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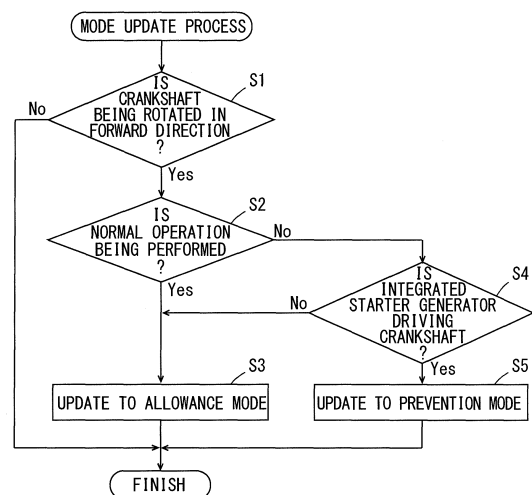
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(54) **ENGINE SYSTEM AND SADDLE-TYPE VEHICLE**

(57) A forward rotation positioning operation of rotating a crankshaft in a forward direction is performed before start-up of an engine, and a reverse rotation start-up operation of rotating the crankshaft in a reverse direction is performed during the start-up of the engine. In the forward rotation positioning operation, a rotation driver drives the crankshaft such that a crank angle reaches a predetermined reverse starting range. In the reverse rotation start-up operation, the rotation driver drives the crankshaft such that the crank angle exceeds a predetermined start-up intake range from the reverse rotation starting range and reaches a predetermined start-up ignition range, a fuel injection device injects fuel such that a fuel-air mixture is introduced into a combustion chamber from an intake passage through an intake port, when the crank angle is in the start-up intake range, and an ignition device ignites when the crank angle is in the start-up ignition range. Ignition performed by the ignition device is prevented during the forward rotation positioning operation.

FIG. 5



Description

[Technical Field]

[0001] The present invention relates to an engine system and a straddled vehicle that includes the engine system.

[Background Art]

[0002] In a straddled vehicle such as a motorcycle, during a start-up operation of an engine, a large torque is required in order for a crank angle to exceed an angle corresponding to a first compression top dead center. There is a technique for rotating a crankshaft in a reverse direction in order to increase startability of the engine.

[0003] In an engine system described in Patent Document 1, during start-up of the engine, a fuel-air mixture is introduced into a combustion chamber while a crankshaft is rotated in a reverse direction. With the fuel-air mixture in the combustion chamber being compressed by rotation of the crankshaft in the reverse rotation, the fuel-air mixture in the combustion chamber is ignited. Rotation of the crankshaft is driven in a forward direction by energy generated by combustion of the fuel-air mixture, and a torque of the crankshaft in the forward direction is increased.

[0004] Further, before the start-up of the engine, the crankshaft is rotated in the forward or reverse direction such that a crank angle is a predetermined angle. Thus, during the start-up of the engine, the crankshaft can be rotated in the reverse direction from a constant position.

[0005] [Patent Document 1] JP 2014-77405 A

[Summary of Invention]

[Technical Problem]

[0006] The inventors have discovered a problem that, in a case in which the above-mentioned positioning of the crankshaft is performed before the start-up of the engine, the engine performs an unintentional operation in response to output of a crank angle sensor during the positional operation and cannot appropriately adjust a crank angle.

[0007] An object of the present invention is to provide an engine system and a straddled vehicle in which a crank angle can be appropriately adjusted before start-up of an engine.

[Solution to Problem]

[0008]

(1) An engine system according to one aspect of the present invention includes an engine unit that includes an engine and a rotation driver, and a controller that controls the engine unit, wherein the en-

gine includes a fuel injection device arranged to inject fuel into an intake passage for leading air to a combustion chamber, an ignition device configured to ignite a fuel-air mixture in the combustion chamber, and a valve driver configured to drive each of an intake valve for opening and closing an intake port and an exhaust valve for opening and closing an exhaust port, the rotation driver is configured to drive rotation of a crankshaft in a forward or reverse direction, the controller controls the engine unit such that a forward rotation positioning operation of rotating the crankshaft is rotated in the forward direction is performed before start-up of the engine, and controls the engine unit such that a reverse rotation start-up operation of rotating the crankshaft in the reverse direction is performed during the start-up of the engine, the rotation driver drives the crankshaft such that a crank angle reaches a predetermined reverse positioning operation, and drives the crankshaft such that the crank angle exceeds a predetermined start-up intake range from the reverse rotation starting range and reaches a predetermined start-up ignition range, in the reverse rotation start-up operation, the valve driver drives the intake valve such that the intake port is opened when the crank angle is in the start-up intake range, in the reverse rotation start-up operation, the fuel injection device injects the fuel such that the fuel-air mixture is introduced into the combustion chamber from the intake passage through the intake port when the crank angle is in the start-up intake range, in the reverse rotation start-up operation, the ignition device ignites when the crank angle is in the start-up ignition range, in the reverse rotation start-up operation, and the controller prevents ignition by the ignition device during the forward rotation positioning operation.

In this engine system, the engine unit performs the forward rotation positioning operation before the start-up of the engine. In the forward rotation positioning operation, the crankshaft is rotated in the forward direction such that the crank angle reaches the reverse rotation starting range. In this case, the ignition by the ignition device is prevented, so that unintentional combustion of the fuel-air mixture in the engine in response to output of a crank angle sensor is prevented. Thus, the crank angle can be appropriately adjusted in the reverse rotation starting range.

Thereafter, the engine unit performs the reverse rotation start-up operation during the start-up of the engine. In this case, because the crankshaft is rotated in the reverse direction from a state in which the crank angle is in the reverse rotation starting range, the crank angle reliably goes through the start-up intake range. Therefore, the fuel-air mixture is appropriately introduced into the combustion chamber, and the combustion of the fuel-air mixture

can appropriately occur in the combustion chamber. Thus, a torque of the crankshaft in the forward direction is increased, and the crank angle can easily exceed the angle corresponding to the first compression top dead center.

(2) The controller may prevent injection of the fuel by the fuel injection device during the forward rotation positioning operation.

In this case, an occurrence of the combustion of the fuel-air mixture is prevented during the forward rotation positioning operation, and an adverse effect on a catalyst due to discharge of an uncombusted fuel-air mixture is prevented.

(3) The engine system may further include a main switch operated by a driver, wherein the controller may control the engine unit such that the forward rotation positioning operation is performed when the main switch is turned on.

In this case, the forward rotation positioning operation is appropriately performed before the start-up of the engine.

(4) The engine system may further include a starter switch operated by a driver, wherein the controller may control the engine unit such that the forward rotation positioning operation is performed when the starter switch is turned on.

In this case, the forward rotation positioning operation is appropriately performed before the start-up of the engine.

(5) the controller may control the engine unit such that operations of the fuel injection device and the ignition device are stopped and the forward rotation positioning operation is performed after rotation of the crankshaft is stopped, when a predetermined idling stop condition is satisfied, and may control the engine unit such that the reverse rotation start-up operation is performed, when a predetermined idling stop release condition is satisfied.

