



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
19.12.2012 Bulletin 2012/51

(51) Int Cl.:
F02N 11/08 ^(2006.01) **F02P 19/02** ^(2006.01)
F02D 41/06 ^(2006.01)

(21) Application number: **12172005.6**

(22) Date of filing: **14.06.2012**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(71) Applicant: **Toyota Jidosha Kabushiki Kaisha**
Toyota-shi, Aichi 471-8571 (JP)

(72) Inventor: **Terada, Yasuyuki**
Toyota-shi, Aichi 471-8571 (JP)

(74) Representative: **Albutt, Anthony John**
D Young & Co LLP
120 Holborn
London EC1N 2DY (GB)

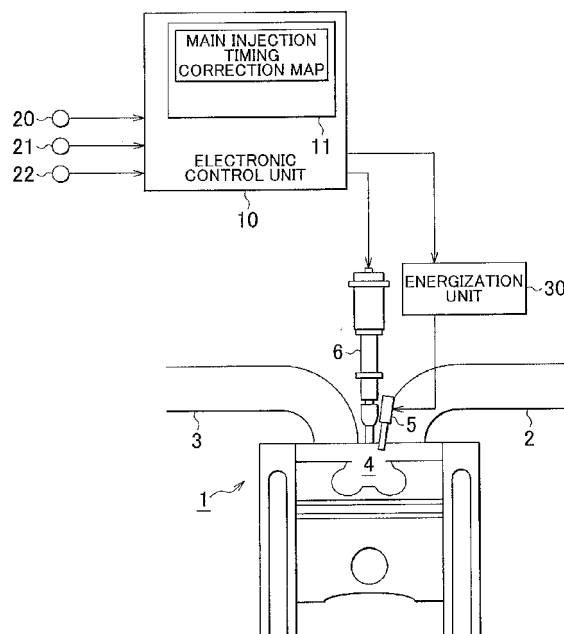
(30) Priority: **14.06.2011 JP 2011132160**

(54) **Starting Control System for Diesel Engine**

(57) In a starting control system for a diesel engine, which performs control of a starting parameter that changes a starting timing of an engine (1), while energizing a glow plug (5) during a period from switching of an engine switch (22) to "Ignition On" to switching to "Starter On", a required glow waiting time as an energization time of the glow plug (5) required for the tem-

perature of the glow plug (5) to increase to a level suitable for starting of the engine (1) is compared with an actual glow waiting time as an actual energization time of the glow plug (5) from switching of the engine switch (22) to "Ignition On" to switching to "Starter On", and the starting parameter is controlled according to a result of the comparison.

FIG. 1



Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The invention relates to a starting control system for a diesel engine including a glow plug.

2. Description of Related Art

[0002] Generally, a diesel engine includes a glow plug that is energized and heated so as to promote ignition and combustion of fuel, and cranking needs to be started upon starting of the engine after the glow plug is sufficiently heated. Namely, when the engine is started, energization of the glow plug is normally started upon switching of an engine switch to ON (Ignition-On), and a glow lamp provided in a driver's cabin or compartment is turned on so as to inform the driver of a period of time (glow waiting time) required for the glow plug to be heated to a given temperature. It has been proposed to start energization of the glow plug earlier than turn-on of the glow lamp, so as to shorten the glow waiting time physically sensed by the driver (see, for example, Japanese Patent Application Publication No. 61-275586 (JP 61-275586 A)).

[0003] In diesel engines of the related art, including the engine as described in JP 61-275586 A, starting control is performed on the assumption that the driver adequately waits for completion of heating of the glow plug, namely, that the engine switch is switched to "START" (Starter-On) after the glow lamp goes out, and then cranking is started. However, some drivers do not wait until the glow lamp goes out, and switch the engine switch to "Starter-On" before the glow lamp goes out. In this case, the glow waiting time is insufficient or short, and fuel injection is initiated in a condition where the glow plug is not sufficiently heated; as a result, unburned gas, which turns into white gas, or the like, may be discharged from the engine, resulting in deterioration of emissions, as well as deterioration of starting performance of the engine.

SUMMARY OF THE INVENTION

[0004] The present invention provides a starting control system for a diesel engine, which makes it possible to achieve appropriate combustion of fuel even when the glow waiting time is insufficient.

[0005] A starting control system for a diesel engine according to one aspect of the invention performs control of a starting parameter that changes a starting timing of the engine, while energizing a glow plug during a period from switching of an engine switch to an ignition-on position to switching of the engine switch to a starter-on position. In the starting control system, a required glow waiting time as an energization time of the glow plug required for the temperature of the glow plug to increase

to a temperature level suitable for starting of the engine is compared with an actual glow waiting time as an actual energization time for which the glow plug is actually energized from switching of the engine switch to the ignition-on position to switching of the engine switch to the starter-on position, and the starting parameter is controlled according to a result of the comparison.

[0006] With the starting control system configured as described above, the actual glow waiting time is measured and compared with the required glow waiting time, and the starting parameter is controlled according to the result of the comparison, so that the engine may be appropriately started in accordance with the driver's operating condition. Namely, the starting parameter is controlled so that the diesel engine may be smoothly started when the glow waiting time is sufficiently long, and so that appropriate combustion of the fuel takes place even when the glow waiting time is insufficient or short and the temperature of the glow plug is low. Accordingly, even when the glow waiting time is insufficient, appropriate combustion of the fuel may be accomplished.

[0007] In the starting control system for the diesel engine according to the above aspect of the invention, the starting parameter may be controlled by switching a starting constant of the starting parameter, between a normal starting constant and an insufficient glow waiting starting constant, according to the result of the comparison between the required glow waiting time and the actual glow waiting time.

[0008] With the above arrangement, the starting parameter may be controlled in a simple manner, i.e., by switching between two kinds of constants.

[0009] In the starting control system for the diesel engine as described above, the starting constant of the starting parameter may be switched from the insufficient glow waiting starting constant to the normal starting constant, when a difference obtained by subtracting the actual glow waiting time from the required glow waiting time is smaller than a predetermined value.

[0010] With the starting control system configured such that the insufficient glow waiting starting constant is set as the default of the starting parameter, the starting constant is prevented from being switched or changed when the starter is actuated while the engine is being started. In this case, the predetermined value may be set to "0" or a value close to "0".

[0011] In the starting control system for the diesel engine as described above, the predetermined value may be 500 milliseconds.

[0012] When the predetermined value is equal to 500 milliseconds (a value close to "0"), it is presumed that the glow waiting time is sufficiently long, and the engine is started with the starting parameter switched to the normal starting constant. Accordingly, starting control may be more appropriately performed, assuring improved starting performance.

[0013] In the starting control system for the diesel engine according to the above aspect of the invention, the

starting parameter may be controlled by correcting the starting parameter according to a time difference between the actual glow waiting time and the required glow waiting time when the actual glow waiting time is shorter than the required glow waiting time.

[0014] With the above arrangement, the starting parameter may be appropriately adjusted in accordance with the degree of shortness of the glow waiting time.

[0015] In the starting control system for the diesel engine as described above, the starting parameter may be corrected so as to slow down starting of the engine as the time difference is larger.

[0016] With the above arrangement, the starting parameter may be controlled so that more appropriate combustion of the fuel takes place in the engine.

[0017] In the starting control system for the diesel engine according to the above aspect of the invention, the starting parameter subjected to the control may be at least one of the main injection timing during starting of the engine, a common rail pressure during starting of the engine, a pilot injection amount of a fuel, the pilot injection timing of the fuel, and a target glow temperature.

[0018] In the starting control system for the diesel engine as described above, the starting parameter may be the main injection timing during starting of the engine, and a correction value for the starting parameter may be set so that the greater a time difference between the actual glow waiting time and the required glow waiting time when the actual glow waiting time is shorter than the required glow waiting time is, the more the main injection timing during starting of the engine is advanced.

[0019] In the starting control system for the diesel engine as described above, the starting parameter may be the common rail pressure during starting of the engine, and a correction value for the starting parameter may be set so that the greater a time difference between the actual glow waiting time and the required glow waiting time when the actual glow waiting time is shorter than the required glow waiting time is, the more the common rail pressure during starting of the engine is reduced..

[0020] In the starting control system for the diesel engine as described above, the starting parameter may be the pilot injection amount of the fuel, and a correction value for the starting parameter may be set so that the greater a time difference between the actual glow waiting time and the required glow waiting time when the actual glow waiting time is shorter than the required glow waiting time is, the more the pilot injection amount of the fuel is increased.

