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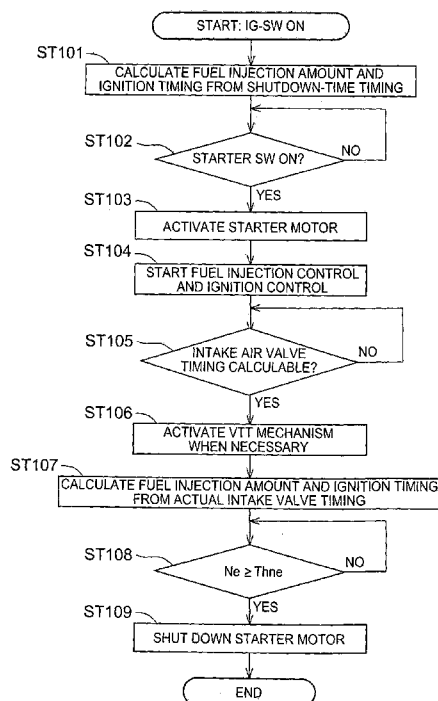
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(54) Title: CONTROL APPARATUS AND CONTROL METHOD FOR INTERNAL COMBUSTION ENGINE

FIG. 5



(57) Abstract: A control apparatus of an internal combustion engine includes a variable valve timing mechanism that varies an operation timing of an intake valve, and a controller. The controller is configured to store an operation timing of the intake valve at engine shutdown as a shutdown-time operation timing. The controller is configured to perform start-up control based on an operation timing of the intake valve when the operation timing is detected or calculated at engine start-up. The controller is configured to perform start-up control based on the shutdown-time operation timing when the operation timing is not detected or calculated at engine start-up.



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CONTROL APPARATUS AND CONTROL METHOD FOR INTERNAL COMBUSTION ENGINE

BACKGROUND OF THE INVENTION

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1. Field of the Invention

[0001] This invention relates to a control apparatus and a control method for an internal combustion engine mounted on a vehicle or the like. More specifically, the invention relates to start-up control when an internal combustion engine is provided with a variable valve mechanism capable of varying an operation timing of an intake valve.

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2. Description of Related Art

[0002] More and more internal combustion engines mounted on a vehicle or the like are adopting a variable valve timing mechanism (hereinafter, a VVT mechanism) which varies an operation timing of an intake valve. For example, an internal combustion engine described in Japanese Patent Application Publication No. 6-346764 (JP 6-346764 A) has, on an intake side thereof, a VVT mechanism that is driven by a stepper motor. The VVT mechanism is activated in accordance with variations in engine rotation speed and intake air volume.

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[0003] In addition, according to JP 6-346764 A, when the internal combustion engine is in an intermediate rotation range, a basic advance angle of the VVT mechanism is set further to an advance side than in a low rotation range or a high rotation range. Meanwhile, the basic advance angle is set to 0 at start-up in order to reduce internal exhaust gas recirculation (EGR) by reducing valve overlap between an intake valve and an exhaust valve to enhance combustion performance of an air-fuel mixture.

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[0004] With an internal combustion engine including a VVT mechanism, the VVT mechanism is activated in advance to a predetermined target position at engine shutdown so that an intake valve operation timing (hereinafter, also simply referred as an intake valve timing) at next engine start-up is a suitable intake valve timing. However,

there is a possibility that, for some reason or other, the intake valve timing at engine start-up may not be the suitable intake valve timing due to the VVT mechanism not reaching the target position or, subsequently, the VVT mechanism is inadvertently activated.

5 **[0005]** Therefore, when start-up control is performed on the assumption that the VVT mechanism is at the target position, for example, there is a possibility that a large amount of fuel is inadvertently injected in a state where cylinder filling efficiency is lower than a target value, which results in a decline in start-up performance. Conversely, when the filling efficiency is high, there is a possibility that an excessive and abrupt increase in
10 engine rotation may occur and cause discomfort to a passenger.

[0006] An actual intake valve timing can be calculated based on a signal from a crank position sensor or a cam position sensor. However, at engine start-up, a pulse signal from a cam position sensor may not be obtained immediately after start of cranking and an intake valve timing may not be calculated.

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SUMMARY OF THE INVENTION

[0007] The invention provides a technique for achieving a smooth start-up during which an abrupt increase in the rotation of an internal combustion engine including a variable valve timing mechanism (hereinafter, a VVT mechanism) is suppressed while
20 securing favorable start-up performance of the internal combustion engine.

[0008] In a first aspect of the invention, a control apparatus of an internal combustion engine includes a variable valve timing mechanism that varies an operation timing of an intake valve, and a controller configured to store an operation timing of the intake valve at engine shutdown as a shutdown-time operation timing, the controller being
25 configured to perform start-up control based on an operation timing of the intake valve when the operation timing is detected or calculated at engine start-up, and the controller being configured to perform start-up control based on the shutdown-time operation timing when the operation timing is not detected or calculated at engine start-up.

[0009] According to the configuration, when there is possibility that an operation

timing of an intake valve cannot be detected or calculated at start-up of an internal combustion engine, start-up control is performed based on an shutdown-time operation timing stored at a previous engine shutdown. Therefore, even if the VVT mechanism does not return to a target position for some reason or other at engine shutdown, accurate
5 start-up control can be performed based on a shutdown-time operation timing that approximates an actual operation timing of the intake valve.

[0010] When the operation timing of the intake valve can be detected or calculated at engine start-up, start-up control can be performed based on the operation timing. Therefore, even if the VVT mechanism deviates from the target position between
10 shutdown and start-up of the internal combustion engine, an influence of the deviation can be minimized and accurate start-up control can be performed.

[0011] In the control apparatus, the controller may be configured to start start-up control of the internal combustion engine based on the shutdown-time operation timing and, subsequently, switch to start-up control of the internal combustion engine based on an
15 actual operation timing of the intake valve once the actual operation timing is detected or calculated in accordance with cranking.

[0012] When detection or calculation of an actual operation timing of the intake valve can be performed, signals are respectively outputted from a crank position sensor and a cam position sensor. According to the configuration, by performing start-up control
20 promptly and as accurately as possible at engine start-up, a smooth start-up during which an abrupt increase in engine rotation is suppressed can be achieved while securing favorable start-up performance.

[0013] The shutdown-time operation timing may be calculated based on signals from the crank position sensor and the cam position sensor at engine shutdown after fuel
25 injection or ignition is finished and until a crankshaft that rotates due to inertia comes to a stop.

[0014] In the control apparatus, the controller may be configured to control a fuel injection amount based on any of the shutdown-time operation timing and the operation timing of the intake valve that is detected or calculated at engine start-up.

[0015] With the control of the fuel injection amount, favorably, the fuel injection amount is controlled so as to match the cylinder filling efficiency. Injecting and supplying an appropriate amount of fuel that matches an actual filling efficiency in this manner enables combustion performance of an air-fuel mixture to be enhanced, which is advantageous in securing start-up performance.

[0016] In the control apparatus, the controller may be configured to control an ignition timing based on any of the shutdown-time operation timing and the operation timing of the intake valve that is detected or calculated at engine start-up.

[0017] In this case, when the filling efficiency is lower than a target value, start-up performance is secured by advancing the ignition timing. On the other hand, when the filling efficiency is high, an abrupt increase in engine rotation can be suppressed by retarding the ignition timing.

[0018] In the control apparatus, the controller may be configured to control the VVT mechanism based on any of the shutdown-time operation timing and the operation timing of the intake valve that is detected or calculated at engine start-up.

[0019] For example, when the shutdown-time operation timing or an actual operation timing that is detected or calculated at start-up deviates from a predetermined timing (which corresponds to a target position of the VVT mechanism) suitable for engine start-up, the VVT mechanism can be controlled so as to reduce the deviation.

[0020] In the control apparatus, the controller may be configured to control the VVT mechanism in accordance with a temperature state of the internal combustion engine at engine start-up, advance the operation timing of the intake valve when the temperature of the internal combustion engine is low, and retard the operation timing of the intake valve when the temperature of the internal combustion engine is high.

[0021] According to this configuration, the cylinder filling efficiency can be increased at low temperature to enhance the combustion performance of the air-fuel mixture. On the other hand, the filling efficiency can conversely be reduced at high temperature to suppress an abrupt increase in engine rotation.

[0022] In other words, by varying an operation timing of the intake valve in

accordance with a temperature state of the internal combustion engine at start-up, a filling efficiency suitable for start-up can be attained. Accordingly, both the securing of engine start-up performance and a smooth start-up can be achieved at higher levels.

[0023] In the control apparatus, the internal combustion engine may be mounted on a vehicle, and the controller may be configured to start control of the VVT mechanism in accordance with a predetermined operation performed by a passenger of the vehicle before an operation to start cranking is performed by the passenger at engine start-up.

[0024] According to this configuration, activation of the VVT mechanism can be promptly started in accordance with a predetermined operation such as an ON operation of an ignition switch and control to a preferable filling efficiency can be performed more promptly.

[0025] In the control apparatus, the controller may be configured to start control of the VVT mechanism based on the shutdown-time operation timing of the intake valve in accordance with a predetermined operation performed by the passenger and, subsequently, control the VVT mechanism based on an actual operation timing of the intake valve once the actual operation timing is detected or calculated in accordance with cranking.

[0026] In the control apparatus, the controller may be configured to retard the start of cranking and change the operation timing of the intake valve to a retard side by the VVT mechanism when a temperature of the internal combustion engine is equal to or higher than a predetermined temperature when starting up the internal combustion engine.

[0027] When the temperature state of the internal combustion engine is considerably high, there is a possibility that fuel remaining in an intake port or the like is sucked into a cylinder and self-ignites due to cranking. According to this configuration, by retarding cranking and retarding an operation timing of the intake valve in advance in such a high temperature state, cylinder filling efficiency and effective compression ratio can be reduced and self-ignition can be suppressed.

[0028] In a second aspect of the invention, a control method of an internal combustion engine includes storing an operation timing of an intake valve at engine shutdown as a shutdown-time operation timing, performing start-up control based on an

operation timing of the intake valve when the operation timing is detected or calculated at engine start-up, and performing start-up control based on the shutdown-time operation timing when the operation timing is not detected or calculated at engine start-up.

