'un moteur diesel

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(73) Proprietor: **DENSO CORPORATION**
Kariya-city,
Aichi-pref. 448-8661 (JP)

(72) Inventor: **Nishiyori, Yoichi**
Kariya-city
Aichi-pref., 448-8661 (JP)

(74) Representative: **Winter, Brandl, Fűrnis, Hübner,**
Röss, Kaiser, Polte - Partnerschaft
Alois-Steinecker-Strasse 22
85354 Freising (DE)

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Description

1 Technical Field of the Invention

[0001] The present invention relates generally to a fuel injection apparatus for diesel engines, and more particularly to such a fuel injection apparatus designed to diagnose a failure in injecting fuel into each cylinder of a diesel engine.

2 Background Art

[0002] There are known fuel injection apparatuses designed to diagnose whether a failure has occurred in injecting fuel into each cylinder of an automotive diesel engine. Typical ones of such fuel injection apparatuses include an injector drive unit and a control unit. The injector drive unit works to actuate injectors which inject fuel into cylinders of the engine, respectively. The control unit connects with the injector drive unit through a diagnostic signal line and works to control an operation of the injector drive unit. When the control unit directs the injector drive unit to drive the injectors, the injector drive unit outputs a pulse signal to the diagnostic signal line. The control unit monitors the pulse signal appearing on the diagnostic signal line and diagnoses whether the injectors have been driven to complete injection of fuel into the cylinders of the engine or not.

[0003] In recent years, in order to meet strengthened exhaust emission regulations, injection systems have been employed which work to perform additional injection of fuel in a combustion cycle of each cylinder of the diesel engine for reducing or burning particulates contained in exhaust emissions. This results in an increased total number of injections of fuel into each cylinder of the diesel engine, which leads to a difficulty in securing the time required for diagnosing the failure of the fuel injection. In order to alleviate this drawback, an approach may be proposed to perform parallel diagnoses using pairs of diagnostic signal lines and diagnostic units. This, however, results in complexity of the system and increased production costs thereof. The diagnoses may be suspended when fuel injections are being performed for the purpose of reducing or burning out particulates contained in exhaust gasses of the engine. This is, however, un-
useful because it may result in an increased period of time during which the diagnoses are suspended, thus requiring much time for activating a diesel particulate filter to burn out the particulates trapped therein.

SUMMARY OF THE INVENTION

[0004] It is therefore a principal object of the invention to avoid the disadvantages of the prior art.

[0005] It is another object of the invention to provide a fuel injection apparatus which is designed to ensure accurate diagnosis of a failure in injecting fuel into each cylinder of a diesel engine.

[0006] According to one aspect of the invention, there is provided a fuel injection apparatus for diesel engines which is designed to diagnose a failure in injecting fuel into each cylinder of the engine. The fuel injection apparatus comprises: (a) injectors designed to inject fuel into cylinders of a diesel engine, respectively; (b) an injector controller working to control the injectors to perform a plurality of injections of the fuel into each of the cylinders of the engine in each combustion cycle thereof; (c) a single diagnostic signal line to which a diagnostic signal is provided which indicates whether the injection of fuel into each of the cylinders has been completed or not; and (d) an injection failure diagnosing circuit working to select one of the cylinders that is to be diagnosed, inhibit the injectors from injecting the fuel into others of the cylinders when the injectors are required by the injector controller to inject the fuel into the others of the cylinders, and monitor the diagnostic signal appearing on the diagnostic signal line to make an injection failure diagnosis of whether a failure in injecting the fuel into the selected one of the cylinders has occurred or not. This ensures accurate diagnoses of whether the failure has occurred in injecting the fuel into each of the cylinders of the engine or not in a case where the engine is so controlled that a plurality of injections of fuel into each of the cylinders every combustion cycle thereof.

[0007] In the preferred mode of the invention, the injection failure diagnosing circuit sets a diagnosis time during which the injection failure diagnosis is to be performed on the selected one of the cylinders and a non-injection time during which no injection of fuel into the others of the cylinders is to be performed and which coincides with the diagnosis time. The injection failure diagnosing circuit permits the injection of fuel into the selected one of the cylinders to be performed during the diagnosis time and inhibits the injection of fuel into each of the others of the cylinders during the non-injection time when it is required to inject the fuel into the each of the others of the cylinders.

[0008] The injection failure diagnosing circuit may work to select one of the cylinders to be diagnosed in sequence.

[0009] Upon completion of a determination of whether the injection of fuel into the selected one of the cylinders has been completed or not, the injection failure diagnosing circuit determines whether each of the cylinders is to be diagnosed subsequently or not.

[0010] The injection failure diagnosing circuit suspends the injection failure diagnosis of each of the cylinders of the engine for a given period of time after completion of one or a given number of times of the injection failure diagnoses of the selected one of the cylinders.

[0011] The apparatus may further comprise injection failure counters, one for each of the cylinders of the engine, each of which counts an event that no injection of fuel has been performed in a corresponding one of the cylinders of the engine for the diagnosis time. The injection failure diagnosing circuit works to make the injection

failure diagnosis of each of the cylinders of the engine a plurality of times. When a count value of each of the injection failure counters exceeds a preselected value, the injection failure diagnosing circuit determines that the failure has occurred in injecting the fuel into a corresponding one of the cylinders.

[0012] The injection failure diagnosing circuit performs the injection failure diagnosis for a period of time between completion of all injections of the fuel into the selected one of the cylinders in the combustion cycle and a time when the fuel is to start to be injected into a subsequent one of the cylinders. The preselected value may be two or more.

[0013] When the fuel has been injected into the selected one of the cylinders at least one time during the diagnosis time, the injection failure diagnosing circuit resets a corresponding one of the injection failure counters.

[0014] When each of the injectors has injected the fuel into one of the cylinders, the injector controller outputs the diagnostic signal in the form of a pulse signal to the diagnostic signal line. The apparatus also includes injection counters, one for each of the cylinders, which count the number of times the injectors have performed the injections of fuel into the cylinders during the diagnosis time, respectively. The injection failure diagnosing circuit monitors the injection counters to know the number of times each of the injectors has completed the injection of fuel into a corresponding one of the cylinders.

[0015] The injection failure diagnosing circuit resets each of the injection counters when a corresponding one of the cylinders is placed in the non-injection time.

[0016] The plurality of injections of the fuel into each of the cylinders of the engine every combustion cycle include an injection of the fuel serving to produce torque in the diesel engine and an injection of the fuel serving to produce no torque in the diesel engine. The injection of fuel inhibited from being performed by the injection failure diagnosing circuit during the non-injection time is the injection of the fuel serving to produce no torque in the diesel engine.

[0017] The diesel engine is connected to a trapping device working to trap particulates contained in exhaust emissions of the diesel engine. The injection of the fuel serving to produce no torque in the diesel engine works to burn the particulates trapped in the trapping device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] The present invention will be understood more fully from the detailed description given hereinbelow and from the accompanying drawings of the preferred embodiments of the invention, which, however, should not be taken to limit the invention to the specific embodiments but are for the purpose of explanation and understanding only.

[0019] In the drawings:

Fig. 1 is a block diagram which shows a fuel injection

system according to the invention;

Fig. 2 is a timechart which demonstrates a relation among an injector drive signal, an injector drive current, and an injection failure diagnostic signal;

Fig. 3 is a timechart which demonstrates a sequence of fuel injections performed in each cylinder of a diesel engine, injector drive signals, and count value indicating the number of the fuel injections;

Fig. 4 is a flowchart of a program to perform post injection of fuel into each cylinder of a diesel engine;

Fig. 5 is a flowchart of a program to control operations of injection counters which count the number of injections of fuel into cylinders of a diesel engine, respectively;

Fig. 6 is a flowchart of a program to diagnose a failure in injecting fuel into each cylinder of a diesel engine; and

Fig. 7 is a flowchart of a program to determine whether an injection failure diagnosis should be continued or suspended.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020] Referring to the drawings, wherein like reference numbers refer to like parts in several views, particularly to Fig. 1, there is shown a fuel injection system 1 according to the invention which is designed to control injection of fuel into a diesel engine 2 mounted in an automotive vehicle. An exhaust emission purification device 3 is joined to an exhaust pipe extending from the engine 2 to purify potentially polluting exhaust gasses.

[0021] The structure and operation of the exhaust emission purification device 3 will first be described below.

[0022] The exhaust emission purification device 3 works to suck in exhaust gasses discharged from the engine 2 and capture or trap particulates contained in the exhaust gasses through a diesel particulate filter (not shown) to clean up the exhaust gasses, which are, in turn, discharged outside the vehicle. The exhaust emission purification device 3 has disposed therein an oxidation catalyst (not shown) which reacts with fuel (HC) to produce heat to burn out the trapped particulates. The exhaust emission purification device 3 is equipped with a pressure difference sensor 31, an inlet temperature sensor 32, and an outlet temperature sensor 33. The pressure difference sensor 31 works to measure a difference in pressure between the exhaust gases entering and going out of the exhaust emission purification device 3. The inlet temperature sensor 32 works to measure the temperature of the exhaust gasses entering the exhaust emission purification device 3. The outlet temperature sensor works to measure the temperature of the exhaust gasses discharged from the exhaust emission purification device 3. The sensors 31, 32, and 33 provide sensor outputs to the fuel injection system 1.

