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(54) **Accumulation-type fuel injection system and accumulation chamber pressure control method therefor**

Speicherkraftstoffeinspritzsystem und Verfahren zur Regelung des Kraftstoffdruckes dafür

Dispositif d'injection de combustible à accumulateur et méthode de commande de pression associé

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COMMON-RAIL-EINSPRITZSYSTEM-EIN NEUES
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Description

[0001] The present invention relates to an accumulation-type fuel injection system which has an accumulation chamber (common rail) for accumulating a high pressure fuel fed from a fuel supply pump and injects high pressure fuel in the accumulation chamber into cylinders of a diesel engine, and a method for controlling pressure in the accumulation chamber.

[0002] An accumulation-type fuel injection system which is equipped with an accumulation chamber, that is, a common rail, is used to supply a diesel engine mounted in a vehicle with fuel. In this accumulation-type fuel injection system, target fuel pressure in the common rail (common rail pressure), fuel injection amount and fuel injection timing are calculated in response to operating conditions (rotation speed, load or the like) of the diesel engine. The discharge amount of fuel from a fuel supply pump is feedback controlled so that an actual common rail pressure is maintained at the target common rail pressure. Injectors are controlled to be driven so that the high pressure fuel in the common rail is injected into the cylinders of the diesel engine in the calculated fuel injection amount and at the calculated fuel injection timing.

[0003] Each injector used in this kind of system normally includes an injection unit having a valve body which opens in response to pressure of the fuel supplied from the common rail through a first fluid passage and injects the fuel into a cylinder of the diesel engine, a driving unit which closes the valve body in response to the pressure of fuel supplied from the common rail through a second fluid passage, and an electromagnetic valve which spills the fuel supplied from the common rail to the driving unit to a low pressure side of a fuel system. The valve body opens when the electromagnetic valve opens and the fuel supplied to the driving unit spills to the low pressure side, and closes in response to the pressure of fuel supplied to the driving unit when the electromagnetic valve closes.

[0004] It often occurs in the conventional accumulation-type fuel injection system that the common rail pressure increases above the target common rail pressure and the unnecessarily high pressure fuel is injected, for instance, when the diesel engine is accelerated immediately after its rapid deceleration or when the engine is re-started immediately after its stop. For instance, the fuel injection amount is zeroed to stop the fuel injection, when a driver stops pedaling an accelerator pedal to rapidly decelerate the diesel engine. The fuel injection amount and the fuel injection timing are calculated in response to operating conditions at that time to re-start the fuel injection, when the accelerator pedal is pedaled again. The common rail pressure at this moment is maintained at a value close to the target pressure before the deceleration, and is not reduced. As a result, it is likely to occur that the common rail pressure at the time of re-starting is higher than the target common rail pres-

sure, and the fuel is injected immediately at the same time as opening of the valve body of the injector.

[0005] The similar problem may also occur, when the diesel engine is re-started after stopping the engine immediately after its high load operation or when a starter switch for starting the engine is repeatedly turned on and off. This condition continues until the common rail pressure is reduced below the target common rail pressure. This will cause drawbacks such as noise, because the injector injects an unnecessarily high pressure fuel during this period.

[0006] US 5 711 274 describes a system for reducing the fuel pressure in a fuel injection system after shut off of the internal combustion engine.

[0007] It is proposed herein to drive the electromagnetic valve which controls the injector to open and close for a period shorter than that required to open the valve body for injecting fuel so that the high pressure fuel is spilled out to a low pressure side of a fuel system to thereby reduce the common rail pressure. That is, it is possible to spill the high pressure fuel supplied to the driving unit and reduce the common rail pressure by an ineffective driving in which the electromagnetic valve is driven to open for the period shorter than a delay period of the injector, because the injector has the delay period (that is, ineffective injection period) from starting to open the electromagnetic valve to actual opening of the valve body in the injection unit.

[0008] In the proposed system, the common rail pressure control by the ineffective driving is effected at timings synchronized with the rotation of the diesel engine (specifically, rotation of a crankshaft), when a predetermined pressure reducing condition is satisfied, that is, when the calculated fuel injection amount is zero and the common rail pressure is higher than the target common rail pressure. It is, however, more effective to repeatedly effect the ineffective driving at every predetermined cycle period (for instance, 4 ms) asynchronously with the rotation of the diesel engine, because the number of the ineffective driving per unit time is reduced if effected synchronously with the rotation of the diesel engine under the condition that the diesel engine is running at slow speeds. The ineffective driving at the predetermined cycle period is advantageous when stopping of the diesel engine is associated. Thus, this is advantageous in that a minimum required number of ineffective driving is ensured irrespective of rotation condition of the diesel engine.

[0009] In the case that the cycle period of the ineffective driving is predetermined as above, however, the cycle period of the ineffective driving need be so set that the thermal load which the driving circuit for the injector does not increase too much. That is, the cycle period of the ineffective driving must be set in consideration of a high temperature condition to which the driving circuit is subjected. As a result, a difference between an allowable cycle period set from the thermal load limit of the driving circuit and the actual cycle period increases un-

der a low temperature condition where the thermal load is less. Thus, it is disadvantageous in that the pressure reducing effect is not provided sufficiently.

[0010] It is therefore an object of the present invention to provide an accumulation-type fuel injection system and an accumulation chamber pressure control method which are capable of quickly reducing a common rail pressure under a low temperature condition to maximize its pressure reducing performance while restricting an increase in a thermal load applied to a driving circuit of an injector.

[0011] According to the present invention, it is checked whether a pressure reducing condition for reducing fuel pressure in an accumulation chamber is satisfied in response to operating conditions of a diesel engine. An ineffective driving is effected in response to a check result indicating the pressure reducing condition to drive a control valve such as an electromagnetic valve to open for a short period shorter than a delay period in which a valve body opens to thereby spill a high pressure fuel in the accumulation chamber to a low pressure side. A cycle period of the ineffective driving is varied in response to temperature of a control unit so that a thermal load to the control unit does not exceed a limit.

[0012] Preferably, when the fuel pressure in the accumulation chamber is reduced by the ineffective driving and the pressure reducing condition is determined as not being satisfied, the fuel injection of the fuel injecting means which is to occur immediately thereafter is disabled. The temperature of a driving circuit of the control unit for the injector is indirectly detected, that is estimated, from at least one of a coolant temperature and an intake temperature of the engine. The period of the ineffective driving is varied in response to the fuel pressure in the accumulation chamber. The control valve of each cylinder is driven to open sequentially or simultaneously with at least one other.

[0013] The above and other objects, features and advantages of the present invention will become more apparent from the following detailed description made with reference to the accompanying drawings. In the drawings:

Fig. 1 is a schematic diagram showing an entire construction of an accumulation-type fuel injection system according to a first embodiment of the present invention;

Fig. 2 is a timing diagram showing an opening operation of an injector in the first embodiment;

Fig. 3 is a flow diagram showing a common rail pressure control process executed in the first embodiment;

Fig. 4 is a flow diagram showing an injector control process executed in the first embodiment;

Fig. 5 is a flow diagram showing an ineffective driving control (angle-synchronized) process executed in the first embodiment;

Fig. 6 is a flow diagram showing an ineffective driv-

ing control (off interrupt) process executed in the first embodiment;

Fig. 7 is a flow diagram showing details of an driving stop interval calculation process executed in the process of Fig. 6;

Fig. 8 is a graph showing a relation between engine coolant temperature and injector driving circuit temperature;

Figs. 9 (a) and (b) are a diagram showing a relation between an driving stop interval and an ineffective driving cycle period, and a graph showing a relation between driving circuit temperature and the ineffective driving cycle period;

Fig. 10 is a timing diagram showing operation of the first embodiment;

Figs. 11 (a) and (b) are a flow diagram showing an ineffective driving control (angle-synchronized) process executed in a second embodiment of the present invention, and a flow diagram showing an ineffective driving control (off interrupt) process executed in the second embodiment;

Fig. 12 is a flow diagram showing details of an driving stop interval calculation process executed in the process of Fig. 11;

Fig. 13 is a flow diagram showing details of an ineffective driving period calculation process executed in the process of Fig. 11;

Fig. 14 is a graph showing a relation between a common rail pressure and the ineffective driving period;

Fig. 15 is a timing diagram showing operation of the second embodiment;

Figs. 16 (a), (b) and (c) are timing diagrams showing operations of a third, fourth and fifth embodiments of the present invention, respectively;

Figs. 17 (a), (b) and (c) are a flow diagram showing an ineffective driving control (angle-synchronized) process executed in a third embodiment, a flow diagram showing an ineffective driving control (off interrupt) process executed in the third embodiment, and a table showing a relation of correspondence between an ineffective driving cylinder counter and an ineffective driving cylinder;

Figs. 18 (a) and (b) are a flow diagram showing an ineffective driving control (angle-synchronized) process executed in the fourth and fifth embodiments, and is a flow diagram showing an ineffective driving control (off interrupt) process;

Fig. 19 is a diagram showing an operation of a sixth embodiment of the present invention; and

Figs. 20 (a), (b) and (c) are a flow diagram showing an ineffective driving control (angle-synchronized) process executed in the sixth embodiment, a flow diagram showing an ineffective driving control (off interrupt) process, and a table showing a relation of correspondence between an ineffective driving cylinder group counter and an ineffective driving cylinder.

[0014] An accumulation-type fuel injection system applied to a diesel engine will be described hereunder with reference to various embodiments shown in the drawings.

(First Embodiment)

[0015] Referring first to Fig. 1, an accumulation-type fuel injection system is equipped with four injectors (fuel injection valves) 1 for injecting fuel into each cylinder of the engine, a common rail 3 used as an accumulation chamber for accumulating fuel supplied to each injector 1, a high pressure pump 5 used as a fuel supply pump for feeding a high pressure fuel to the common rail 3, and an electronic control unit (ECU) 7 used as a control unit for controlling the above components in response to operating conditions of the engine.

[0016] Fig. 1 shows details of the injector 1, its piping arrangement and a control arrangement with respect to only one cylinder. The same arrangement is provided for other three injectors 1. The high pressure pump 5 is a conventional type which is capable of variably changing its discharge amount of fuel. The pump 5 sucks fuel stored in a fuel tank 9 through a low pressure pump 11 and pressurizes the fuel in its pressurizing chamber to a high pressure. The pump 5 feeds the high pressure fuel to the common rail 3 through a feed pipe 3.

[0017] Each injector 1 is provided with an injecting unit at its lower part and a driving unit at its upper part. The injection part has a nozzle needle 37 as a valve body which opens in response to the pressure of supplied fuel to inject the fuel, and the driving unit which closes the nozzle needle 37 in response to the pressure of supplied fuel. The injector 1 is connected to the common rail 3 through a pipe 15. The high pressure fuel supplied through the pipe 15 is branched in the injector 1, and supplied to a control chamber 43 of the driving unit through a first flow passage and to a fuel reservoir chamber 47 of the injecting part through a second flow passage. The driving unit of the injector 1 is connected to a flow passage 51 which is in communication with the fuel tank 9 provided at a low pressure side of the fuel system. An electromagnetic valve 1a is disposed as control valve in the flow passage 51.

[0018] The driving unit of the injector 1 has a cylindrical holder body 21 as a main part, two disk-shaped orifice plates 23 and 25 stacked on the upper end of the holder body 21, a piston 27 disposed slidably in upward and downward directions within its hollow inner part, and a piston pin 31 extending in the downward direction from the bottom end of the piston 27 within the hollow inner part. A flange 29 is attached to the end (bottom end in the figure) of the piston 3.

[0019] A generally cylindrical bottomed nozzle body 35 which is a main part of the injecting part of the injector 1 is attached to the holder body 21 through a tip packing 33. The nozzle needle 37 which is a valve body is disposed in the hollow inner part of the nozzle body 35. A

large diameter part 37a formed at the upper part of the nozzle needle 37 is disposed slidably in the upward and downward directions within the hollow inner part of the nozzle body 35.

[0020] A connecting part 37b extends from the large diameter part 35 into the inner side of the holder body 21 while passing through the tip packing 33. The connecting part 37b is connected to the flange 29 provided at the bottom end of the piston pin 31 so that the piston 27 and the nozzle needle 37 is movable in the upward and downward directions integrally. Further, a spring 39 is disposed between the flange 29 and the inside wall of the holder body 21 existing above the flange 29 to apply a biasing force to the nozzle needle 37 in a valve closing direction (downward direction in the figure).

[0021] A flow passage 41 is formed in the holder body 21 to be in communication with the pipe 15 which is connected to the common rail 3. The flow passage 41 is branched in the upward and downward directions in its midway. One of its flow passages extending in the downward direction provide a first flow passage together with the flow passage 45 which passes through the tip packing 33 and extends to the nozzle body 35. The first flow passage is in communication with the fuel reservoir 47 formed around the nozzle needle 37 provided below the large diameter part 37a.

[0022] A plurality of injection holes 49 for fuel injection are formed in the end (bottom end in the figure) of the nozzle body 35 and in communication with the fuel reservoir 47. The communication between the fuel reservoir 47 and the injection holes 49 are interrupted to render the injector 1 into a valve-closure condition (shown in the figure), when a conical end part (bottom end part in the figure) of the nozzle needle 37 is pressed to a conical valve, seat 35a formed in the nozzle body 35 by the fuel pressure in the control chamber 43 and a biasing force of the spring 39.

[0023] The other flow passage of the flow passage 41 extending in the upward direction provides a second flow passage together with an orifice 23a formed in the orifice plate 23 and the flow passage 23b. The second flow passage is in communication with the control chamber 43 formed on the back side (upper surface side in the figure) in the holder body 21.

[0024] The control chamber 43 is connected to the flow passage 51 communicated with the fuel tank 9 through an orifice 25a formed in the orifice plate 25. The electromagnetic valve 1a which is controlled to open and close by the ECU 7 is disposed in the midway of the flow passage 51 so that the high pressure fuel in the control chamber 43 is spilled out to the fuel tank 9 through the orifice 25a and the flow passage 51 when the electromagnetic valve 1a is opened. The electromagnetic valve 1a is opened when its coil (not shown in the figure) is energized by the ECU 7, and is closed when not energized.

[0025] The fuel reservoir 47 is communicated with a chamber 81 within the holder body 21 accommodating

the spring 39 through an upper spacing between the large diameter part 37a and the nozzle body 35, and the control chamber 43 is communicated with the chamber 81 through a lower spacing between the piston 27 and the holder body 21. The chamber 81 is in communication with a flow passage 83 which passes through the holder body 21 and the orifice plates 23 and 25. The flow passage 83 is connected through a flow passage 53 to the flow passage 51 provided at the downstream side of the electromagnetic valve 1a. Thus, the excess high pressure fuel overflowing from the fuel reservoir 47 and the control chamber 43 into the chamber 81 is enabled to flow into the fuel tank 9 through the flow passage 83, 53 and 51.

[0026] In the above-constructed injector 1, the high pressure fuel fed from the common rail 3 through the pipe 15 is branched into two directions (upward and downward directions) in the flow passage 41. The fuel branched toward the downward flows into the fuel reservoir 47 in the nozzle body 35 through the flow passage 45 formed as the first flow passage in the tip packing 33 and the nozzle body 35. The fuel branched in the other direction also flows into the control chamber 43 provided at the back side of the piston 27 through the second flow passage including the orifice 23a of the orifice plate 23 and the flow passage 23.