[0029] According to the invention, with an internal combustion engine including a VVT mechanism, even if an operation timing of an intake valve cannot be detected or calculated at start-up, a smooth start-up during which an abrupt increase in engine rotation is suppressed can be achieved while securing favorable engine start-up performance.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] 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 schematic configuration diagram showing an example of an internal combustion engine according to an embodiment of the invention;

FIG. 2 is a sectional view showing a configuration of a VVT mechanism according to the embodiment;

FIG. 3 is a sectional view taken along line III-III in FIG. 2;

FIG. 4 is a block diagram showing a configuration of a control system of the internal combustion engine according to the embodiment;

FIG. 5 is a flow chart showing an example of start-up control of the internal combustion engine that is executed by an electronic control unit (ECU) according to the embodiment;

FIG. 6A is an explanatory diagram showing an example of a characteristic chart related to start-up control according to the embodiment and shows a relationship between intake valve timing and filling efficiency;

FIG. 6B is an explanatory diagram showing an example of a characteristic chart related to start-up control according to the embodiment and shows a control map on which target values of a fuel injection amount are set in accordance with intake valve timing;

FIG. 6C is an explanatory diagram showing an example of a characteristic chart

related to start-up control according to the embodiment and shows a control map on which target values of an ignition timing are set in accordance with intake valve timing;

FIG. 7 is a timing chart showing an example of engine start-up control according to the embodiment;

5 FIG. 8 is a diagram comparable to FIG. 5 according to a modification in which a VVT mechanism is activated at start-up;

FIG. 9 is an explanatory diagram showing an example of a control map used in VVT control according to the modification; and

FIG. 10 is a diagram comparable to FIG. 7 according to the modification.

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DETAILED DESCRIPTION OF EMBODIMENTS

[0031] Hereinafter, embodiments of this invention will be described with reference to the drawings.

[0032] An internal combustion engine (hereinafter, also referred to as an engine) 15 according to an embodiment of the invention will be described with reference to FIG. 1. An engine 1 according to the embodiment is a 4-cylinder gasoline engine mounted on a vehicle. In the engine 1, a vertically-reciprocating piston 1c is housed inside each of four cylinders (only one cylinder is shown in FIG. 1) formed inside a cylinder block 1a. A water jacket is formed in the cylinder block 1a so as to enclose the four cylinders. A 20 engine coolant temperature sensor 32 is arranged in the water jacket so as to detect a temperature of engine cooling water (a coolant).

[0033] Reciprocating motions of the pistons 1c in the four cylinders are respectively converted into a rotation of a crankshaft 15 via a connecting rod 16. The crankshaft 15 is coupled to a transmission (not shown) via a torque converter (or a clutch) 25 or the like. Accordingly, output of the engine 1 is transmitted to drive wheels of the vehicle via the transmission. For example, the transmission may be a multistage automatic transmission, a belt-type continuously variable transmission, or the like.

[0034] A starter motor 10 activated at start-up of the engine 1 can be coupled to the crankshaft 15. The starter motor 10 is capable of forcibly rotating (cranking) the

crankshaft 15. A signal rotor 17 is attached to the crankshaft 15. An outer circumferential surface of the signal rotor 17 is provided with a plurality of teeth (protrusions) 17a at regular angular intervals as well as toothless portions 17b corresponding to two missing teeth 17a.

5 **[0035]** A crank position sensor 31 which detects a crank angle is arranged in a lateral vicinity of the signal rotor 17. The crank position sensor 31 is, for example, an electromagnetic pickup and generates a pulsed signal corresponding to the teeth 17a of the signal rotor 17 when the crankshaft 15 rotates. An engine rotation speed N_e can be calculated from a pulse signal of the crank position sensor 31.

10 **[0036]** An oil pan 18 that stores lubricating oil (engine oil) is provided in a lower part of the cylinder block 1a so as to cover the crankshaft 15. The lubricating oil stored in the oil pan 18 is pumped up by an oil pump (not shown) during operation of the engine 1. The lubricating oil pumped up in this manner is supplied to various parts of the engine including the pistons 1c, the crankshaft 15, and the connecting rod 16 and is used for
15 lubrication, cooling, and the like of the various parts.

[0037] A cylinder head 1b is fastened to an upper end of the cylinder block 1a. A combustion chamber 1d whose capacity varies in accordance with the reciprocating motion of the piston 1c is formed in each cylinder in the cylinder block 1a whose upper end is closed by the cylinder head 1b. A spark plug 3 is arranged at a position facing the
20 combustion chamber 1d for each cylinder on the cylinder head 1b. Ignition timings of the spark plugs 3 are adjusted by an igniter 4. The igniter 4 is controlled by an electronic control unit (ECU) 200 (can be regarded as a controller of the invention).

[0038] An intake passage 11 and an exhaust passage 12 are respectively communicated with the combustion chamber 1d to respectively perform intake of fresh air
25 and discharge of combustion gas. A downstream side of the intake passage 11 (a downstream side of an intake flow) is constituted by an intake port 11a and an intake manifold 11b, and a surge tank 11c is arranged on an upstream side of the intake port 11a and the intake manifold 11b. An air cleaner 7, a hot-wire air flow meter 33, an intake air temperature sensor 34, a throttle valve 5, and the like are arranged in the intake passage 11.

The air cleaner 7 filters intake air. In this embodiment, the intake air temperature sensor 34 is built into, for example, the air flow meter 33. The throttle valve 5 adjusts an intake air amount of the engine 1.

[0039] In this embodiment, for example, the throttle valve 5 is provided on an upstream side of the surge tank 11c and is driven by a throttle motor 6. An opening amount of the throttle valve 5 is detected by a throttle opening amount sensor 35. An opening amount of the throttle valve 5 is feedback-controlled by the ECU 200 so that an optimum intake air amount in accordance with an operation state of the engine 1 is attained.

[0040] An injector (a fuel injection valve) 2 is arranged in the intake port 11a of each cylinder. The injectors 2 are connected to a common delivery pipe 101, and fuel is supplied to the injectors 2 from a fuel supply system 100. In this embodiment, for example, the fuel supply system 100 includes a fuel supply pipe 102 connected to the delivery pipe 101, a fuel pump 103, a fuel tank 104, and the like.

[0041] The injector 2 is controlled by the ECU 200 and fuel injection is performed at a predetermined timing for each cylinder. Fuel injected into the intake port 11a from the injector 2 is mixed with intake air and is introduced into the combustion chamber 1d in each cylinder when an intake valve 13 is opened. The air-fuel mixture is ignited by the spark plug 3 and combusts and explodes in a final stage of a compression stroke of a cylinder. After high-temperature high-pressure combustion gas pushes down the piston 1c, the air-fuel mixture is discharged to the exhaust passage 12 when an exhaust valve 14 is opened.

[0042] An upstream side of the exhaust passage 12 (an upstream side of an exhaust flow) is constituted by an exhaust port 12a and an exhaust manifold 12b, and a three-way catalyst 8 is arranged on a downstream side of the exhaust port 12a and the exhaust manifold 12b. In the three-way catalyst 8, oxidation of CO and HC and reduction of NO_x in the exhaust gas discharged into the exhaust passage 12 are performed to purify the exhaust gas by producing CO₂, H₂O, and N₂ from the CO, HC, and NO_x.

[0043] A front air-fuel ratio sensor 37 that has, for example, linear characteristics

with respect to an air-fuel ratio is arranged in the exhaust passage 12 on an upstream side of the three-way catalyst 8. Meanwhile, a rear O₂ sensor 38 that is constituted by, for example, a lambda sensor is arranged in the exhaust passage 12 on a downstream side. Output signals of the front air-fuel ratio sensor 37 and the rear O₂ sensor 38 are fed back to the ECU 200 and used to control the air-fuel ratio.

[0044] The intake and discharge of air to/from the combustion chamber 1d described above are performed by opening/closing operations of the intake valve 13 and the exhaust valve 14. Specifically, the intake valve 13 is provided between the intake port 11a and the combustion chamber 1d. The exhaust valve 14 is provided between the exhaust port 12a and the combustion chamber 1d. Due to respective intake and exhaust cam shafts 21 and 22 that are rotated by the crankshaft 15 via a timing chain or the like, the intake valve 13 and the exhaust valve 14 are respectively opened and closed at predetermined timings.

[0045] More specifically, the intake and exhaust cam shafts 21 and 22 respectively rotate at 1/2 rotation speed of the crankshaft 15 and make one rotation as the piston 1c makes two reciprocations. In other words, during two rotations (a 720-degree rotation) of the crankshaft 15 in which the piston 1c performs the respective strokes of intake, compression, expansion, and exhaust, the respective cam shafts 21 and 22 rotate once to open the intake valve 13 in an intake stroke and open the exhaust valve 14 in an exhaust stroke of respective cylinders thereof.

[0046] A cam position sensor 39 is provided in a vicinity of the intake cam shaft 21 that rotates in this manner so as to generate a pulse-like signal when the piston 1c of a specific cylinder (for example, a first cylinder) reaches a compression top dead center (TDC). The cam position sensor 39 is constituted by an electromagnetic pickup in a similar manner to the crank position sensor 31. Therefore, the cam position sensor 39 outputs a pulse signal when a single tooth (not shown) on a rotor outer circumference of the intake cam shaft 21 passes by.

[0047] In this embodiment, an electric variable valve mechanism (hereinafter, abbreviated as a VVT mechanism) 40 to be described below is attached to the intake cam

shaft 21. By activating the VVT mechanism 40, a rotational phase of the intake cam shaft 21 which uses a rotation of the crankshaft 15 as a reference is continuously varied. Accordingly, a timing at which the intake valve 13 is opened or closed (hereinafter, also referred to as an intake valve timing) can be continuously varied toward an advance side or
5 a retard side.

[0048] As shown in FIGS. 2 and 3, the VVT mechanism 40 (not shown in FIG. 1) is arranged on an end portion of the intake cam shaft 21. FIG. 2 is a sectional view showing an internal structure of the VVT mechanism 40. FIG. 3 is a sectional view taken along line III-III in FIG. 2. A similar VVT mechanism may also be provided on the
10 exhaust cam shaft 22.

[0049] In the example shown in FIGS. 2 and 3, the VVT mechanism 40 is driven by an electric motor 42 (hereinafter, simply referred to as a motor) that is controlled by the ECU 200. As shown in FIG. 2, the electric motor 42 is a three-phase motor that is constituted by a motor shaft 44, bearings 46, a rotation speed sensor 47, a stator 50, and the
15 like. The motor shaft 44 is supported by two bearings 46, 46 and is rotatable around an axis O. A disk-like rotor portion 45 that protrudes radially outward is fixed to the motor shaft 44. A plurality of magnets 45a are embedded in an outer circumferential wall of the rotor portion 45.