[0023] The fuel injection system 1 consists essentially of a high-pressure fuel pump 11, a common rail 12, in-

jectors 13, 14, 15, and 16, and an injection control ECU 17.

[0024] The high-pressure fuel pump 11 is implemented by a typical automotive supply pump which works to draw the fuel from a fuel tank (not shown) installed in the vehicle and pressurize it up to a target pressure (e.g., 135 to 180 MPa) to produce a high-pressure fuel which is, in turn, supplied to the common rail 12. The high-pressure fuel pump 11 is so designed that the target pressure may be changed selectively.

[0025] The common rail 12 works as an accumulator which accumulates therein the high-pressure fuel supplied from the high-pressure fuel pump 11 and delivers it to the injectors 13 to 16 selectively. The common rail 12 is equipped with a pressure sensor (not shown) which measures the pressure of fuel in the common rail 12 and outputs a signal indicative thereof to the injection control ECU 17.

[0026] Each of the injectors 13 to 16 is equipped with a solenoid-operated fuel injection valve (not shown) which is energized by a drive current supplied from the injection control ECU 17 to inject the fuel into a corresponding one of first to fourth cylinders 21, 22, 23, and 24 of the engine 2.

[0027] The injection control ECU 17 consists of an injector drive unit 18 and a microcomputer 19. The microcomputer 19 works to direct the injector drive unit 18 to output the drive current to each of the injectors 13 to 16 to control the injection of fuel into a corresponding one of the cylinders 21 to 24 of the engine 2. The injection control ECU 17 also includes drive signal lines 1A to 1D through which the microcomputer 19 transmits drive signals to the injector drive unit 18 to output the drive currents to the injectors 13 to 16, respectively, and a single diagnostic signal line 1E through which the injector drive unit 18 outputs a diagnostic signal in the form of a pulse signal to the microcomputer 19 which indicates completion of supply of the drive currents to the injectors 13 to 16.

[0028] The injector drive unit 18 is equipped with a drive current output circuit 1F and a drive current detector 1G. When the drive signal in a high level is outputted from the microcomputer 19 to one of the drive signal lines 1A to 1D, the injector drive unit 18 activates the drive current output circuit 1F to output the drive current to a corresponding one of the injectors 13 to 16. The drive current detector 1G works to detect the output of the drive current from the drive current output circuit 1F and output the diagnostic signal in a high level to the diagnostic signal line 1E. When the drive current reaches a peak, the drive current detector 1G outputs the diagnostic signal in a low level to the diagnostic signal line 1E. Additionally, when no drive signal is outputted from the drive current output signal 1F, the drive current detector 1G outputs the diagnostic signal in the low level to the diagnostic signal line 1E. Fig. 2 demonstrates examples of the drive signal outputted to each of the drive signal lines 1A to 1D, the drive current produced by the injector drive unit 18, and the diagnostic signal outputted to the diag-

nostic signal line 1E.

[0029] The microcomputer 19 has a typical structure and receives an output of an accelerator sensor (not shown) indicating a stroke or an effort on an accelerator pedal of the vehicle, an output of a speed sensor (not shown) indicating the speed of the engine 2, and an output of a crankshaft position sensor (not shown) indicating an angular position of a crank shaft of the engine 2 to direct the injector drive unit 18 to produce the drive signals for the injectors 13 to 16, respectively.

[0030] Fig. 3 demonstrates an example of operation of the microcomputer 19. Specifically, the microcomputer 19 analyzes the outputs of the above sensors and calculates times (i.e., the injection timings) when the fuel is to be injected three times during every compression stroke of each of the cylinders 21 to 24 of the engine 2, a time when the fuel is to be injected one time during every combustion stroke of each of the cylinders 21 to 24, and the quantities of fuel to be injected into the engine 2. The microcomputer 19 monitors the output of the crankshaft position sensor and determines whether each of the cylinders 21 to 24 has reached the injection timing or not. When it is determined that one of the cylinders 21 to 24 has reached the injection timing thereof, the microcomputer 19 outputs the drive signal in the high level to one of the drive signal lines 1A to 1D for activating a corresponding one of the injectors 13 to 16 to inject the fuel into the one of the cylinders 21 to 24 for a period of time corresponding to the injection quantity of fuel calculated. The injector drive unit 18 then outputs the drive current to energize the one of the injectors 13 to 16. The engine 2 is, as described above, a diesel engine, so that the fuel is burned right after injection thereof in the combustion stroke of each of the cylinders 21 to 24. In this embodiment, the microcomputer 19 works to perform three injections (i.e., pilot- and pre-injections) of fuel into each of the cylinders 21 to 24 of the engine 2 in each compression stroke thereof in order to reduce exhaust emissions or mechanical engine vibrations and one injection (i.e., a main-injection) of fuel into each of the cylinders 21 to 24 in each combustion stroke (also called an expansion stroke) thereof in order to produce an engine torque.

[0031] When the amount of particulates trapped in the exhaust emission purification device 3 reaches a given level, and the temperature of exhaust gas discharged from the engine 2 is lower than a given value, the microcomputer 19 directs the injector drive unit 18 to initiate an additional injection, called post injection, of fuel in an exhaust stroke of each of the cylinders 21 to 24 in order to burn out the particulates in the exhaust emission purification device 3.

[0032] Specifically, when the output of the pressure difference sensor 31 is less than a preselected value, and outputs of the inlet and outlet temperature sensors 32 and 33 are also less than a preselected value, the microcomputer 19 decides that the post injection should be performed and determines a timing of the post injection.

tion and the quantity of fuel to be injected into the engine 2. The microcomputer 19 monitors the output of the crankshaft position sensor and determines whether each of the cylinders 21 to 24 has reached the timing of the post injection or not. If one of the cylinders 21 to 24 is determined to have reached the timing of the post injection, the microcomputer 19 outputs the drive signal in the high level to one of the drive signal lines 1A to 1D for a corresponding one of the injectors 13 to 16 that is to inject the fuel into the one of the cylinders 21 to 24 for a period of time corresponding to the injection quantity of fuel calculated. The injector drive unit 18 then outputs the drive current to activate the one of the injectors 13 to 16. Note that the post injection is the injection of fuel not serving to produce drive torque in the engine 2.

[0033] The engine 2 is so designed that the pistons of the cylinders 21 to 24 experience, in sequence, the intake, exhaust, combustion, and compression strokes, respectively. For instance, when the first cylinder 21 is on the intake stroke, the second cylinder 22, the third cylinder 23, and the fourth cylinder 24 are on the exhaust, combustion, and compression strokes, respectively. The microcomputer 19 directs the injector drive unit 18 to perform fuel injections, in sequence, on the cylinders 21 to 24 of the engine 2. The microcomputer 19 also works to calculate a target pressure using outputs of the speed sensor indicating the speed of the engine 2 and the pressure sensor indicating the pressure of fuel in the common rail 12 and controls the high-pressure pump 11 to bring an output thereof into agreement with the target pressure. The microcomputer 19 also outputs control signals to a supercharger, an exhaust gas recirculation (EGR) system, an intake throttle valve, a radiator fan relay, etc.

[0034] The microcomputer 19 is also equipped with injection counters 51, 52, 53, and 54 and injection failure counters 61, 62, 63, and 64. Each of the injection counters 51 to 54 works to count the number of times the fuel has been injected into a corresponding one of the cylinders 21 to 24. Each of the injection failure counters 61 to 64 works to count the number of times a corresponding one of the cylinders 21 to 24 has experienced a failure in injecting the fuel thereinto. The microcomputer 19 also operates in four post injection inhibit modes A, B, C, and D to inhibit the fuel from being injected into the cylinders 21, 22, 23, and 24, respectively. Each time the piston of each of the cylinders 21 to 24 experiences a given number of rotations, the microcomputer 19 starts to diagnose whether the failure in fuel injection has occurred in a selected one of the cylinders 21 to 24 or not. For example, the microcomputer 19 may start to diagnose each of the cylinders 21 to 24 after a given number of revolutions of the engine 4 following completion of diagnosis of a preceding one of the cylinders 21 to 24 or a sequence of diagnoses of others of the cylinders 21 to 24. The post injection inhibit modes A, B, C, and D are each entered only when requirements to perform such injection failure diagnosis and the post injection are met. For instance, when it is required to perform the post in-

jection to burn out the particulates trapped in the exhaust emission purification device 3 and to diagnose the first cylinder 21, the microcomputer 19 enters the post injection mode D to inhibit the post injection of fuel into the fourth cylinder 24.

[0035] The microcomputer 19 performs the injection failure diagnosis of each of the cylinders 21 to 24 in the following manner. First, the microcomputer 19 selects one of the cylinders 21 to 24 to be diagnosed and sets as a diagnosis time a time interval between completion of a sequence of injections (not including the post injection) of fuel into one of the cylinders 21 to 24 preceding the selected one and a time when the injection of fuel into one of the cylinders 21 to 24 following the selected one is to be started. For instance, when the third cylinder 23 is selected to be diagnosed, a time interval between completion of a sequence of injections of fuel into the second cylinder 22 and a time when the injection of fuel into the fourth cylinder 24 is to be started is determined as the diagnosis time. The microcomputer 19 also sets a non-injection time coinciding with the diagnosis time during which the others of the cylinders 21 to 24 undergo no injection of fuel thereinto.