[0021] In the starting control system for the diesel engine as described above, the starting parameter may be the pilot injection timing of the fuel, and a correction value for the starting parameter may be set so that the greater a time difference between the actual glow waiting time and the required glow waiting time when the actual glow waiting time is shorter than the required glow waiting time is, the more the pilot injection timing is advanced.

[0022] In the starting control system for the diesel en-

gine as described above, the starting parameter may be the target glow temperature, and a correction value for the starting parameter may be set so that the greater a time difference between the actual glow waiting time and the required glow waiting time when the actual glow waiting time is shorter than the required glow waiting time is, the more the target glow temperature is higher..

[0023] With the above arrangement, when the glow waiting time is insufficient, the starting control may be performed by adequately changing starting timing of the engine so that appropriate combustion takes place in the engine.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] Features, advantages, and technical and industrial significance of exemplary embodiments of the invention will be described below with reference to the accompanying drawings, in which like numerals denote like elements, and wherein:

FIG. 1 is a block diagram schematically showing the construction of a diesel engine to be controlled by a starting control system for a diesel engine according to a first embodiment of the invention, along with the control system;

FIG. 2 is a flowchart illustrating a control routine of starting control executed by the starting control system of the first embodiment;

FIG. 3 is a view showing an example of main injection timing correction map used by the starting control system of the first embodiment;

FIG. 4 is a block diagram schematically showing the construction of a diesel engine to be controlled by a starting control system for a diesel engine according to a second embodiment of the invention, along with the control system;

FIG. 5 is a flowchart illustrating a control routine of starting control executed by the starting control system of the second embodiment; and

FIG. 6A through FIG. 6I show a timing chart illustrating one example of starting control performed by the starting control system of the second embodiment.

DETAILED DESCRIPTION OF EMBODIMENTS

[0025] A starting control system for a diesel engine according to a first embodiment of the invention will be described with reference to FIG. 1 through FIG. 3. Referring first to FIG. 1, the diesel engine as an object controlled by the starting control system according to this embodiment, and its surrounding equipment, will be described.

[0026] As shown in FIG. 1, the diesel engine 1 has a combustion chamber 4 connected to an intake passage 2 and an exhaust passage 3, and a glow plug 5 and an injector 6 are mounted in the diesel engine 1 so as to be exposed to the combustion chamber 4.

[0027] An electronic control unit 10 that performs var-

ious kinds of control on the diesel engine 1 is installed on the vehicle. To the electronic control unit 10 are connected a water temperature sensor 20 that senses the engine coolant temperature, a crank angle sensor 21 that senses the speed of rotation (or rotational angle) of the crankshaft, and an engine switch 22 that is operated by the vehicle driver to one of two or more positions and generates a signal corresponding to the currently selected position. With this arrangement, the electronic control unit 10 receives information, such as the water temperature of the coolant, the engine speed, and the currently selected position of the engine switch. The electronic control unit 10 includes a memory 11 in which a main injection timing correction map used for engine starting control is stored. The memory 11 may be a rewritable ROM (read-only memory) that permits data to be rewritten, or may be a RAM (random access memory) into which necessary data is transferred from a ROM (not shown), or the like, and written each time the electronic control unit 10 is turned on.

[0028] Then, on the basis of the above-indicated items of information, the electronic control unit 10 controls energization of the glow plug 5 via an energization unit 30, and also performs control (adaptive control) of a starting parameter or parameters that can change engine start-up characteristics. In this embodiment, in particular, the electronic control unit 10 adaptively controls the main injection timing of fuel during starting of the engine. More specifically, current is applied to the glow plug 5 during a period from switching of the engine switch 22 to "Ignition On" to switching of the engine switch 22 to "Starter On", and the adaptive control of the starting parameter is performed according to the energization time.

[0029] The starting control of the diesel engine according to this embodiment will be described in detail with reference to FIG. 2. The electronic control unit 10 repeatedly executes a routine shown in FIG. 2, at given computation intervals.

[0030] In the control routine of FIG. 2, it is initially determined in step S11 whether the engine switch 22 is in the "Ignition On" position. If it is determined that the engine switch 22 is not in the "Ignition On" position, for example, if the engine switch 22 is switched to a position for accessories, the following steps will not be executed.

[0031] If it is determined in step S11 that the engine switch 22 is in the "Ignition On" position, the control proceeds to step S12 to determine whether the engine has been started. If it is determined that the engine has been started, namely, if the engine has already been started and is currently in operation, the following steps will not be executed.

[0032] If it is determined in step S12 that the engine has not been started, the control proceeds to step S13 to determine whether the engine switch 22 has been switched to the "Starter On" position. If the engine switch 22 has not been switched to the "Starter On" position, the control proceeds to step S14 to measure time T1. Thereafter, step S13 and step S14 are repeatedly exe-

cuted to keep measuring time T1 until it is determined in step S13 that the engine switch 22 has been switched to the "Starter On" position. Then, if it is determined in step S13 that the engine switch 22 has been switched to the "Starter On" position, the control proceeds to step S15 to stop measuring time T1, and store its value (a value of time T1) in the memory 11 of the electronic control unit 10.

[0033] Meanwhile, the glow plug 5 is energized during a period from switching of the engine switch 22 to "Ignition On" to switching of the engine switch 22 to "Starter On". Namely, the above-indicated time T1 represents an actual glow waiting time as a period of time for which the glow plug 5 is actually energized during starting of the diesel engine 1, until the starter is actuated and cranking is started.

[0034] Subsequently, in step S16, the above-indicated actual glow waiting time T1 is compared with a required glow waiting time T0 as an energization time required for the temperature of the glow plug 5 to increase to a temperature suitable for start-up of the engine. Namely, an insufficient glow waiting time T' is obtained by subtracting the actual glow waiting time T1 from the required glow waiting time T0. The required glow waiting time T0 is set according to the coolant temperature, and has a tendency of becoming longer as the coolant temperature is lower. The required glow waiting time T0 is stored in advance in the memory 11 of the electronic control unit 10.

[0035] Then, in step S17, a correction value for the main injection timing of the fuel during starting is determined according to the insufficient glow waiting time T' obtained in the above step S16. The correction value is stored in the memory 11 of the electronic control unit 10, as a value in a main injection timing correction map as shown in FIG. 3. In the main injection timing correction map, the correction value is "0" when the insufficient glow waiting time T' is "0" or less, namely, when the glow plug has been energized for a sufficient period of time. Where the insufficient glow waiting insufficient time T' is larger than "0", on the other hand, the correction value is set so that the main injection timing has a tendency of being advanced by a larger degree as the value of T' increases, namely, as the glow waiting time is more insufficient or shorter.

[0036] Then, in step S18, the correction value determined in the above step S17 is added to a specified value of the main injection timing during starting. The specified value of the main injection timing is determined according to the water temperature of the coolant and the engine speed during starting, which are obtained from the above-mentioned water temperature sensor 20 and crank angle sensor 21, respectively. More specifically, the specified value of the main injection timing is set to be more advanced as the coolant temperature is lower, or as the engine speed is higher.

[0037] Thus, the main injection timing during starting is corrected in step S18, and the engine is started in step S19, according to the corrected main injection timing. In

the following, the operation of the starting control system for the diesel engine according to this embodiment, which performs the above-described starting control, will be described.

[0038] Since the main injection timing of the fuel during starting is corrected according to the insufficient glow waiting time T' , as described above, the engine is appropriately started in accordance with driver's operating conditions. Namely, the engine can be smoothly started when the glow waiting time is sufficiently long (i.e., when the driver waited until the glow plug is sufficiently heated); furthermore, even when the glow waiting time is short and the temperature of the glow plug 5 is low, the main injection timing during starting is suitably adjusted so that the fuel is appropriately burned. In the latter case, the correction value is set so that the main injection timing is advanced by a larger degree as the insufficient glow waiting time T' is longer; therefore, as the glow waiting time is more insufficient or shorter, the fuel is premixed with air for a prolonged time, and the fuel is more likely to be burned. Accordingly, even when the glow waiting time is insufficient, the likelihood of deterioration of the engine starting performance and emissions can be reduced.

[0039] In the control routine of FIG. 2, the actual glow waiting time $T1$ is measured under a condition that the engine has not been started. This makes it possible to prevent the actual glow waiting time $T1$ from being measured when the engine switch is in the "Ignition On" position during normal operation of the engine after it is started.