In this case, the engine is automatically stopped and restarted, and the forward rotation positioning operation is appropriately performed before the re-start of the engine.

(6) The controller does not have to prevent the ignition by the ignition device when the crankshaft is rotated in the forward direction without driving of the crankshaft by the rotation driver, before the start-up of the engine, and may prevent the ignition by the ignition device when the crankshaft is rotated in the forward direction by the driving of the crankshaft by the rotation driver, before the start-up of the engine. When the crankshaft is rotated in the forward direction by the start-up operation such as push start or kick start-up, the crankshaft is not driven by the rotation driver. On the other hand, when the crankshaft is rotated in the forward direction in the forward rotation start-up operation, the crankshaft is driven by the rotation driver. Therefore, presence and absence of the ignition by the ignition device can be appro-

priately controlled based on the presence and absence of the driving of the crankshaft by the rotation driver. Therefore, when the start-up operation such as the push start or the kick start-up occurs, it is possible to start the engine by appropriately combusting the fuel-air mixture while preventing an occurrence of the combustion of the fuel-air mixture during the forward rotation positioning operation without requiring the complicated configuration and control.

(7) The engine system may further include a kick starter, which a driver operates with his or her foot in order to rotate the crankshaft in the forward direction, wherein the controller does not have to prevent the ignition by the ignition device when the crankshaft is rotated in the forward direction by an operation of the kick starter by the driver.

In this case, it is possible to start the engine by appropriately combusting the fuel-air mixture at a time of an operation of the kick starter while an occurrence of the combustion of the fuel-air mixture is prevented during the forward rotation positioning operation.

(8) A straddled vehicle according to another aspect of the present invention includes a main body having a drive wheel, and an engine system, described above, that generates motive power for rotating the drive wheel.

[0009] In this straddled vehicle, the above-mentioned engine system is used, so that the crank angle can be appropriately adjusted in the reverse rotation starting range before the start-up of the engine.

[Advantageous Effects of Invention]

[0010] The present invention enables the crank angle to be appropriately adjusted before the start-up of the engine.

[Brief Description of Drawings]

[0011]

[FIG. 1] FIG. 1 is a schematic side view showing the schematic configuration of a motorcycle according to one embodiment of the present invention.

[FIG. 2] FIG. 2 is a schematic diagram for explaining the configuration of an engine system.

[FIG. 3] FIG. 3 is a diagram for explaining a normal operation of an engine unit.

[FIG. 4] FIG. 4 is a diagram for explaining a forward rotation positioning operation and a reverse rotation start-up operation of the engine unit.

[FIG. 5] FIG. 5 is a flow chart of a mode update process.

[FIG. 6] FIG. 6 is a flow chart for explaining an engine start-up process.

[FIG. 7] FIG. 7 is a flow chart for explaining the engine

start-up process.

[FIG. 8] FIG. 8 is a flow chart for explaining the engine start-up process.

[FIG. 9] FIG. 9 is a flow chart for explaining the engine start-up process.

[Description of Embodiments]

[0012] A motorcycle will be described below as one example of a straddled vehicle according to embodiments of the present invention with reference to drawings.

(1) Motorcycle

[0013] Fig. 1 is a schematic side view showing schematic configuration of the motorcycle according to one embodiment of the present invention. In the motorcycle 100 of Fig. 1, a front fork 2 is provided at the front of a vehicle body 1 to be swingable to the right and the left. A handle 4 is attached to the upper end of the front fork 2, and a front wheel 3 is attached to the lower end of the front fork 2 to be rotatable.

[0014] A seat 5 is provided at substantially the center of the upper portion of the vehicle body 1. An ECU (Engine Control Unit) 6 and an engine unit EU are provided below the seat 5. The engine unit EU includes a single-cylinder engine 10, for example. Further, in the engine unit EU, a kick pedal KP for starting the engine 10 is provided. An engine system 200 is constituted by the ECU 6, the engine unit EU and the kick pedal KP. A rear wheel 7 is attached to the lower portion of the rear end of the vehicle body 1 to be rotatable. Rotation of the rear wheel 7 is driven by motive power generated by the engine 10.

(2) Engine System

[0015] Fig. 2 is a schematic diagram for explaining the configuration of the engine system 200. As shown in Fig. 2, the engine unit EU includes the engine 10 and an integrated starter generator 14. The engine 10 includes a piston 11, a connecting rod 12, a crankshaft 13, an intake valve 15, an exhaust valve 16, a valve driver 17, an ignition plug 18 and an injector 19.

[0016] The piston 11 is provided to be reciprocable in a cylinder 31 and connected to the crankshaft 13 via the connecting rod 12. The reciprocating motion of the piston 11 is transformed into the rotational motion of the crankshaft 13. The integrated starter generator 14 is provided at the crankshaft 13. The integrated starter generator 14 is a generator having the function of a starter motor, drives the rotation of the crankshaft 13 in forward and reverse directions and generates electric power by the rotation of the crankshaft 13. The forward direction is a rotation direction of the crankshaft 13 during a normal operation of the engine 10, and the reverse direction is the opposite direction to the forward direction. The inte-

grated starter generator 14 directly transmits a torque to the crankshaft 13 without a reduction gear therebetween. The rotation of the crankshaft 13 in the forward direction is transmitted to the rear wheel 7, so that the rotation of the rear wheel 7 is driven.

[0017] The kick pedal KP is connected to the crankshaft 13. A driver operates the kick pedal KP with his or her foot, so that the crankshaft 13 is rotated in the forward direction. Hereinafter, start-up of the engine 10 by the operation of the kick pedal KP will be referred to as kick start-up.

[0018] A combustion chamber 31 a is formed on the piston 11. The combustion chamber 31a communicates with an intake passage 22 through an intake port 21 and communicates with an exhaust passage 24 through an exhaust port 23. The intake valve 15 is provided to open and close the intake port 21, and the exhaust valve 16 is provided to open and close the exhaust port 23. The intake valve 15 and the exhaust valve 16 are driven by the valve driver 17. A throttle valve TV for adjusting a flow rate of air from the outside is provided in the intake passage 22. The ignition plug 18 is configured to ignite a fuel-air mixture in the combustion chamber 31a. The injector 19 is configured to inject fuel into the intake passage 22.

[0019] The ECU 6 includes a CPU (Central Processing Unit) and a memory, for example. A microcomputer may be used instead of the CPU and the memory. A main switch 40, a starter switch 41, an intake pressure sensor 42, a crank angle sensor 43 and a current sensor 44 are electrically connected to the ECU 6. The main switch 40 is provided below the handle 4 of Fig. 1, for example, and the starter switch 41 is provided on the handle 4 of Fig. 1, for example. The main switch 40 and the starter switch 41 are operated by the driver. The intake pressure sensor 42 detects pressure in the intake passage 22. The crank angle sensor 43 detects a rotation position of the crankshaft 13 (hereinafter referred to as a crank angle). The current sensor 44 detects a current that flows in the integrated starter generator 14 (hereinafter referred to as a motor current).