[0036] Next, immediately after the one of the cylinders 21 to 24 of the engine 2 selected to be diagnosed enters the compression stroke, the microcomputer 19 determines whether it is required to initiate the post injection of fuel into each of the cylinders 21 to 24 or not. When such post injection requirement is met, the microcomputer 19 commences post injection initialization and enters one of the post injection inhibit modes A, B, C, and D which inhibits the post injection of fuel into one of the cylinders 21 to 24 preceding one thereof selected to be diagnosed. This causes the post injection of fuel not to be performed to ones of the cylinders 21 to 24 not selected to be diagnosed during the diagnosis time and permits the fuel to be injected only into the one of the cylinders 21 to 24 selected to be diagnosed. Specifically, in the example as illustrated in Fig. 3, when the first cylinder 21 is placed in the diagnosis time, the second cylinder 22 is in a time range of the suction stroke to the compression stroke within which the injection of fuel is not to be performed. The third cylinder 23 is in a time range of the exhaust stroke to the suction stroke within which the injection of fuel is not to be performed. The fourth cylinder 24 is in a time range of the combustion stroke to the exhaust stroke within which the post injection of fuel, as indicated by a broken line, is to be performed. Therefore, the microcomputer 19 enters the post injection inhibit mode D to inhibit the fuel from being injected into the fourth cylinder 24, thereby placing all ones of the cylinders 21 to 24 not selected to be diagnosed, that is, the second to fourth cylinders 22 to 24 in a condition where they do not undergo the injection of fuel thereinto at all. In a case where the engine 2 is so controlled that two of the cylinders 21 to 24 undergo the post injections sequentially during the diagnosis time of another of the cylinders 21 to 24, the microcomputer 19

works to enter two of the post injection inhibit modes *A*, *B*, *C*, and *D* to inhibit the fuel from being injected into the two of the cylinders 21 to 24. Alternatively, when the post injection requirement is not met, the microcomputer 19 proceeds to steps, as described below, without entering any of the post injection inhibit modes *A*, *B*, *C*, and *D*.

[0037] The microcomputer 19 analyzes inputs from the sensors, as described above, and directs the injection drive unit 18 to initiate a sequence of injections of fuel into the one of the cylinders 21 to 24 as selected to be diagnosed. Afterwards, when the diagnostic signal on the diagnostic signal line 1E is changed from the high to low level, the microcomputer 19 determines that a corresponding one of the injectors 13 to 16 has been successful in injecting the fuel into the selected one of the cylinders 21 to 24, increments the count value of a corresponding one of the injection counters 51 to 54 by one (1) through interruption handling, and resets the count values of others of the injection counters 51 to 54. Alternatively, when the diagnostic signal on the diagnostic signal line 1E remains unchanged to the low level, that is, it is kept at the high level, the microcomputer 19 determines that the selected one of the cylinders 21 to 24 has undergone no injection of fuel thereinto and holds the count value of the corresponding one of the injection counters 51 to 54 as it is.

[0038] Upon expiry of a period of time during which a total of four injections of fuel into the one of the cylinders 21 to 24 as selected to be diagnosed are to be performed in the compression and combustion strokes thereof, the microcomputer 19 diagnoses whether a corresponding one of the injectors 13 to 16 has failed to inject the fuel into the selected one of the cylinders 21 to 24 or not during a period of time until start of injection of fuel into a subsequent one of the cylinders 21 to 24, which will also be referred to a non-injection period. Specifically, the microcomputer 19 samples the count value from one of the injection counters 51 to 54 corresponding to the selected one of the cylinders 21 to 24. When the count value is zero (0), the microcomputer 19 increments a corresponding one of the injection failure counters 61 to 64 by one (1). When a resulting value of the one of the injection failure counters 61 to 64 indicates two (2), the microcomputer 19 determines that the corresponding one of the injectors 13 to 16 has failed to inject the fuel into the selected one of the cylinders 21 to 24 and turn on a warning lamp. Alternatively, when the resulting value of the one of the injection failure counters 61 to 64 is less than or equal to one (1), the microcomputer 19 remains the warning lamp off. When the resulting value of the one of the injection failure counters 61 to 64 is more than or equal to one (1), the microcomputer 19 resets it to zero (0).

[0039] After expiry of the diagnosis time and completion of the diagnosis of whether the corresponding one of the injectors 13 to 16 has failed to inject the fuel into the selected one of the cylinders 21 to 24 or not, the microcomputer 19 determines whether all the cylinders

21 to 24 have been diagnosed or not and suspends the injection failure diagnosis until the engine 2 rotates a given number of times.

[0040] Fig. 4 is a flowchart of a sequence of logical steps or program executed by the microcomputer 19 of the fuel injection system 1 to control the post injection of fuel into each of the cylinders 21 to 24 when it is required to diagnose the failure in injecting the fuel into each of the cylinders 21 to 24 of the engine. The program is initiated at the beginning of the compression stroke in each of the cylinders 21 to 24 of the engine 2.

[0041] After entering the program, the routine proceeds to step 401 wherein it is determined whether the requirements to perform the post injection of fuel into each of the cylinders 21 to 24 of the engine 2 have been met or not using outputs of the pressure difference sensor 31, the inlet temperature sensor 32, and the output temperature sensor 33. If a NO answer is obtained, the routine terminates. Alternatively, if a YES answer is obtained, then the routine proceeds to step 402 wherein it is determined whether the post injection has already been performed or not. If a NO answer is obtained, then the routine proceeds to step 403 wherein the microcomputer 19 performs initialization to select one of the post injection inhibit modes *A*, *B*, *C*, and *D* to inhibit the post injection of fuel into one of the cylinders 21 to 24 preceding one thereof as selected to be diagnosed and starts to operate in the selected one of the post injection inhibit modes *A*, *B*, *C*, and *D*. Alternatively, if a YES answer is obtained, then the routine proceeds to step 404 wherein the microcomputer 19 alters a selected one of the post injection inhibit modes *A*, *B*, *C*, and *D* to one that inhibits the post injection of fuel into one of the cylinders 21 to 24 preceding one thereof as selected to be diagnosed.

[0042] In step 405, the post injection quantity and post injection timing for one of the cylinders 21 to 24, as selected to be diagnosed, are determined. The routine proceeds to step 406 wherein the microcomputer 19 directs the injector drive unit 18 to perform the post injection to the selected one of the cylinders 21 to 24 in one of the post injection inhibit modes *A*, *B*, *C*, and *D*, as set in step 403 or 404.

[0043] For example, when the first cylinder 21 is selected to be diagnosed, the microcomputer 19 selects the post injection inhibit mode *D* to inhibit the post injection of fuel into the fourth cylinder 24 and is allowed to initiate a sequence of injections of fuel only into the first cylinder 21 during the diagnosis time.

[0044] Fig. 5 is a flowchart of a program to be executed by the microcomputer 19 to count the number of times the fuel has been injected into one of the cylinders 21 to 24, which is selected to be diagnosed, during the diagnosis time. The program is initiated each time the diagnostic signal appearing in the form of a pulse signal on the diagnostic signal line 1E is changed from the high to low level.

[0045] After entering the program, the routine proceeds to step 501 to interrupt input of any signals to the

diagnostic signal line E1 in order to avoid an error in the following counting operation of the microcomputer 19 arising from chattering or electrical noises.

[0046] The routine proceeds to step 502 wherein it is determined which of the cylinders 21 to 24 is selected to be diagnosed. If the first cylinder 21 is selected, then the routine proceeds to step 503. If the second cylinder 22 is selected, then the routine proceeds to step 505. If the third cylinder 23 is selected, then the routine proceeds to step 507. If the fourth cylinder 24 is selected, then the routine proceeds to step 509.

[0047] In step 503, the count value of the injection counter 51 is incremented by one (1). Similarly, in steps 505, 507, 509, the count values of the injection counters 52, 53, and 54 are incremented by one (1), respectively. After steps 503, 505, 507, and 509, the routine proceeds to steps 504, 506, 508, and 510, respectively.

[0048] In step 504, the injection counters 52, 53, and 54 are reset to zero (0). In step 506, the injection counters 51, 53, and 54 are reset to zero (0). In step 507, the injection counters 51, 52, and 54 are reset to zero (0). In step 510, the injection counters 51, 52, and 53 are reset to zero (0).

[0049] After step 504, 506, 508, or 510, the routine proceeds to step 511 wherein the interruption of input of signals into the diagnostic signal line 1E is released and then terminates.

[0050] The program of Fig. 5 works to ensure counting of the number of times the fuel has been injected into each of the cylinders 21 to 24 during the diagnosis time and avoid errors in incrementing the count values of ones of the counters 51 to 54 for ones of the cylinders 21 to 24 not being diagnosed.

[0051] Fig. 6 is a flowchart of a program to be executed by the microcomputer 19 to diagnose whether a failure in injecting the fuel into each of the cylinders 21 to 24 of the engine 2 has occurred or not. This program is initiated during the non-injection period defined between completion of a sequence of four injections of fuel into each of the cylinders 21 to 24 and start of injection of fuel into a following one of the cylinders 21 to 24.