[0050] The stator 50 is arranged on an outer circumferential side of the motor shaft 44. The stator 50 includes a plurality of coils which are arranged at equal intervals
20 around the axis O of the motor shaft 44. The coils are made by winding a winding 52 around a core 51. When a current supplied from a drive circuit 108 flows through the coils, a rotating magnetic field is formed on the outer circumferential side of the motor shaft 44 and a rotary torque is generated. The rotation speed sensor 47 is arranged in a
25 vicinity of the rotor portion 45 and senses an intensity of a magnetic field formed by each magnet 45a. Accordingly, the rotation speed sensor 47 detects a rotation speed of the motor shaft 44 (hereinafter, referred to as a motor rotation speed).

[0051] As shown in FIG. 3 in addition to FIG. 2, the VVT mechanism 40 includes a phase change mechanism 60. The phase change mechanism 60 includes a sprocket 62,

a ring gear 63, an eccentric shaft 64, a planetary gear 65, an output shaft 66, and the like. The sprocket 62 is coaxially provided on an outer circumferential side of the output shaft 66. The sprocket 62 is relatively rotatable around the same axis O as the motor shaft 44 with respect to the output shaft 66.

5 **[0052]** When a rotation of the crankshaft 15 is transmitted to the sprocket 62 by a chain or the like, the sprocket 62 rotates clockwise in FIG. 3 around the axis O while maintaining a rotational phase with respect to the crankshaft 15. The ring gear 63 is constituted by an internal gear and is coaxially fixed on an inner circumferential wall of the sprocket 62, and integrally rotates with the sprocket 62.

10 **[0053]** The eccentric shaft 64 is eccentrically arranged with respect to the axis O by being coupled and fixed to the motor shaft 44, and integrally rotates with the motor shaft 44. The planetary gear 65 is an external gear and is arranged on an inner circumferential side of the ring gear 63 so as to mesh with the ring gear 63 and to be capable of planetary movement. The planetary gear 65 that is coaxially supported on an
15 outer circumferential wall of the eccentric shaft 64 is relatively rotatable around an eccentric axis P with respect to the eccentric shaft 64.

[0054] The output shaft 66 is coaxially fixed to the intake cam shaft 21 by a bolt. The output shaft 66 integrally rotates with the intake cam shaft 21 around the same axis O as the motor shaft 44. An annular plate-like engagement portion 67 centered on the axis
20 O is formed on the output shaft 66. A plurality of engagement holes 68 are provided at equal intervals on the engagement portion 67 around the axis O. A plurality of engagement protrusions 69 are provided at equal intervals on the planetary gear 65 around the eccentric axis P so as to oppose the engagement holes 68. Each of the engagement protrusions 69 protrudes toward the shaft 66 and penetrates a corresponding engagement
25 hole 68.

[0055] In the VVT mechanism 40 structured as described above, when the motor shaft 44 does not relatively rotate with respect to the sprocket 62, a rotation of the crankshaft 15 causes the planetary gear 65 to integrally rotate clockwise in FIG. 3 with the sprocket 62 while maintaining a meshing position with the ring gear 63. At this point,

since the engagement protrusion 69 pushes an inner circumferential wall of the engagement hole 68 in a direction of rotation, the output shaft 66 rotates clockwise in FIG. 3 without relatively rotating with respect to the sprocket 62. Accordingly, a rotational phase of the intake cam shaft 21 with respect to the crankshaft 15 is maintained.

5 **[0056]** On the other hand, when the motor shaft 44 relatively rotates counter-clockwise in FIG. 3 with respect to the sprocket 62, due to a planetary movement of the planetary gear 65, the planetary gear 65 changes a meshing position with the ring gear 63 while relatively rotating clockwise in FIG. 3 with respect to the eccentric shaft 64. At this point, since a force with which the engagement protrusion 69 pushes the engagement hole 68 in the direction of rotation increases, the output shaft 66 advances with respect to the sprocket 62. Accordingly, the rotational phase of the intake cam shaft 21 changes to an advance side.

15 **[0057]** Conversely, when the motor shaft 44 relatively rotates clockwise in FIG. 3 with respect to the sprocket 62, due to a planetary movement of the planetary gear 65, the planetary gear 65 changes a meshing position with the ring gear 63 while relatively rotating counter-clockwise in FIG. 3 with respect to the eccentric shaft 64. At this point, since the engagement protrusion 69 pushes the engagement hole 68 in a counter-rotation direction, the output shaft 66 is retarded with respect to the sprocket 62. Accordingly, the rotational phase of the intake cam shaft 21 changes to a retard side.

20 **[0058]** Next, the ECU 200 will be described. As shown in FIG. 4, the ECU 200 includes a central processing unit (CPU) 201, a read only memory (ROM) 202, a random access memory (RAM) 203, a backup RAM 204, and the like.

25 **[0059]** The ROM 202 stores various control programs, maps which are referenced when the various control programs are executed, and the like. The CPU 201 executes various arithmetic processing based on the various control programs and the maps stored in the ROM 202. The RAM 203 is a memory which temporarily stores the result of computations by the CPU 201, data input from the respective sensors, and the like. The backup RAM 204 is a non-volatile memory that stores data and the like which must be stored when, for example, the engine 1 is shut down.

[0060] The CPU 201, the ROM 202, the RAM 203, and the backup RAM 204 are connected to one another via a bus 207 and are connected to an input interface 205 and an output interface 206.

[0061] Various sensors including the crank position sensor 31, the engine coolant temperature sensor 32, the air flow meter 33, the intake air temperature sensor 34, the throttle opening amount sensor 35, an accelerator depression amount sensor 36, the front air-fuel ratio sensor 37, the rear O₂ sensor 38, and the cam position sensor 39 are connected to the input interface 205. The accelerator depression amount sensor 36 outputs a detection signal in accordance with a depression amount of an accelerator pedal.

[0062] In addition, an ignition switch 48 and a starter switch 49 are connected to the input interface 205. The ignition switch 48 turns on and off a main power supply of the vehicle. The starter switch 49 is used by a passenger of the vehicle to perform operations related to start-up of the engine 1. When an ON operation of the ignition switch 48 is performed, control of the engine 1 is started by the ECU 200. When an ON operation of the starter switch 49 is performed, cranking of the engine 1 is started by the starter motor 10.

[0063] For example, the injectors 2 of each of the cylinders, the igniter 4 of the spark plug 3 of each of the cylinders, the throttle motor 6 of the throttle valve 5, the starter motor 10, the VVT mechanism 40 of the intake cam shaft 21, and the like are connected to the output interface 206.

[0064] Based on signals from the various sensors and switches described above, the ECU 200 executes various controls of the engine 1 including drive control of the injector 2 (control of injection amount and injection timing of fuel), control of ignition timing by the spark plugs 3, drive control of the throttle motor 6 (control of the opening amount of the throttle), and control of the VVT mechanism 40 or, in other words, control of an intake valve timing. Furthermore, the ECU 200 executes engine start-up control as described below.

[0065] The control apparatus of an internal combustion engine according to this embodiment is realized by a program related to the following engine start-up control that is

executed by the ECU 200. More specifically, the CPU 201, the ROM 202, the RAM 203, and the like of the ECU 200 correspond to start-up control means, and the backup RAM 204 of the ECU 200 corresponds to storage means.

[0066] Engine start-up control will be described below. The engine 1 according to this embodiment is configured to activate the VVT mechanism 40 to a predetermined target position at engine shutdown so that an intake valve timing at next engine start-up is a suitable intake valve timing. However, there is a possibility that, for some reason or other, the intake valve timing at engine start-up may not be the suitable intake valve timing due to the VVT mechanism 40 not reaching the target position or the VVT mechanism 40 is inadvertently activated before a subsequent engine start-up and deviates from the target position.

[0067] At this point, when start-up control is performed on the assumption that the VVT mechanism 40 is at the target position, for example, there is a possibility that fuel whose volume corresponds to a target value (which corresponds to the target position of the VVT mechanism 40) is injected even though the cylinder filling efficiency is lower than the target value. In this case, a low volume of air and an excessively large amount of fuel in the cylinder may possibly combine to impair start-up performance. Conversely, when the filling efficiency is high, there is a possibility that an excessive and abrupt increase in engine rotation may occur and cause discomfort to a passenger.

[0068] An actual position of the VVT mechanism 40 or, in other words, the intake valve timing can be calculated based on detection of an omission of a pulse signal corresponding to the toothless portions 17b of the signal rotor 17 from a signal of the crank position sensor 31 and on an input of a pulse signal from the cam position sensor 39.

[0069] However, even when cranking is started at engine start-up, there is a possibility that a pulse signal from the cam position sensor 39 is not immediately input. In some cases, there is a possibility that the intake valve timing cannot be calculated until the crankshaft 15 rotates at least two times.

[0070] In consideration thereof, in this embodiment, the intake valve timing is calculated in advance before the crankshaft 15 that rotates due to inertia comes to a stop at

engine shutdown. The calculated intake valve timing is stored in the backup RAM 204 as a shutdown-time timing (a shutdown-time operation timing). At engine start-up, start-up control is initially performed based on the stored shutdown-time timing. Subsequently, when an actual intake valve timing becomes calculable in accordance with cranking, start-up control is performed based on the actual intake valve timing.

[0071] Hereinafter, an example of engine start-up control such as that shown above will be described with reference to the flow chart in FIG. 5. The illustrated start-up control routine is started (start) when an ON operation of the ignition switch 48 is performed (IG-SW ON). In step ST101, first, using an intake valve timing (shutdown-time timing) stored at a previous engine shutdown, target values of a fuel injection amount and an ignition timing corresponding to a filling efficiency due to the intake valve timing are calculated.

[0072] With the intake valve timing upon engine startup according to this embodiment, basically, a timing at which the intake valve 13 closes is set on a retard side. As in the example represented by the characteristic chart shown in FIG. 6A, when the intake valve timing is advanced by the VVT mechanism 40, a degree of late closing of the intake valve 13 declines and the cylinder filling efficiency increases. Conversely, when the intake valve timing is retarded, the filling efficiency gradually declines.