[0020] An operation of the main switch 40 and the starter switch 41 is supplied to the ECU 6 as an operation signal, and the results of detection by the intake pressure sensor 42, the crank angle sensor 43 and the current sensor 44 are supplied to the ECU 6 as detection signals. The ECU 6 controls the integrated starter generator 14, the ignition plug 18 and the injector 19 based on the supplied operation signal and detection signals.

(3) Operation of Engine

[0021] For example, the engine 10 is started when the starter switch 41 is turned on after the main switch 40 of Fig. 2 is turned on, and the engine 10 is stopped when the main switch 40 is turned off. Further, the engine 10 can be started by a start-up operation such as a push start or the kick start-up.

[0022] Further, the engine 10 may be automatically stopped when a predetermined idling stop condition is satisfied, and the engine 10 may be automatically restarted afterwards when a predetermined idling stop release condition is satisfied. The idling stop condition includes a condition that relates to at least one of a throttle opening (a degree of opening of the throttle valve TV), a vehicle speed and a rotation speed of the engine 10, for example. The idling stop release condition is that the throttle opening is larger than 0 when an accelerator grip is operated, for example. Hereinafter, a state in which the engine 10 is automatically stopped when the idling stop condition is satisfied is referred to as an idling stop state.

[0023] The engine unit EU performs a forward rotation positioning operation before the start-up of the engine 10, and performs a reverse rotation start-up operation during the start-up of the engine 10. However, when the engine 10 is started by the push start, the kick start-up or the like, the engine unit EU does not perform the reverse rotation start-up operation. Thereafter, the engine unit EU performs the normal operation. Fig. 3 is a diagram for explaining the normal operation of the engine unit EU. Fig. 4 is a diagram for explaining the forward rotation positioning operation and the reverse rotation start-up operation of the engine unit EU.

[0024] In the following description, a top dead center through which the piston 11 passes at a time of shifting from a compression stroke to an expansion stroke is referred to as a compression top dead center, and a top dead center through which the piston 11 passes at a time of shifting from an exhaust stroke to an intake stroke is referred to as an exhaust top dead center. A bottom dead center through which the piston 11 passes at a time of shifting from the intake stroke to the compression stroke is referred to as an intake bottom dead center, and a bottom dead center through which the piston 11 passes at a time of shifting from the expansion stroke to the exhaust stroke is referred to as an expansion bottom dead center.

[0025] In Figs. 3 and 4, a rotation angle in a range of two rotations (720 degrees) of the crankshaft 13 is indicated by one circle. The two rotations of the crankshaft 13 is equivalent to one cycle of the engine 10. The crank angle sensor 43 of Fig. 2 detects the rotation position in a range of one rotation (360 degrees) of the crankshaft 13. The ECU 6 determines based on the pressure in the intake passage 22 detected by the intake pressure sensor 42 which one of the two rotations of the crankshaft 13 equivalent to the one cycle of the engine 10 the crank position detected by the crank angle sensor 43 corresponds to. Thus, the ECU 6 can acquire the rotation position in the range of the two rotations (720 degrees) of the crankshaft 13.

[0026] In Figs. 3 to 4, an angle A0 is a crank angle when the piston 11 (Fig. 2) is positioned at the exhaust top dead center, an angle A2 is a crank angle when the piston 11 is positioned at the compression top dead center, an angle A1 is a crank angle when the piston 11 is

positioned at the intake bottom dead center and an angle A3 is a crank angle when the piston 11 is positioned at the expansion bottom dead center. An arrow R1 indicates a direction in which the crank angle changes during the forward rotation of the crankshaft 13, and an arrow R2 indicates a direction in which the crank angle changes during the reverse rotation of the crankshaft 13. Arrows P1 to P4 indicate moving directions of the piston 11 during the forward rotation of the crankshaft 13, and arrows P5 to P8 indicate the moving directions of the piston 11 during the reverse rotation of the crankshaft 13.

(3-1) Normal Operation

[0027] The normal operation of the engine unit EU will be described with reference to Fig. 3. In the normal operation, the crankshaft 13 (Fig. 2) is rotated in the forward direction. Thus, the crank angle changes in the direction of the arrow R1. In this case, as indicated by the arrows P1 to P4, the piston 11 (Fig. 2) falls in a range from the angle A0 to the angle A1, the piston 11 rises in a range from the angle A1 to the angle A2, the piston 11 falls in a range from the angle A2 to the angle A3 and the piston 11 rises in a range from the angle A3 to the angle A0.

[0028] At an angle A11, the fuel is injected into the intake passage 22 (Fig. 2) by the injector 19 (Fig. 2). In the forward direction, the angle A11 is positioned at a further advanced angle than the angle A0. Then, in a range from an angle A12 to an angle A13, the intake port 21 (Fig. 2) is opened by the intake valve 15 (Fig. 2). In the forward direction, the angle A12 is positioned at a further retarded angle than the angle A11 and a further advanced angle than the angle A0, and the angle A13 is positioned at a further retarded angle than the angle A1. The range from the angle A12 to the angle A13 is an example of a normal intake range. Thus, the fuel-air mixture including air and the fuel is introduced into the combustion chamber 31a (Fig. 2) through the intake port 21.

[0029] Next, at an angle A14, the fuel-air mixture in the combustion chamber 31 a (Fig. 2) is ignited by the ignition plug 18 (Fig. 2). In the forward direction, the angle A14 is positioned at a further advanced angle than the angle A2. The fuel-air mixture is ignited, so that an explosion (combustion of the fuel-air mixture) occurs in the combustion chamber 31a. Energy generated by the combustion of the fuel-air mixture is turned into driving force for the piston 11. Thereafter, in a range from an angle A15 to an angle A16, the exhaust port 23 (Fig. 2) is opened by the exhaust valve 16 (Fig. 2). In the forward direction, the angle A15 is positioned at a further advanced angle than the angle A3, and the angle A16 is positioned at a further retarded angle than the angle A0. The range from the angle A15 to the angle A16 is an example of a normal exhaust range. Thus, a combusted gas is discharged from the combustion chamber 31 a through the exhaust port 23.

(3-2) Forward Rotation Positioning Operation and Reverse Rotation Start-up Operation

[0030] The forward rotation positioning operation and the reverse rotation start-up operation of the engine unit EU will be described with reference to Fig. 4. In the forward rotation positioning operation, the crankshaft 13 (Fig. 2) is rotated in the forward direction, so that the crank angle is adjusted in a reverse rotation starting range. In the forward direction, the reverse rotation starting range is in a range from the angle A0 to the angle A2, for example, and is preferably in a range from the angle A13 to the angle A2. In the present example, the reverse rotation starting range is a range from an angle A30a to an angle A30b. The range from the A30a to the angle A30b is included in the range from the angle A13 to the angle A2. When the engine 10 is stopped with the crank angle being in the reverse rotation starting range, the forward rotation positioning operation is not performed.