[0027] That is, the nozzle needle 37 receives a force in a direction (valve closing direction) to be pushed down by the fuel pressure in the control chamber 43 as well as a force in a direction (valve opening direction) to be pushed up by the fuel pressure in the fuel reservoir 47.

[0028] Here, the area of the back surface of the piston 27 which receives the fuel pressure in the control chamber 43 is larger than the area of the large diameter part 37a of the nozzle needle 37 (area of the lower surface outer peripheral part of the large diameter part 37a facing the fuel reservoir 47) which receives the fuel pressure in the fuel reservoir 47. Therefore, the force in the downward direction in Fig. 1 prevails, when the coil of the electromagnetic valve 1a is not energized by the ECU 7 and the electromagnetic valve 11a is closed. Thus, the bottom end of the nozzle needle 37 is pressed to the valve seat 35a of the nozzle body 35 and the fuel is not injected into the cylinder of the engine under the valve closure condition, while the electromagnetic valve 1a is in the valve closure condition.

[0029] When the coil of the electromagnetic valve 1a is energized by the ECU 7 and the electromagnetic valve 1a is opened, the high pressure fuel flowing from the common rail 3 into the control chamber 43 spills out into the fuel tank 9 at the low pressure side through the orifice 25a in the orifice plate 25, the electromagnetic valve 1a and the flow passage 51. As a result, the nozzle needle 37 is lifted by the fuel pressure in the fuel reservoir 47 so that its bottom end leaves away from the valve seat 35a. The fuel is injected from the injection holes 49 into the corresponding cylinder of the engine during the valve opening period.

[0030] When the energization of the coil of the electromagnetic valve 1a is interrupted by the ECU 7 and the electromagnetic valve 7 is closed, the fuel pressure in the control chamber 43 rises again. The nozzle needle 37 moves in the valve closing direction until it abuts the valve seat 35a, and the injector 1 is held in the valve closure condition.

[0031] This operation is shown in Fig. 2. When the electromagnetic valve 1a opens, the fuel pressure in the control chamber 43 (control chamber pressure) starts to fall. At this timing, the lift amount of the nozzle needle 37 in Fig. 2 (amount of movement in the valve opening direction) does not change. The nozzle needle 37 starts to move in the valve opening direction, only when the control chamber pressure gradually falls thereafter and the sum of the force in the pushing-down direction (valve closing direction) provided by the control chamber pressure and the biasing force of the spring 39 decreases below the force in the pushing-up direction (valve opening direction) due to the fuel pressure provided by the fuel reservoir 47.

[0032] At this time, the injector 1 according to the present embodiment requires a predetermined delay period t_m (for instance, 0.4 ms) until the nozzle needle 37 starts to move in the valve opening direction from the opening of the electromagnetic valve 1a as shown in Fig. 2, because the flow of the fuel from the control chamber 43 into the fuel tank 9 is restricted by the orifice 25a in the orifice plate 25. Therefore, it is possible to spill the high pressure fuel from the common rail 3 out from the control chamber 43 to thereby reduce the pressure in the common rail 3 without injecting the fuel by opening the electromagnetic valve 1a only for a period shorter than the delay period t_m (hereinafter referred to as an ineffective driving).

[0033] The ECU 7 as the control unit is constructed with a known microcomputer as a main component which has a CPU 61 for executing a program for controlling the engine, a ROM 63 storing the program which the CPU 61 executes, a RAM for 65 temporarily storing calculation results of the CPU 61, and the like.

[0034] The ECU 7 has an input circuit 77 for inputting signals from various sensors and an output circuit 79 for driving the electromagnetic valve 1a of each injector, the high pressure pump 5 and the like in response to commands from the CPU 61.

[0035] The various sensors include a crank angle sensor 67 for producing a pulse-shaped crank angle signal at every 30 degrees (30° CA) rotation of a crankshaft of the engine, an accelerator sensor 69 for detecting an accelerator position A_c indicative of an engine load, a coolant temperature sensor 7 for detecting an engine coolant temperature THW and operating as temperature detecting means to indirectly detect the temperature of the control unit, a cylinder discrimination sensor 73 for producing a pulse-shaped cylinder discrimination signal KS at every two rotations of the crankshaft of the engine and at every arrival of the crankshaft at a spec-

ified rotation angle position, a common rail pressure sensor 75 for detecting an actual fuel pressure in the common rail 3 (actual common rail pressure) PC, and the like.

[0036] The ECU 7 detects the engine operating conditions such as the rotational speed of the engine (engine rotational speed) Ne, the accelerator position Ac, the coolant temperature THW and the actual common rail pressure PC in response to the signals from the sensors 67 to 75 and the like. It further feedback controls the common rail pressure by calculating a target fuel pressure (target common rail pressure) PF in the common rail 3 to realize a fuel injection pressure for the most optimum combustion corresponding to the detected operating conditions, and controlling the driving of the high pressure pump 5 so that the actual common rail pressure PC detected by the common rail pressure sensor 75 becomes the target common rail pressure PF.

[0037] The ECU 7 controls the fuel injection into the engine by calculating a target fuel injection amount and a target injection timing in response to the detected operating conditions and driving the electromagnetic valve 1a of each injector 1 at a timing synchronized with the rotation of the engine in response to the signals from the crank angle sensor 67 and the cylinder discrimination sensor 73.

[0038] The ECU 7 effects the ineffective driving when it is determined that a pressure reducing condition for reducing the common rail pressure is satisfied in response to the detected operating conditions. That is, the electromagnetic valve 1a of the injector 1 is driven to open for the period shorter than the delay period (period required for the nozzle needle 37 of the injector 1 to open) tm. Thus, the high pressure fuel flowing into the control chamber 43 of the injector 1 from the common rail 3 is spilled out to reduce the common rail pressure.

[0039] It is to be noted the cycle period of the ineffective driving is set in response to, for instance, the temperature of the ECU 7 indirectly detected from the coolant temperature THW, specifically the temperature of the injector driving circuit (corresponding to the output circuit 79 in Fig. 1) which is likely to generate heat. Thus, the common rail pressure is effectively reduced by changing the cycle period of the ineffective driving in response to changes in the temperature of the ECU 7 within a range in which the thermal load of the injector driving circuit does not exceed a limit.

[0040] Here, the process of the ECU 7 executed to control the fuel injection into the engine and the pressure in the common rail 7 in the present embodiment is described with reference to flow diagrams shown in Figs. 3 to 9, while also referring to Fig. 10.

[0041] In the ECU 7, detection process which is not shown is executed periodically separately from the process of Figs. 3 to 6, so that the latest engine rotation speed Ne, the accelerator position Ac, the coolant temperature THW, the actual common rail pressure PC and the like are detected from the signals from the above

sensors 67 to 75. For instance, the engine rotation speed Ne is detected by measuring a time interval of the crank angle signal CS produced from the crank angle sensor 67, and the accelerator position Ac, the coolant temperature THW and the actual common rail pressure PC are detected by A/D-converting analog signals of the accelerator position sensor 69, the coolant temperature sensor 71 and the common rail pressure sensor 75. This detection process and the process shown in Figs. 3 to 6 are executed in practice by the CPU 61 in the ECU 7. The programs for causing the CPU 61 to execute those process are pre-stored in the ROM 63.

[0042] Fig. 3 is a flow diagram showing a common rail pressure control process which is normally executed as an interrupt routine in synchronized relation with a predetermined time interval or the rotation of the engine.

[0043] As shown in Fig. 3, when the execution of the common rail pressure control process starts, the engine rotation speed Ne, the injection amount command value Q and the actual common rail pressure PC are read in at step (S) 100, and the target common rail pressure PF is calculated at the following S101 from the engine rotation speed Ne and the injection amount command value Q read in as above. The injection amount command value Q is calculated at S202 in Fig. 4. The target common rail pressure PF is generally determined to be larger as the engine rotation speed Ne and the injection amount command value Q become larger. At S102 the high pressure pump 5 is driven to feed the fuel to the common rail 3 so that the actual common rail pressure PC becomes the target common rail pressure PF, thus ending this process.

[0044] Fig. 4 is a flow diagram showing an injector control process executed as an angle-synchronized routine which is executed at every 180 degrees rotation of the crankshaft of the engine (at every 180° CA) in the case of four-cylinder engine. In the present embodiment, as shown in Fig. 10, this process is started each time the crank angle signal CS indicative of the crankshaft rotation angle = 0° CA is produced (for instance, at times t1, t2, t3, t4 and t5 in Fig. 10). In Fig. 10, the fuel injection amount command value Q, an ineffective driving flag FK which indicates whether the ineffective driving is effected, the energization signal to the electromagnetic valve 1a which controls the injector 1, the actual common rail pressure PC and the target common rail pressure PF are also shown.

[0045] In Fig. 4, when execution of the injector control process starts, the engine rotation speed Ne and the accelerator position Ac are read in at S201, the injection amount command value Q is calculated at the following S202 in response to the read engine rotation speed Ne and the accelerator position Ac. The injection amount command value Q is normally calculated to be larger as the accelerator position Ac becomes larger. Next at S203, the ineffective driving flag FKold for storing the value of the ineffective driving flag FK at that moment is set to 0 or 1. It is checked at S204 whether the calculated

injection amount command value Q is 0 or not, and the process proceeds to S205 if the calculated value is not less than 0, that is, if it is not necessary to effect the ineffective driving.

[0046] It is checked at S205 whether the ineffective driving flag FKold is 1 indicating the ineffective driving. If the ineffective driving flag FKold is 1, the ineffective driving flag FK is set to 0 to indicate that the ineffective driving is not necessitated, thus ending this injector control process. If the ineffective driving flag FKold is not 1 at S205, the normal fuel injection control process is executed at S207 and this injector control process is ended.

[0047] The fuel injection control process at S207 is described further. For instance, in the injector control process executed at timing t1 in Fig. 10, the process proceeds to S207 because the check results are NO at S204 and S205, that is, the injection amount command value Q is larger than 0 and the ineffective driving flag FKold is 0. Here, the period TQ (> tm which corresponds to the fuel injection amount) for opening the electromagnetic valve 1a of the injector 1 and the opening start timing TT (corresponding to the fuel injection timing) of the same are calculated first in response to the engine rotation speed Ne, the injection amount command value Q, the actual common rail pressure PC and the like. When it becomes the time of the calculated electromagnetic valve opening timing TT (timing t11 in Fig. 10), the coil of the electromagnetic valve 1a is energized to open for the calculated electromagnetic valve opening period TQ. The fuel is injected from the injection holes 49 of the injector 1 during this period.

[0048] The processes in S205 and S206 are for stopping the normal fuel injection control process only once immediately after effecting the ineffective driving as shown at timing t41 in Fig. 10. For instance, when the time period from completing the ineffective driving due to attainment of the actual common rail pressure PC to the target common rail pressure PF to the next fuel injection timing (the period between the timings t4 and t41) is very short, it is likely that the pressure in the fuel reservoir 47 of the injector 1 does not decrease sufficiently and an unnecessarily large amount of fuel is injected into the cylinder of the engine at the time of opening of the injector 1. However, this is prevented by stopping the fuel injection immediately after effecting the ineffective driving process as in the present embodiment.

[0049] If it is determined at S204 that the injection amount command value Q is below 0, the process proceeds to S208 to effect the ineffective driving. It is checked at S208 as another condition for effecting the ineffective driving whether a pressure difference (PC - PF) between the actual common rail pressure PC and the target common rail pressure PF is larger than a predetermined pressure H (for instance, 2 Mpa (mega pascal)). If it is determined that (PC - PF) is larger than H, the high pressure pump 5 is stopped at S209 and the ineffective driving flag FK is set to 1 at S210, thus ending this process. If it is determined that (PC - PF) is not larger

than H, the ineffective driving flag FK is set to 0 at S211 thus ending this injector control process.

[0050] The process in Fig. 4 is for determining whether the ineffective driving should be effected. The ineffective driving is effected in practice by the ineffective driving control process shown in the flow diagrams of Figs. 5 and 6.

[0051] Fig. 5 is an angle-synchronized routine to be executed at every 180 degrees rotation of the crankshaft of the engine (at every 180° CA) in the case of four-cylinder engine. In this embodiment, as shown in Fig. 10, the process is executed in synchronized relation with the crank angle signal indicating that the crank angle is at 150° CA (for instance, timings t21 and t23 in Fig. 10). It is checked first at S301 whether the ineffective driving flag FKold set at S203 in Fig. 4 is 1. If FKold is 1, the process is ended. If FKold is not 1 at S301, the process proceeds to S302.

[0052] The process at S301 is for checking whether the ineffective driving process is being continued. In this embodiment, the ineffective driving is effected at the same cycle period during the period from the start of the ineffective driving control process to the completion of the pressure reduction and the process following S302 in Fig. 5 which determines the ineffective driving condition, because the temperature condition does not change so much in one pressure reducing process. For instance, in the ineffective driving control process executed at timing t31 in Fig. 10, the ineffective driving control process executed at timing t21 is being continued and the FKold = 1 at S301, the ineffective driving of this process is not effected.

[0053] It is checked at S302 whether the ineffective driving flag FK is 1 to check whether the ineffective driving condition is satisfied. If the ineffective driving flag FK is 1 at S302, the driving stop interval Tint is calculated. The calculation of the driving stop interval Tint at S303 is executed specifically as shown in the flow diagram of Fig. 7.

[0054] In the flow diagram of Fig. 7, the engine coolant temperature THW is read in at S501, and the driving stop interval Tint is calculated at S502 from a one-dimensional mapped data provided relative to the engine coolant temperature THW. Here, the driving stop interval Tint is determined in the following manner as shown in Figs. 8 and 9.

[0055] Fig. 8 shows the relation between the engine coolant temperature THW and the temperature of the ECU 7 which is the control unit, particularly the injector driving circuit which is likely to become high temperature. In estimating the driving circuit temperature from the engine coolant temperature THW, the driving circuit temperature is set to the engine coolant temperature THW plus 25 (°C) by estimating 25° C higher in view of the heat generation of the driving circuit itself.

[0056] Fig. 9(b) shows, relative to the thus estimated injector driving circuit temperature, a limit value (dotted line in the figure) of the allowable cycle period of the

ineffective driving which is determined by the thermal load limit and a set value (solid line in the figure) of the cycle period of the ineffective driving determined in consideration of a certain margin.

[0057] The cycle period of the ineffective driving is, as shown in Fig. 9(a), a sum of a driving period T_q (period of energization of the electromagnetic valve 1a) and the driving stop interval T_{int} (interval after turning off the energization). According to the present embodiment, the ineffective driving period T_q is fixed and the driving stop interval T_{int} is calculated by subtracting the ineffective driving period T_q from the value of the cycle period of the ineffective driving.

[0058] In Fig. 7, the driving stop interval T_{int} is calculated at S502 from the engine coolant temperature THW read in at S501 based on the one-dimensional mapped data pre-stored as above. If the ineffective driving cycle period is fixed irrespective of the temperature condition as in the conventional system, the ineffective driving cycle period is necessarily set to a period (4350 μ s) in correspondence with the upper limit, 100° C, of the driving circuit temperature. However, by setting the ineffective driving period variably with the driving circuit temperature estimated from the engine coolant temperature THW, the ineffective driving cycle period under the low temperature condition is set short to effectively reduce the pressure.