[0073] In consideration of the relationship described above, in this embodiment, the fuel injection amount is set so as to increase as the intake valve timing is set further to the advance side and to gradually decrease as the intake valve timing changes to the retard side as in the example represented by the control map shown in FIG. 6B. In other words, by injecting an appropriate amount of fuel that matches the amount of air filled in the cylinder, an air-fuel ratio of the air-fuel mixture can be made preferable for start-up and start-up performance can be secured.

[0074] Meanwhile, as far as ignition timing is concerned, the further the intake valve timing is on the advance side, the more the ignition timing is retarded as in the example represented by the control map shown in FIG. 6C. On the other hand, the ignition timing is gradually advanced when the intake valve timing changes to the retard

side. This retardation control of the ignition timing is performed in order to suppress an excessive and abrupt increase in engine rotation when the cylinder filling efficiency is high.

[0075] The control maps shown in FIGS. 6B and 6C are both map representations of adaptation values of a preferable fuel injection amount and a preferable ignition timing that are adapted by an experiment, a calculation, or the like so as to correspond to the cylinder filling efficiency and are stored in the ROM 202 of the ECU 200. Moreover, the maps are not restrictive and the fuel injection amount and the ignition timing may be set by further taking various conditions (engine coolant temperature, intake air temperature, and the like) at engine startup into consideration.

[0076] In step ST102 following step ST101, a determination is made on whether or not an ON operation of the starter switch 49 has been performed (starter SW ON?). In ST102, the routine stands by in case of a negative determination (NO) and proceeds to step ST103 in case of a positive determination (YES). In ST103, the starter motor 10 is activated to start cranking of the engine 1. Subsequently, in step ST104, control of fuel injection by the injector 2 and control of ignition by the spark plugs 3 are started in sequence from a predetermined cylinder.

[0077] Next, in step ST105, a determination is made on whether or not an actual intake valve timing can be calculated from signals of the crank position sensor 31 and the cam position sensor 39. In ST105, the routine stands by when a negative determination (NO) is made and proceeds to step ST106 when a positive determination (YES) is made. In ST106, if the calculated intake valve timing is deviated from a target timing corresponding to a target position of the VVT mechanism 40, the VVT mechanism 40 is activated so that the calculated intake valve timing matches the target timing (activate VVT mechanism as needed).

[0078] Subsequently, in step ST107, based on the calculated intake valve timing, target values of the fuel injection amount and the ignition timing are calculated by referring to the control maps in FIGS. 6B and 6C and fuel injection control and ignition control are performed so that the target values are matched. In other words, start-up control is

switched so that a fuel injection amount and an ignition timing matching a filling efficiency corresponding to the calculated intake valve timing are attained.

[0079] In step ST108, a determination is made on whether or not an engine rotation speed N_e that is calculated from a signal of the crank position sensor 31 has reached a predetermined start-up completion determination value Th_{ne} (for example, 500 rpm: refer to FIG. 7). When a negative determination (NO) is made in ST108, the routine stands by. On the other hand, when the engine rotation speed N_e has reached the determination value Th_{ne} and a positive determination (YES) is made in ST108, the routine proceeds to step ST109. In ST109, activation of the starter motor 10 is shut down (starter off) and the start-up control routine is finished (end).

[0080] FIG. 7 shows variations in the engine rotation speed N_e , the intake valve timing, and the like in the start-up control described above. In the illustrated example, in the intake valve timing during shutdown of the engine 1 or, in other words, when the engine rotation speed $N_e = 0$, an actual intake valve timing that is depicted by a solid line deviates from a target timing that is depicted by a dashed line toward the advance side. In other words, a degree of late closing of the intake valve 13 is smaller and the cylinder filling efficiency exceeds a target value.

[0081] In this state, when an ON operation of the ignition switch 48 is performed, an ON operation of the starter switch 49 is performed shortly afterward, and cranking of the engine 1 due to activation of the starter motor 10 is started (time t_1), the engine rotation speed N_e increases up to a predetermined rotation speed (for example, around 200 rpm). In addition, although not shown, the four cylinders receive supply of fuel and are ignited in a predetermined order.

[0082] Due to the cranking, predetermined signals are input from the crank position sensor 31 and the cam position sensor 39 and an actual intake valve timing can be calculated (time t_2 : timing finalization flag OFF $\rightarrow$ ON). Since the actual intake valve timing (actual timing) is deviated from the target timing, the VVT mechanism 40 is activated in accordance with the deviation and the actual intake valve timing varies toward the retard side.

[0083] Since the actual intake valve timing is deviated from the target timing and the cylinder filling efficiency is higher than a target value, the fuel injection amount to each cylinder is corrected so as to increase and the air-fuel ratio of the air-fuel mixture attains a value at which favorable start-up performance can be obtained. On the other hand, the ignition timing is corrected so as to be retarded as illustrated in accordance with the deviation of the actual intake valve timing from the target timing. Therefore, even if the filling efficiency is high, an excessively high engine torque can be suppressed.

[0084] As a result, the engine rotation speed N_e that had risen at time t_3 does not excessively and abruptly increase as depicted by a two-dot dashed line in the diagram but, rather, rises smoothly as depicted by a solid line. In addition, due to activation of the VVT mechanism 40, the actual intake valve timing is gradually varied toward the retard side. Accordingly, in correspondence with a gradual decline in filling efficiency, the fuel injection amount to each cylinder is reduced and the ignition timing is gradually restored toward the advance side.

[0085] Subsequently, when the smoothly-risen engine rotation speed N_e reaches the determination value Th_{ne} (time t_4), activation of the starter motor 10 is shut down and the engine 1 starts self-rotation. At this point, the intake valve timing roughly matches the target timing and the fuel injection amount and the ignition timing also roughly match their original target values. Subsequently, the start-up control is finished and a transition is made to normal control in accordance with an operation state of the engine 1.

[0086] Therefore, with the control apparatus of the engine 1 according to this embodiment, start-up control is performed based on a shutdown-time timing stored at engine shutdown when an intake valve timing cannot be calculated at engine start-up. In addition, once the intake valve timing becomes calculable after cranking, start-up control is performed based on the calculated intake valve timing. As a result, even if the VVT mechanism 40 is deviated from a target position, a smooth start-up during which an abrupt increase in engine rotation is suppressed can be achieved while securing favorable start-up performance.

[0087] In other words, fuel is injected and supplied in a preferable amount that

matches an actual cylinder filling efficiency based on any of the shutdown-time timing and an intake valve timing calculated at start-up. At the same time, as far as a deviation of an actual filling efficiency from a target value is concerned, a resultant deviation in engine torque is corrected by controlling ignition timing. Accordingly, an excessive and abrupt increase in engine rotation can be suppressed while securing necessary engine torque.

[0088] In this embodiment, if the intake valve timing calculated at start-up is deviated from a target timing corresponding to a target position of the VVT mechanism 40, the VVT mechanism 40 is activated so that the calculated intake valve timing matches the target timing. Accordingly, the filling efficiency can also be brought closer to a target value and more preferable start-up control can be realized.

[0089] Next, a modification in which the VVT mechanism 40 is activated at start-up of the engine 1 in accordance with a temperature state of the engine 1 will be described. For example, in the case of a cold-engine start-up, favorably, the cylinder filling efficiency is increased to enhance combustion performance of the air-fuel mixture. On the other hand, in the case of a warm restart such as after an idle stop, there is a risk that an abrupt increase in engine rotation cannot be suppressed unless the filling efficiency is lowered.

[0090] An example of this modification is shown in FIG. 8. In FIG. 8, when an ON operation of the ignition switch 48 is performed (start: IG-SW ON), in step ST201, an engine coolant temperature and an intake air temperature are detected from respective output signals of the engine coolant temperature sensor 32 and the intake air temperature sensor 34. Subsequently, based on the shutdown-time timing, control of the VVT mechanism 40 is started in accordance with a temperature state of the engine 1.

[0091] In other words, for example, by referring to a control map such as that shown in FIG. 9, an intake valve timing at which a preferable filling efficiency is attained in accordance with the temperature state of the engine 1 is calculated. According to the control map shown in FIG. 9, the lower the engine coolant temperature or the intake air temperature, the filling efficiency is set higher by advancing the intake valve timing. On the other hand, the higher the engine coolant temperature or the intake air temperature, the

filling efficiency is set lower by retarding the intake valve timing.

[0092] Such a control map is a map representation of adaptation values of a preferable intake valve timing that are adapted by an experiment, a simulation, or the like so as to correspond to engine coolant temperature and intake air temperature, and are stored in the ROM 202 of the ECU 200. The VVT mechanism 40 is activated toward the advance side or the retard side in accordance with a deviation between a preferable intake valve timing calculated from the control map and the shutdown-time timing.

[0093] Subsequently, in step ST202, target values of a fuel injection amount and an ignition timing are calculated based on the shutdown-time timing in a similar manner to step ST101 in the flow shown in FIG. 5 according to the embodiment described above. In subsequent step ST203, a positive determination (YES) is made when an ON operation of the starter switch 49 has been performed and the routine proceeds to step ST204 and step ST205. In steps ST204 and ST205, cranking due to the starter motor 10 and controls of fuel injection and ignition timing are respectively started. On the other hand, when a negative determination (NO) is made in step ST203, the routine stands by.

[0094] In step ST206, a determination is made on whether or not an actual intake valve timing can be calculated in a similar manner to step ST105 in the flow shown in FIG. 5. In step ST206, the routine stands by when a negative determination (NO) is made and proceeds to step ST207 when a positive determination (YES) is made. In step ST207, the VVT control is executed based on the actual intake valve timing. In subsequent step ST208, control of fuel injection and ignition timing are performed. In other words, a switchover is made from start-up control based on the shutdown-time timing to start-up control based on an actual intake valve timing.

[0095] Subsequent steps ST209 and ST210 are similar to steps ST108 and ST109 in the flow shown in FIG. 5. In other words, when a negative determination (NO) is made in ST209, the routine stands by. On the other hand, when the engine rotation speed N_e has reached the start-up completion determination value Th_{ne} and a positive determination (YES) is made in ST209, the routine proceeds to step ST210. In ST210, activation of the starter motor 10 is shut down and the start-up control routine is finished (end).

[0096] With the start-up control according to the modification described above, as in the example shown in FIG. 10, the VVT mechanism 40 is activated in accordance with an ON operation of the ignition switch 48 (time t1). As shown in FIG. 10, an actual intake valve timing that is depicted by a solid line approximates a target timing which is depicted by a dashed line and which is preferable with respect to a temperature state of the engine 1. Since the VVT control is performed based on the shutdown-time timing, even if activation of the VVT mechanism 40 is shut down at time t2, a deviation remains between the actual timing and the target timing.