[0040] While the starting parameter as an object to be corrected is the main injection timing of the fuel during starting in this embodiment, any of other starting parameters, such as the common rail pressure during starting, the pilot injection amount of the fuel, the pilot injection timing of the fuel, and the target glow temperature, or a combination thereof, may be corrected.

[0041] In the case where the starting parameter is the common rail pressure during starting, the common rail pressure may be preferably reduced as the insufficient glow waiting time is longer. This makes it possible to reduce the amount of fuel deposited on walls within the combustion chamber, so that the fuel can be readily ignited.

[0042] In the case where the starting parameter is the pilot injection amount of the fuel, the pilot injection amount may be preferably increased as the insufficient glow waiting time is longer, so as to increase the amount of fuel premixed with air, and make it easier to burn the fuel.

[0043] In the case where the starting parameter is the pilot injection timing of the fuel, the pilot injection timing as a whole may be preferably advanced by a larger degree as the insufficient glow waiting time is longer. Where two or more pilot injections are conducted, the interval of the pilot injections may be preferably reduced as the insufficient glow waiting time is longer. This also promotes premixing of the fuel with air, so that the fuel is

more likely to be burned.

[0044] In the case where the starting parameter is the target glow temperature, the target glow temperature may be preferably increased as the insufficient glow waiting time is longer. This makes it possible to increase the amount of current applied to the glow plug, and rapidly raise the temperature of the glow plug.

[0045] Thus, the above-indicated starting parameters are corrected so as to slow down or retard start-up of the engine as the insufficient glow waiting time is longer. As explained above, the starting control system for the diesel engine according to this embodiment provides the following effects.

15 (First Effect)

[0046] The required glow waiting time $T0$ as the glow-plug energization time required for the temperature of the glow plug to increase to a temperature level suitable for starting of the engine, and the actual glow waiting time $T1$ as the actual glow-plug energization time measured until cranking is started are compared with each other, and the starting parameter is adaptively controlled according to the result of the comparison. With this arrangement, the engine can be smoothly started when the glow waiting time is sufficiently long (i.e., the driver waited until the glow plug is sufficiently heated), and, even when the glow waiting time is insufficient or short, and the temperature of the glow plug 3 is low, the starting parameter is suitably adjusted so as to achieve appropriate combustion of the fuel. Accordingly, even if the glow waiting time is insufficient or short, appropriate combustion can be accomplished.

35 (Second Effect)

[0047] The starting parameter is corrected according to a time difference between the actual glow waiting time $T1$ and the required glow waiting time $T0$ when $T1$ is shorter than $T0$. Thus, the starting parameter can be appropriately adjusted in accordance with the degree of insufficiency of the glow waiting time.

[0048] Next, a starting control system for a diesel engine according to a second embodiment of the invention, mainly, its differences from the first embodiment, will be described with reference to FIG. 4 through FIG. 6I. The basic construction of the starting control system of the second embodiment is substantially identical with that of the first embodiment. In FIG. 4, the same reference numerals as used in FIG. 1 are assigned to substantially the same elements as those of the first embodiment, and repeated explanation thereof will not be provided.

[0049] In this embodiment, too, the electronic control unit 10 controls energization of the glow plug 5, and also performs adaptive control of a starting parameter or parameters that can change starting timing (starting characteristics) of the engine, as shown in FIG. 4. In this embodiment, however, a normal starting constant and an

insufficient glow waiting starting constant are stored as constant values of each starting parameter, in a memory 12 of the electronic control unit 10. More specifically, parameters, such as the main injection timing of the fuel during starting, the common rail pressure during starting, the pilot injection amount of the fuel, the pilot injection timing of the fuel, and the target glow temperature, are stored as the above-indicated two kinds of constants. Then, the adaptive control of the starting parameter is performed by switching between the normal starting constant and the insufficient glow waiting starting constant. The memory 12 may also be a rewritable ROM (read-only memory) that permits data to be rewritten, or may be a RAM (random access memory) into which necessary data is transferred from a ROM (not shown), or the like, and written each time the electronic control unit 10 is turned on.

[0050] Next, the starting control of the diesel engine according to the second embodiment will be described in detail with reference to FIG. 5. The electronic control unit 10 repeatedly executes a routine as shown in FIG. 5, at given computation intervals.

[0051] In the control routine of FIG. 5, too, it is initially determined in step S21 whether the engine switch 22 is in the "Ignition On" position, and then determined in step S22 whether the engine has been started, and it is determined in step S23 whether the engine switch 22 has been switched to the "Starter On" position, as in the first embodiment. If it is determined that the engine switch 22 is in the "Ignition On" position, the engine has not been started, and that the engine switch 22 has not been switched to the "Starter On" position, the control proceeds to step S24, to measure the actual glow waiting time T1.

[0052] Subsequently, step S23 and step S24 are repeatedly executed and the actual glow waiting time T1 keeps being measured until it is determined in step S23 that the engine switch 22 has been switched to the "Starter On" position. Then, if it is determined in step S23 that the engine switch 22 has been switched to the "Starter On" position, the control proceeds to step S25 to stop measuring the actual glow waiting time T1. Then, in step S26, the insufficient glow waiting time T' is obtained by subtracting the actual glow waiting time T1 from the required glow waiting time T0.

[0053] In this embodiment, it is determined in step S27 whether the insufficient glow waiting time T' is shorter than a criteria value α . The criteria value α is set to a value close to "0", for example, is set to "500 ms (milliseconds)". If it is determined in step S27 that the insufficient glow waiting time T' is smaller than the criteria value α , it is determined in step S28 that the glow waiting time is sufficient, and a glow waiting time sufficiency flag is set to ON (FLAG ON). If the glow waiting time sufficiency flag is ON, the constant value of the starting parameter is switched to the above-mentioned normal starting constant, and the engine is started according to the normal starting constant.

[0054] If, on the other hand, it is determined in step S27 that the insufficient glow waiting time T' is equal to or longer than the criteria value α , the control proceeds to step S29 to set the glow waiting time sufficiency flag to OFF (FLAG OFF). If the glow waiting time sufficiency flag is OFF, the engine is started with the starting parameter set to the above-mentioned insufficient glow waiting starting constant. In this embodiment, the insufficient glow waiting starting constant is initially set (as a default) as the constant value of the starting parameter, and the constant value of the starting parameter is switched or changed to the normal starting constant when the glow waiting time sufficiency flag is ON.

[0055] Referring next to FIG. 6A through FIG. 6I, a specific example of the starting control of the diesel engine according to the above-described second embodiment will be described in detail. In this example, the engine switch 22 is placed in the "Ignition On" position at time t1, as shown in FIG. 6B. Then, the glow-lamp lighting time (the required glow waiting time T0) is set, and the glow lamp lights up, as shown in FIG. 6E and FIG. 6F, while current starts being applied to the glow plug 5. With the energization of the glow plug 5 thus started, measurement of the actual glow waiting time T1 is started, as shown in FIG. 6G. The actual glow waiting time T1 keeps being measured until the engine switch 22 is switched to the "Starter On" position, and the insufficient glow waiting time T' is reduced as the actual glow waiting time T1 increases, as shown in FIG. 6H. Then, at time t3 at which the insufficient glow waiting time T' becomes shorter than "500 ms", the glow waiting time sufficiency flag is set to ON, as shown in FIG. 6I.

[0056] If the engine switch 22 is switched to the "Starter On" position at time t4 at which the glow lamp turns off, as indicated by the solid line in FIG. 6C, the constant value of the starting parameter is switched to the normal starting constant since the glow waiting time sufficiency flag is ON, and the engine is started according to the normal starting constant. Subsequently, the engine speed increases, as shown in FIG. 6A, and, when it is determined at time t5 at which the engine speed becomes higher than a speed at which the engine can be regarded as starting self-revolution that the engine has been started, as shown in FIG. 6D, the starter is turned off at time t6, as shown in FIG. 6C.

[0057] If, on the other hand, the engine switch 22 is switched to the "Starter On" position at time t2 while the glow lamp is lighting (ON), as indicated by the one-dot chain line in FIG. 6C, the constant value of the starting parameter is not changed since the glow waiting time sufficiency flag is OFF, and the engine is started according to the insufficient glow waiting starting constant as the default of the starting parameter.