[0059] Fig. 10 shows the difference in the ineffective driving cycle periods caused by different temperature conditions as the low temperature operation and the high temperature operation in the comparative manner.

[0060] In Fig. 5, at the following S304, the predetermined ineffective driving period T_q is read in. The driving period T_q is set to be shorter than the delay period t_m , and is set to a predetermined value, 320 μ s, for instance in the present embodiment. A pulse (driving period T_q and driving stop interval T_{int}) is output at S305 for effecting the ineffective driving, thus ending this process. For instance, in the ineffective driving control process executed at timing t_{21} in Fig. 10, because FKold is 0 at S301 and the ineffective driving flag FK is 1 at S302, the process proceeds to S303 and subsequent steps to effect the ineffective driving. The electromagnetic valve 1a of the injector 1 is opened only for the predetermined ineffective driving period T_q to thereby reduce the common rail pressure, and then the ineffective driving is stopped for the calculated driving stop interval T_{int} .

[0061] The ineffective driving control process in the angle-synchronized routine shown in Fig. 5 is for effecting the first ineffective driving after the ineffective driving flag FK is changed from 0 to 1. After this, the ineffective driving control process is executed in an off interrupt routine which is executed as shown in Fig. 6 each time the energization of the electromagnetic valve 1a is turned off.

[0062] This process is started, when the energization of the electromagnetic valve 1a is turned off after the ineffective driving control process is executed in the an-

gle-synchronized routine of Fig. 5 at, for instance, t_{21} in Fig. 10. It is checked at S401 whether the ineffective driving flag FK is 1 or not to check whether the ineffective driving condition is satisfied.

[0063] If the ineffective driving flag is not 1 at step S401, the process is ended. If the ineffective driving flag FK is 1, the driving stop interval T_{int} is read in at step S402. The driving stop interval T_{int} to be read in is the one which is calculated at the first ineffective driving. Then, the ineffective driving period T_q predetermined at S403 is read in, and the pulse (driving period T_q and driving stop interval T_{int}) for the ineffective driving is output at S404. As a result, the ineffective driving according to this process is effected after the set driving stop interval T_{int} elapses from the first ineffective driving at timing t_{21} in Fig. 10, thus ending this process.

[0064] The ineffective driving control process in the off interrupt routine of Fig. 6 is repeated each time the energization of the electromagnetic valve 1a is turned off. The ineffective driving is effected repeatedly with the set driving period T_q and the driving stop interval T_{int} until it is determined at S401 that the ineffective driving flag FK is changed to 0 (until timing t_4 in Fig. 10). At this time, the ineffective driving control process in the angle-synchronized routine shown in Fig. 5 is executed at timing t_{31} in Fig. 10.

[0065] However, it is determined at S301 that FKold is changed to 1, and it is determined that the ineffective driving control process is being continued. Thus, the ineffective driving according to this process is not effected. The first ineffective driving is executed by the angle-synchronized routine and the subsequent ineffective driving is executed by the energization-off interrupt routine, so that unexpectedly large amount of fuel is prevented from being injected when the previous fuel injection and the first ineffective driving occur at too close timings.

[0066] Thus, according to the present embodiment, the driving stop interval T_{int} in the ineffective driving is variably set in response to the engine coolant temperature THW from time to time. As a result, as shown in Fig. 10, the cycle period of the ineffective driving is set shorter under the low temperature condition when the thermal load is still acceptable than under the high temperature condition. Therefore, the ineffective driving is effected at the most optimum cycle period of the ineffective driving in response to the temperature condition, and the pressure reducing performance is maximized.

[0067] The leak fuel leaking from the flow passage 83 in the injector 1 to the flow passage 53 in Fig. 1 influences the pressure reducing performance. The leak fuel decreases under the low temperature condition because the viscosity of fuel increases. Therefore, the pressure reducing performance is lessened in correspondence with the amount of the leak fuel if the ineffective driving is effected irrespective of the temperature condition as in the conventional system. However, according to the present embodiment, the pressure of fuel

is reduced quickly by shortening the cycle period of the ineffective driving as the temperature decreases thereby increasing the number of the ineffective driving per unit time. As a result, as shown in Fig. 10, the actual common rail pressure PC is reduced to the target common rail pressure PF within the substantially the same period as in the high temperature condition. This is advantageous in that the pressure reducing performance is ensured stably.

(Second Embodiment)

[0068] Figs. 11 to 15 show a second embodiment of the present invention. In the above first embodiment, the ineffective driving period T_q is fixed and the driving stop interval T_{int} is varied in response to the engine coolant temperature THW. In the second embodiment, the ineffective driving period T_q is varied in response to the common rail pressure PC and the driving stop interval T_{int} is varied in response to the engine coolant temperature THW. The basic construction and operation of the fuel injection system are the same as the first embodiment. Therefore, only the part for setting the ineffective driving period T_q and the driving stop interval T_{int} are shown.

[0069] Fig. 11(a) corresponds to Fig. 5 of the first embodiment. The ineffective driving period T_q is calculated at S603 after determining at S601 and S602 that the ineffective driving flag FKold is not 1 and the ineffective driving flag FKold is 1, respectively. The process at S603 is the characterized part of this embodiment, and the ineffective driving period T_q is calculated based on the flow diagram shown in Fig. 12 in place of reading in the fixed ineffective driving period T_q . In the flow diagram of Fig. 12, the actual common rail pressure PC is read in at S701 and the ineffective driving period T_q is calculated at S702 using a one-dimensional map data provided in relation to the actual common rail pressure PC.

[0070] It is preferred in setting the ineffective driving period T_q to set it as long as possible without causing the fuel injection from the injector to the cylinder of the engine so that the pressure reducing performance is ensured. Parameters which influence the ineffective driving period T_q include a pressure in the cylinder, the common rail pressure, a fuel temperature, power source voltage and the like. Further, variations and aging changes in injectors also are influential. It is a general practice to set the ineffective driving period T_q short so that the fuel is not injected into the cylinder under any conditions.

[0071] From a study of the relation between the actual common rail pressure PC of the parameters which is continuously monitored during the engine operation and the ineffective driving period T_q , it is found that the allowable maximum ineffective driving period T_q changes in dependence on the magnitude of the actual common rail pressure PC as shown in Fig. 14.

[0072] Therefore, based on this finding, the optimum

ineffective driving period T_q is calculated at S702 in Fig. 12 in response to the actual common rail pressure PC. Then, the driving stop interval T_{int} is calculated at S604. This detail is shown in Fig. 13. The engine coolant temperature THW is read in at S801, and the ineffective driving cycle period T_{cycl} is calculated in response to the engine coolant temperature at S802. The driving stop interval T_{int} is calculated at S803 by subtracting the ineffective driving period T_q calculated at S603 from the ineffective driving cycle period T_{cycl} .

[0073] The ineffective driving pulse is output at S605 in Fig. 11(a) to effect the ineffective driving with the calculated driving period T_q and driving stop interval T_{int} . The ineffective driving after this is effected by a pulse off interrupt routine shown in Fig. 11(b). However, in this embodiment, the ineffective driving is effected at S614 after calculating the ineffective driving period T_q again at S613 and reading the driving stop interval T_{int} at S613, because the common rail pressure changes from time to time in response to the ineffective driving. This sequence of operation is shown in Fig. 15.

[0074] Here, if the ineffective driving period T_q is fixed irrespective of the common rail pressure, the ineffective driving period T_q which is the shortest for the common rail pressure 48 Mpa. The pressure reducing performance is lessened by the amount of shortening of the ineffective driving period when the common rail pressure increases above or decreases below 48 Mpa. According to this embodiment, on the contrary, the ineffective driving control is effected effectively because the ineffective driving period T_q is set from time to time in response to the actual common rail pressure PC. Further, as shown in Fig. 15, the ineffective driving period T_q is calculated for each ineffective driving and the most appropriate ineffective driving period T_q is selected constantly. Therefore, it provides a great advantage in that the pressure reducing performance is maximized.

(Third Embodiment)

[0075] It is preferred in practice that only specified one of the injectors 1 is not subjected but a plurality of the injectors 1 are subjected sequentially thereby to distribute the thermal load. For instance, in a third embodiment shown in Fig. 16(a), the injectors 1 corresponding to the cylinders #1 to #4 are subjected to the ineffective driving in order of #1, #3, #4 and #2 in the ineffective driving from timing t_{21} to timing t_4 in Fig. 10. A flow diagram which corresponds to the ineffective driving control process shown in Figs. 5 and 6 is shown in Figs. 17(a) and 17(b).

[0076] Fig. 17(a) is an angle-synchronized routine executed every 180° CA and executed in synchronism with the crank angle signal of 150° CA (timing t_{21} in Fig. 16(a)). S311 to S314 are the same process as S301 to S304 in Fig. 5. In the case that the ineffective driving flag FKold is not 1 and the ineffective driving flag FK is 1, the driving stop interval T_{int} is calculated in the flow

diagram of Fig. 7, and the predetermined ineffective driving period T_q is read in.

[0077] An ineffective driving cylinder counter CCYLNK is set to 0 at S315. The relation between the ineffective driving cylinder counter CCYLNK and the cylinder for the ineffective driving is shown in Fig. 17(c). If CCYLNK is 0, the injector 1 of the cylinder #1 is subjected to the ineffective driving. The pulse (driving period T_q and the driving stop interval T_{int}) for the first ineffective driving is output at S316 thus ending this routine.

[0078] The subsequent ineffective driving is executed in the off interrupt routine of Fig. 17(b). The processes from S411 to S413 are the same as S401 to S403 in Fig. 6. The calculated driving stop interval T_{int} and the predetermined ineffective driving period T_q are read in after checking that the ineffective driving flag FK is 1. The ineffective driving cylinder counter CCYLNK is updated ($CCYLNK = CCYLNK + 1$) at S414, and it is checked at S415 whether the updated CCYLNK is equal to or less than 4. If the updated CCYLNK is equal to or less than 4, the ineffective driving (driving period T_q and the driving stop interval T_{int}) is effected at S417. If CCYLNK is more than 4, CCYLNK is set to 0 at S416 and the ineffective driving is effected at S417.

[0079] Thus, after the ineffective driving is effected for the cylinder #1 at timing t_{21} , the ineffective driving is effected for the cylinders in order of #3, #4 and #2. This process is ended if it is determined at S411 that the ineffective driving flag FK is 0 (timing t_4 in Fig. 16(a)).

[0080] It is preferred to drive the injectors 1 in sequence so that the thermal load applied to the injector driving circuit is distributed. In this instance, as shown in Fig. 16(a), the actual common rail pressure PC gradually decreases and reaches the target common rail pressure PF at timing t_4 . It is also possible to set CCYLNK as $CCYLNK = CCYLN + 1$ by using the immediately previous injection cylinder CCYLN in place of setting CCYLNK = 0 at S315.

(Fourth and Fifth Embodiments)

[0081] Alternatively, as shown in Figs. 16(b) and 16(c) as a fourth and a fifth embodiments, it is possible to subject a plurality of the injectors 1 to the ineffective driving at the same time. In this instance, all the four injectors 1 are subjected to the ineffective driving. The ineffective driving cycle period may be the same as that of Fig. 16(a) as shown in Fig. 16(b), or longer, four times longer, than that of Fig. 16(a) as shown in Fig. 16(c). The ineffective driving control processes for operations shown in Figs. 16(b) and 16(c) are shown in Figs. 18(a) and 18(b).

[0082] Fig. 18(a) is an angle-synchronized routine executed every 180° CA. In the case that it is determined at S321 and S322 that the ineffective driving flag FKold is not 1 and the ineffective driving flag FK is 1, respectively, the driving stop interval T_{int} is calculated at S323. In the case of Fig. 16(b), the driving stop interval T_{int} is

calculated in the flow diagram of Fig. 7 in the same manner as in Fig. 16(a). In the case of Fig. 16(c), the ineffective driving cycle period is calculated based on predetermined mapped data so that it is four times longer.

The ineffective driving cycle period is read in at S324, and the pulse (driving period T_q and driving stop interval T_{int}) is output for the first ineffective driving at S325.

[0083] In an off interrupt routine shown in Fig. 18(b), the actual common rail pressure PC is read in at S422 and the target common rail pressure PF is read in at S423 after checking at S421 that the ineffective driving flag FK is 1. If it is determined at S426 that $(PC - PF)$ is larger than the predetermined pressure H, the calculated driving stop interval is read in at S425 and the predetermined ineffective driving period T_q is read in at S426. At the following S427, the four injectors 1 are subjected to the ineffective driving (driving period T_q and driving stop interval T_{int}) at the same time. This is repeated until it is determined at S424 that $(PC - PF)$ becomes larger than H.

[0084] Thus, the common rail pressure is reduced more quickly to the target common rail pressure PF by subjecting the four injectors to the ineffective driving at the same time. If the ineffective driving cycle period is set to the same as that in Fig. 16(a) as shown in Fig. 16(b), the period required to reduce the pressure is shortened and the pressure reducing performance is improved. If the ineffective driving cycle period is set longer as shown in Fig. 16(c), the pressure reduction period becomes slightly longer but the thermal load is reduced.

(Sixth Embodiment)

[0085] It is also possible to subject the injectors 1 to the ineffective driving two by two alternately as shown in a sixth embodiment shown in Fig. 19. Here, the two injectors 1 of the cylinders #1 and #4 are subjected to the simultaneous ineffective driving as one group, and the other two injectors 1 of the cylinders #2 and #3 are subjected to the simultaneous ineffective driving as the other group. The ineffective driving control process in this instance is shown in flow diagrams of Figs. 20(a) and 20(b). The pressure reducing performance is shortened if the ineffective driving cycle period is set to the same as that shown in Fig. 16(a), and the thermal load is reduced if it is set longer than that shown in Fig. 16(a).

[0086] Fig. 20(a) is an angle-synchronized routine executed every 180° CA. The processes from S331 to S334 are the same as the processes from S311 to S314 of Fig. 17. The ineffective driving cylinder group counter CCYLNG is set to 0 at the following S315. The relation between the ineffective cylinder group counter CCYLNG and the ineffective driving cylinder is shown in Fig. 20(c). If CCYLNG is 0, the injectors 1 of the cylinders #1 and #4 are subjected to the ineffective driving. The pulse (driving period T_q and the driving stop interval T_{int}) for the first ineffective driving is output at S316, thus ending this process.

[0087] The subsequent ineffective driving is executed in an off interrupt routine of Fig. 20(b). The processes from S431 to S433 are the same as the processes from S411 to S413 of Fig. 17. At the following S434, the ineffective driving cylinder counter CCYNNG is updated (CCYLNG = CCYLNG + 1). It is checked at S435 whether CCYLNG is equal to or less than 1. If the updated CCYLNG is equal to or less than 1, the ineffective driving (driving period Tq and driving stop interval Tint) is effected at S437. If CCYLNG is larger than 1, the CCYLNG is set to 0 at S436 and the ineffective driving is effected at S437. Thus, the two groups, one being the cylinders #1 and #4 and the other being the cylinders #2 and #3, are subjected to the ineffective driving alternately and repeatedly. This process is ended when it is determined at S431 that the ineffective driving flag FK is 0.