[0097] An ON operation of the starter switch 49 is performed in this state, and cranking of the engine 1 due to activation of the starter motor 10 is started at time t3. Accordingly, the engine rotation speed N_e rises to a predetermined rotation speed and controls of fuel injection to a cylinder and ignition of the cylinder are started. When the actual intake valve timing becomes calculable based on signals from the crank position sensor 31 and the cam position sensor 39 (time t4), the VVT mechanism 40 is once again activated in accordance with a deviation of the actual intake valve timing from the target timing.

[0098] At this point, since VVT control has already been performed in accordance with an ON operation of the ignition switch 48 and the deviation in the intake valve timing has been reduced, the actual timing promptly converges to the target timing at time t5 as shown in FIG. 10. In addition, since the filling efficiency is only slightly higher than the target valve, only a small increase in fuel injection amount is required and only a small retard correction amount of the ignition timing is required.

[0099] The engine rotation speed N_e having risen at time t6 rises smoothly without involving an abrupt increase. When the engine rotation speed N_e reaches the determination value Th_{ne} at time t7, activation of the starter motor 10 is shut down and a transition is made to normal control in accordance with the operation state of the engine 1.

[0100] According to this modification, in addition to the embodiment described earlier, the VVT mechanism 40 is controlled in accordance with a temperature state at start-up of the engine 1. Therefore, for example, at low temperature, the filling efficiency

can be increased to secure combustion performance of the air-fuel mixture. On the other hand, the filling efficiency can be reduced at high temperature to sufficiently suppress an abrupt increase in engine rotation. Therefore, both the securing of start-up performance and a smooth start-up of the engine 1 can be achieved while minimizing a decline in fuel economy due to an increase in the fuel injection amount or a retardation of the ignition timing.

[0101] In the modification, before an operation to start cranking is performed by a passenger of the vehicle, the VVT mechanism 40 is activated in accordance with, for example, an ON operation of the ignition switch 48. Accordingly, due to the control of the VVT mechanism 40, the intake valve timing can be converged to the target value as quickly as possible to attain a filling efficiency preferable for start-up.

[0102] The descriptions of the embodiment and the modification presented above are merely examples and are not intended to limit configurations, applications, and the like of the invention. For example, in the embodiment and the modification described above, as start-up control of the engine 1, controls of the fuel injection amount, the ignition timing, and the VVT mechanism 40 are performed based on a shutdown-time timing at an initial stage of start-up and are subsequently switched to controls based on a calculated intake valve timing. However, this configuration is not restrictive and controls may alternatively be performed as follows.

[0103] For example, during start-up control, only control of the fuel injection amount may be switched and the ignition timing and the VVT mechanism 40 may continue to be controlled based on the shutdown-time timing. Alternatively, the controls of the fuel injection amount and the ignition timing may be switched and the VVT mechanism 40 may continue to be controlled based on the shutdown-time timing.

[0104] In addition, switching between start-up control methods is not limited to switching when control is being executed. For example, start-up control may be performed based on the shutdown-time timing when an intake valve timing cannot be calculated at start-up of the engine 1, and once the intake valve timing becomes calculable, start-up control may be performed based on the calculated intake valve timing.

Alternatively, a configuration in which an intake valve timing is directly detected may be adopted.

[0105] While the VVT mechanism 40 is activated before the start of cranking in accordance with an ON operation of the ignition switch 48 in the modification described earlier, this configuration is not restrictive. For example, the VVT mechanism 40 may be activated at the same time as the start of cranking when a predetermined operation such as an operation of the starter switch 49 is performed.

[0106] Furthermore, for example, at restart in high temperature after idle stop, when the temperature of the engine 1 is significantly high and there is possibility that an abnormal combustion such as pre-ignition may occur, the VVT mechanism 40 may be activated by retarding the start of cranking. Accordingly, an abnormal combustion can be suppressed by changing the intake valve timing to a retard side prior to cranking and by sufficiently lowering cylinder filling efficiency and effective compression ratio.

[0107] Moreover, while an example in which the invention is applied to the port injection-type engine 1 has been described in the embodiment and the modification presented above, the invention is not limited thereto. For example, the invention can also be applied to a cylinder direct injection-type engine and to an engine including both port injection-type and cylinder injection-type fuel injection valves.

[0108] Moreover, while a case where the invention is applied to a four-cylinder engine has been described in the embodiment and the modification presented above, the invention is not limited thereto. The invention can also be applied to start-up control of an engine with another arbitrary number of cylinders such as a six-cylinder engine. Furthermore, in addition to start-up control of an in-line multi-cylinder engine, the invention can also be applied to start-up control of a V-type multi-cylinder engine.

[0109] This invention is applicable to an internal combustion engine (an engine) including a VVT mechanism and is capable of realizing a smooth start-up during which an abrupt increase in engine rotation is suppressed while securing favorable start-up performance. Therefore, the invention is particularly effective when mounted on a passenger vehicle or the like.

CLAIMS:

1. A control apparatus of an internal combustion engine comprising:

a variable valve timing mechanism that varies an operation timing of an intake valve,

and

a controller configured to store an operation timing of the intake valve at engine shutdown as a shutdown-time operation timing,

the controller being configured to perform start-up control based on an operation timing of the intake valve when the operation timing is detected or calculated at engine start-up, and

the controller being configured to perform start-up control based on the shutdown-time operation timing when the operation timing is not detected or calculated at engine start-up.

2. The control apparatus of an internal combustion engine according to claim 1,

wherein

the controller is configured to start start-up control of the internal combustion engine based on the shutdown-time operation timing and, subsequently, switch to start-up control of the internal combustion engine based on an actual operation timing of the intake valve once the actual operation timing is detected or calculated in accordance with cranking.

3. The control apparatus of an internal combustion engine according to claim 1 or 2,

wherein

the controller is configured to control a fuel injection amount based on any of the shutdown-time operation timing and the operation timing of the intake valve that is detected or calculated at engine start-up.

4. The control apparatus of an internal combustion engine according to any one of

claims 1 to 3, wherein

the controller is configured to control an ignition timing based on any of the shutdown-time operation timing and the operation timing of the intake valve that is detected or calculated at engine start-up.

5. The control apparatus of an internal combustion engine according to any one of claims 1 to 4, wherein

the controller is configured to control the variable valve timing mechanism based on any of the shutdown-time operation timing and the operation timing of the intake valve that is detected or calculated at engine start-up.

6. The control apparatus of an internal combustion engine according to claim 5, wherein

the controller is configured to control the variable valve timing mechanism in accordance with a temperature state of the internal combustion engine at engine start-up, advance the operation timing of the intake valve when the temperature of the internal combustion engine is low, and retard the operation timing of the intake valve when the temperature of the internal combustion engine is high.

7. The control apparatus of an internal combustion engine according to claim 6, wherein

the internal combustion engine is mounted on a vehicle, and

the controller is configured to start control of the variable valve timing mechanism in accordance with a predetermined operation performed by a passenger of the vehicle before an operation to start cranking is performed by the passenger at engine start-up.

8. The control apparatus of an internal combustion engine according to claim 7, wherein

the controller is configured to start control of the variable valve timing mechanism based on the shutdown-time operation timing of the intake valve in accordance with a

predetermined operation performed by the passenger and, subsequently, control the variable valve timing mechanism based on an actual operation timing of the intake valve once the actual operation timing is detected or calculated in accordance with cranking.

9. The control apparatus of an internal combustion engine according to any one of claims 1 to 8, wherein

the controller is configured to retard the start of cranking and change the operation timing of the intake valve to a retard side by the variable valve timing mechanism when a temperature of the internal combustion engine is equal to or higher than a predetermined temperature when starting up the internal combustion engine.

10. A control method of an internal combustion engine comprising:

storing an operation timing of an intake valve at engine shutdown as a shutdown-time operation timing;

performing start-up control based on an operation timing of the intake valve when the operation timing is detected or calculated at engine start-up; and

performing start-up control based on the shutdown-time operation timing when the operation timing is not detected or calculated at engine start-up.