[0031] During the forward rotation positioning operation, injection of the fuel by the injector 19 and ignition by the ignition plug 18 are prevented. Thus, even when the crank angle reaches the angle A11 of Fig. 3, the fuel is not injected by the injector 19, and even when the crank angle reaches the angle A14 of Fig. 3, the ignition by the ignition plug 18 is not performed. Therefore, during the forward rotation positioning operation, the fuel-air mixture is not combusted in the combustion chamber 31 a.

[0032] In the reverse rotation start-up operation, the crankshaft 13 is rotated in the reverse direction from a state in which the crank angle is in the reverse rotation starting range. Thus, the crank angle changes in a direction of the arrow R2. In this case, as indicated by the arrows P5 to P8, the piston 11 falls in a range from the angle A2 to the angle A1, the piston 11 rises in a range from the angle A1 to the angle A0, the piston 11 falls in a range from the angle A0 to the angle A3, and the piston 11 rises in a range from the angle A3 to the angle A2. The moving direction of the piston 11 during the reverse rotation of the crankshaft 13 is opposite to the moving direction of the piston 11 during the forward rotation of the crankshaft 13.

[0033] In the present example, also during the reverse rotation of the crankshaft 13, the intake port 21 is opened in a range from the angle A13 to the angle A12, and the exhaust port 23 is also opened in a range from the angle A16 to the angle A15, similarly to during the forward rotation. However, the present invention is not limited to this. During the reverse rotation of the crankshaft 13, the intake port 21 does not have to be opened in the range from the angle A13 to the angle A12, and further, the exhaust port 23 does not have to be opened in the range from the angle A16 to the angle A15.

[0034] At an angle A23, the fuel is injected into the intake passage 22 (Fig. 2) by the injector 19 (Fig. 2). In the reverse direction, the angle A23 is positioned at a further advanced angle than the angle A0. Further, in a

range from an angle A21 to an angle A22, the intake port 21 (Fig. 2) is opened by the intake valve 15 (Fig. 2). The range from the angle A21 to the angle A22 is an example of a start-up intake range. In the reverse direction, the angles A21, A22 are in the range from the angle A0 to the angle A3. Because the piston 11 rises in the range from the angle A1 to the angle A0, even when the intake port 21 is opened in the range from the angle A13 to the angle A12, air and the fuel are hardly introduced into the combustion chamber 31 a. On the other hand, the piston 11 falls in the range from the angle A0 to the angle A3, and the intake port 21 is opened in the range from the angle A21 to the angle A22, so that the fuel-air mixture including air and the fuel is introduced into the combustion chamber 31 a from the intake passage 22 through the intake port 21.

[0035] Then, at an angle A31 a, energization to the ignition coil connected to the ignition plug 18 (Fig. 2) is started, and at an angle A31, the fuel-air mixture in the combustion chamber 31a is ignited by the ignition plug 18 (Fig. 2). In the reverse direction, the angle A31a is positioned at a further advanced angle than the angle A31, and the angle A31 is positioned at a further advanced angle than the angle A2. The angle A31 is an example of a start-up ignition range.

[0036] Further, at the angle A31, the rotation direction of the crankshaft 13 is switched from the reverse direction to the forward direction. In this case, a torque of the crankshaft 13 in the forward direction is increased by the combustion of the fuel-air mixture. Thereafter, the engine 10 is shifted to the normal operation of Fig. 3.

[0037] In the present embodiment, after the reverse rotation of the crankshaft 13 is stopped, the fuel-air mixture in the combustion chamber 31 a is ignited by the ignition plug 18. Thus, the crankshaft 13 can be reliably driven in the forward direction. If it is possible to drive the crankshaft 13 in the forward direction by adjusting timing of the ignition and the like, the fuel-air mixture in the combustion chamber 31 a may be ignited by the ignition plug 18 before the reverse rotation of the crankshaft 13 is stopped.

[0038] In this manner, at the start-up of the engine 10, the fuel-air mixture is led to the combustion chamber 31 a while the crankshaft 13 is rotated in the reverse direction by the integrated starter generator 14 in the present embodiment. Thereafter, with the piston 11 being close to the compression top dead center, the fuel-air mixture in the combustion chamber 31a is ignited. Thus, the piston 11 is driven such that the crankshaft 13 is rotated in the forward direction, so that a sufficient torque in the forward direction is acquired. As a result, the crank angle exceeds the angle A2 corresponding to a first compression top dead center.

(3-3) Adjustment of Crank Angle

[0039] At a time of stop of the engine 10, with the crank angle being in the range from the angle A0 to the angle

A2, the rotation of the crankshaft 13 is sometimes stopped due to the following reasons.

[0040] When the valve driver 17 of Fig. 2 is made of a camshaft, the valve driver 17 is rotated in conjunction with the rotation of the crankshaft 13. When the valve driver 17 lifts the intake valve 15, energizing force of a valve spring (not shown) is applied from the intake valve 15 to the valve driver 17 as reaction force. Similarly, when the valve driver 17 lifts the exhaust valve 16, the energizing force of the valve spring (not shown) is applied from the exhaust valve 16 to the valve driver 17 as the reaction force.

[0041] At the time of the stop of the engine 10, combustion of the fuel-air mixture is not performed in the combustion chamber 31 a, so that the rotational force of the crankshaft 13 and the valve driver 17 is gradually reduced. In that case, the rotation of the valve driver 17 is sometimes stopped by the reaction force from the intake valve 15 or the exhaust valve 16, and the rotation of the crankshaft 13 is sometimes stopped accordingly.

[0042] When the crank angle is in the vicinity of the angle A15, the reaction force from the exhaust valve 16 is applied to the valve driver 17. Thus, when the crank angle is in the vicinity of the angle A15, the rotation of the crankshaft 13 is likely to be stopped. Further, when the crank angle is in the vicinity of the angle A0, the respective reaction force from the intake valve 15 and reaction force from the exhaust valve 16 are applied to the valve driver 17. Thus, the rotation of the crankshaft 13 is also likely to be stopped when the crank angle is in the vicinity of the angle A0.

[0043] As described above, the crankshaft 13 is rotated in the reverse direction by the reverse rotation start-up operation during the start-up of the engine 10. During that time, when the reverse rotation start-up operation is started from a state in which the crank angle is in a range from the angle A0 to the angle A31 in the reverse direction, the start-up of the engine 10 cannot be appropriately performed.

[0044] Specifically, when the reverse rotation of the crankshaft 13 is started from a state in which the crank angle is in a range from the angle A15 to the angle A31, the crank angle reaches the angle A31 without going through the range from the angle A21 to the angle A22. In this case, the fuel-air mixture is not introduced into the combustion chamber 31 a. Therefore, at the angle A31, combustion of the fuel-air mixture does not occur in the combustion chamber 31 a, so that driving force for rotating the crankshaft 13 in the forward direction is not acquired.