[0088] In the above embodiments, the coolant temperature sensor 71 is used as temperature detecting means to estimate the injector driving circuit temperature from the engine coolant temperature THW. The injector driving circuit temperature may be estimated from the intake temperature or from both of the temperatures.

[0089] In each of the above embodiments, the method of reducing the pressure in the common rail 3 is explained with reference to the case where the injection amount command value is less than 0 and the actual common rail pressure PC is larger than the target common rail pressure PF because of, for instance, a rapid deceleration. The present invention may also be applied when the common rail pressure rises excessively than necessary because of re-starting of the engine after the high load operation or repetition of turning on and off of a starter switch. In this instance, as the pressure reducing condition to reduce the fuel pressure in the common rail 3, it is only necessary to check whether an ignition switch or a starter switch is changed from turned-on condition to turned-off condition. The pressure in the common rail 3 is reduced effectively by effecting the ineffective driving in the similar manner thereafter.

[0090] The above embodiments and modifications may be further modified. For instance, a piezoelectric-type valve may be used in place of an electromagnetic-type valve.

[0091] A spill control valve such as an electromagnetic valve (1a) of an injector (1) is ineffectively driven to open for a period (Tq) shorter than a delay period (tm) by which a nozzle needle (37) opens, when a pressure reducing condition to reduce fuel pressure in a common rail (3) is satisfied. A temperature of an injector driving circuit (79) in an ECU (7) is estimated from a coolant temperature detected by a coolant temperature sensor (71). A cycle period of an ineffective driving is determined from the estimated temperature so that a thermal load applied to the injector driving circuit does not exceed a limit.

Claims

1. An accumulation-type fuel injection system comprising an accumulation chamber (3) for accumulating high pressure fuel fed from a fuel supply pump (5, 11), an injector (1) for injecting the high pressure fuel from the accumulation chamber into a cylinder of a diesel engine, a control valve (1a) which spills the fuel supplied from the accumulation chamber to the injector to a low pressure side (9) when driven to open, the injector being constructed to open the valve body while the control valve is driven to open, a control unit (7) for controlling a driving of the fuel supply pump (5) and the injector (1) in response to operating conditions of the diesel engine to thereby supply the fuel into the diesel engine, and temperature detecting means (71) for directly or indirectly detecting a temperature of the control unit, wherein the control unit includes:

condition checking means (61, S204, S208), checking, in response to the operating conditions of the diesel engine, whether a pressure reducing condition for reducing a fuel pressure in the accumulation chamber is satisfied;

pressure reducing means (1a, 7), effecting an ineffective driving by which the control valve is driven to open for a short period (Tq) shorter than a delay period (tm) in which the valve body opens to thereby spill a high pressure fuel in the accumulation chamber to the low pressure side; and

pressure reduction effecting means (7), determining a cycle period (Tq + Tint) of the ineffective driving by the pressure reducing means, in response to the temperature of the control unit detected by the temperature detecting means when the condition checking means determines that the pressure reducing condition is satisfied, so that a thermal load applied to the control unit does not exceed a limit, and, driving the pressure reducing means at the determined cycle period to thereby reduce the fuel pressure in the accumulation chamber.

2. An accumulation-type fuel injection system of claim 1, wherein the control unit includes fuel injection stopping means, stopping, when the condition checking means determines that the fuel pressure in the accumulation chamber is reduced by the ineffective driving and the pressure reducing condition is determined as not being satisfied, the fuel injection of the fuel injecting means which is to occur immediately thereafter.
3. An accumulation-type fuel injection system of claim 1 or 2, wherein the temperature detecting means detects a temperature of a driving circuit (79) of the

control unit for the injector indirectly from at least one of a coolant temperature and an intake temperature of the diesel engine.

4. An accumulation-type fuel injection system of any one of claims 1 to 3, wherein the pressure reduction effecting means determines a valve-open driving period (T_q) of the control valve for the ineffective driving in response to the fuel pressure in the accumulation chamber. 5 10
5. An accumulation-type fuel injection system of any one of claims 1 to 4, wherein the diesel engine has the cylinder in a plurality of numbers and the injector in a plurality of numbers in correspondence with the numbers of the cylinder, and the control valve of each cylinder is driven to open sequentially or simultaneously with at least one other. 15
6. An accumulation-type fuel injection system of any one of claims 1 to 5, wherein the control valve is an electromagnetic type, the injector includes an injection unit having a valve body (37) which opens in response to pressure of the fuel supplied from the accumulation chamber through a first fluid passage (45) and injects the fuel into a cylinder of the diesel engine, and a driving unit which closes the valve body in response to a pressure of the fuel supplied from the accumulation chamber through a second fluid passage (41). 20 25 30
7. A control method for an accumulation-type fuel injection system which comprises an accumulation chamber (3) for accumulating a high pressure fuel fed from a fuel supply pump (5, 11), an injector (1) for injecting the high pressure fuel from the accumulation chamber into a cylinder of a diesel engine, a control unit (7) for controlling a driving of the fuel supply pump and the injector in response to operating conditions of the diesel engine to thereby supply the fuel into the diesel engine, and temperature detecting means (71) for directly or indirectly detecting a temperature of the control unit, wherein 35 40
 - an accumulation chamber pressure control method controls a pressure (PC) in the accumulation chamber by effecting an ineffective driving by which the control valve is driven to open for a short period (T_q) shorter than a delay period (t_m) in which the valve body opens to thereby spill a high pressure fuel in the accumulation chamber to the low pressure side when a pressure reducing condition for reducing a fuel pressure in the accumulation chamber is satisfied, the method comprising the steps of: 45 50
 - detecting directly or indirectly the temperature of the control unit; and 55
 - determining a cycle period of the ineffective driving by the pressure reducing means in response

to the detected temperature so that a thermal load applied to the control unit does not exceed a limit.

8. The control method of claim 7, further comprising the step of:
 - stopping, when the fuel pressure in the accumulation chamber is reduced and the ineffective driving of the control valve is stopped, the fuel injection of the injector which is to occur immediately thereafter.
9. The control method of claim 7 or 8, wherein the temperature of the control unit is indirectly detected from at least one of a coolant temperature and an intake temperature of the diesel engine.
10. The control method of any one of claims 7 to 9, wherein the injector is provided in a plurality of numbers in correspondence with the number of cylinders of the diesel engine, and the control valve of each cylinder is driven to open sequentially or simultaneously with at least one other.

Patentansprüche

1. Speicherkraftstoffeinspritzsystem, das eine Speicherkammer (3) zum Speichern von Hochdruckkraftstoff aufweist, der durch eine Kraftstoffpumpe (5, 11) zugeführt ist, einen Injektor (1) zum Einspritzen des Hochdruckkraftstoffs aus der Speicherkammer in einen Zylinder einer Dieselmotormaschine, ein Steuerventil (1a), welches den Kraftstoff, der aus der Speicherkammer dem Injektor zugeführt ist, zu einer Niederdruckseite (9) überströmen lässt, wenn zur Öffnung angesteuert, wobei der Injektor aufgebaut ist, den Ventilkörper zu öffnen, während das Steuerventil zum Öffnen angesteuert ist, eine Steuereinheit (7) zum Steuern eines Antriebs der Kraftstoffpumpe (5) und des Injektors (1) als Reaktion auf Betriebszustände der Dieselmotormaschine, um dadurch den Kraftstoff in die Dieselmotormaschine zuzuführen, und eine Temperaturerfassungsvorrichtung (71) zum direkten oder indirekten Erfassen einer Temperatur der Steuereinheit,
 - wobei die Steuereinheit aufweist:
 - eine Zustandsprüfvorrichtung (61, S204, S208), um als Reaktion auf die Betriebszustände der Dieselmotormaschine zu prüfen, ob eine Druckminderungsbedingung zum Verringern eines Kraftstoffdrucks in der Speicherkammer erfüllt ist,
 - eine Druckminderungsansteuerung (1a, 7), um eine Unwirksamkeitsansteuerung auszuführen, durch welche das Steuerventil angesteuert wird, um für eine kurze Periode (T_q) zu öffnen,

- die kürzer als eine Verzögerungsperiode (t_m) ist, in welcher der Ventilkörper öffnet, um dadurch einen Hochdruckkraftstoff in der Speicherkammer zu der Niederdruckseite überströmen zu lassen, und
- eine Druckminderung-Ausführvorrichtung (7), die eine Taktperiode ($T_q + T_{int}$) der Unwirksamkeitsansteuerung durch die Druckminderungs-
vorrichtung als Reaktion auf die Temperatur der
Steuereinheit bestimmt, welche durch die Tem-
peraturerfassungsvorrichtung erfaßt ist, wenn
die Zustandsprüfvorrichtung bestimmt, daß die
Druckminderungsbedingung erfüllt ist, daß eine
Wärmebelastung, die an der Steuereinheit
einwirkt, einen Grenzwert nicht übersteigt, und
die Druckminderungs-
vorrichtung mit der be-
stimmten Taktperiode ansteuert, um dadurch
den Kraftstoffdruck in der Speicherkammer zu
verringern.
2. Speicherkraftstoffeinspritzsystem gemäß An-
spruch 1, wobei die Steuereinheit eine Kraftstoffe-
inspritzanhaltevorrichtung aufweist, welche die
Kraftstoffeinspritzung der Kraftstoffeinspritzvorrich-
tung anhält, die unmittelbar danach eintritt, wenn
die Zustandsprüfvorrichtung bestimmt, daß der
Kraftstoffdruck in der Speicherkammer durch die
Unwirksamkeitsansteuerung verringert ist und die
Druckminderungsbedingung als nicht erfüllt be-
stimmt ist.
 3. Speicherkraftstoffeinspritzsystem gemäß An-
spruch 1 oder Anspruch 2, wobei die Temperatur-
erfassungsvorrichtung eine Temperatur einer An-
steuerschaltung (79) der Steuereinheit für den In-
jektor indirekt aus mindestens einer der Tempera-
turen, eine Kühlmitteltemperatur und eine Ansaug-
temperatur, der Dieselmotormaschine erfaßt.
 4. Speicherkraftstoffeinspritzsystem gemäß einem
der Ansprüche 1 bis 3, wobei die Druckminderung-
Ausführvorrichtung eine Ventilöffnung-Ansteuerpe-
riode (T_q) des Steuerventils für die Unwirksam-
keitsansteuerung als Reaktion auf den Kraftstoff-
druck in der Speicherkammer bestimmt.
 5. Speicherkraftstoffeinspritzsystem gemäß einem
der Ansprüche 1 bis 4, wobei die Dieselmotormaschi-
ne eine Vielzahl von Zylindern und eine Vielzahl von
Injektoren entsprechend der Anzahl der Zylinder
aufweist und das Steuerventil jedes Zylinders an-
gesteuert wird, aufeinanderfolgend oder gleichzei-
tig mit mindestens einem anderen Steuerventil zu
öffnen.
 6. Speicherkraftstoffeinspritzsystem gemäß einem
der Ansprüche 1 bis 5, wobei das Steuerventil ein
Elektromagnetventil ist, der Injektor eine Einspritz-
- einheit mit einem Ventilkörper (37) aufweist, wel-
ches als Reaktion auf den Druck des aus der Spei-
cherkammer durch einen ersten Fluidkanal (45) zu-
geführten Kraftstoffs öffnet und den Kraftstoff in ei-
nen Zylinder der Dieselmotormaschine einspritzt,
und eine Ansteuereinheit, welche den Ventilkörper
als Reaktion auf einen Druck des aus der Speicher-
kammer durch einen zweiten Fluidkanal (41) zuge-
führten Kraftstoffs schließt.
7. Steuerverfahren für ein Speicherkraftstoffeinspritz-
system, welches eine Speicherkammer (3) zum
Speichern eines Hochdruckkraftstoffs aufweist, der
von einer Kraftstoffpumpe (5, 11) zugeführt ist, ei-
nen Injektor (1) zum Einspritzen des Hochdruck-
kraftstoffs aus der Speicherkammer in einen Zylin-
der einer Dieselmotormaschine, eine Steuereinheit
(7) zum Steuern eines Antriebs der Kraftstoffpumpe
und des Injektors als Reaktion auf Betriebszustän-
de der Dieselmotormaschine, um dadurch den Kraft-
stoff in die Dieselmotormaschine zuzuführen, und ei-
ne Temperaturerfassungsvorrichtung (71) zum di-
rekten oder indirekten Erfassen einer Temperatur
der Steuereinheit, wobei
ein Speicherkammer-Druckregelverfahren,
das einen Druck (PC) in der Speicherkammer durch
Ausführen einer Unwirksamkeitsansteuerung re-
gelt, wodurch das Steuerventil angesteuert wird, für
eine kurze Periode (T_q) zu öffnen, die kürzer als ei-
ne Verzögerungsperiode (t_m) ist, in welcher der
Ventilkörper öffnet, um dadurch einen Hochdruck-
kraftstoff in der Speicherkammer zu der Nieder-
druckseite überströmen zu lassen, wenn eine
Druckminderungsbedingung zum Verringern eines
Kraftstoffdrucks in der Speicherkammer erfüllt ist,
wobei das Verfahren die Schritte aufweist:
 - direktes oder indirektes Erfassen der Tempera-
tur der Steuereinheit, und
 - Bestimmen einer Taktperiode der Unwirksam-
keitsansteuerung durch die Druckminderungs-
vorrichtung als Reaktion auf die erfaßte Tem-
peratur auf eine Weise, daß eine auf die Steu-
ereinheit einwirkende Wärmebelastung einen
Grenzwert nicht übersteigt.
 8. Steuerverfahren gemäß Anspruch 7, das ferner den
Schritt aufweist:

Anhalten der Kraftstoffeinspritzung des Injek-
tors, wenn der Kraftstoffdruck in der Speicher-
kammer verringert ist und die Unwirksamkeits-
ansteuerung des Steuerventils angehalten ist,
unmittelbar darauffolgend.
 9. Steuerverfahren gemäß Anspruch 7 oder Anspruch
8, wobei die Temperatur der Steuereinheit aus min-
destens einer der Temperaturen, eine Kühlmittel-

température et une Ansaugtemperatur, der Dieselmotorkraftmaschine indirekt erfaßt wird.

10. Steuerverfahren gemäß einem der Ansprüche 7 bis 9, wobei der Injektor in einer Vielzahl entsprechend der Anzahl der Zylinder der Dieselmotorkraftmaschine angeordnet ist und das Steuerventil jedes Zylinders angesteuert wird, aufeinanderfolgend oder gleichzeitig mit mindestens einem anderen Steuerventil zu öffnen.