FIG. 1

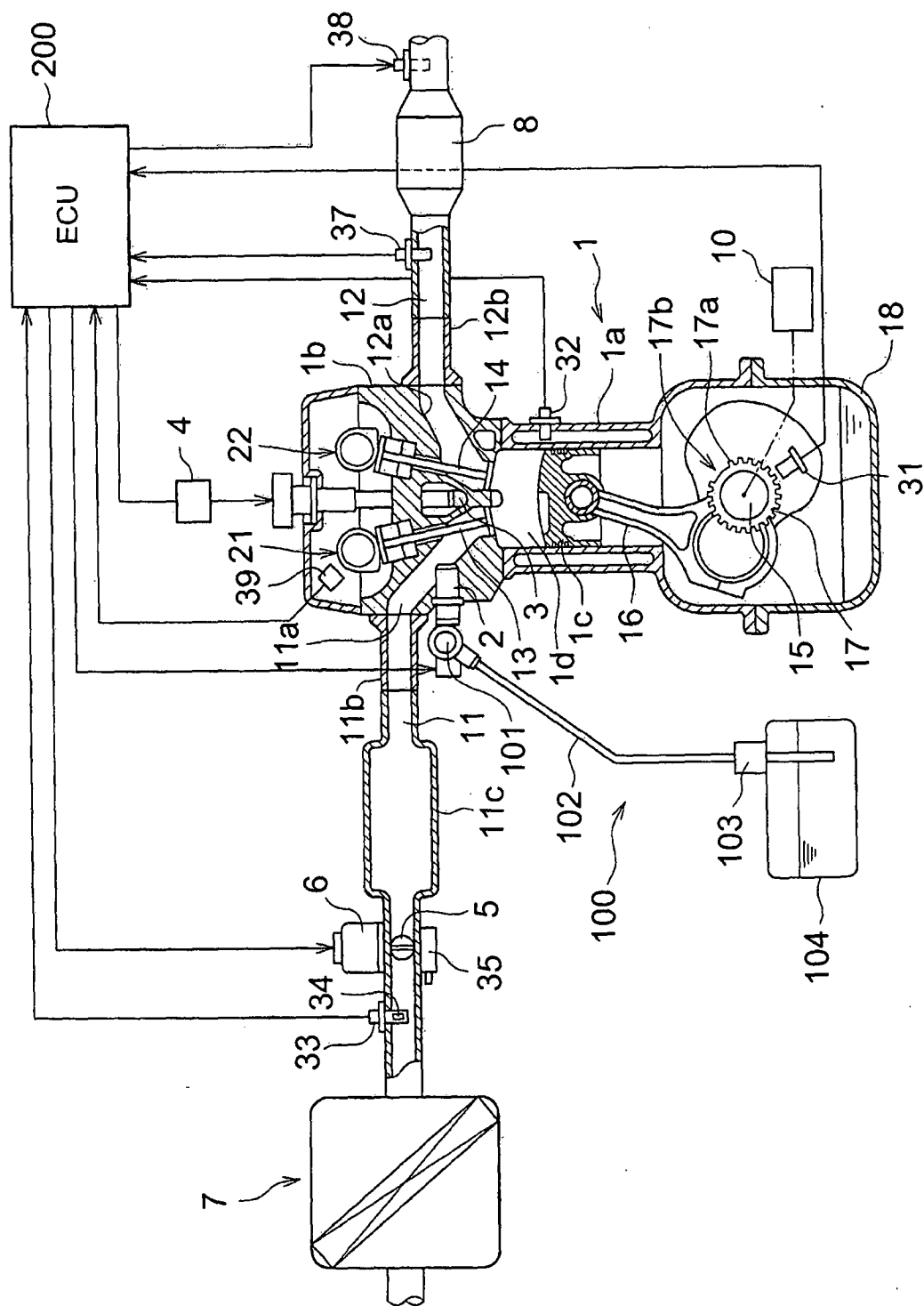


FIG. 2

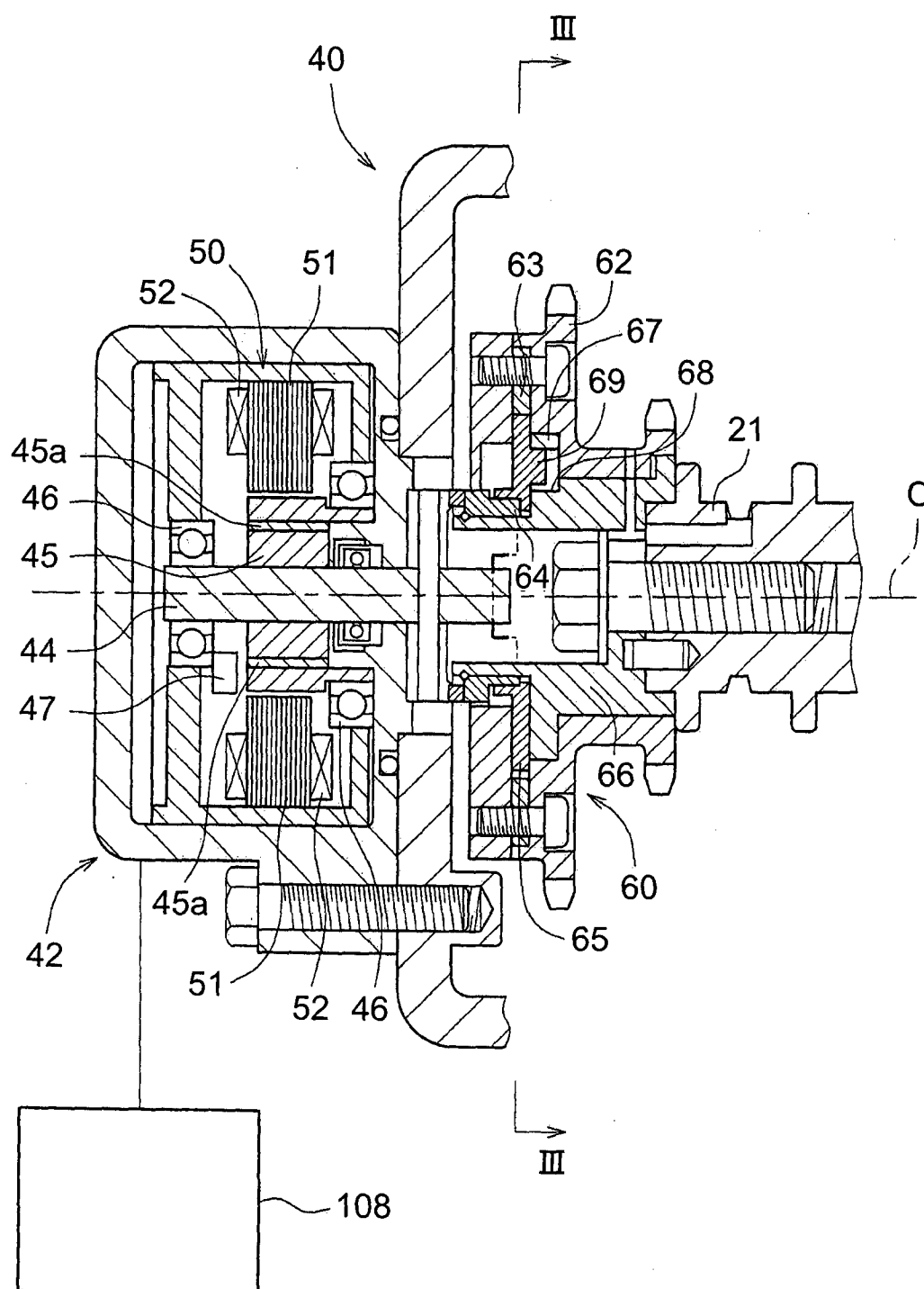


FIG. 3

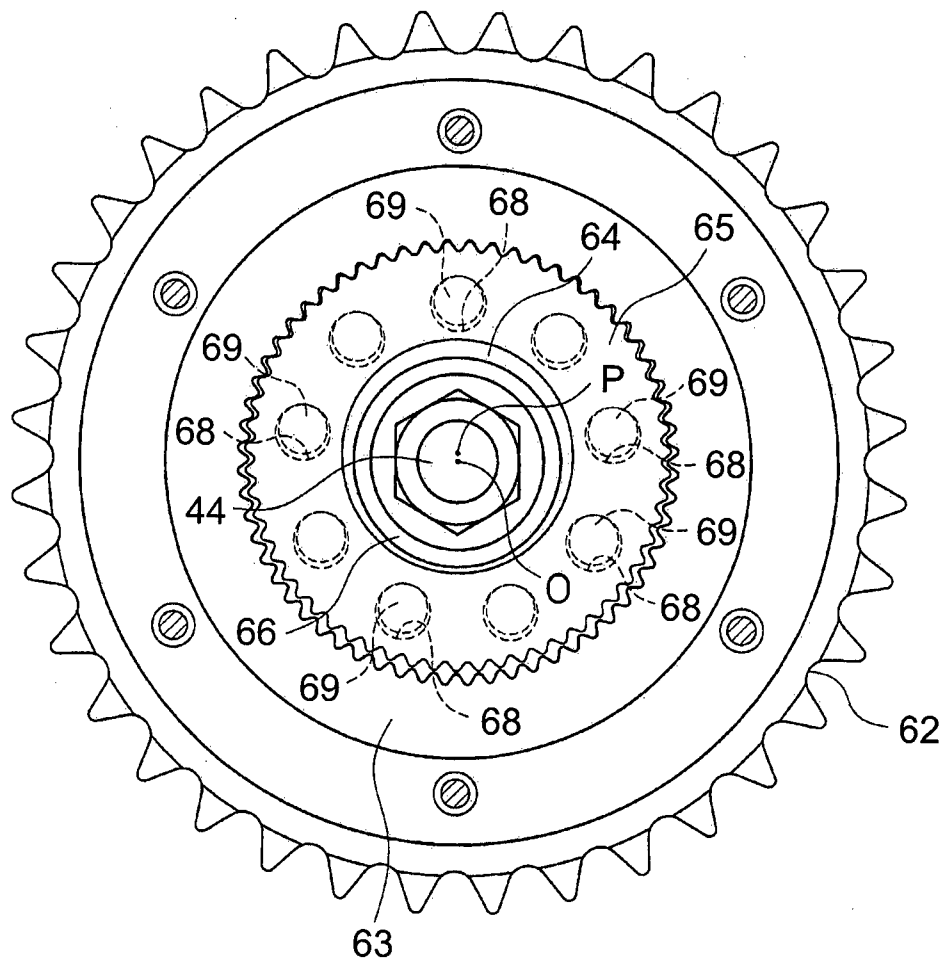


FIG. 4

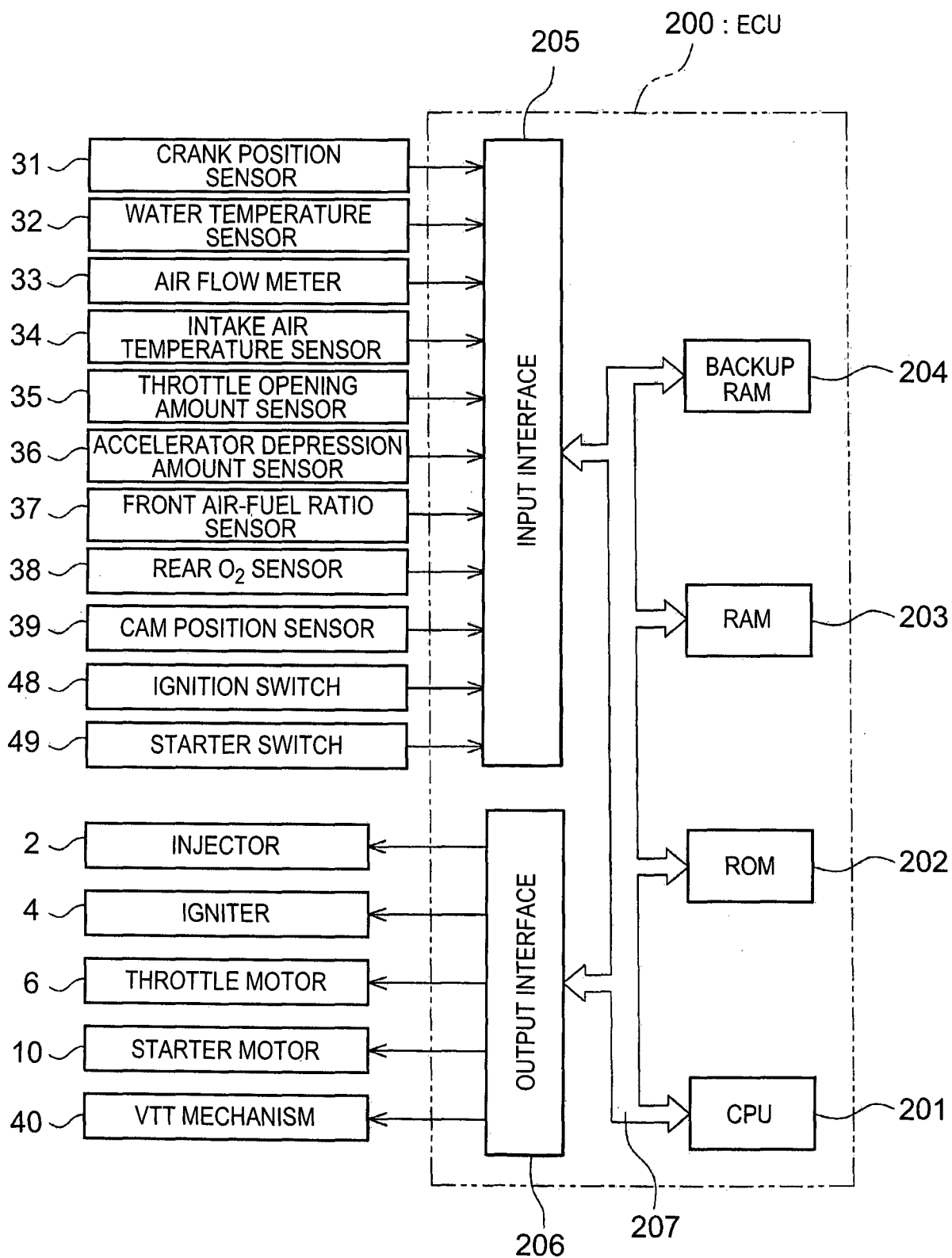


FIG. 5

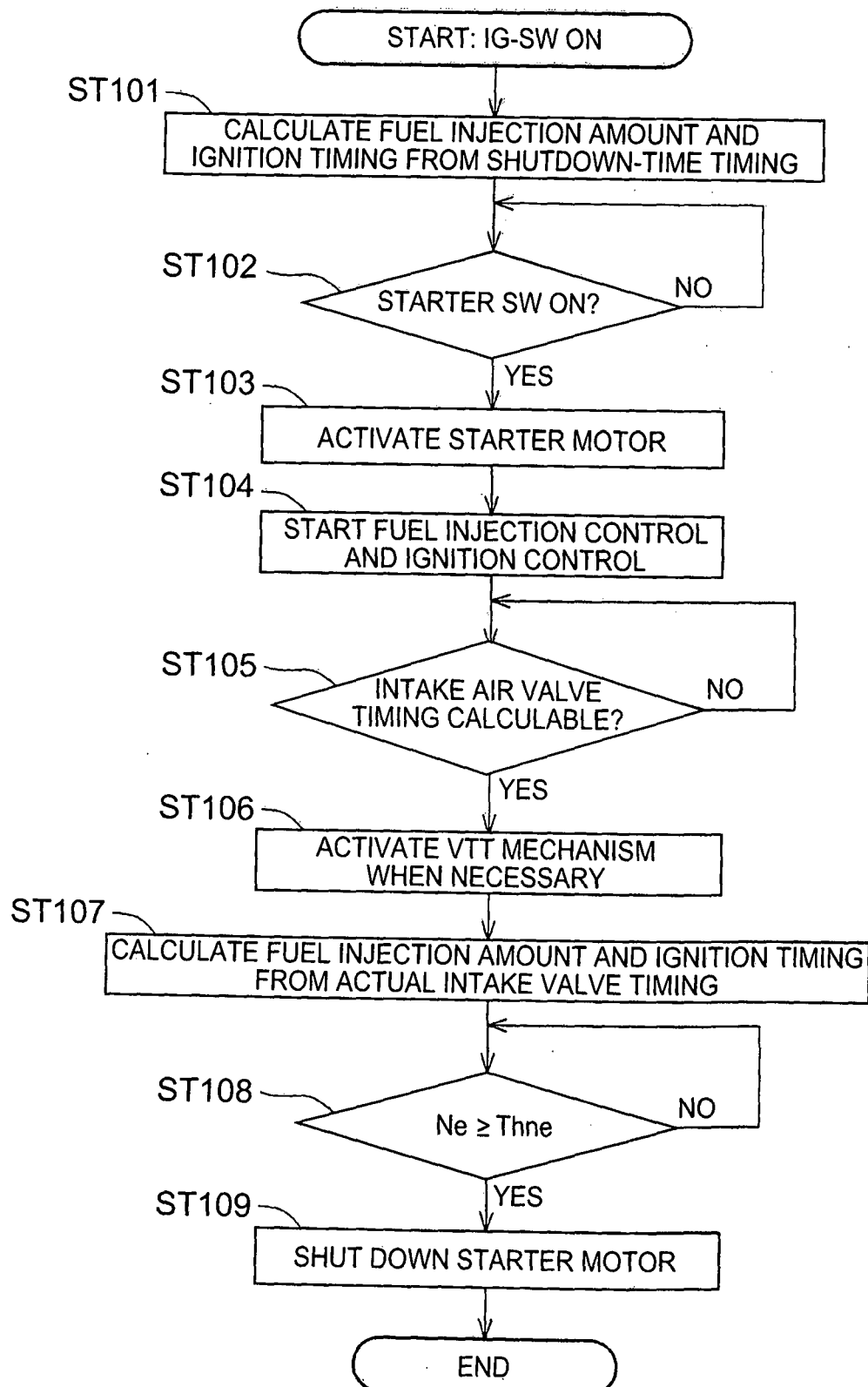


FIG. 6A

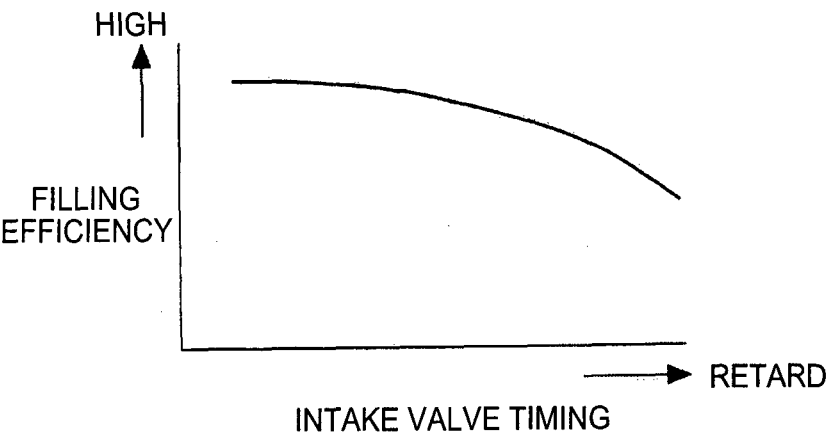


FIG. 6B

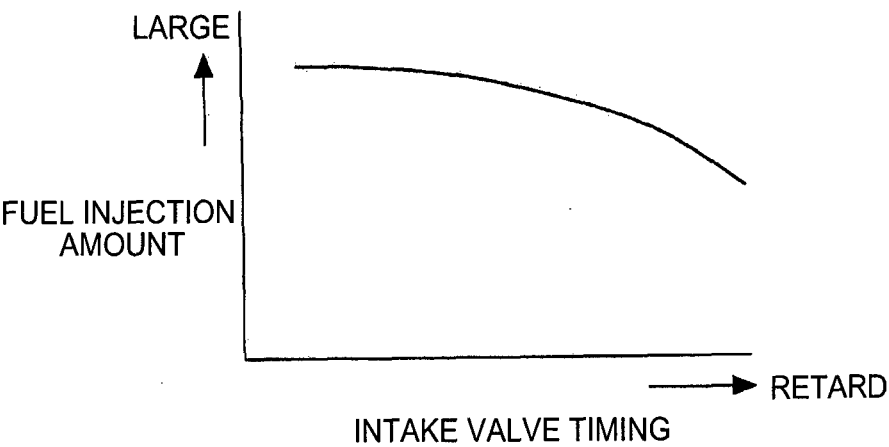


FIG. 6C

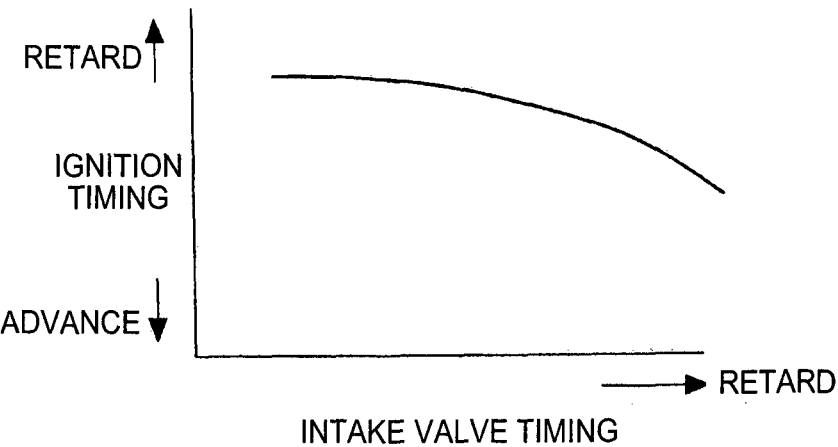


FIG. 7