[0058] The operation of the starting control system for the diesel engine according to the second embodiment, in which the starting control as described above is performed, will be described. Since the constant value of the starting parameter during starting is switched or

changed depending on the insufficient glow waiting time T', as described above, the engine is appropriately started in accordance with the driver's operating conditions. Namely, the engine can be smoothly started when the glow waiting time is sufficiently long (i.e., the driver waited until the glow plug is sufficiently heated); furthermore, even when the glow waiting time is insufficient, and the temperature of the glow plug 5 is low, the engine is started with the insufficient glow waiting starting constant, so that the fuel is appropriately burned.

[0059] Also, the determination as to whether the constant value of the starting parameter should be switched is made using the criteria value α ; therefore, when the insufficient glow waiting time T' is a considerably small value, it is presumed that the glow waiting time is sufficient (i.e., the glow plug 5 is sufficiently heated), and the starting parameter is switched to the normal starting constant, according to which the engine is started. Accordingly, appropriate starting control can be performed, assuring improved start-up performance.

[0060] The insufficient glow waiting constant is the default of the constant value of the starting parameter, and the constant value of the starting parameter is switched to the normal starting constant when the glow waiting time sufficiency flag is ON. Thus, the constant is prevented from being switched while the engine is being started after the starter is actuated.

[0061] As explained above, the starting control system for the diesel engine according to this embodiment provides the following effects, in addition to the first effect of the first embodiment as described above.

(Third Effect)

[0062] The starting parameter is suitably adjusted by switching the constant value of the starting parameter between the normal starting constant and the insufficient glow waiting starting constant, according to the result of comparison between the required glow waiting time T0 and the actual glow waiting time T1. Thus, the adjustment or adaptation of the starting parameter can be accomplished with a simple arrangement like switching between two kinds of constants. Depending on the type of the starting parameter, switching of the starting parameter between two kinds of constants as in the second embodiment may be more suitable or favorable than correcting the starting parameter according to the insufficient glow waiting time T' as in the first embodiment.

(Fourth Effect)

[0063] When the difference between the required glow waiting time T0 and the actual glow waiting time T1 is smaller than the criteria value α , the starting constant of the starting parameter is switched from the insufficient glow waiting starting constant to the normal starting constant. Thus, by setting the insufficient glow waiting starting constant as the default of the starting parameter, the

starting constant is prevented from being switched or changed while the engine is being started after the starter is actuated.

[0064] The above-described embodiments may be modified as follows.

[0065] While the criteria value α is set to a value (e.g., 500 ms) close to "0" in the second embodiment, the criteria value α may be set to "0". In each of the illustrated embodiments, the adaptive control is performed on a starting parameter or parameters selected from the main injection timing during starting, the common rail pressure during starting, the pilot injection amount, the pilot injection timing, and the target glow temperature. However, the starting parameter(s) subjected to the adaptive control is/are not limited to these parameters. For example, the fuel injection amount during starting, and a pattern of increase of the fuel amount, or any other parameter that can change starting timing of the engine, may be similarly used as a parameter subjected to the adaptive control.

Claims

1. A starting control system for a diesel engine, which performs control of a starting parameter that changes a starting timing of an engine (1), while energizing a glow plug (5) during a period from switching of an engine switch (22) to an ignition-on position to switching of the engine switch to a starter-on position, **characterized in that** a required glow waiting time as an energization time of the glow plug (5) required for the temperature of the glow plug (5) to increase to a temperature level suitable for starting of the engine (1) is compared with an actual glow waiting time as an actual energization time for which the glow plug (5) is actually energized from switching of the engine switch (22) to the ignition-on position to switching of the engine switch (22) to the starter-on position, and the starting parameter is controlled according to a result of the comparison.
2. The starting control system for the diesel engine according to claim 1, wherein the starting parameter is controlled by switching a starting constant of the starting parameter, between a normal starting constant and an insufficient glow waiting starting constant, according to the result of the comparison between the required glow waiting time and the actual glow waiting time.
3. The starting control system for the diesel engine according to claim 2, wherein the starting constant of the starting parameter is switched from the insufficient glow waiting starting constant to the normal starting constant, when a difference obtained by subtracting the actual glow waiting time from the re-

quired glow waiting time is smaller than a predetermined value.

4. The starting control system for the diesel engine according to claim 3, wherein the predetermined value is 500 milliseconds. 5
5. The starting control system for the diesel engine according to claim 1, wherein the starting parameter is controlled by correcting the starting parameter according to a time difference between the actual glow waiting time and the required glow waiting time when the actual glow waiting time is shorter than the required glow waiting time. 10
6. The starting control system for the diesel engine according to claim 5, wherein the starting parameter is corrected so as to slow down starting of the engine (1) as the time difference is larger. 15
7. The starting control system for the diesel engine according to any one of claims 1 to 6, wherein the starting parameter subjected to the control includes at least one of main injection timing during starting of the engine (1), a common rail pressure during starting of the engine (1), a pilot injection amount of a fuel, pilot injection timing of the fuel, and a target glow temperature. 20
8. The starting control system for the diesel engine according to claim 7, wherein the starting parameter is the main injection timing during starting of the engine (1), and a correction value for the starting parameter is set so that the greater a time difference between the actual glow waiting time and the required glow waiting time when the actual glow waiting time is shorter than the required glow waiting time is, the more the main injection timing during starting of the engine (1) is advanced. 25
9. The starting control system for the diesel engine according to claim 7, wherein the starting parameter is the common rail pressure during starting of the engine (1), and a correction value for the starting parameter is set so that the greater a time difference between the actual glow waiting time and the required glow waiting time when the actual glow waiting time is shorter than the required glow waiting time is, the more the common rail pressure during starting of the engine (1) is reduced. 30
10. The starting control system for the diesel engine according to claim 7, wherein the starting parameter is the pilot injection amount of the fuel, and a correction value for the starting parameter is set so that the greater a time difference between the actual glow waiting time and the required glow waiting time when the actual glow waiting time is shorter than the re- 35

quired glow waiting time is, the more the pilot injection amount of the fuel is increased.

11. The starting control system for the diesel engine according to claim 7, wherein the starting parameter is the pilot injection timing of the fuel, and a correction value for the starting parameter is set so that the greater a time difference between the actual glow waiting time and the required glow waiting time when the actual glow waiting time is shorter than the required glow waiting time is, the more the pilot injection timing is advanced. 40
12. The starting control system for the diesel engine according to claim 7, wherein the starting parameter is the target glow temperature, and a correction value for the starting parameter is set so that the greater a time difference between the actual glow waiting time and the required glow waiting time when the actual glow waiting time is shorter than the required glow waiting time is, the more the target glow temperature is higher. 45