Revendications

1. Système d'injection de carburant du type à accumulation comprenant une chambre d'accumulation (3) pour accumuler du carburant haute pression alimenté depuis une pompe d'alimentation de carburant (5,11), un injecteur (1) pour injecter le carburant haute pression de la chambre d'accumulation à un cylindre d'un moteur diesel, une soupape de régulation (1a) qui amène le combustible délivré de la chambre d'accumulation à l'injecteur à un côté basse pression (9) lorsqu'elle est entraînée en position ouverte, l'injecteur étant conçu pour ouvrir le corps de soupape lorsque la soupape de régulation est entraînée en position ouverte, une unité de commande (7) destinée à commander un entraînement de la pompe d'alimentation en carburant (5) et l'injecteur (1) en réponse aux conditions de fonctionnement du moteur diesel pour délivrer ainsi le carburant dans le moteur diesel et un moyen de détection de la température (71) pour détecter directement ou indirectement une température de l'unité de commande, dans lequel l'unité de commande inclut :

un moyen de vérification de la condition (61, S204, S208) vérifiant, en réponse aux conditions de fonctionnement du moteur diesel, si une condition de réduction de pression pour réduire une pression de carburant dans la chambre d'accumulation est remplie ;

un moyen de réduction de la pression (1a, 7) effectuant un entraînement infructueux par lequel la soupape de régulation est entraînée en position ouverte pendant une courte période (Tq) plus courte qu'une période d'attente, au cours de laquelle le corps de soupape s'ouvre pour amener ainsi

un carburant haute pression dans la chambre d'accumulation au côté basse pression ; et

un moyen pour effectuer la réduction de pression (7) déterminant une durée de cycle de charge (Tq + Tint) de l'entraînement infruc-

teux par le moyen de réduction de pression, en réponse à la température d'une unité de commande détectée par le moyen de détection de température lorsque le moyen de vérification de la condition détermine que la condition de réduction de pression est remplie, si bien qu'une charge thermique appliquée à l'unité de commande ne dépasse pas une limite et entraînant le moyen de réduction de pression à la durée de cycle de charge déterminée pour réduire ainsi la pression de carburant dans la chambre d'accumulation.

2. Système d'injection de carburant du type à accumulation selon la revendication 1, dans lequel l'unité de commande inclut un moyen d'arrêt de l'injection de carburant arrêtant, lorsque le moyen de vérification de condition détermine que la pression de carburant dans la chambre d'accumulation est réduite par l'entraînement infructueux et que la condition de réduction de pression est déterminée comme non remplie, l'injection de carburant du moyen d'injection de carburant devant intervenir immédiatement après.
3. Système d'injection de carburant de type à accumulation selon la revendication 1 ou 2, dans lequel le moyen de détection de température détecte indirectement une température d'un circuit d'entraînement (79) de l'unité de commande pour l'injecteur à partir d'au moins une température de réfrigérant et une température d'admission du moteur diesel.
4. Système d'injection de carburant de type à accumulation selon l'une quelconque des revendications 1 à 3, dans lequel le moyen pour effectuer la réduction de pression détermine une durée d'opération d'entraînement de la soupape en position ouverte (Tq) de la soupape de régulation pour l'entraînement infructueux, en réponse à la pression de carburant dans la chambre d'accumulation.
5. Système d'injection de carburant de type à accumulation selon l'une quelconque des revendications 1 à 4, dans lequel le moteur diesel présente le cylindre dans une pluralité de numéros et l'injecteur dans une pluralité de numéros en correspondance avec le nombre de cylindres et une soupape de régulation de chaque cylindre est entraînée pour s'ouvrir séquentiellement ou simultanément avec au moins une autre.
6. Système d'injection de carburant de type à accumulation selon l'une quelconque des revendications 1 à 5, dans lequel la soupape de régulation est de type électromagnétique, l'injecteur inclut une unité d'injection présentant un corps de soupape (37) qui s'ouvre en réponse à la pression du carbu-

rant délivré depuis la chambre d'accumulation par un premier passage de fluide (45) et injecte le carburant dans un cylindre du moteur diesel, et une unité d'entraînement qui ferme le corps de soupape en réponse à une pression du carburant délivré à partir de la chambre d'accumulation par un second passage de fluide (41).

7. Procédé de commande pour un système d'injection de carburant de type à accumulation comprenant une chambre d'accumulation (3) pour accumuler un carburant haute pression amené par une pompe d'alimentation en carburant (5,11), un injecteur (1) pour injecter le carburant haute pression à partir de la chambre d'accumulation dans un cylindre du moteur diesel, une unité de commande (7) pour commander un entraînement de la pompe d'alimentation en carburant et l'injecteur en réponse aux conditions de fonctionnement du moteur diesel pour délivrer ainsi le carburant dans le moteur diesel et un moyen de détection de température (71) pour détecter directement ou indirectement une température de l'unité de commande, dans lequel un procédé de commande de pression de la chambre d'accumulation commande une pression (PC) dans la chambre d'accumulation en effectuant un entraînement infructueux par lequel la soupape de régulation est entraînée en position ouverte pendant une courte période (Tq) plus courte qu'une période d'attente (tm) dans laquelle un corps de soupape s'ouvre pour amener ainsi un carburant haute pression dans la chambre d'accumulation au côté basse pression lorsqu'une condition de réduction de pression pour réduire une pression de carburant dans la chambre d'accumulation est remplie, ledit procédé comprenant les étapes consistant à :

détecter directement ou indirectement la température de l'unité de commande ; et

déterminer une durée de cycle de charge de l'entraînement infructueux par le moyen de réduction de pression en réponse à la température détectée, de manière à ce qu'une charge thermique appliquée à l'unité de commande ne dépasse pas une limite.

8. Procédé de commande selon la revendication 7, comprenant, en outre, l'étape consistant à :

arrêter, lorsque la pression de carburant dans la chambre d'accumulation est réduite et que l'entraînement infructueux de la soupape de régulation est arrêté, l'injection de carburant de l'injecteur devant intervenir immédiatement après.

9. Procédé de commande selon la revendication 7 ou

8, dans lequel la température de l'unité de commande est indirectement détectée à partir d'au moins une température de réfrigérant et une température d'admission du moteur diesel.

10. Procédé de commande selon l'une quelconque des revendications 7 à 9, dans lequel l'injecteur est délivré dans une pluralité de numéros en correspondance avec le nombre de cylindres du moteur diesel, et la soupape de régulation de chaque cylindre est entraînée pour s'ouvrir séquentiellement ou simultanément avec au moins une autre.