[0052] After entering the program, the routine proceeds to step 601 wherein each of the cylinders 21 to 24 is checked to determine whether it has been selected as an object that should be diagnosed or not by monitoring a currently selected one of the post injection inhibit modes A, B, C, and D. If a NO answer is obtained, then the routine terminates. Alternatively, if a YES answer is obtained, then the routine proceeds to step 602. For the brevity of disclosure, it is assumed in the following discussion that the first cylinder 21 is determined in step 601 to have been selected as the object to be diagnosed. In step 602, the count value is read out from a corresponding one of the injection counters 51 to 54, i.e., the injection counter 51. The routine proceed to step 603 wherein it is determined whether the count value, as derived in step 602, is zero (0) or not. If a NO answer is obtained meaning that the count value is not zero (0),

that is, that the fuel has been injected into the first cylinder 21 at least one time, then the routine proceeds to step 604 wherein it is determined that the injection of fuel into the first cylinder 21 has been completed correctly, and the injection failure counter 61 is reset to zero (0). The routine then terminates. Alternatively, if a NO answer is obtained in step 603 meaning that no injection of fuel into the first cylinder 21 has been performed, then the routine proceeds to step 605.

[0053] In step 605, the count value of the injection failure counter 61 corresponding to the first cylinder 21, as selected to be diagnosed, is incremented by one (1). The routine proceeds to step 606 wherein it is determined whether the count value, as incremented in step 605, is two (2) or more, that is, whether the event that the first cylinder 21 has undergone no injection of fuel therein during the diagnosis time has occurred in sequence two times or not. This is for avoiding an accidental error in determining that the injector 13 has failed to inject the fuel into the first cylinder 21. If a YES answer is obtained in step 606 meaning that the count value is more than or equal to two (2), then the routine proceeds to step 607 wherein a warning lamp is turned on to inform the drive of the vehicle of the event of failure in the fuel injection.

[0054] The program of Fig. 6 is executed during the non-injection period within the diagnosis time in order to minimize an error in determining the failure in injection of fuel into one of the cylinders 21 to 24 as selected to be diagnosed.

[0055] Fig. 7 is a flowchart of a program to be executed by the microcomputer 19 to determine whether the injection failure diagnosis should continue or not. The program is initiated immediately after expiry of the diagnosis time for each of the cylinders 21 to 24.

[0056] After entering the program, the routine proceeds to step 701 wherein the injection failure diagnosis has been completed a preselected number of times or not, that is, whether all the cylinders 21 to 24 have been diagnosed or not. If a NO answer is obtained, then the routine proceeds to step 702 wherein one of the cylinders 21 to 24 is selected which is to be diagnosed subsequently.

[0057] The routine proceeds to step 703 wherein the diagnosis time is determined for the one of the cylinders 21 to 24 selected in step 702. The non-injection time coinciding with the diagnosis time is also set for others of the cylinders 21 to 24, thereby prohibiting the fuel from being injected into the others of the cylinders 21 to 24. The routine then terminates.

[0058] If a YES answer is obtained in step 701 meaning that all the cylinders 21 to 24 have been diagnosed, then the routine proceeds to step 704 wherein the post injection modes A, B, C, and D are released to place the microcomputer 19 out of the post injection modes A, B, C, and D. The routine then terminates. After completion of the injection failure diagnosis of each of the cylinders 21 to 24 of the engine 2, when the microcomputer 19 monitors outputs of the pressure difference sensor 31, the

inlet temperature sensor 32, and the outlet temperature sensor 33 and determines that a need has arisen for the post injection of fuel into one of the cylinders 21 to 24, the microcomputer 19 commences the post injection of fuel into the one of the cylinders 21 to 24.

[0059] The microcomputer 19 does not perform the injection failure diagnosis of one of the cylinders 21 to 24 until the injection failure diagnosis of a preceding one of the cylinders 21 to 24 has been completed, and the cylinders 21 to 24 have experienced a given number of rotations. This is because the frequent injection failure diagnoses will cause the cylinders 21 to 24 to be prohibited from undergoing the post injection, thus requiring much time for burning out particulates trapped in the exhaust emission purification device 3.

[0060] As apparent from the above discussion, the microcomputer 19 works to select one of the cylinders 21 to 24, in sequence, as an object to be diagnosed each time the cylinders 21 to 24 rotate a given number of times and also select one of the post injection modes *A*, *B*, *C*, and *D* which prohibits a preceding one of the cylinders 21 to 24 from undergoing the post injection, thereby enabling a determination to be made as to whether the fuel has been injected into the selected one of the cylinders 21 to 24 correctly or not by monitoring the diagnostic signal appearing on the diagnostic signal line 1E. This ensures the injection failure diagnosis of each of the cylinders 21 to 24 even in a case where many injections of fuel are to be performed every combustion cycle of each of the cylinders 21 to 24.

[0061] The injection control ECU 17, as described above, works to determine that the post injection of fuel into each of the cylinders 21 to 24 should be performed when the pressure indicated by an output of the pressure difference sensor 31 is greater than a given value, and temperatures indicated by outputs of the inlet temperature sensor 32 and the outlet temperature sensor 33 are lower than a given value and calculate the post injection quantity and post injection timing, but however, it may alternatively be designed to perform the post injection of fuel into the cylinders 21 to 24 at all times when the injection failure diagnosis is not carried out.

[0062] The injection control ECU 17, as described above, works to activate each of the injectors 13 to 16 to perform a total of five injections (including the post injection) of fuel into one of the cylinders 21 to 24 in each combustion cycle (i.e., each sequence of four strokes) of the engine 2, but however, it may be designed to perform a total of more or less than five injections of fuel into each of the cylinders 21 to 24. The injection control ECU 17 may also be designed to perform a plurality of post injections sequentially.

[0063] The injection control ECU 17, as described above, works to switch between the post injection modes *A*, *B*, *C*, and *D* to inhibit the post injection of fuel into one of the cylinders 21 to 24 preceding one thereof selected as an object to be diagnosed in order to diagnose whether the fuel has been injected completely into the selected

one of the cylinders 21 to 24 or not by monitoring the diagnostic signal appearing on the diagnostic signal line 1E. The engine 2, however, may be designed according to required specifications so that the post injections of fuel into more than one of the cylinders 21 to 24 other than one thereof as selected to be diagnosed are performed at the same time. In this case, the injection control ECU 17 is designed to establish a post injection inhibit mode to inhibit the more than one of the cylinders 21 to 24 from undergoing the post injection during the injection failure diagnosis of the one of the cylinders 21 to 24 selected to be diagnosed.

[0064] The engine 4 has the four cylinders 21 to 24. The fuel injection system 1 works to inject fuel into and diagnose the injection failures in the cylinders 21 to 24. The engine 4, however, may alternatively be designed to have six, eight, or twelve cylinders. In this case, the injection control ECU 17 is, like the above, designed to establish a post injection inhibit mode to inhibit more than one of the cylinders from undergoing the post injection during the injection failure diagnosis of one of the cylinders selected to be diagnosed.

[0065] The fuel injection system 1 may also be employed for diesel engines installed in trains, boats, or ships, but is most effective to be used for automotive diesel engines.

[0066] While the present invention has been disclosed in terms of the preferred embodiments in order to facilitate better understanding thereof, it should be appreciated that the invention can be embodied in various ways without departing from the principle of the invention. Therefore, the invention should be understood to include all possible embodiments and modifications to the shown embodiments which can be embodied without departing from the principle of the invention as set forth in the appended claims.

Claims

1. A fuel injection apparatus for a diesel engine comprising:

injectors designed to inject fuel into cylinders of a diesel engine, respectively;
 an injector controller working to control said injectors to perform a plurality of injections of the fuel into each of the cylinders of the engine in each combustion cycle thereof;
 a single diagnostic signal line to which a diagnostic signal is provided which indicates whether the injection of fuel into each of the cylinders has been completed or not; and
 an injection failure diagnosing circuit working to select one of the cylinders that is to be diagnosed, inhibit said injectors from injecting the fuel into others of the cylinders when said injectors are required by said injector controller to