FIG. 1

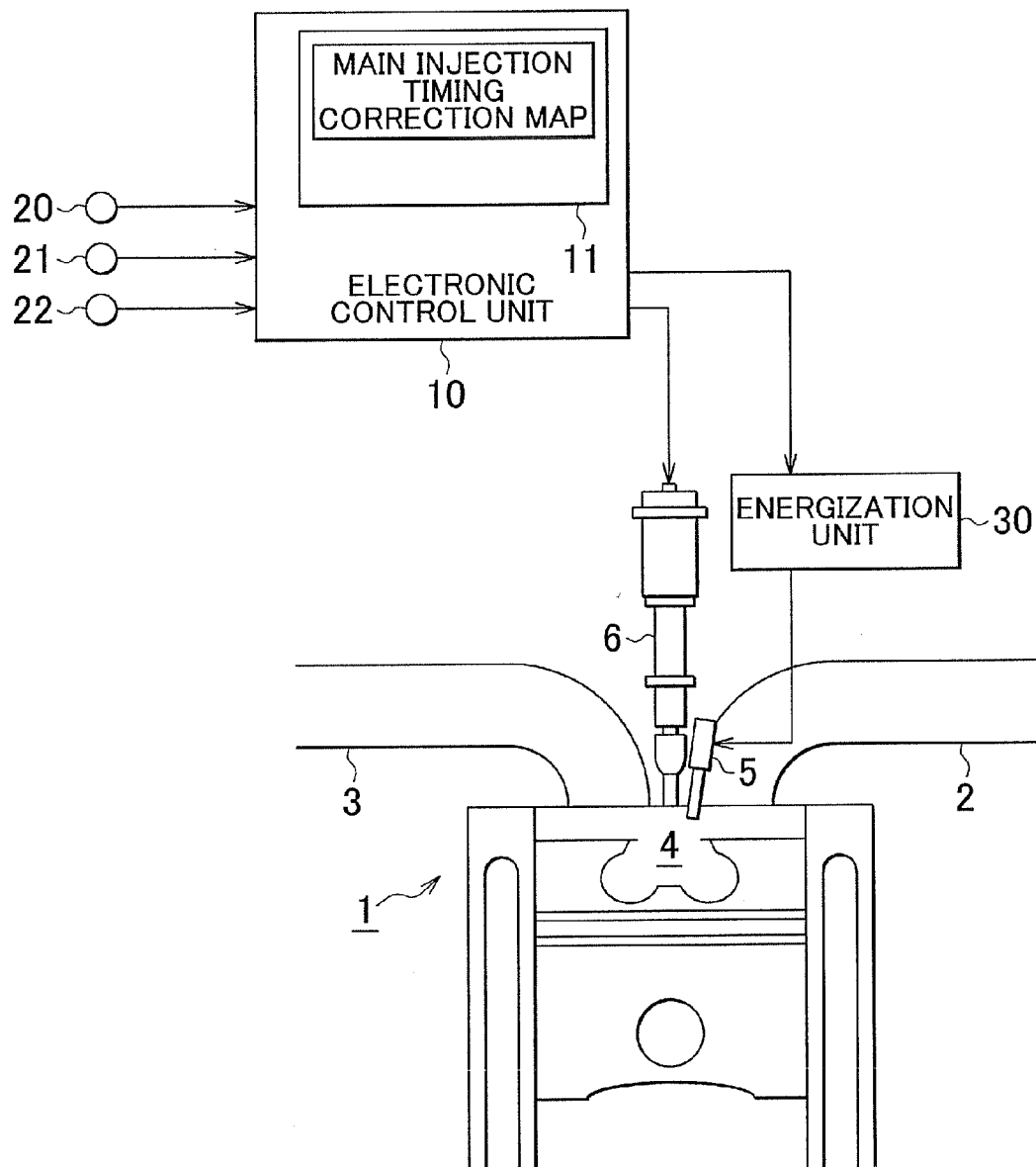


FIG. 2

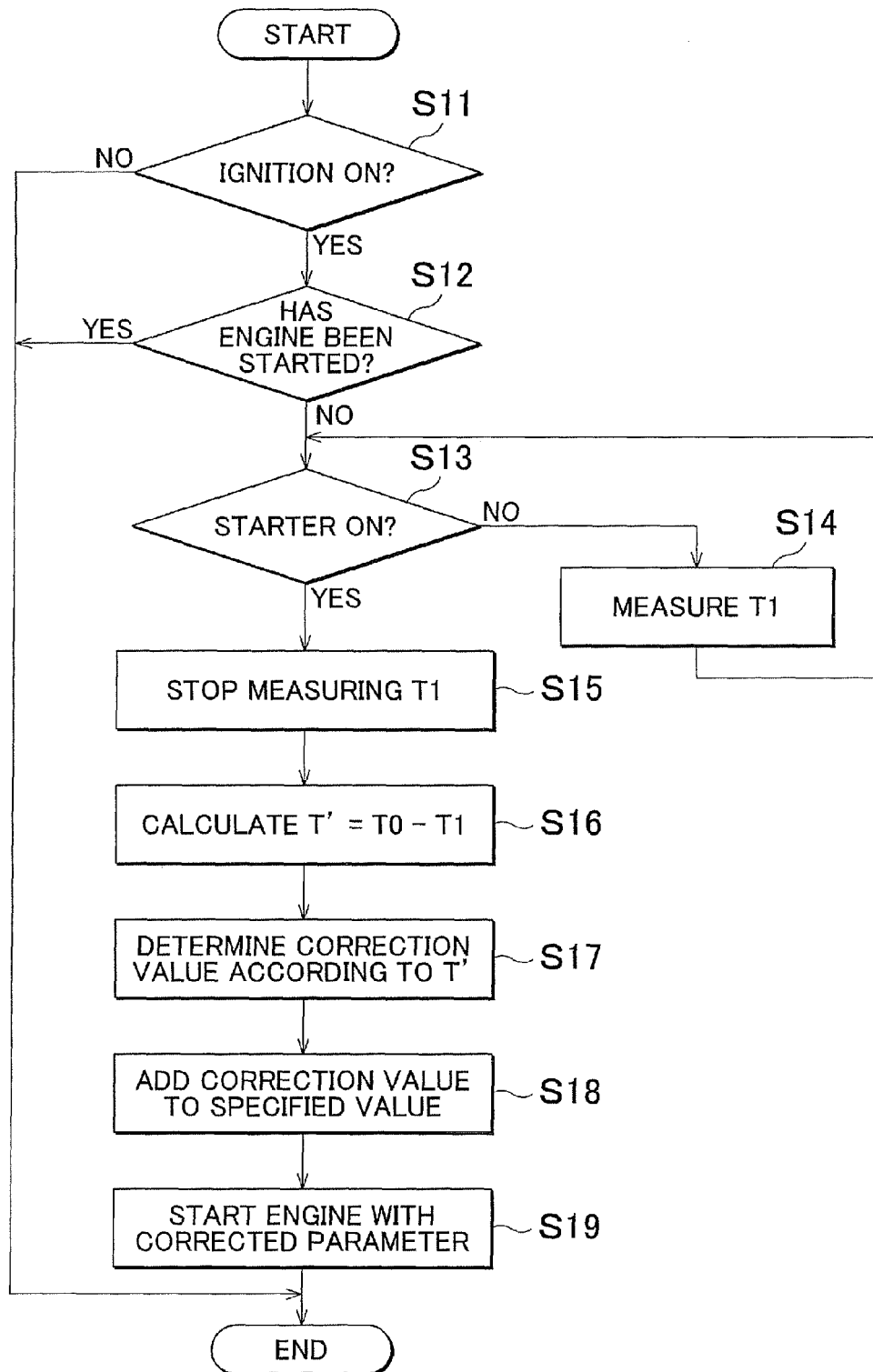


FIG. 3

INSUFFICIENT GLOW WAITING TIME (sec)	0	1	2	3	4	5
CORRECTION VALUE (°CA)	0	-1	-2	-3	-4	-5

FIG. 4

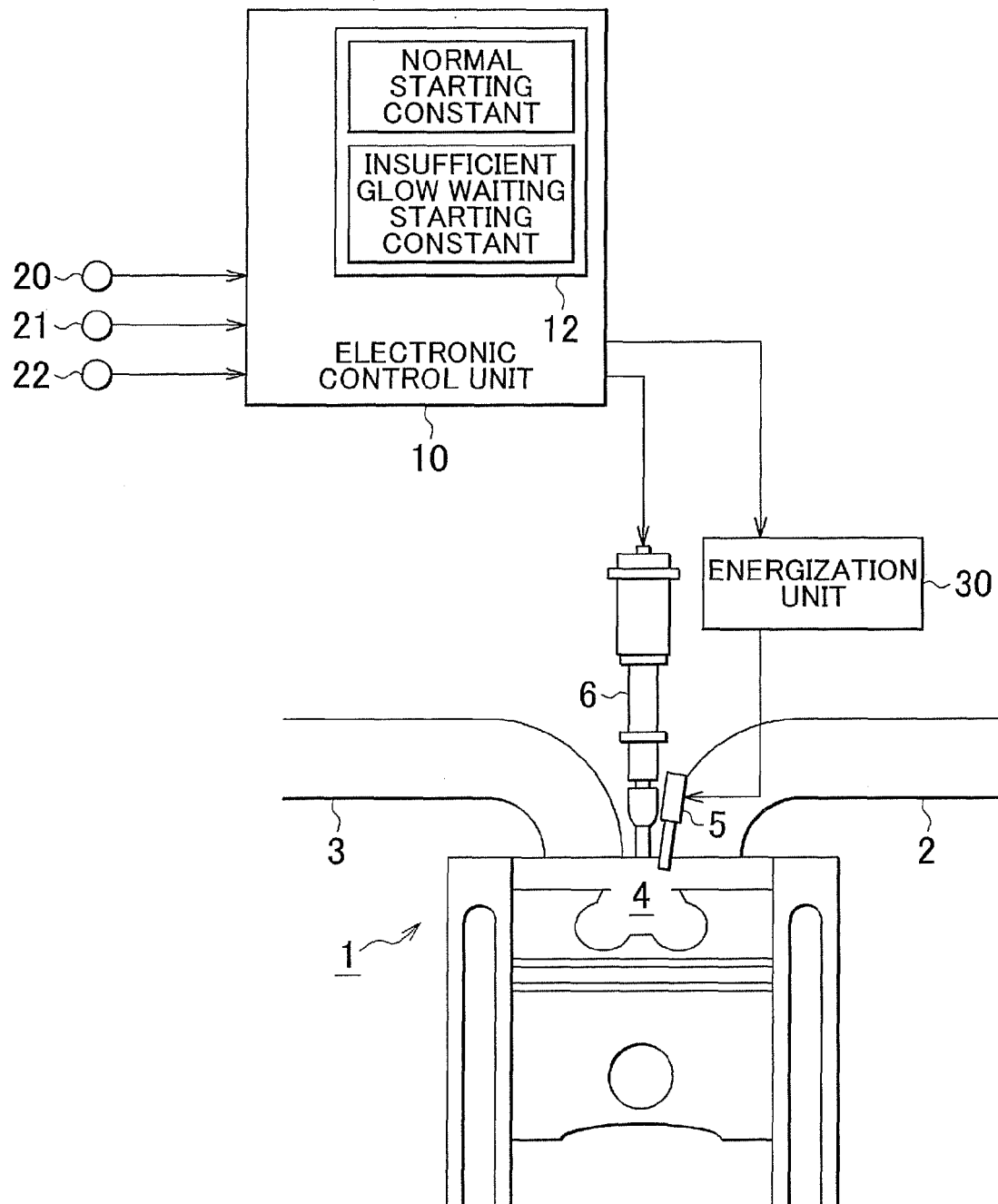


FIG. 5

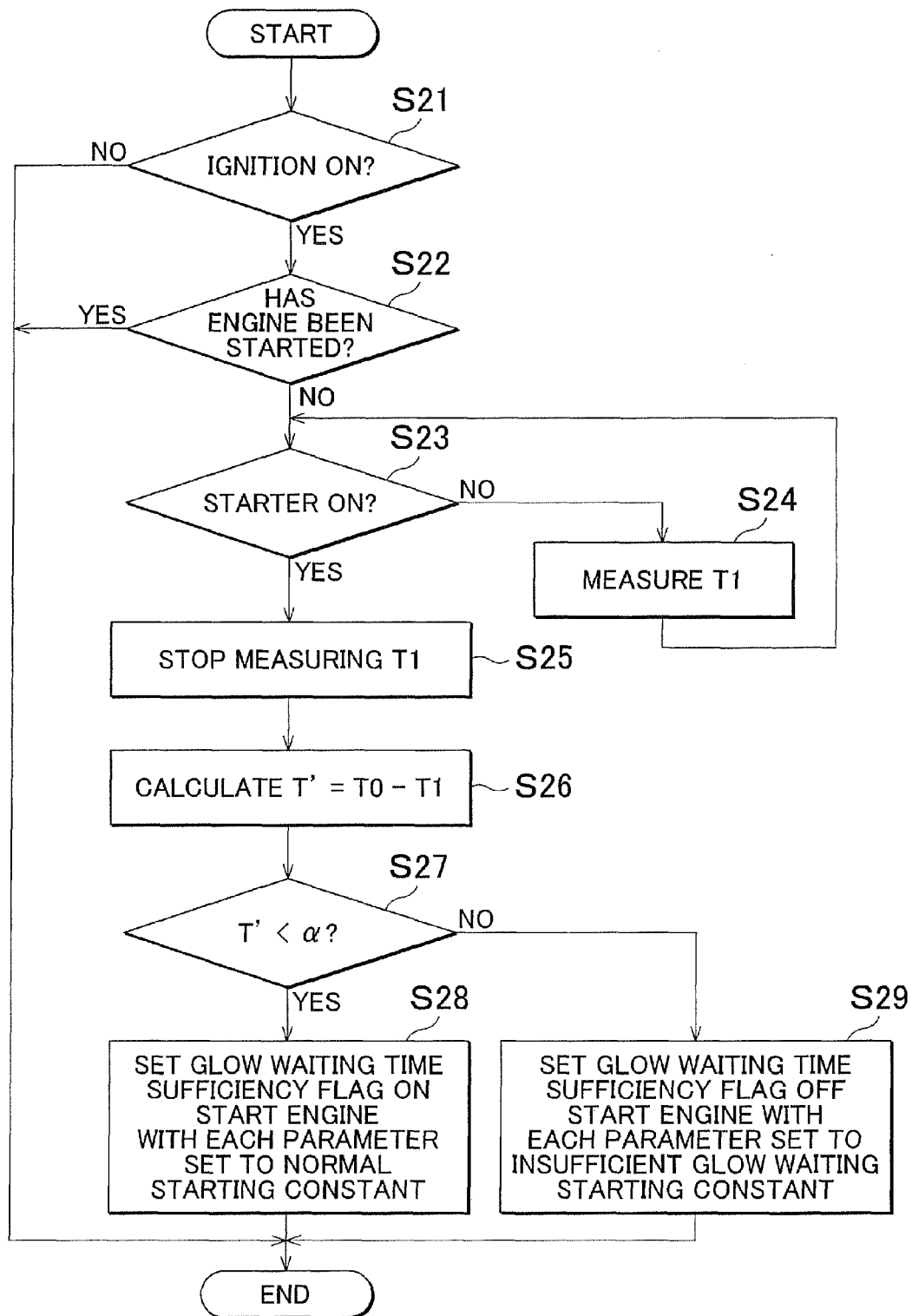


FIG. 6A

ENGINE SPEED



FIG. 6B

IGNITION
OFF

ON

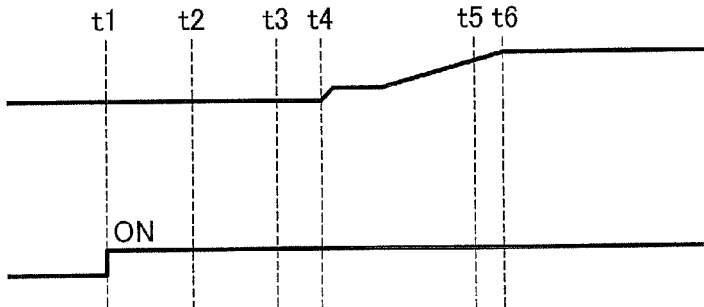


FIG. 6C

STARTER
OFF

ON

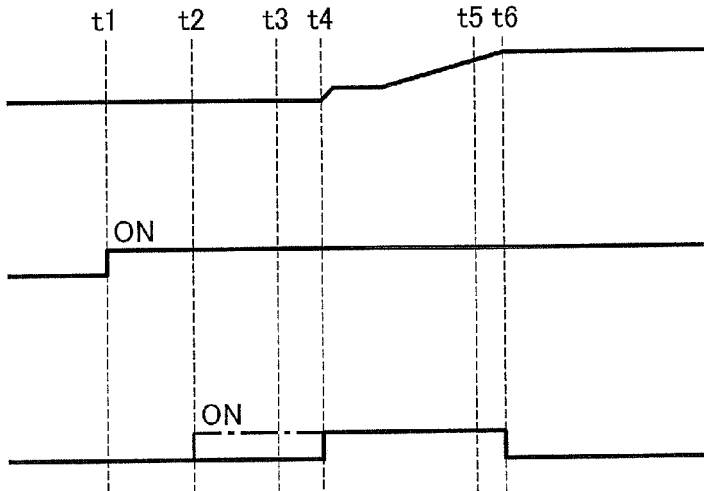


FIG. 6D

ENGINE
STARTING STATUS
NOT STARTED

STARTED

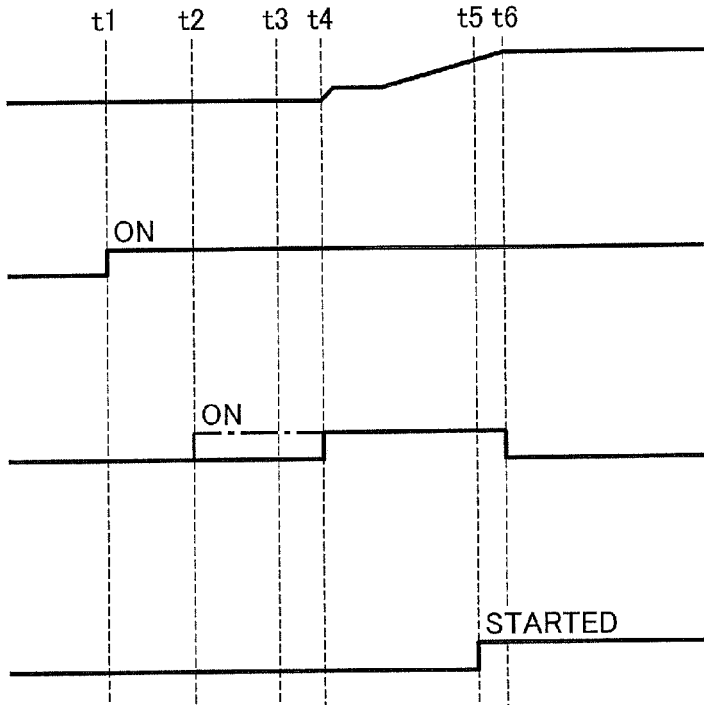