[0045] Further, the closer the crank angle is to the angle A31, the higher the pressure in the combustion chamber 31 a is. Therefore, when the crankshaft 13 does not have more than a certain rotation speed, the crank angle is unlikely to reach the angle A31. When the reverse rotation of the crankshaft 13 is started from a crank angle close to the angle A31, the rotation speed of the crankshaft 13 is not increased, so that the crank angle may

not reach the angle A31.

[0046] When the reverse rotation of the crankshaft 13 is started from a state in which the crank angle is in a range from the angle A0 to the angle A21, the crank angle changes in the range from the angle A21 to the angle A22 with the rotation speed of the crankshaft 13 being low. In this case, in the range from the angle A21 to the angle A22, the fuel-air mixture is unlikely to be led to the combustion chamber 31a. Therefore, at the angle A31, even when the fuel-air mixture in the combustion chamber 31a is ignited, sufficient driving force for rotating the crankshaft 13 in the forward direction is not acquired. Further, similarly to the above, the rotation speed of the crankshaft 13 may not be sufficiently increased, so that the crank angle may not reach the angle A31.

[0047] In the present embodiment, before the reverse rotation start-up operation, the crank angle is adjusted in the reverse rotation starting range (the range from the angle A30a to the angle A30b in the present example) by the forward rotation positioning operation. The reverse rotation of the crankshaft 13 is started from a state in which the crank angle is in the reverse rotation starting range, whereby the rotation speed of the crankshaft 13 is sufficiently increased at a point of time at which the crank angle reaches the angle A21. Therefore, in the range from the angle A21 to the angle A22, the fuel-air mixture is sufficiently introduced into the combustion chamber 31 a. Further, the rotation speed of the crankshaft 13 is sufficiently increased, so that the crank angle reliably reaches the angle A31. Therefore, at the angle A31, the combustion of the fuel-air mixture can appropriately occur in the combustion chamber 31a. Thus, the sufficient driving force for rotating the crankshaft 13 in the forward direction is acquired. As a result, the start-up of the engine 10 can be appropriately performed.

(4) Control of Fuel injection and Ignition

[0048] During the forward rotation of the crankshaft 13, the ECU 6 controls the ignition plug 18 and the injector 19 in any one control mode of an allowance mode and a prevention mode. In the allowance mode, the fuel is injected by the injector 19 when the crank angle is the angle A11 of Fig. 3, and the fuel-air mixture is ignited by the ignition plug 18 when the crank angle is the angle A14 of Fig. 3. On the other hand, in the prevention mode, the fuel injection by the injector 19 and the ignition by the ignition plug 18 are prevented. Thus, at any crank angle, the fuel injection by the injector 19 and the ignition by the ignition plug 18 are not performed.

[0049] The ECU 6 performs a mode update process based on a control program stored in the memory in advance. Thus, the control mode of the ECU 6 is suitably updated. Fig. 5 is a flow chart of the mode update process. The mode update process is continuously performed in a constant period while the main switch 40 is turned on.

[0050] As shown in Fig. 5, the ECU 6 determines based on a result of detection by the crank angle sensor 43 (Fig.

2) whether the crankshaft 13 is rotated in the forward direction (step S1). When the crankshaft 13 is not rotated in the forward direction, the ECU 6 finishes the mode update process without updating the control mode. When the crankshaft 13 is rotated in the forward direction, the ECU 6 determines whether the engine unit EU is performing the normal operation (step S2).

[0051] When the engine unit EU is performing the normal operation, the ECU 6 updates the control mode to the allowance mode (step S3), and finishes the mode update process. Thus, as described above, while the crankshaft 13 is rotated in the forward direction, the fuel is injected by the injector 19 at the angle A11 (Fig. 3), and the fuel-air mixture in the combustion chamber 31a is ignited by the ignition plug 18 at the angle A14 (Fig. 3).

[0052] On the other hand, when the engine unit EU is not performing the normal operation, the ECU 6 determines based on a result of detection by the current sensor 44 whether the integrated starter generator 14 is driving the crankshaft 13 (step S4). When the integrated starter generator 14 is driving the crankshaft 13, the engine unit EU is performing the forward rotation positioning operation. In this case, the ECU 6 updates the control mode to the prevention mode (step S5), and finishes the mode update process. Thus, the fuel injection by the injector 19 and the ignition by the ignition plug 18 are prevented.

[0053] On the other hand, when the integrated starter generator 14 is not driving the crankshaft 13, the crankshaft 13 is likely to be rotated in the forward direction by the start-up operation such as the push start or the kick start-up. In this case, the ECU 6 updates the control mode to the allowance mode (step S3), and finishes the mode update process. Thus, the engine 10 is started by the start-up operation such as the push start or the kick start-up.

[0054] In this manner, during the forward rotation of the crankshaft 13 by the normal operation or during the forward rotation of the crankshaft 13 by the push start, the kick start-up or the like, the fuel injection by the injector 19 and the ignition by the ignition plug 18 are performed based on a change in crank angle. On the other hand, during the forward rotation of the crankshaft 13 by the forward rotation positioning operation, the fuel injection by the injector 19 and the ignition by the ignition plug 18 are prevented.

(5) Engine Start-up Process

[0055] The ECU 6 performs the engine start-up process based on the control program stored in the memory in advance. Figs. 6 to 9 are flow charts for explaining the engine start-up process. The engine start-up process is performed when the main switch 40 or the starter switch 41 of Fig. 2 is turned on or when the engine 10 is shifted to the idling stop state.

(5-1) First Example

[0056] Figs. 6 to 8 are flow charts of the first example of the engine start-up process. In the first example, the ECU 6 first determines whether a current crank angle is stored in the memory (step S11). For example, the current crank angle is stored in the memory at a time of a previous stop of the engine 10. For example, the current crank angle is not stored right after the main switch 40 is turned on, and the current angle is stored in the idling stop state.

[0057] When the current crank angle is not stored, the ECU 6 controls the integrated starter generator 14 such that the crankshaft 13 is rotated in the forward direction (step S12). In this case, a torque of the integrated starter generator 14 is adjusted based on the detection signal from the current motor 44 (Fig. 2) such that the crank angle does not reach the angle A2 corresponding to the compression top dead center (Figs. 3 and 4).

[0058] As described above, during the forward rotation positioning operation, the control mode for the ignition plug 18 and the injector 19 is kept in the prevention mode. Therefore, during the forward rotation of the crankshaft 13 in step S12, and step S16 described below, the fuel injection by the injector 19 and the ignition by the ignition plug 18 are prevented.

[0059] Next, the ECU 6 determines whether a prescribed time period has elapsed since the rotation of the crankshaft 13 was started in step S12 (step S13). In a case in which the prescribed time period has not elapsed, the ECU 6 controls the integrated starter generator 14 such that the rotation of the crankshaft 13 in the forward direction is continued. In a case in which the prescribed time period has elapsed, the ECU 6 controls the integrated starter generator 14 such that the rotation of the crankshaft 13 is stopped (step S14). Thus, the crank angle is adjusted in the reverse rotation starting range.