- inject the fuel into the others of the cylinders, and monitor the diagnostic signal appearing on said diagnostic signal line to make an injection failure diagnosis of whether a failure in injecting the fuel into the selected one of the cylinders has occurred or not.
2. A fuel injection apparatus as set forth in claim 1, wherein said injection failure diagnosing circuit sets a diagnosis time during which the injection failure diagnosis is to be performed on the selected one of the cylinders and a non-injection time during which no injection of fuel into the others of the cylinders is to be performed and which coincides with the diagnosis time, and wherein said injection failure diagnosing circuit permits the injection of fuel into the selected one of the cylinders to be performed during the diagnosis time and inhibits the injection of fuel into each of the others of the cylinders during the non-injection time when it is required to inject the fuel into the each of the others of the cylinders.
 3. A fuel injection apparatus as set forth in claim 1 or 2, wherein said injection failure diagnosing circuit works to select one of the cylinders to be diagnosed in sequence.
 4. A fuel injection apparatus as set forth in any one of claims 1 to 3, wherein upon completion of a determination of whether the injection of fuel into the selected one of the cylinders has been completed or not, said injection failure diagnosing circuit determines whether each of the cylinders is to be diagnosed subsequently or not.
 5. A fuel injection apparatus as set forth in any one of claims 1 to 4, wherein said injection failure diagnosing circuit suspends the injection failure diagnosis of each of the cylinders of the engine for a given period of time after completion of one or a given number of times of the injection failure diagnoses of the selected one of the cylinders.
 6. A fuel injection apparatus as set forth in any one of claims 2 to 5, further comprising injection failure counters, one for each of the cylinders of the engine, each of which counts an event that no injection of fuel has been performed in a corresponding one of the cylinders of the engine for the diagnosis time, and wherein said injection failure diagnosing circuit works to make the injection failure diagnosis of each of the cylinders of the engine a plurality of times, when a count value of each of the injection failure counters exceeds a preselected value, said injection failure diagnosing circuit determining that the failure has occurred in injecting the fuel into a corresponding one of the cylinders.
 7. A fuel injection apparatus as set forth in claim 6, wherein said injection failure diagnosing circuit performs the injection failure diagnosis for a period of time between completion of all injections of the fuel into the selected one of the cylinders in the combustion cycle and a time when the fuel is to start to be injected into a subsequent one of the cylinders.
 8. A fuel injection apparatus as set forth in claim 6 or 7, wherein the preselected value is two or more.
 9. A fuel injection apparatus as set forth in any one of claims 6 to 8, wherein when the fuel has been injected into the selected one of the cylinders at least one time during the diagnosis time, said injection failure diagnosing circuit resets a corresponding one of the injection failure counters.
 10. A fuel injection apparatus as set forth in any one of claims 6 to 9, wherein when each of the injectors has injected the fuel into one of the cylinders, said injector controller outputs the diagnostic signal in the form of a pulse signal to the diagnostic signal line, further comprising injection counters, one for each of the cylinders, which count the number of times said injectors have performed the injections of fuel into the cylinders during the diagnosis time, respectively, and wherein said injection failure diagnosing circuit monitors the injection counters to know the number of times each of the injectors has completed the injection of fuel into a corresponding one of the cylinders.
 11. A fuel injection apparatus as set forth in claim 10, wherein said injection failure diagnosing circuit resets each of the injection counters when a corresponding one of the cylinders is placed in the non-injection time.
 12. A fuel injection apparatus as set forth in any one of claims 2 to 11, wherein the plurality of injections of the fuel into each of the cylinders of the engine every combustion cycle include an injection of the fuel serving to produce torque in the diesel engine and an injection of the fuel serving to produce no torque in the diesel engine, and wherein the injection of fuel inhibited from being performed by said injection failure diagnosing circuit during the non-injection time is the injection of the fuel serving to produce no torque in the diesel engine.
 13. A fuel injection apparatus as set forth in claim 12, wherein the diesel engine is connected to a trapping device working to trap particulates contained in exhaust emissions of the diesel engine, and wherein the injection of the fuel serving to produce no torque in the diesel engine works to burn the particulates trapped in the trapping device.

Patentansprüche

1. Kraftstoffeinspritzvorrichtung für einen Dieselmotor aufweisend:

Einspritzdüsen, die ausgebildet sind, um Kraftstoff in jeweilige Zylinder eines Dieselmotors einzuspritzen;
eine Einspritzdüsensteuerung, die ausgelegt ist, die Einspritzdüsen zu steuern, um eine Mehrzahl von Einspritzungen des Kraftstoffs in jeden der Zylinder des Motors in jedem Verbrennungszyklus des Motors auszuführen;
eine einzelne Diagnosesignalleitung, der ein Diagnosesignal zur Verfügung gestellt wird, das angibt, ob die Einspritzung des Kraftstoffs in jeden der Zylinder abgeschlossen wurde oder nicht; und
einen Einspritzfehlerdiagnoseschaltkreis, der ausgelegt ist, einen der Zylinder, der diagnostiziert werden soll, auszuwählen, die Einspritzdüsen zu hindern, Kraftstoff in andere der Zylinder einzuspritzen, wenn die Einspritzdüsen von der Einspritzdüsensteuerung benötigt werden, den Kraftstoff in die anderen der Zylinder zu spritzen, und das Diagnosesignal, das an der Diagnosesignalleitung anliegt, zu überwachen, um eine Einspritzfehlerdiagnose bezüglich, ob ein Fehler beim Einspritzen des Kraftstoffs in den ausgewählten Zylinder aufgetreten ist oder nicht, auszuführen.

2. Kraftstoffeinspritzvorrichtung gemäß Anspruch 1, wobei
der Einspritzfehlerdiagnoseschaltkreis eine Diagnosezeit, während der die Einspritzfehlerdiagnose an dem ausgewählten der Zylinder durchgeführt werden soll, und eine Nicht-Einspritz-Zeit, während der keine Einspritzung des Kraftstoffs in die anderen der Zylinder durchgeführt werden soll, und die mit der Diagnosezeit zusammenfällt, festlegt, und wobei der Einspritzfehlerdiagnoseschaltkreis das Durchführen der Einspritzung des Kraftstoffes in den ausgewählten der Zylinder während der Diagnosezeit erlaubt und das Einspritzen des Kraftstoffes in jeden der anderen Zylinder während der Nicht-Einspritz-Zeit verhindert, wenn es erforderlich ist, Kraftstoff in jeden der anderen Zylinder einzuspritzen.
3. Kraftstoffeinspritzvorrichtung gemäß Anspruch 1 oder 2, wobei
der Einspritzfehlerdiagnoseschaltkreis ausgelegt ist, um einen der Zylinder auszuwählen, um fortlaufend diagnostiziert zu werden.
4. Kraftstoffeinspritzvorrichtung gemäß einem der Ansprüche 1 bis 3, wobei nach Abschluss einer Entscheidung, ob die Einspritzung von Kraftstoff in den

ausgewählten der Zylinder abgeschlossen wurde oder nicht, der Einspritzfehlerdiagnoseschaltkreis bestimmt, ob jeder der Zylinder anschließend diagnostiziert werden soll oder nicht.

5. Kraftstoffeinspritzvorrichtung gemäß einem der Ansprüche 1 bis 4, wobei der Einspritzfehlerdiagnoseschaltkreis die Einspritzfehlerdiagnose für jeden der Zylinder des Motors für einen gegebenen Zeitabschnitt nach dem Abschluss eines oder einer gegebenen Anzahl der Einspritzfehlerdiagnosen des ausgewählten der Zylinder aussetzt.
6. Kraftstoffeinspritzvorrichtung gemäß einem der Ansprüche 2 bis 5, des Weiteren aufweisend:

Einspritzfehlerzähler, wobei für jeden der Zylinder ein Einspritzfehlerzähler vorgesehen ist, jeder Fehlerzähler ein Ereignis, dass keine Einspritzung von Kraftstoff in einem entsprechenden der Zylinder in der Diagnosezeit durchgeführt wurde, zählt, und wobei der Einspritzfehlerzählerschaltkreis ausgebildet ist, die Einspritzfehlerdiagnose für jeden der Zylinder des Motors mehrzählige Male durchzuführen, wenn ein Zählwert von jedem der Einspritzfehlerzähler einen vorausgewählten Wert überschreitet, und der Einspritzfehlerdiagnoseschaltkreis bestimmt, dass der Fehler bei der Einspritzung des Kraftstoffes in einen entsprechenden Zylinder aufgetreten ist.

7. Kraftstoffeinspritzvorrichtung gemäß Anspruch 6, wobei
der Einspritzfehlerdiagnoseschaltkreis die Einspritzfehlerdiagnose für einen Zeitabschnitt zwischen dem Abschluss aller Einspritzungen des Kraftstoffs in den ausgewählten der Zylinder in dem Verbrennungszyklus und einer Zeit, wenn es vorgesehen ist, dass angefangen wird den Kraftstoff in einen folgenden der Zylinder einzuspritzen, durchführt.
8. Kraftstoffeinspritzvorrichtung gemäß Anspruch 6 oder 7, wobei der vorausgewählte Wert zwei oder mehr beträgt.
9. Kraftstoffeinspritzvorrichtung gemäß einem der Ansprüche 6 bis 8, wobei der Kraftstoff während der Diagnosezeit mindestens einmal in den ausgewählten der Zylinder eingespritzt wurde, und der Einspritzfehlerdiagnoseschaltkreis einen entsprechenden der Einspritzfehlerzähler zurücksetzt.
10. Kraftstoffeinspritzvorrichtung gemäß einem der Ansprüche 6 bis 9, wobei
wenn jede der Einspritzdüsen den Kraftstoff in einen der Zylinder eingespritzt hat, die Einspritzsteuerung das Diagnosesignal in Form eines Pulssignals an

die Diagnosesignalleitung ausgibt, weiter aufweisend:

Einspritzzähler, wobei ein Einspritzzähler für jeden der Zylinder vorgesehen ist, der Einspritzzähler die Anzahl zählt, wie oft die Einspritzdüsen die Einspritzungen von Kraftstoff in die Zylinder jeweils zur Diagnosezeit durchgeführt haben, und wobei
der Einspritzfehlerüberwachungsschaltkreis die Einspritzzähler überwacht um die Anzahl, wie oft jede der Einspritzdüsen die Einspritzung von Kraftstoff in einen entsprechenden der Zylinder abgeschlossen hat, zu kennen.