FIG. 1

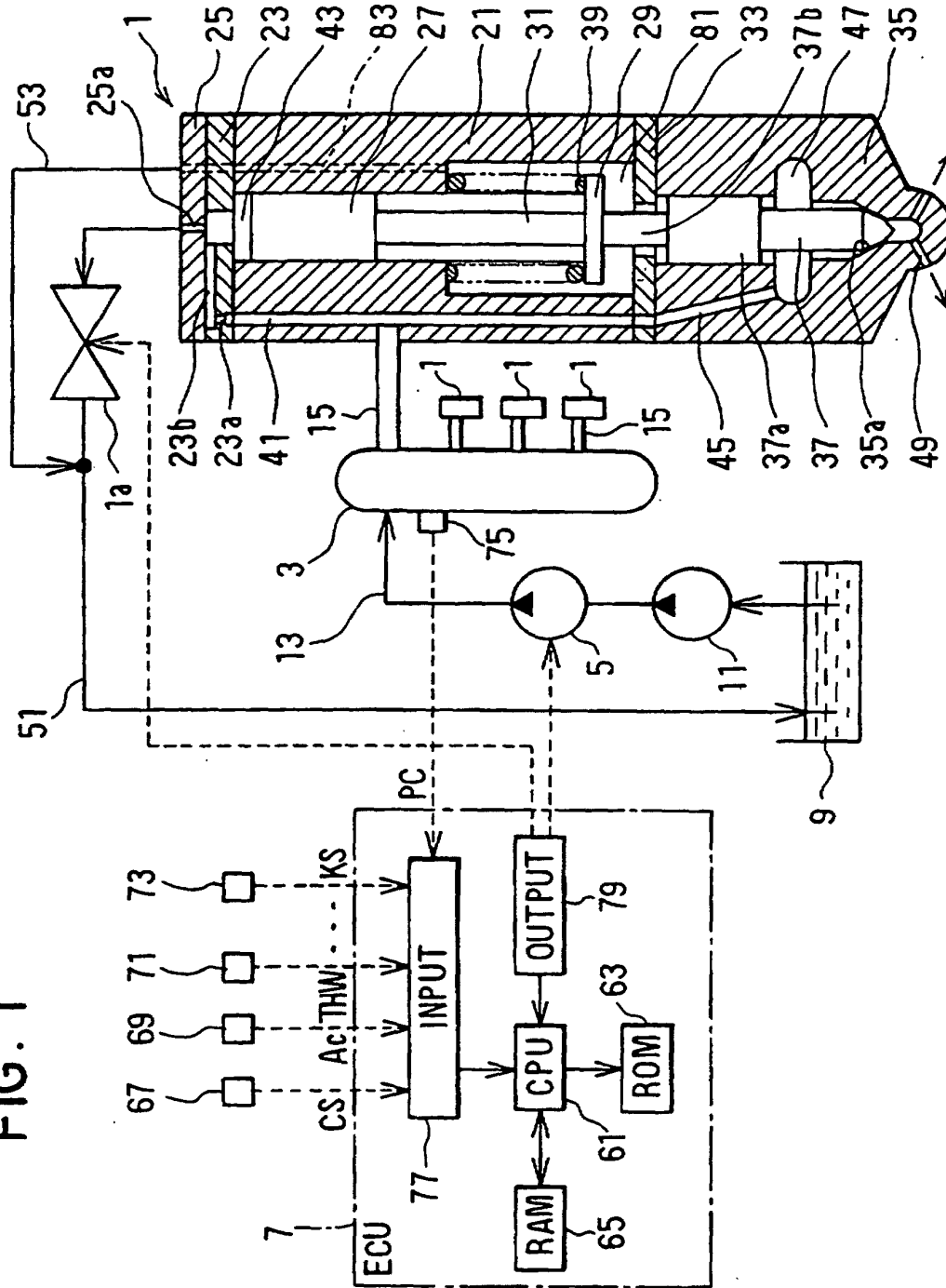


FIG. 2

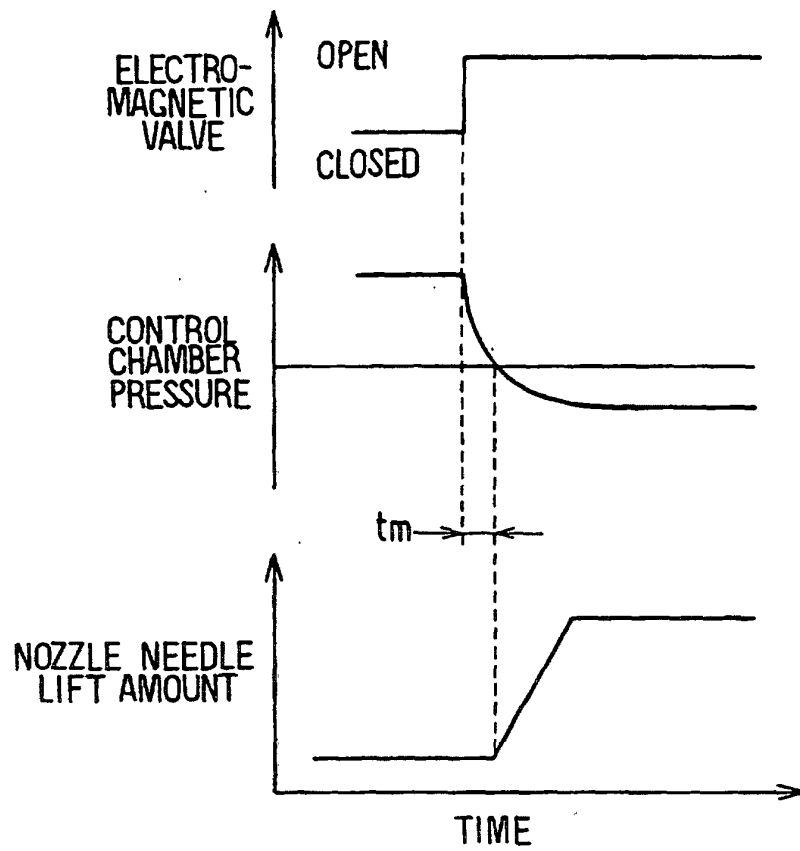


FIG. 3

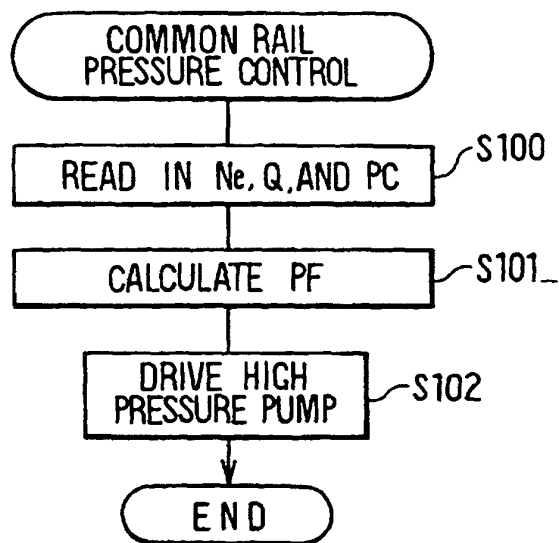


FIG. 4

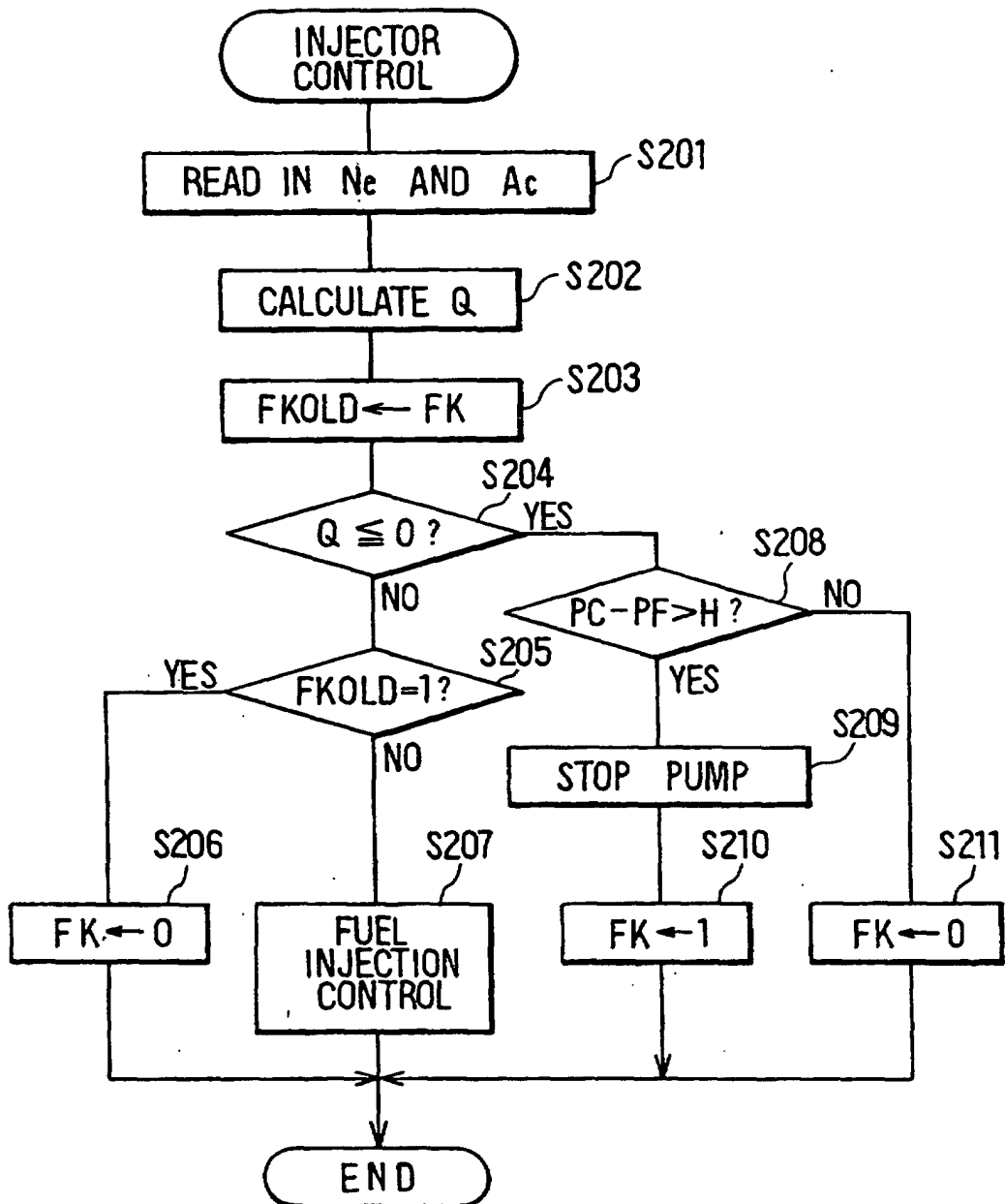


FIG. 5

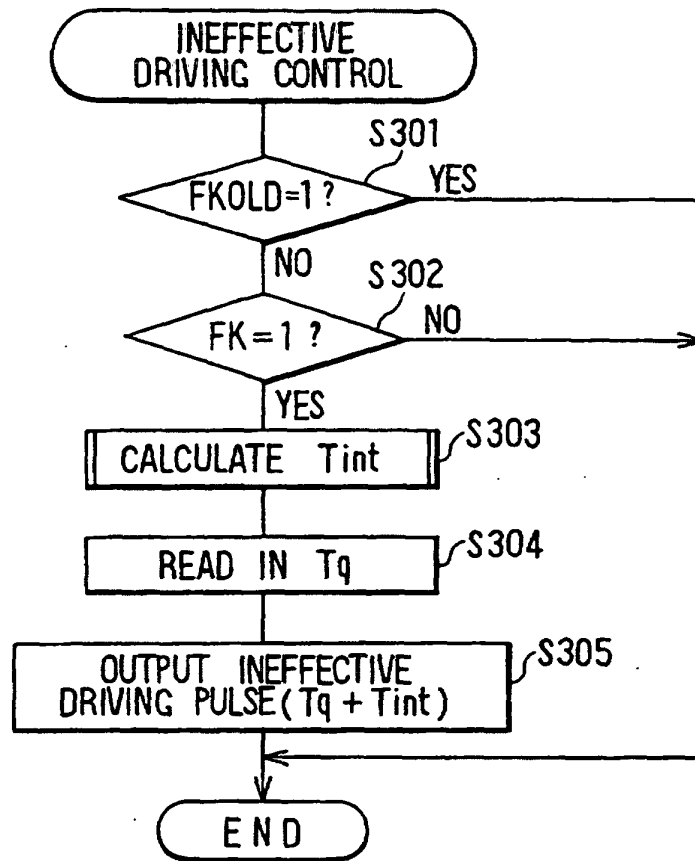


FIG. 6

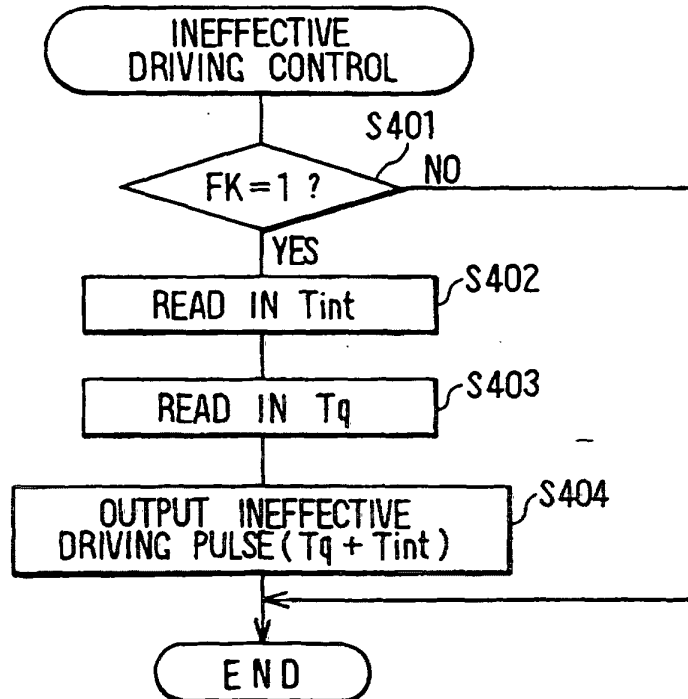


FIG. 7

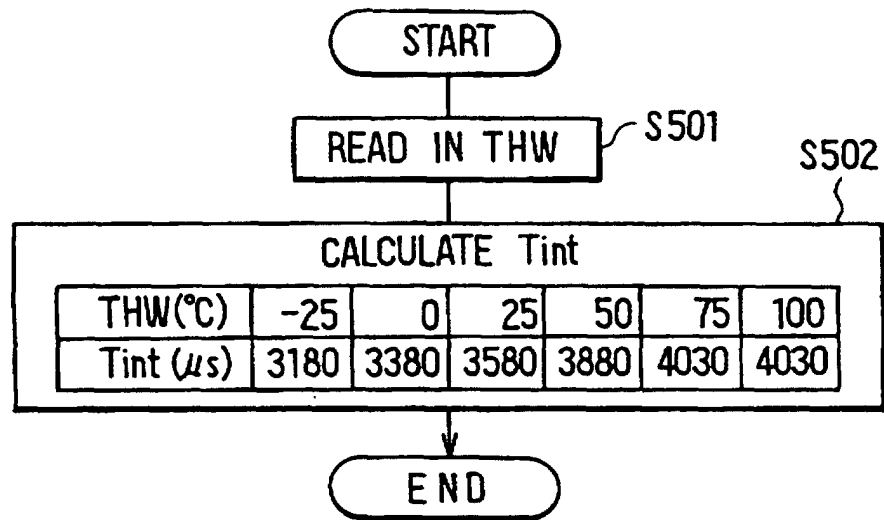


FIG. 8

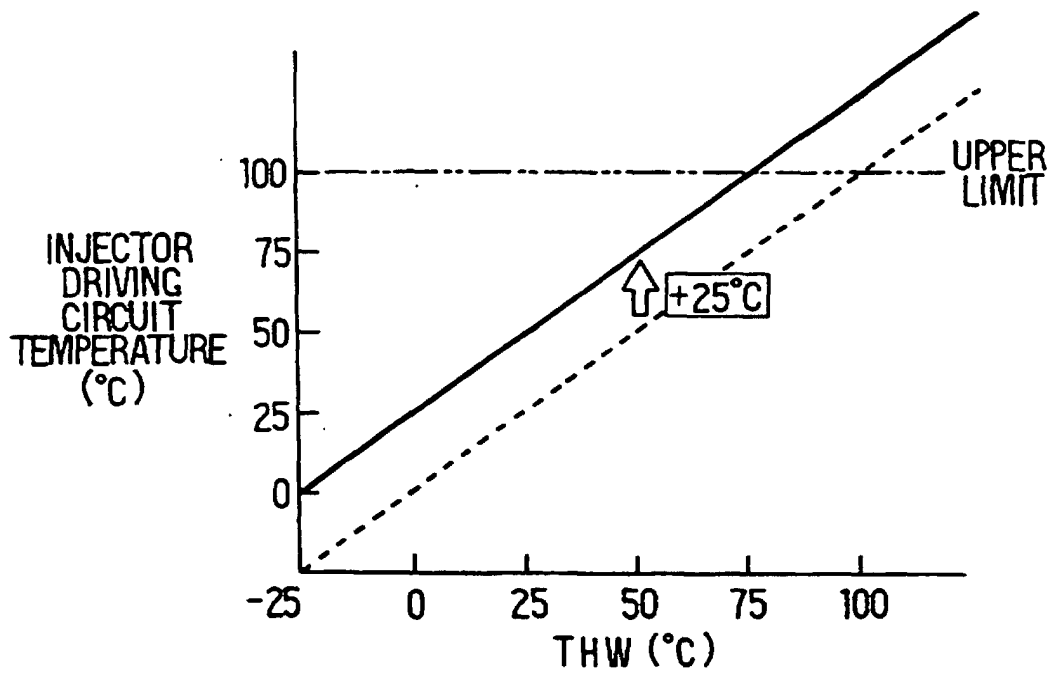
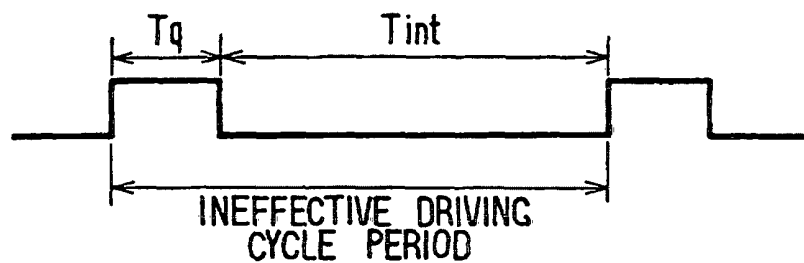


FIG. 9

(a)



(b)