[0060] In step S12, the crank angle may be detected when the crank angle 13 is rotated in the forward direction, and the crank angle may be adjusted in the reverse rotation starting range based on the detected value.

[0061] On the other hand, in step S11, when the current crank angle is stored, the ECU 6 determines whether the current crank angle is in the reverse rotation starting range (step S15). When the current crank angle is not in the reverse rotation starting range, the ECU 6 controls the integrated starter generator 14 such that the crankshaft 13 is rotated in the forward direction (step S16). In this case, a torque of the integrated starter generator 14 is adjusted based on the detection signal from the current sensor 44 (Fig. 2) such that the crank angle does not reach the angle A2 corresponding to the compression top dead center (Figs. 3 and 4).

[0062] Next, the ECU 6 determines based on the detection signals from the intake pressure sensor 42 and the crank angle sensor 43 whether the current crank angle has reached the reverse rotation starting range (step S17). When the current crank angle has not reached the

reverse rotation starting range, the ECU 6 controls the integrated starter generator 14 such that the rotation of the crankshaft 13 in the forward direction is continued (step S16). When the current crank angle has reached the reverse rotation starting range, the ECU 6 controls the integrated starter generator 14 such that the rotation of the crankshaft 13 is stopped (step S14). Thus, the crank angle is adjusted in the reverse rotation starting range.

[0063] In the processes of steps S16, S17, the adjustment of the crank angle is accurately performed and power consumption by the integrated starter generator 14 is inhibited as compared to the processes of steps S12, S13, described above.

[0064] After the crank angle is adjusted in the reverse rotation starting range by the forward rotation of the crankshaft 13, the process of step S21 of Fig. 7 is performed. Further, in step S15, when the current crank angle is in the reverse rotation starting range, the process of step S21 of Fig. 7 is performed as such.

[0065] As shown in Fig. 7, in step S21, the ECU 6 determines whether a predetermined start-up condition of the engine 10 is satisfied. The start-up condition of the engine 10 is that the starter switch 41 (Fig. 2) is turned on or the idling stop release condition is satisfied, for example.

[0066] In a case in which the engine start-up process is started when the starter switch 41 is turned on, the process of step S21 does not have to be performed. In that case, the forward rotation positioning operation and the reverse rotation start-up operation are successively performed.

[0067] When the start-up condition of the engine 10 is satisfied, the ECU 6 performs timeout setting of the engine start-up process (step S22). Specifically, an elapsed time period is measured from that point of time. In a case in which the elapsed time period reaches a predetermined end time period, the engine start-up process is forcibly terminated (step S38, described below).

[0068] Next, the ECU 6 controls the integrated starter generator 14 such that the crankshaft 13 is rotated in the reverse direction (step S23). Next, the ECU 6 determines based on the detection signals from the intake pressure sensor 42 (Fig. 2) and the crank angle sensor 43 (Fig. 2) whether the current crank angle has reached the angle A23 of Fig. 4 (step S24). The ECU 6 repeats the process of step S24 until the current crank angle reaches the angle A23. When the current crank angle reaches the angle A23, the ECU 6 controls the injector 19 such that the injection of the fuel to the intake passage 22 (Fig. 2) is started (step S25). In this case, a pulse signal may be supplied to the ECU 6 from the crank angle sensor 43 when the crank angle reaches the angle A23, and the ECU 6 may control the injector 19 such that the fuel is injected in response to the pulse signal.

[0069] Next, the ECU 6 determines whether a predetermined injection time period has elapsed since the injection of the fuel was started in step S10 (step S26). The

ECU 6 controls the injector 19 such that the injection of the fuel is continued until the predetermined injection time period elapses. In a case in which the predetermined injection time period has elapsed, the ECU 6 controls the injector 19 such that the injection of the fuel is stopped (step S27).

[0070] Next, as shown in Fig. 8, the ECU 6 determines based on the detection signal from the current sensor 44 whether the motor current has reached a predetermined threshold value (step S31). In this case, the closer the crank angle is to the angle A2 of Fig. 4, the larger the motor current is. In the present example, when the crank angle reaches the angle A31 of Fig. 4, the motor current reaches the threshold value.

[0071] When an electric current flowing in the integrated starter generator 14 reaches a predetermined threshold value, the ECU 6 controls the integrated starter generator 14 such that the rotation of the crankshaft 13 in the reverse direction is stopped (step S32), and starts the energization to the ignition coil (step S33). Next, the ECU 6 determines whether a predetermined energization time period has elapsed since the energization was started in step S33 (step S34). The ECU 6 continues the energization to the ignition coil until the predetermined energization time period elapses. In a case in which the predetermined energization time period has elapsed, the ECU 6 stops the energization to the ignition coil (step S35). Thus, the fuel-air mixture in the combustion chamber 31a is ignited by the ignition plug 18. Further, the ECU 6 controls the integrated starter generator 14 such that the crankshaft 13 is rotated in the forward direction (step S36). Thus, the ECU 6 finishes the engine start-up process, and the engine unit EU is shifted to the normal operation of Fig. 3. The driving of the crankshaft 13 by the integrated starter generator 14 is stopped after a constant time period has elapsed since the process of step S36, for example.

[0072] In step S31, when the motor current has not reached the threshold value, the ECU 6 determines whether the predetermined end time period has elapsed since the timeout setting of step S22 of Fig. 7 (step S37). Due to a problem with the engine unit EU, the predetermined end time period sometimes elapses from the timeout setting when the electric current flowing in the integrated starter generator 14 does not reach the threshold value. As the problem with the engine unit EU, there are an operational problem with the integrated starter generator 14, an operational problem with the valve driver 17 or the like. In a case in which the end time period has not elapsed, the ECU 6 returns to the process of step S21. In a case in which the end time period has elapsed, the ECU 6 controls the integrated starter generator 14 such that the rotation of the crankshaft 13 in the reverse rotation is stopped (step S38), and warns the driver that a problem has occurred in the engine unit EU (step S39). Specifically, a warning lamp (not shown) is lit, for example. Thus, the ECU 6 finishes the engine start-up process.

(5-2) Second Example

[0073] Fig. 9 is a flow chart of the second example of the engine start-up process. The ECU 6 may perform the processes of steps S41 to S51 of Fig. 9 instead of the processes of steps S31 to S39 of Fig. 8.

[0074] In the example of Fig. 9, the ECU 6 determines based on the detection signal from the crank angle sensor 43 (Fig. 2) whether the crankshaft 13 has rotated by a predetermined reverse rotation angle after the reverse rotation of the crankshaft 13 was started in step S23 of Fig. 7 (step S41). The reverse rotation angle is equivalent to an angle from the angle A30a to the angle A31 of Fig. 4, for example. For example, when a prescribed number of pulses corresponding to the reverse rotation angle are supplied from the crank angle sensor 43 as the detection signals after the reverse rotation of the crankshaft 13 is started, the ECU 6 determines that the crankshaft 13 has rotated by the reverse rotation angle.