11. Kraftstoffeinspritzvorrichtung gemäß Anspruch 10, wobei
der Fehlerdiagnoseschaltkreis jeden der Einspritzzähler, wenn ein entsprechender der Zylinder in die Nicht-Einspritzzeit eingebracht wird, rücksetzt.
12. Kraftstoffeinspritzvorrichtung gemäß einem der Ansprüche 2 bis 11, wobei die Mehrzahl der Einspritzungen des Kraftstoffs in jeden der Zylinder in jeden Verbrennungszyklus eine Einspritzung des Kraftstoffs, die dazu dient ein Drehmoment in dem Dieselmotor zu erzeugen und eine Einspritzung des Kraftstoffs um kein Drehmoment in dem Dieselmotor zu erzeugen beinhaltet, und wobei
die Einspritzung des Kraftstoffs, deren Durchführung durch den Einspritzfehlerdiagnoseschaltkreis während der Nicht-Einspritzzeit verhindert wird, die Einspritzung ist, die dazu dient, keinen Drehmoment in dem Dieselmotor zu erzeugen.
13. Kraftstoffeinspritzvorrichtung gemäß einem Anspruch 12, wobei der Dieselmotor mit einer Fallenvorrichtung verbunden ist, die ausgelegt ist, Partikel, die in Abgasemissionen des Dieselmotors enthalten sind, zu fangen, und wobei
die Einspritzung des Kraftstoffs, die dazu dient, kein Drehmoment in dem Dieselmotor zu erzeugen, ausgelegt ist, die Partikel die in der Fallenvorrichtung gefangen sind zu verbrennen.

Revendications

1. Appareil d'injection de carburant pour un moteur diesel, comprenant :

les injecteurs conçus pour injecter du carburant dans des cylindres d'un moteur diesel, respectivement ;
un contrôleur d'injecteur fonctionnant pour contrôler lesdits injecteurs afin de réaliser une pluralité d'injections du carburant dans chacun des cylindres du moteur dans chacun de ses cycles

de combustion ;

un seul circuit d'acheminement des signaux auquel un signal de diagnostic est proposé, qui indique si l'injection du carburant dans chacun des cylindres est terminée ou pas, et
un circuit de diagnostic de défaillance d'injection fonctionnant pour sélectionner l'un des cylindres qui doit être diagnostiqué, empêchant lesdits injecteurs d'injecter le carburant dans les autres cylindres lorsque lesdits injecteurs sont sollicités par ledit contrôleur d'injecteur pour injecter le carburant dans les autres cylindres, et surveiller le signal de diagnostic apparaissant sur ledit circuit d'acheminement des signaux de diagnostic afin de faire un diagnostic de défaillance d'injection selon si une défaillance d'injection du carburant dans le cylindre sélectionné s'est produite ou pas.

2. Appareil d'injection de carburant selon la revendication 1, dans lequel ledit circuit de diagnostic de défaillance d'injection détermine un temps de diagnostic pendant lequel le diagnostic de défaillance d'injection doit être réalisé sur le cylindre sélectionné et un temps sans injection pendant lequel aucune injection de carburant dans les autres cylindres n'est réalisée et qui coïncide avec le temps de diagnostic, et dans lequel ledit circuit de diagnostic de défaillance d'injection permet de réaliser l'injection du carburant dans les cylindres sélectionnés pendant le temps de diagnostic et empêche l'injection du carburant dans chacun des autres cylindres pendant le temps sans injection lorsqu'il faut injecter le carburant dans chacun des autres cylindres.
3. Appareil d'injection de carburant selon la revendication 1 ou 2, dans lequel ledit circuit de diagnostic de défaillance d'injection fonctionne pour sélectionner l'un des cylindres à diagnostiquer, en séquence.
4. Appareil d'injection de carburant selon l'un quelconque des revendications 1 à 3, dans lequel, suite à l'achèvement d'une détermination selon si l'injection de carburant dans le cylindre sélectionné est terminée ou pas, ledit circuit de diagnostic de défaillance d'injection détermine si chacun des cylindres doit être diagnostiqué en séquence ou pas.
5. Appareil d'injection de carburant selon l'une quelconque des revendications 1 à 4, dans lequel ledit circuit de diagnostic de défaillance d'injection suspend le diagnostic de défaillance d'injection de chacun des cylindres du moteur pendant une période de temps donnée après l'achèvement d'une fois ou d'un nombre de fois donné de diagnostics de défaillance d'injection des cylindres sélectionnés.
6. Appareil d'injection de carburant selon l'une quel-

conque des revendications 2 à 5, comprenant en outre des compteurs de défaillance d'injection, un pour chacun des cylindres du moteur, dont chacun compte un évènement dans lequel aucune injection de carburant n'a été réalisée dans un cylindre correspondant des cylindres du moteur pendant le temps de diagnostic, et dans lequel ledit circuit de diagnostic de défaillance d'injection fonctionne pour faire le diagnostic de défaillance d'injection de chacun des cylindres du moteur plusieurs fois, lorsqu'une valeur de comptage de chacun des compteurs de défaillance d'injection dépasse une valeur présélectionnée, ledit circuit de diagnostic de défaillance d'injection détermine que la défaillance s'est produite lors de l'injection du carburant dans un cylindre correspondant des cylindres.

7. Appareil d'injection de carburant selon la revendication 6, dans lequel ledit circuit de diagnostic de défaillance d'injection réalise le diagnostic de défaillance d'injection pendant une période de temps située entre l'achèvement de toutes les injections du carburant dans les cylindres sélectionnés lors du cycle de combustion et un moment pendant lequel le carburant doit commencer à être injecté dans un cylindre suivant.

8. Appareil d'injection de carburant selon la revendication 6 ou 7, dans lequel la valeur présélectionnée est de deux ou plus.

9. Appareil d'injection de carburant selon l'une quelconque des revendications 6 à 8, dans lequel lorsque le carburant a été sélectionné dans un cylindre sélectionné au moins une fois pendant le temps de diagnostic, ledit circuit de diagnostic de défaillance d'injection réinitialise un compteur correspondant des compteurs de défaillance d'injection.

10. Appareil d'injection de carburant selon l'une quelconque des revendications 6 à 9, dans lequel lorsque chacun des injecteurs a injecté le carburant dans l'un des cylindres, ledit contrôleur d'injecteur produit le signal de diagnostic sous la forme d'un signal d'impulsion sur le circuit d'acheminement de signaux de diagnostic, comprenant en outre des compteurs d'injection, un pour chacun des cylindres, qui compte le nombre de fois que lesdits injecteurs ont réalisé les injections de carburant dans les cylindres pendant le diagnostic, respectivement, et dans lequel ledit circuit de diagnostic de défaillance d'injection surveille les compteurs d'injection pour connaître le nombre de fois que chacun des injecteurs a terminé l'injection de carburant dans un cylindre correspondant.

11. Appareil d'injection de carburant selon la revendication 10, dans lequel ledit circuit de diagnostic de dé-

faillance d'injection réinitialise chaque compteur d'injection lorsqu'un cylindre correspondant des cylindres est placé dans le temps sans injection.

12. Appareil d'injection de carburant selon l'une quelconque des revendications 2 à 11, dans lequel la pluralité d'injections du carburant dans chacun des cylindres du moteur à chaque cycle de combustion, comprend une injection de carburant servant à produire le couple dans le moteur diesel et une injection de carburant servant à ne produire aucun couple dans le moteur diesel, et dans lequel l'injection de carburant dont on empêche la réalisation par ledit circuit de diagnostic de défaillance d'injection pendant le temps sans injection est l'injection du carburant servant à ne produire aucun couple dans le moteur diesel.

13. Appareil d'injection de carburant selon la revendication 12, dans lequel le moteur diesel est raccordé à un dispositif de piège fonctionnant pour piéger des particules contenues dans les émissions d'échappement du moteur diesel, et dans lequel l'injection de carburant servant à ne produire aucun couple dans le moteur diesel fonctionne pour brûler les particules piégées dans le dispositif de piège.