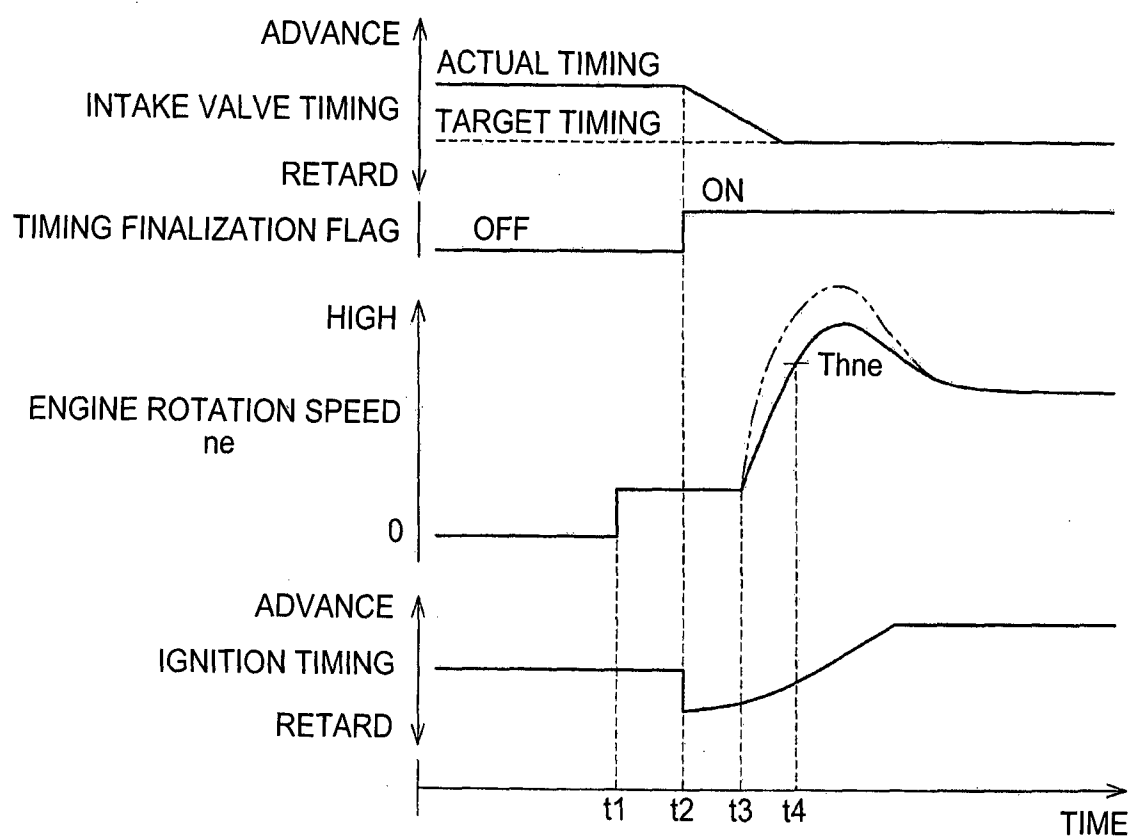


FIG. 8

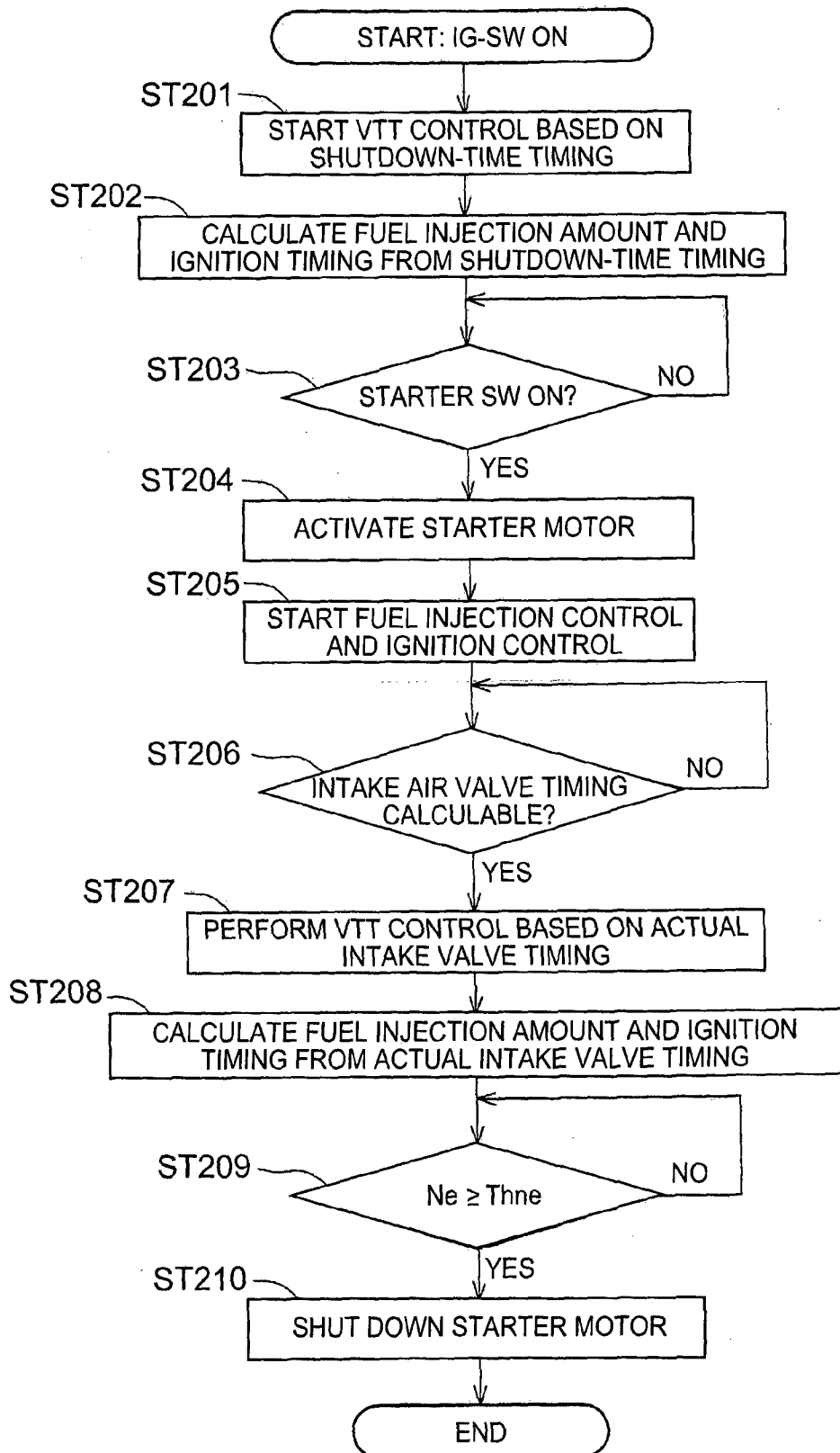


FIG. 9

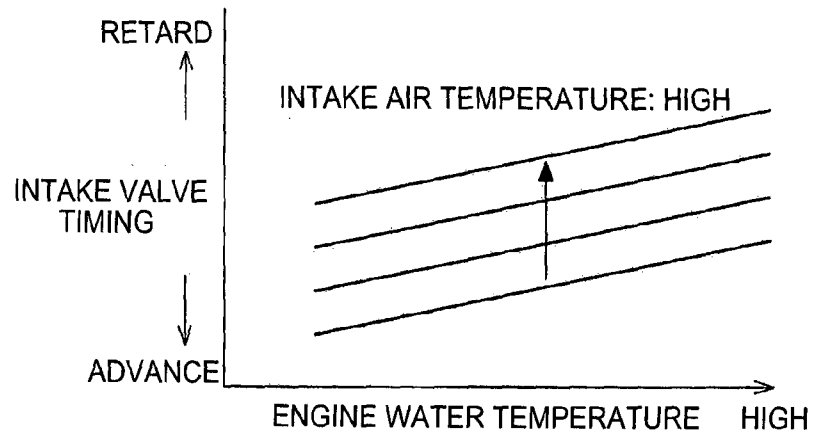
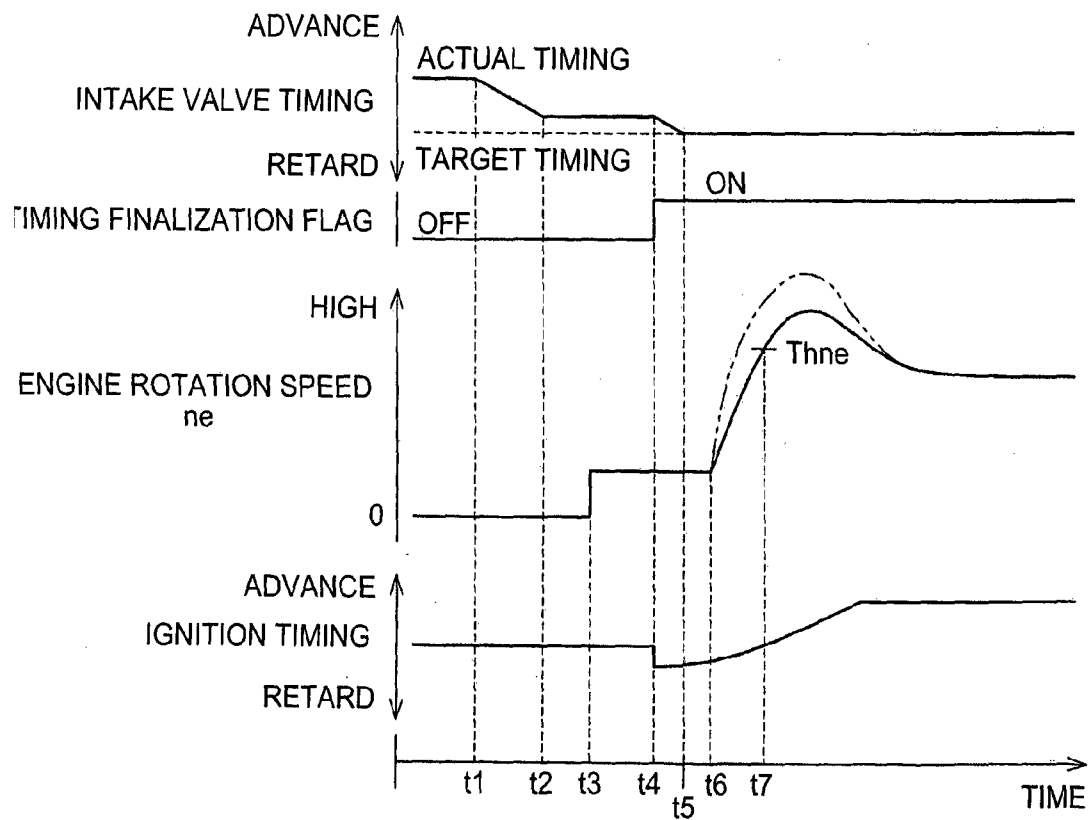


FIG. 10



INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2013/002415

A. CLASSIFICATION OF SUBJECT MATTER

INV. F02D41/06 F02D13/02
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F02D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Further documents are listed in the continuation of Box C.



See patent family annex.

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

10 March 2014

Date of mailing of the international search report

19/03/2014

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2013/002415

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Information on patent family members

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