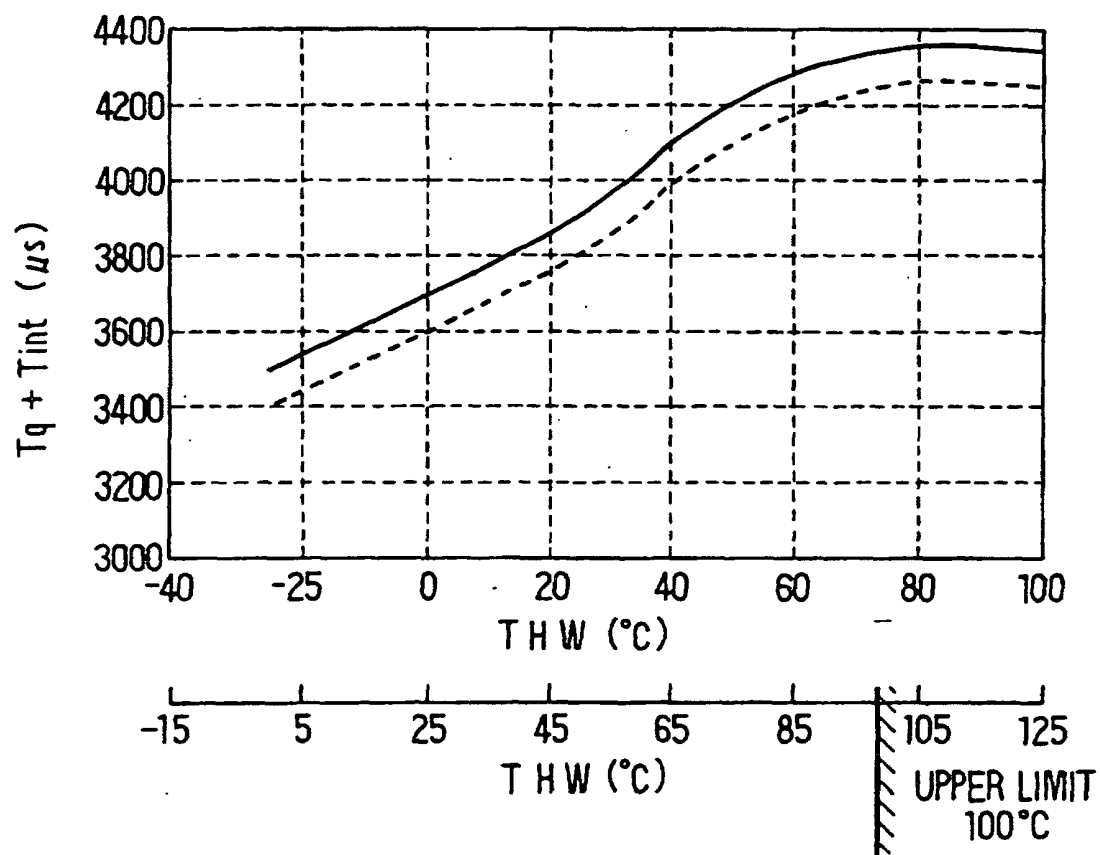


FIG. 10

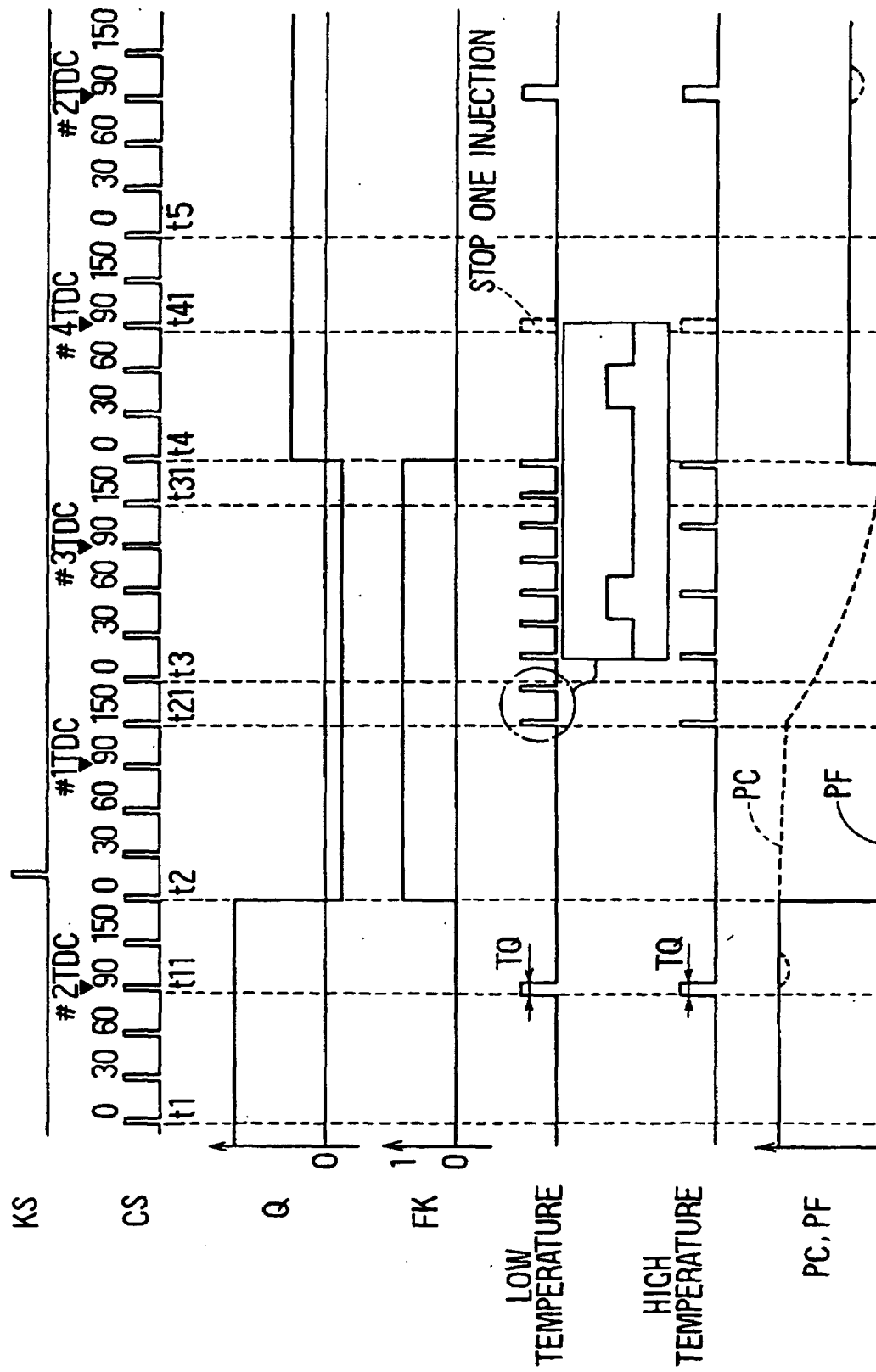


FIG. 11

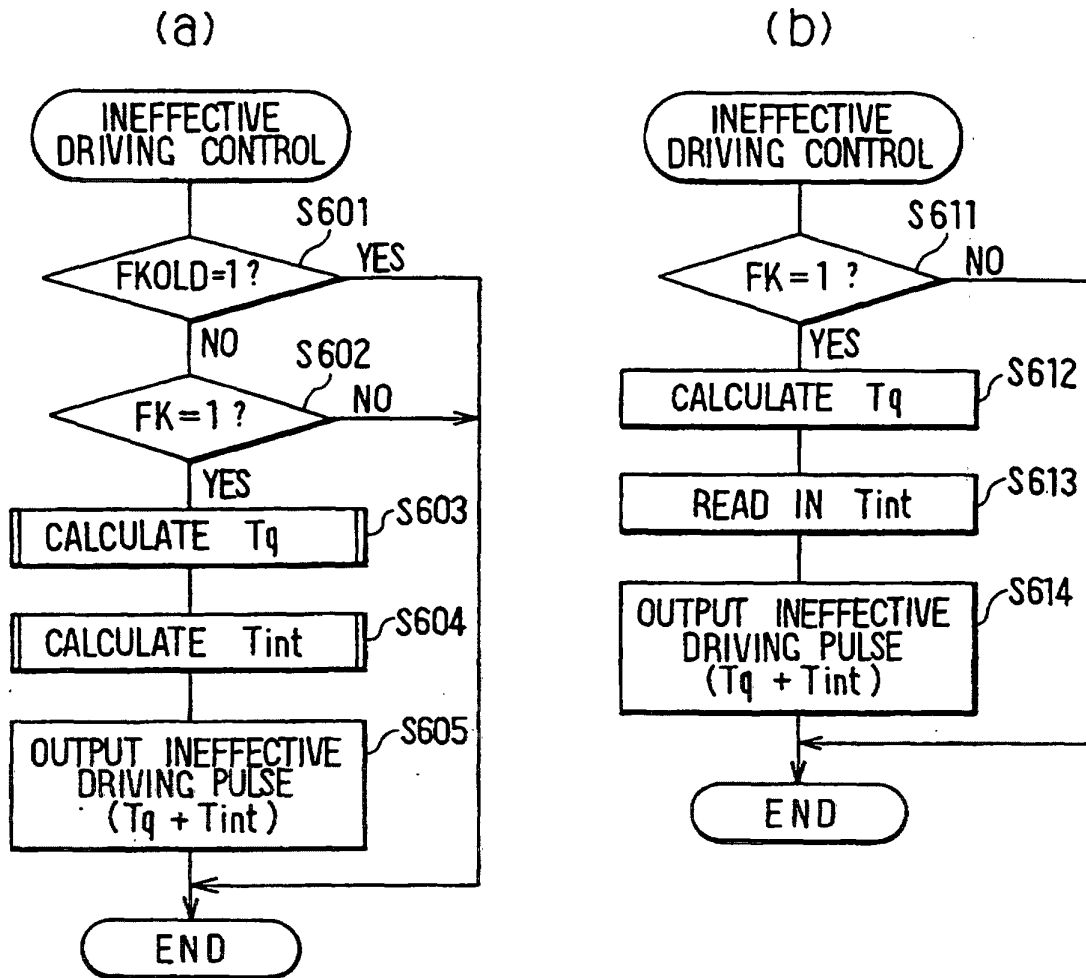


FIG. 12

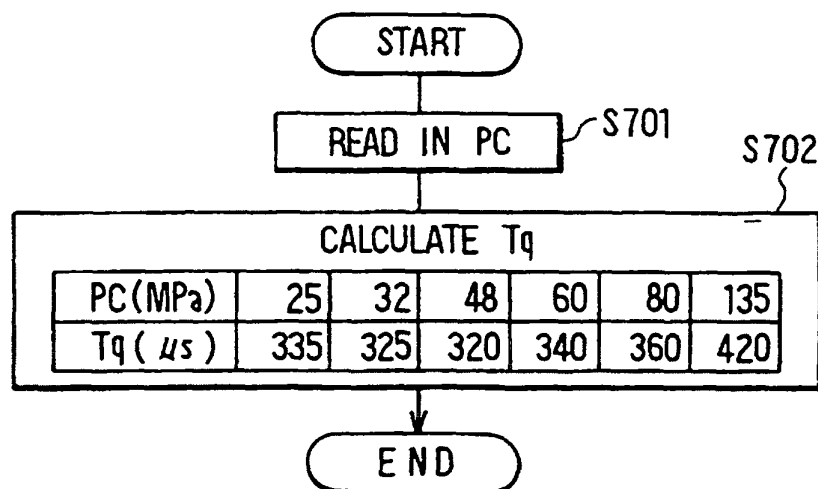


FIG. 13

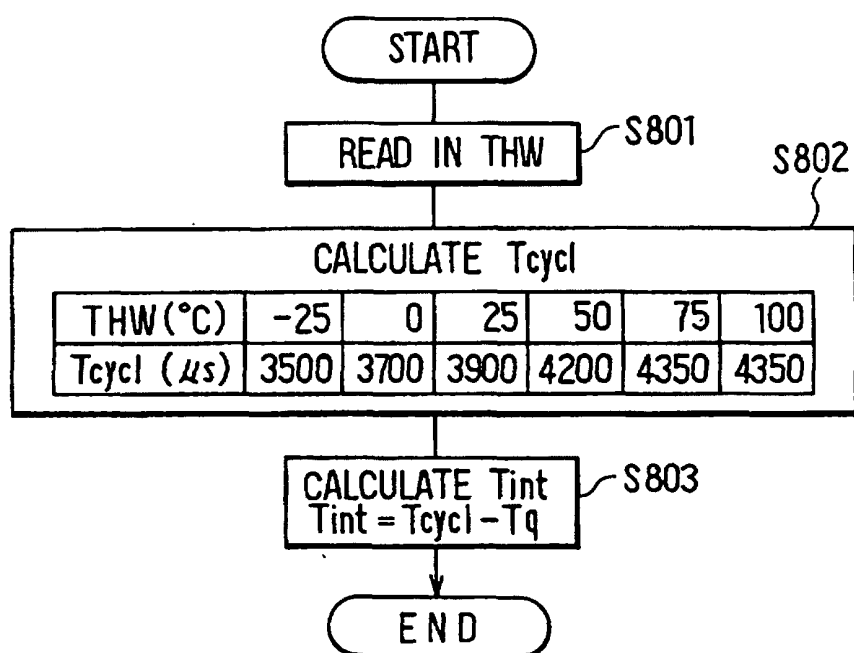


FIG. 14

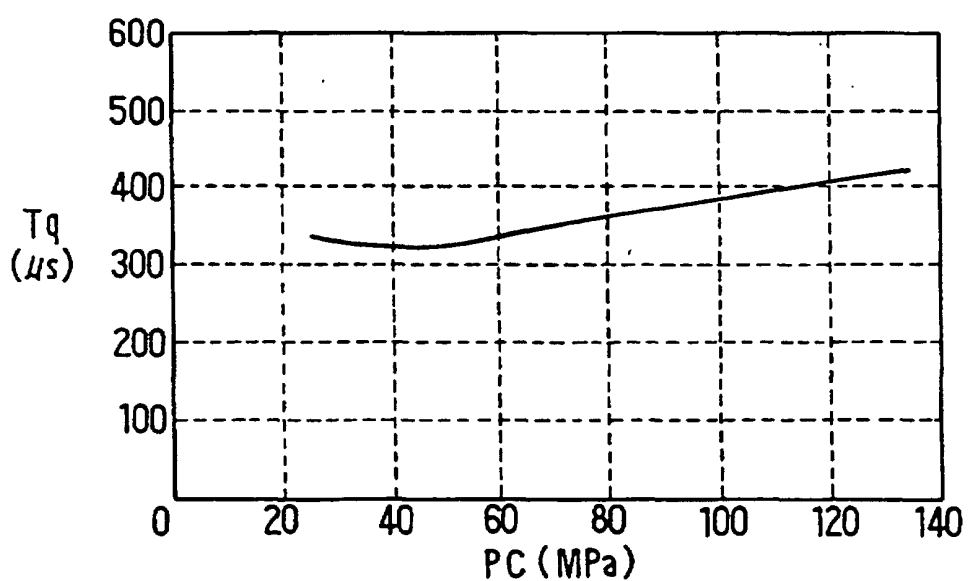


FIG. 15

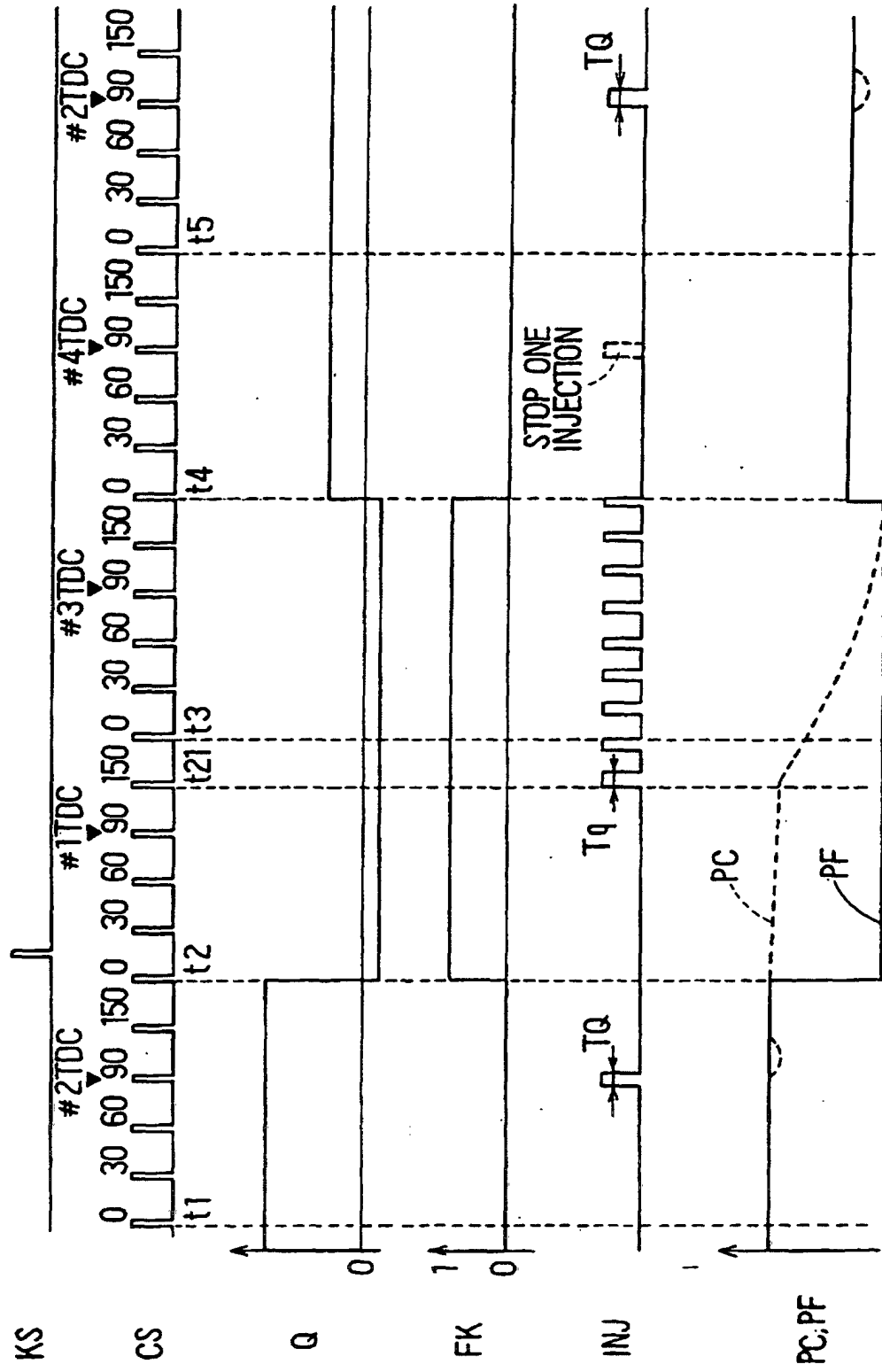