FIG. 1

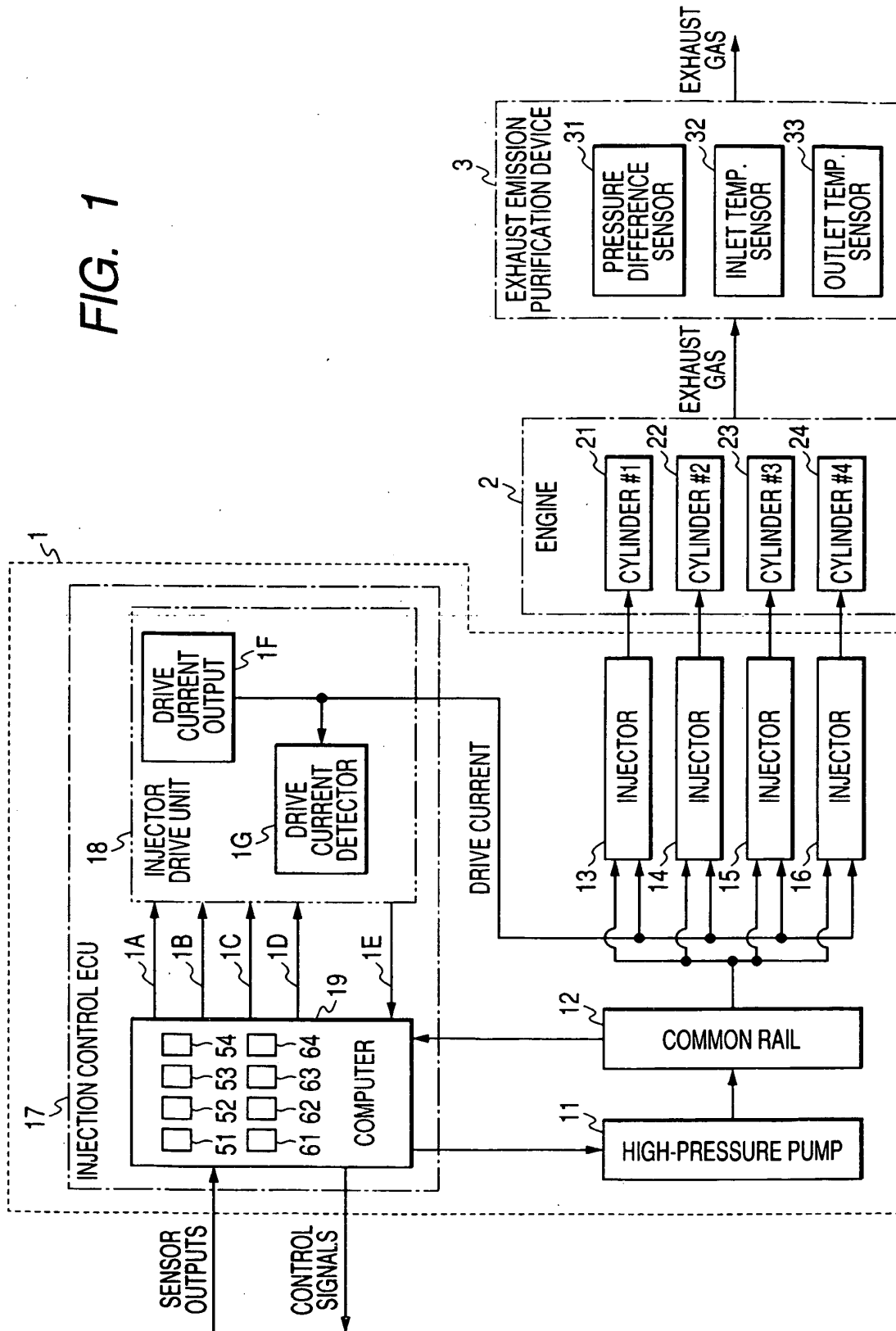


FIG. 2

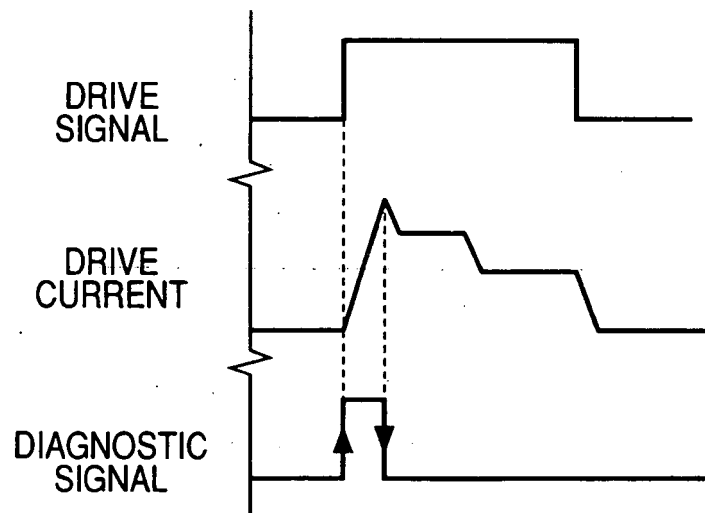


FIG. 3

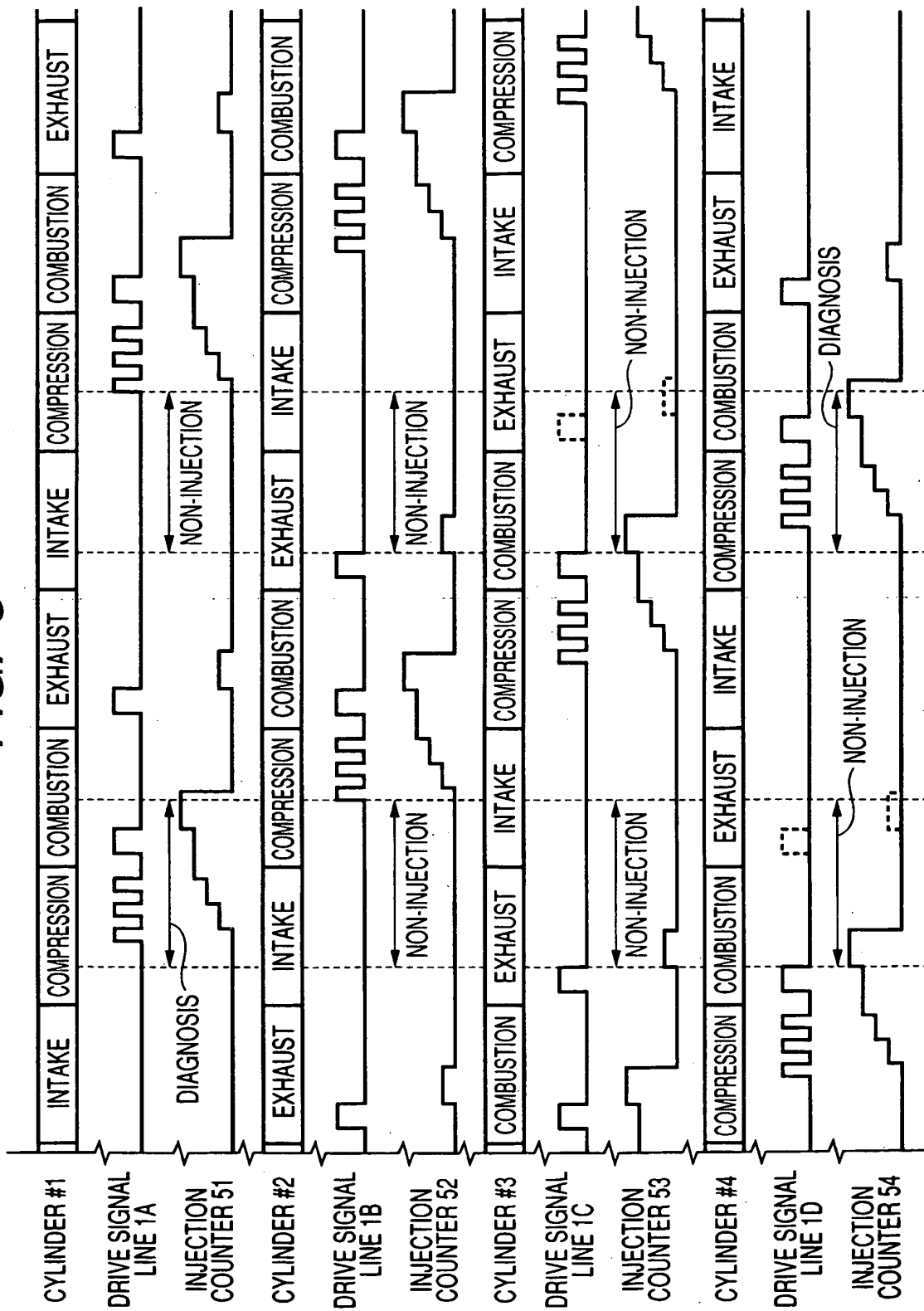