[0075] When the crankshaft 13 has rotated by the reverse rotation angle, the ECU 6 controls the integrated starter generator 14 such that the rotation of the crankshaft 13 in the reverse direction is stopped (step S42), and starts the energization to the ignition coil (step S43).

[0076] Next, the ECU 6 determines whether the crankshaft 13 has rotated by a predetermined energization angle after the energization was started in step S43 (step S44). The energization angle is equivalent to an angle by which the crankshaft 13 is rotated in the energization time period of step S24 of Fig. 8. For example, after the energization is started, when the prescribed number of pulses corresponding to the energization angle are supplied from the crank angle sensor 43 as the detection signals, the ECU 6 determines that the crankshaft 13 has rotated by the energization angle.

[0077] When the crankshaft 13 has rotated by the energization angle, the ECU 6 stops the energization to the ignition coil (step S45), controls the integrated starter generator 14 such that the crankshaft 13 is rotated in the forward direction (step S46) and finishes the engine start-up process.

[0078] On the other hand, in step S31, when the crankshaft 13 has not rotated by the reverse rotation angle, the ECU 6 determines whether a first end time period has elapsed since the timeout setting of step S7 (step S47). In a case in which the first end time has not elapsed, the ECU 6 returns to the process of step S41. In a case in which the first end time period has elapsed, the ECU 6 controls the integrated starter generator 14 such that the rotation of the crankshaft 13 in the reverse direction is stopped (step S48), warns the driver that a problem has occurred in the engine unit EU (step S51) and finishes the engine start-up process.

[0079] Further, in step S44, when the crankshaft 13 has not rotated by the energization angle, the ECU 6 determines whether a second end time period has elapsed since the timeout setting in step S22 of Fig. 7 (step S49). The second end time period is set longer than

the above-mentioned first end time period. In a case in which the second end time period has not elapsed, the ECU 6 returns to the process of step S44. In a case in which the second end time has elapsed, the ECU 6 stops the energization to the ignition coil (step S50), warns the driver that a problem has occurred in the engine unit EU (step S51) and finishes the engine start-up process.

[0080] In this manner, in the second example, the reverse rotation of the crankshaft 13 is stopped based on the result of detection from the crank angle sensor 43 (steps S41, S42). Further, the energization to the ignition coil is stopped based on the detection signal from the crank angle sensor 43 (steps S44, S45). Thus, the reverse rotation of the crankshaft 13 and the energization to the ignition coil can be stopped at appropriate points of time.

[0081] Further, in a case in which the second end time period has elapsed in step S39 after the energization to the ignition coil was started in step S43, the energization to the ignition coil is stopped in step S50. Thus, the energization to the ignition coil is prevented from being continued for a long period of time.

(6) Effects

[0082] In the engine system 200 according to the present embodiment, the injection of the fuel by the injector 19 and the ignition by the ignition plug 18 are prevented during the forward rotation positioning operation. Thus, an occurrence of unintended combustion of the fuel-air mixture in the engine 10 in response to the detection signal from the crank angle sensor 43 (a pulse signal, for example) is prevented. Thus, before the start-up of the engine 10, the crank angle can be appropriately adjusted in the reverse rotation starting range.

[0083] Thereafter, the engine unit EU performs the reverse rotation start-up operation during the start-up of the engine 10. In this case, the crank angle reliably goes through the start-up intake range. Therefore, the fuel-air mixture can be appropriately introduced into the combustion chamber 31a, and the combustion of the fuel-air mixture can appropriately occur in the combustion chamber 31 a. Thus, the torque of the crankshaft 13 in the forward direction can be increased, and the crank angle can easily exceed the angle A2 corresponding to the first compression top dead center.

[0084] Further, in the present embodiment, before the start-up of the engine 10, in a case in which the crankshaft 13 is rotated in the forward direction without driving of the crankshaft 13 by the integrated starter generator 14, the fuel injection by the injector 19 and the ignition by the ignition plug 18 are not prevented. Thus, when the crankshaft 13 is rotated in the forward direction by the push start, the kick start-up or the like, it is possible to start the engine 10 by appropriately combusting the fuel-air mixture. Further, because absence and presence of the prevention of the fuel injection and the ignition are controlled based on the operation of the integrated starter generator

14, combustion of the fuel-air mixture during the forward rotation positioning operation is prevented without requirement of the complicated configuration and control.

(7) Other Embodiments

(7-1)

[0085] While both of the injection of the fuel by the injector 19 and the ignition by the ignition plug 18 are prevented during the forward rotation positioning operation in the above-mentioned embodiment, the present invention is not limited to this. The ignition by the ignition plug 18 is prevented, so that the fuel-air mixture is prevented from being combusted in the combustion chamber 31a. Therefore, during the forward rotation positioning operation, the injection of the fuel by the injector 19 does not have to be prevented. However, in order to appropriately adjust an air-fuel ratio in the combustion chamber 31 a in the reverse rotation start-up operation, and in order to prevent an uncombusted fuel-air mixture from being discharged to the outside from the combustion chamber 31 a through the exhaust passage 24, the ignition by the ignition plug 18 and the injection of the fuel by the injector 19 are preferably prevented.

(7-2)

[0086] While the above-mentioned embodiment is an example in which the present invention is applied to the motorcycle 100 having the kick pedal KP, the present invention may be applied to the motorcycle 100 that does not have the kick pedal KP. Further, the present invention may be applied to another straddled vehicle such as a motor tricycle, an All-Terrain Vehicle (ATV) or the like.

(8) Correspondences between Constituent Elements in Claims and Parts in Preferred Embodiments

[0087] In the following paragraphs, non-limiting examples of correspondences between various elements recited in the claims below and those described above with respect to various preferred embodiments of the present invention are explained.

[0088] In the above-mentioned embodiment, the engine unit EU is an example of an engine unit, the engine 10 is an example of an engine, the integrated starter generator 14 is an example of a rotation driver, the ECU 6 is an example of a controller, the injector 19 is an example of a fuel injection device, the ignition plug 18 is an example of an ignition device, the valve driver 17 is an example of a valve driver, the intake valve 15 is an example of an intake valve, the exhaust valve 16 is an example of an exhaust valve, the main switch 40 is an example of a main switch, the starter switch 41 is an example of a starter switch and the kick pedal KP is an example of a kick starter. Further, the motorcycle 100 is an example of a straddled vehicle, the rear wheel 7 is an example of

a drive wheel and the vehicle body 1 is an example of a main body.

[0089] As each of constituent elements recited in the claims, various other elements having configurations or functions described in the claims can be also used.

[Industrial Applicability]

[0090] The present invention is applicable to various types of engine systems and straddled vehicles.