FIG. 16

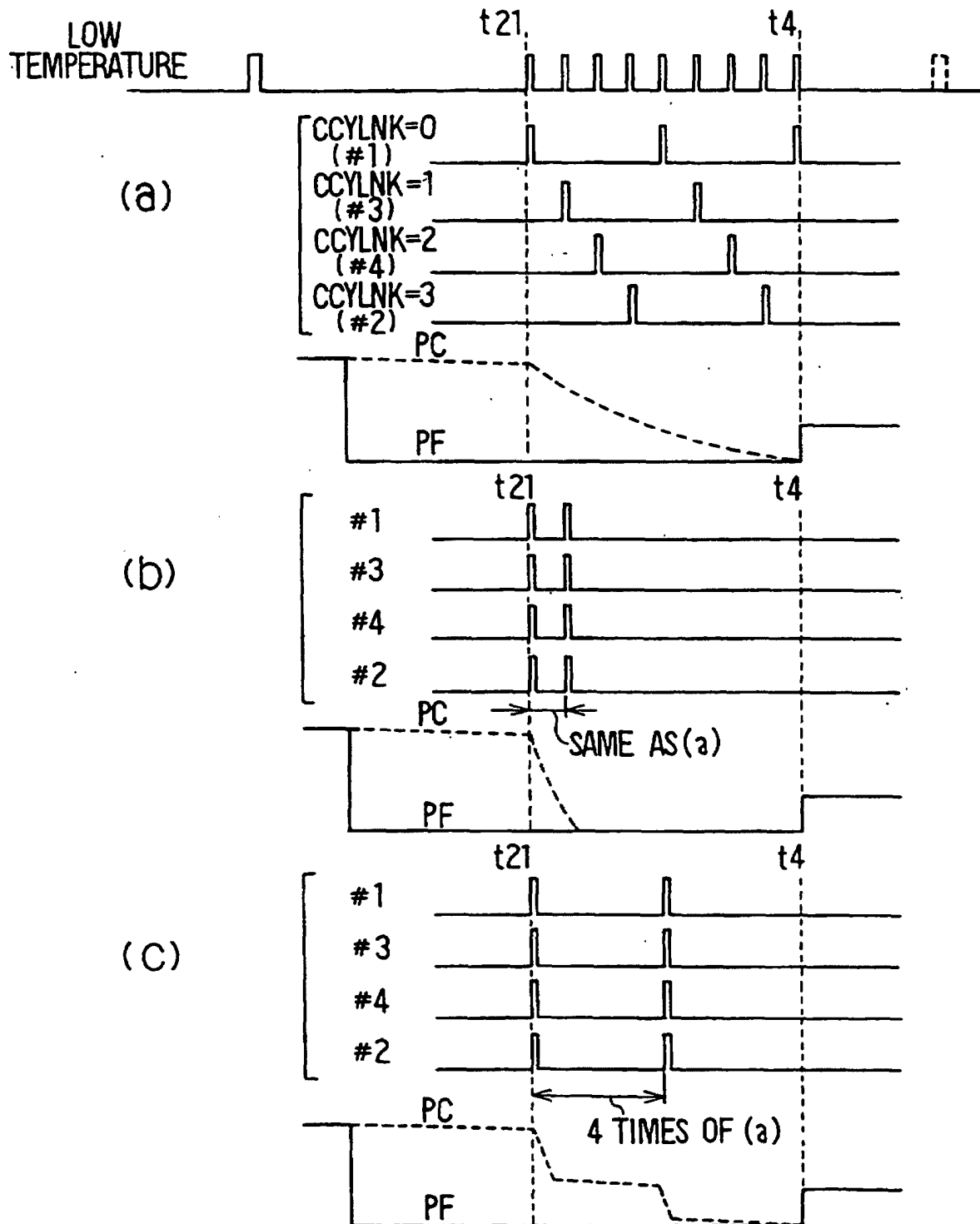
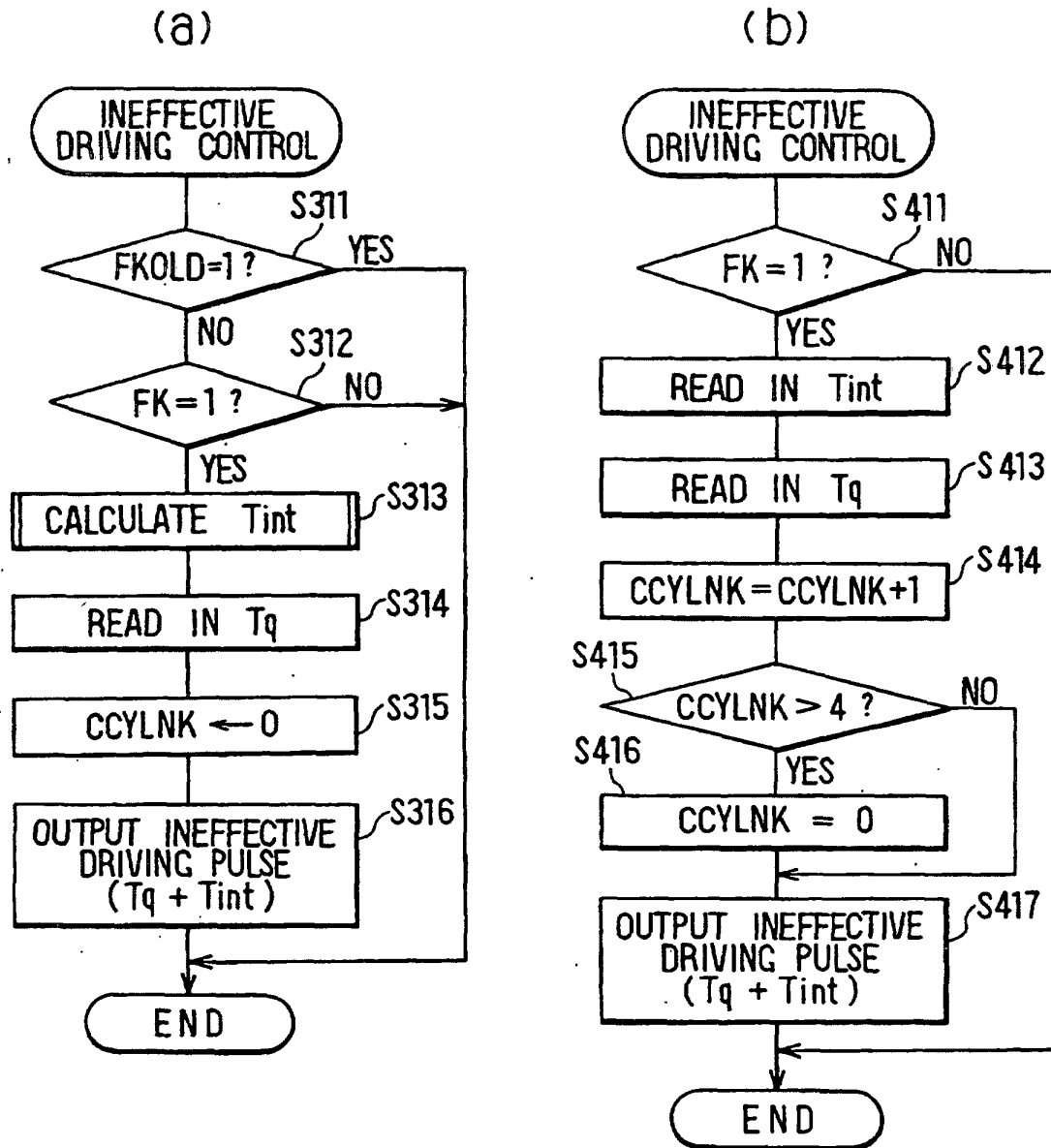


FIG. 17



(C)

CCYLNK	0	1	2	3
CYLINDER	#1	#3	#4	#2

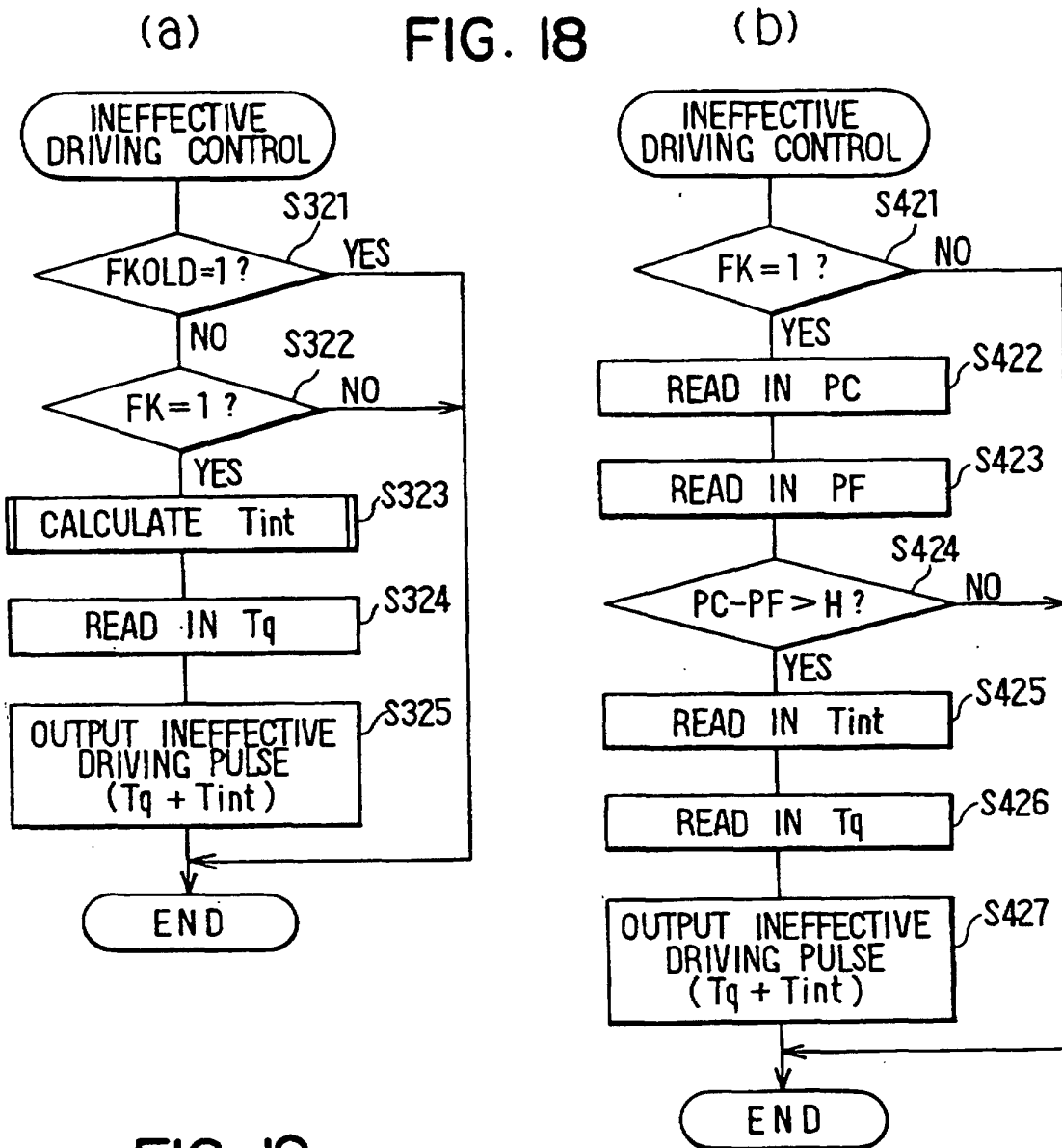
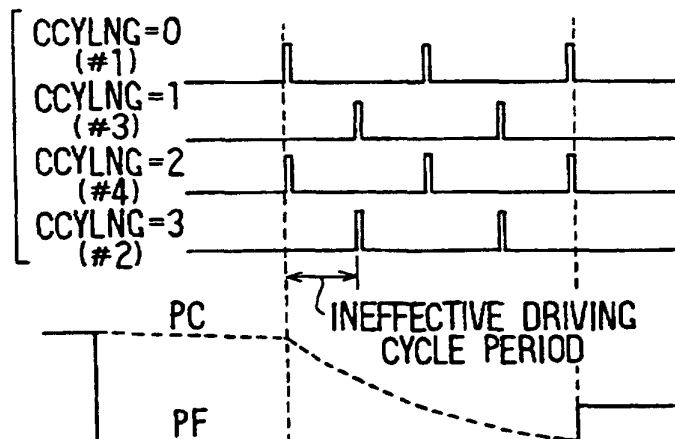
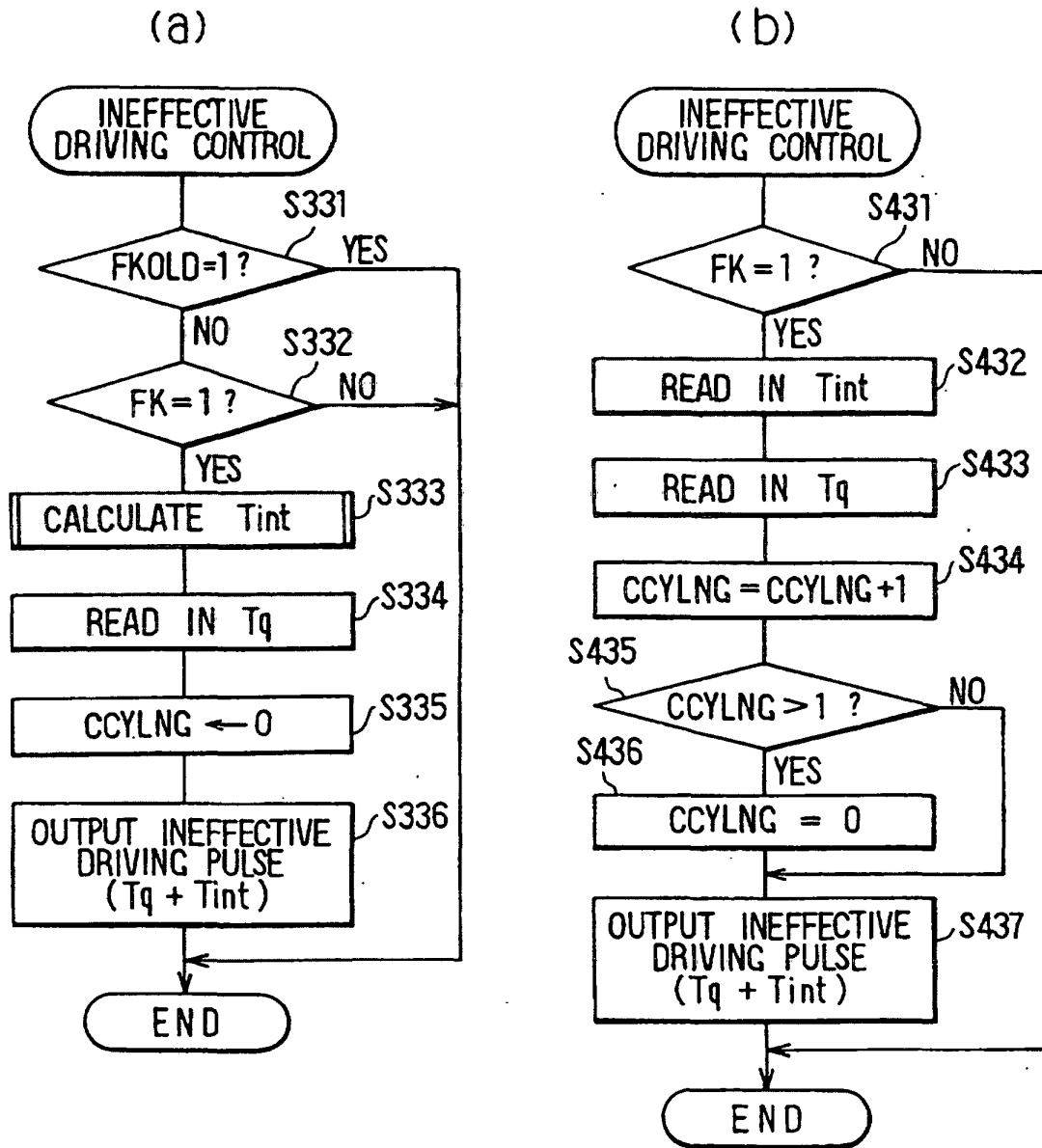
**FIG. 19**

FIG. 20



(C)

CCYLNG	0	1	0	1
CYLINDER	#1	#3	#4	#2