FIG. 4

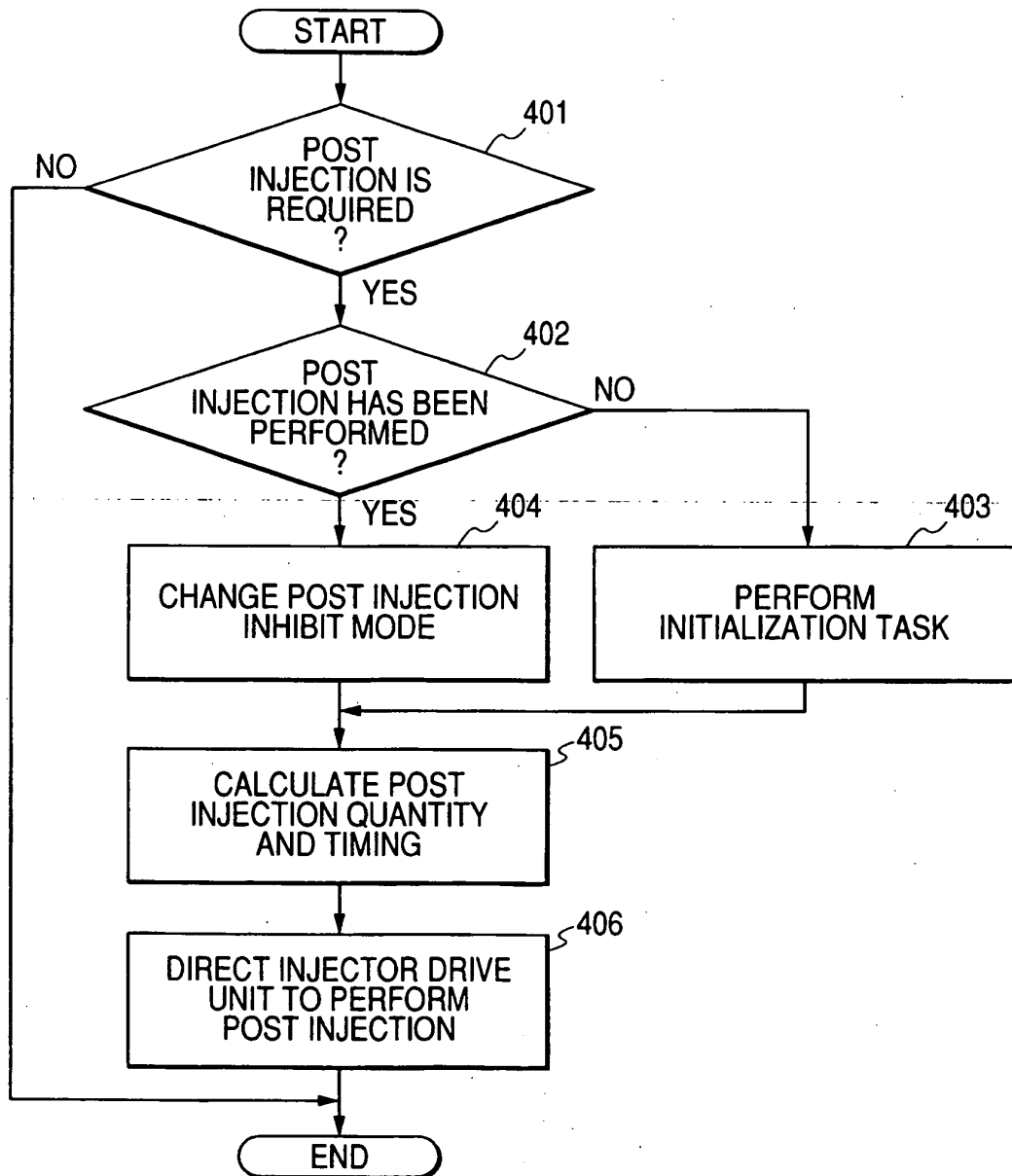


FIG. 5

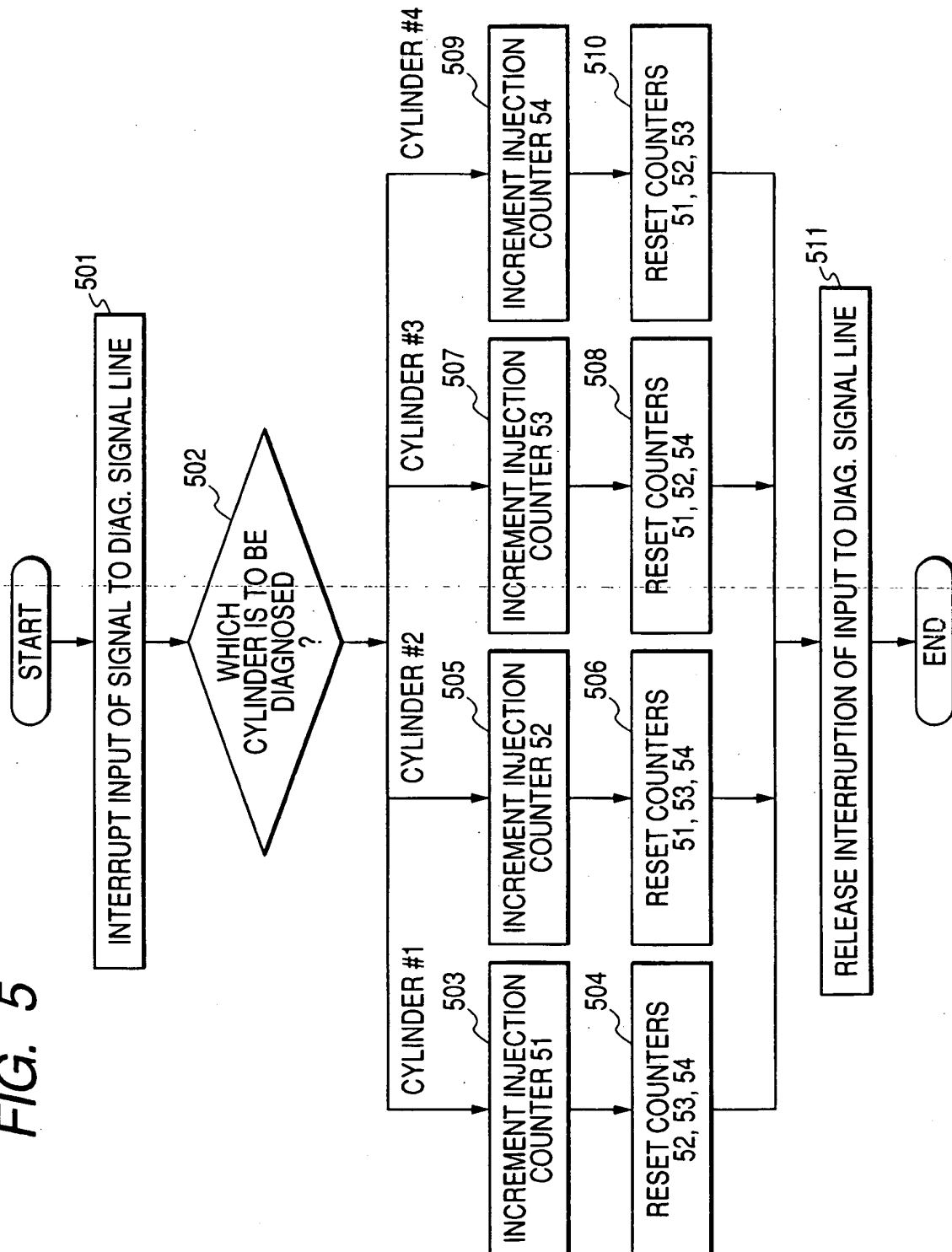


FIG. 6

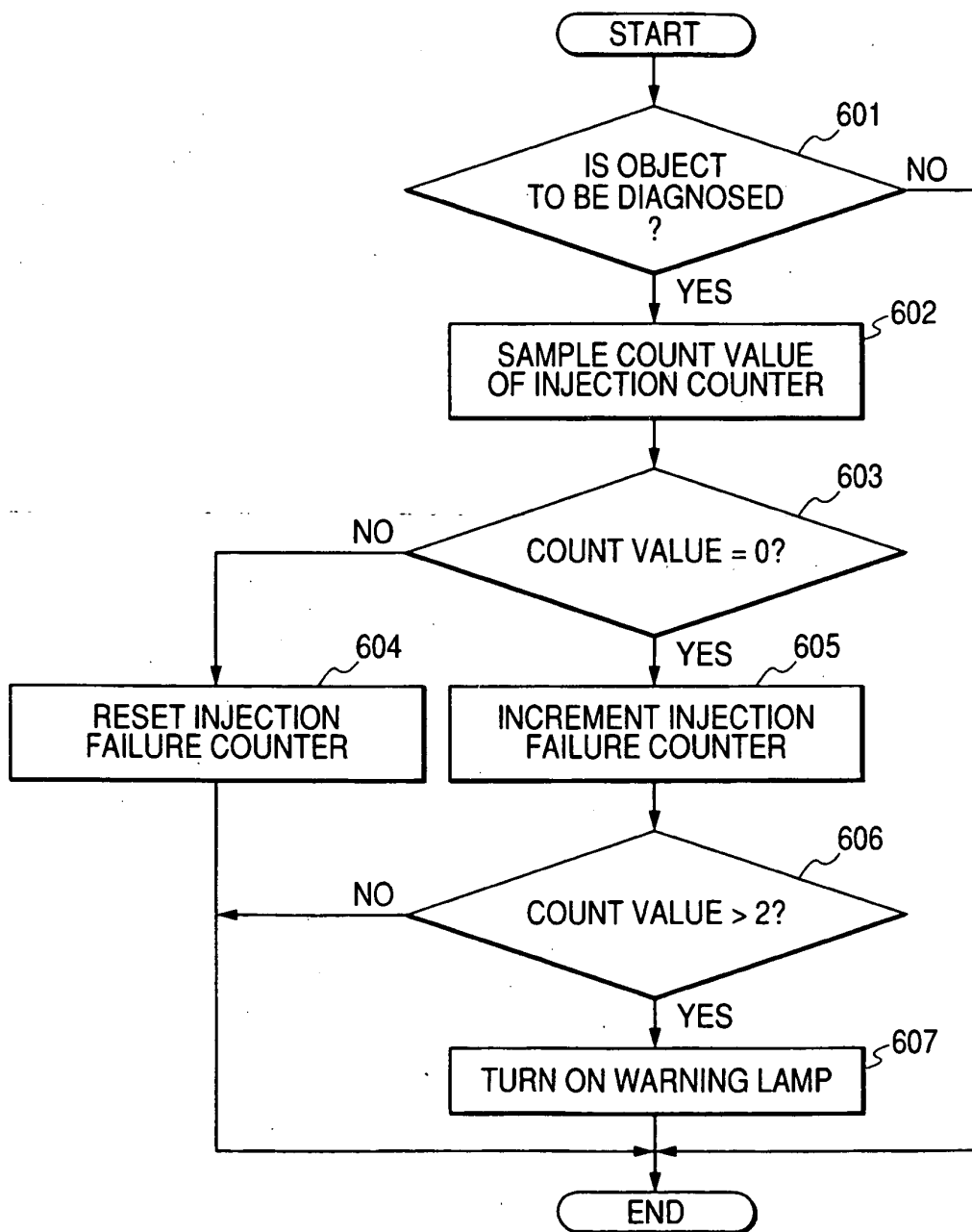


FIG. 7