FIG. 6E

GLOW LAMP
LIGHTING TIME

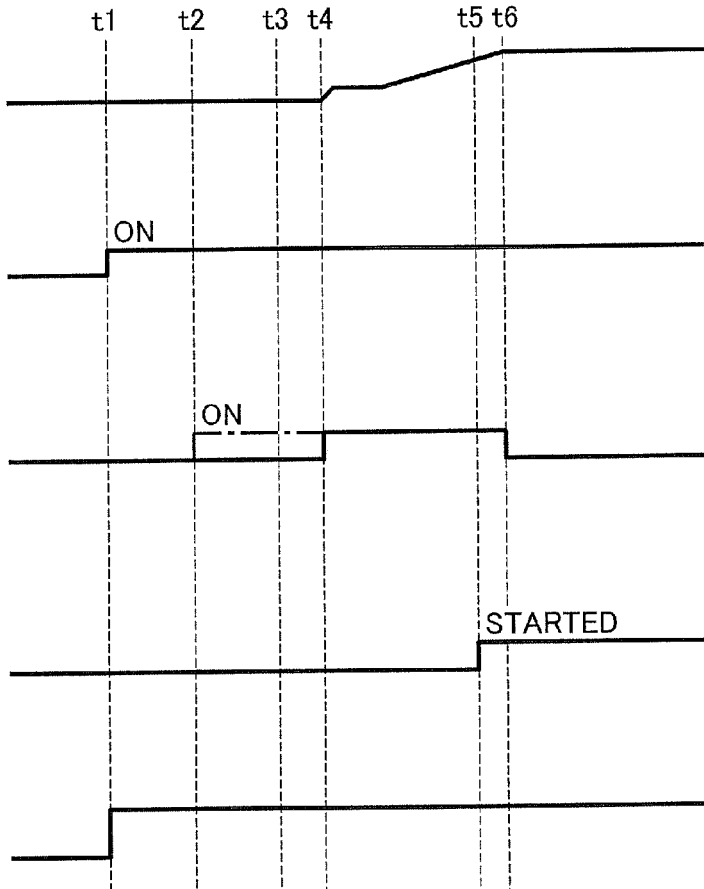


FIG. 6F

GLOW LAMP
OFF

ON

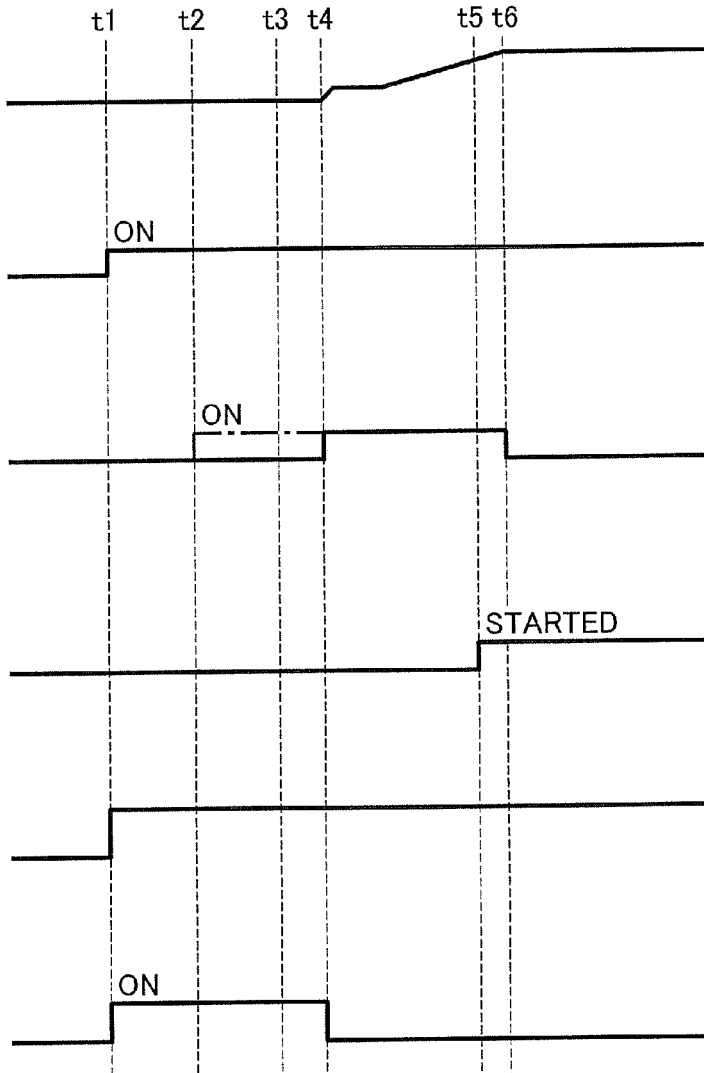


FIG. 6G

GLOW WAITING TIME

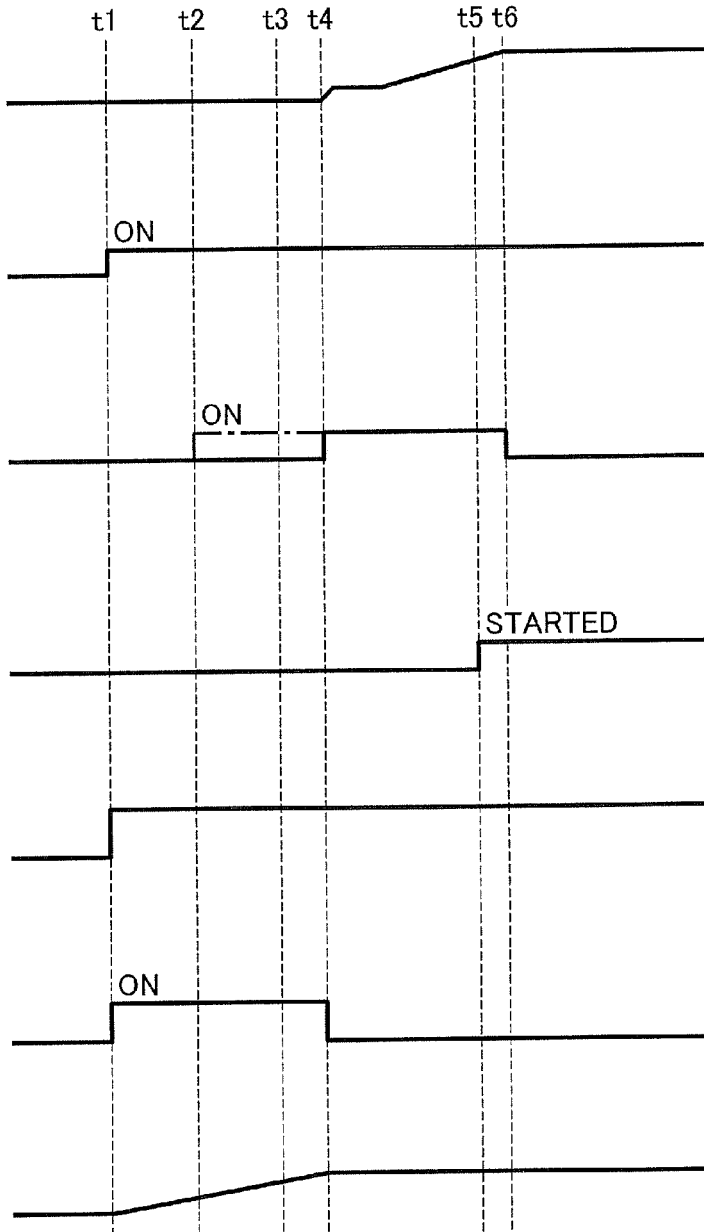


FIG. 6H

INSUFFICIENT
GLOW WAITING TIME

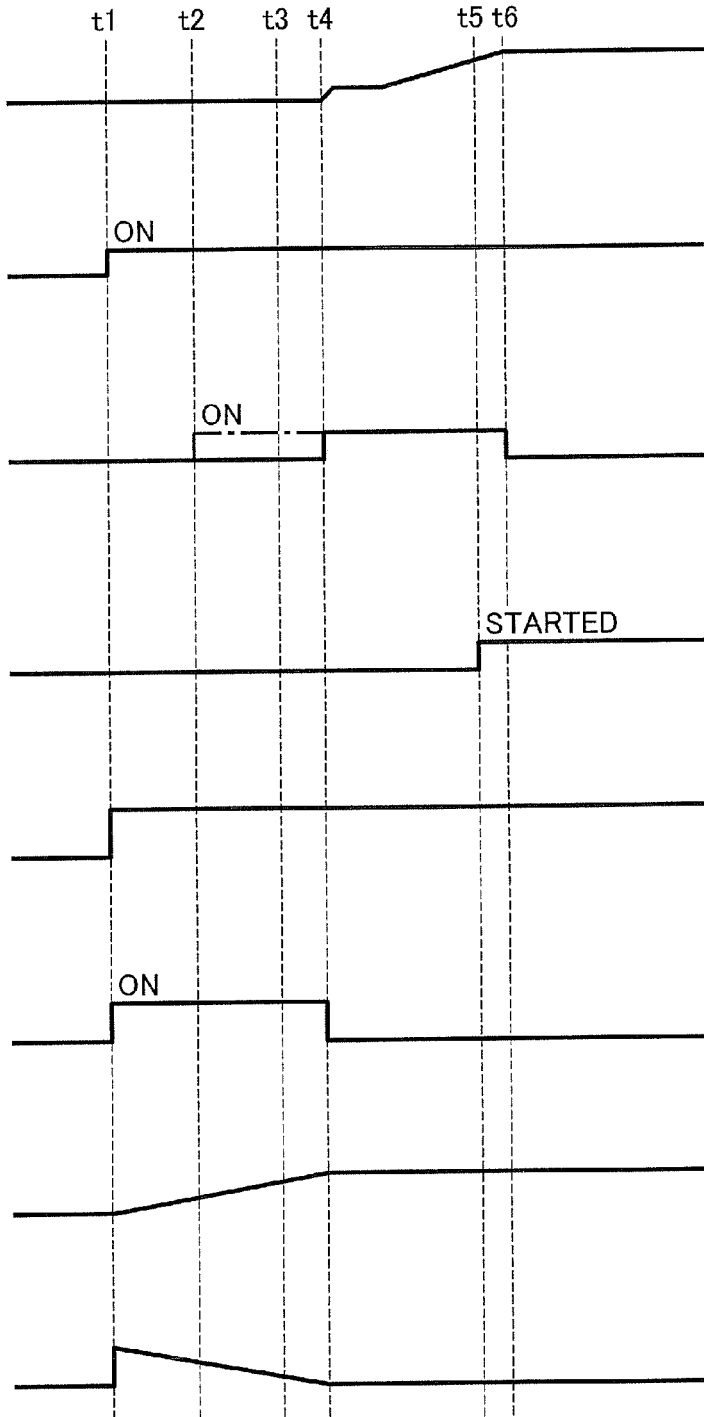
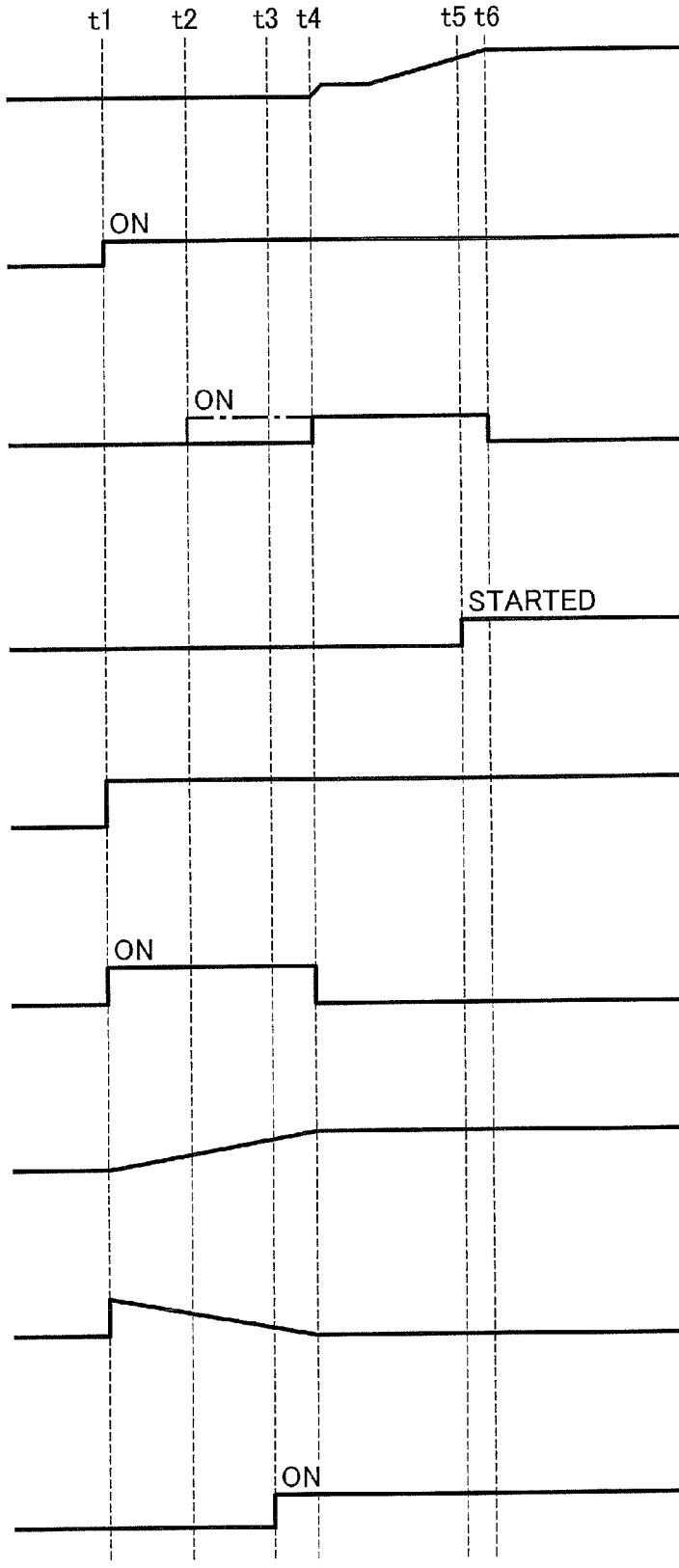


FIG. 6I

GLOW WAITING TIME
SUFFICIENCY FLAG
OFF

ON





EUROPEAN SEARCH REPORT

Application Number
EP 12 17 2005

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	GB 2 323 631 A (KEENE DAVID MARTIN [GB]; RICHMOND DESIGN & MARKETING LT [GB]) 30 September 1998 (1998-09-30) * page 1, line 3 - page 1, line 24 *	1-12	INV. F02N11/08 F02P19/02 F02D41/06
A	US 6 164 258 A (PETROVICH PAUL A [US] ET AL) 26 December 2000 (2000-12-26) * the whole document *	1-12	
A	US 2007/240663 A1 (HIRAMATSU HIROMI [JP]) 18 October 2007 (2007-10-18) * the whole document *	1-12	
			TECHNICAL FIELDS SEARCHED (IPC)
			F02N F02P F02D
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 11 September 2012	Examiner Calabrese, Nunziante
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

1
EPO FORM 1503 03.82 (P04C01)

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ON EUROPEAN PATENT APPLICATION NO.**

EP 12 17 2005

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The members are as contained in the European Patent Office EDP file on
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11-09-2012

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GB 2323631	A	30-09-1998	NONE
US 6164258	A	26-12-2000	NONE
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REFERENCES CITED IN THE DESCRIPTION

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