Claims

1. An engine system comprising:

an engine unit that includes an engine and a rotation driver; and
a controller that controls the engine unit, wherein the engine includes
a fuel injection device arranged to inject fuel into an intake passage for leading air to a combustion chamber,
an ignition device configured to ignite a fuel-air mixture in the combustion chamber, and
a valve driver configured to drive each of an intake valve for opening and closing an intake port and an exhaust valve for opening and closing an exhaust port,
the rotation driver is configured to drive rotation of a crankshaft in a forward or reverse direction, the controller controls the engine unit such that a forward rotation positioning operation of rotating the crankshaft is rotated in the forward direction is performed before start-up of the engine, and controls the engine unit such that a reverse rotation start-up operation of rotating the crankshaft in the reverse direction is performed during the start-up of the engine,
the rotation driver drives the crankshaft such that a crank angle reaches a predetermined reverse rotation starting range, in the forward rotation positioning operation, and drives the crankshaft such that the crank angle exceeds a predetermined start-up intake range from the reverse rotation starting range and reaches a predetermined start-up ignition range, in the reverse rotation start-up operation,
the valve driver drives the intake valve such that the intake port is opened when the crank angle is in the start-up intake range, in the reverse rotation start-up operation,
the fuel injection device injects the fuel such that the fuel-air mixture is introduced into the combustion chamber from the intake passage through the intake port when the crank angle is in the start-up intake range, in the reverse rotation start-up operation,

the ignition device ignites when the crank angle is in the start-up ignition range, in the reverse rotation start-up operation, and the controller prevents ignition by the ignition device during the forward rotation positioning operation.

2. The engine system according to claim 1, wherein the controller prevents injection of the fuel by the fuel injection device during the forward rotation positioning operation. 10
3. The engine system according to claim 1 or 2, further comprising a main switch operated by a driver, wherein the controller controls the engine unit such that the forward rotation positioning operation is performed when the main switch is turned on. 15
4. The engine system according to claim 1 or 2, further comprising a starter switch operated by a driver, wherein the controller controls the engine unit such that the forward rotation positioning operation is performed when the starter switch is turned on. 20 25
5. The engine system according to any one of claims 1 to 4, wherein the controller controls the engine unit such that operations of the fuel injection device and the ignition device are stopped and the forward rotation positioning operation is performed after rotation of the crankshaft is stopped, when a predetermined idling stop condition is satisfied, and controls the engine unit such that the reverse rotation start-up operation is performed, when a predetermined idling stop release condition is satisfied. 30 35
6. The engine system according to any one of claims 1 to 5, wherein the controller does not prevent the ignition by the ignition device when the crankshaft is rotated in the forward direction without driving of the crankshaft by the rotation driver, before the start-up of the engine, and prevents the ignition by the ignition device when the crankshaft is rotated in the forward direction by the driving of the crankshaft by the rotation driver, before the start-up of the engine. 40 45
7. The engine system according to any one of claims 1 to 6, further comprising a kick starter, which a driver operates with his or her foot in order to rotate the crankshaft in the forward direction, wherein the controller does not prevent the ignition by the ignition device when the crankshaft is rotated in the forward direction by an operation of the kick starter by the driver. 50 55

8. A straddled vehicle comprising:

a main body having a drive wheel; and
an engine system according to any one of claims 1 to 7 that generates motive power for rotating the drive wheel.

FIG. 1

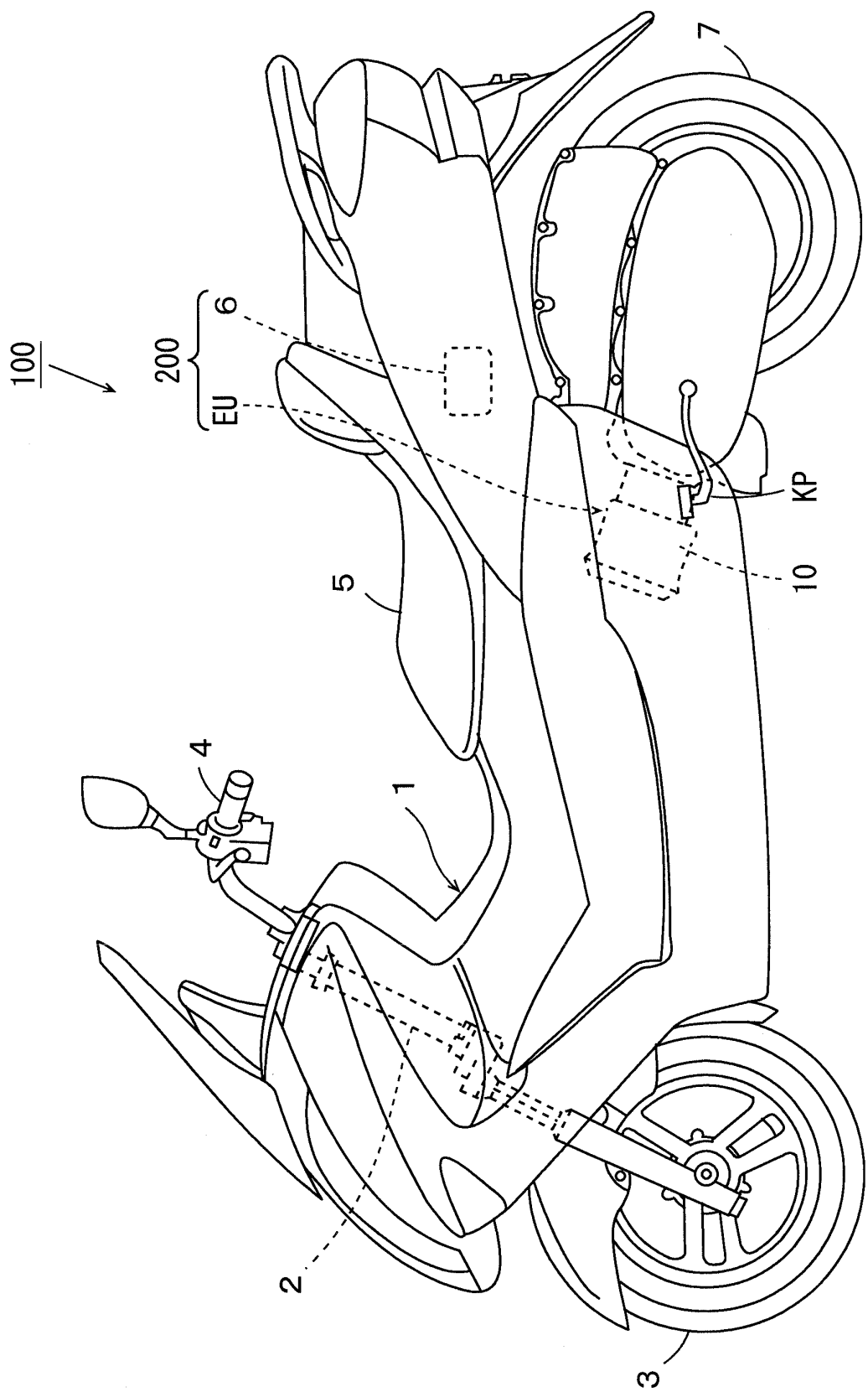


FIG. 2

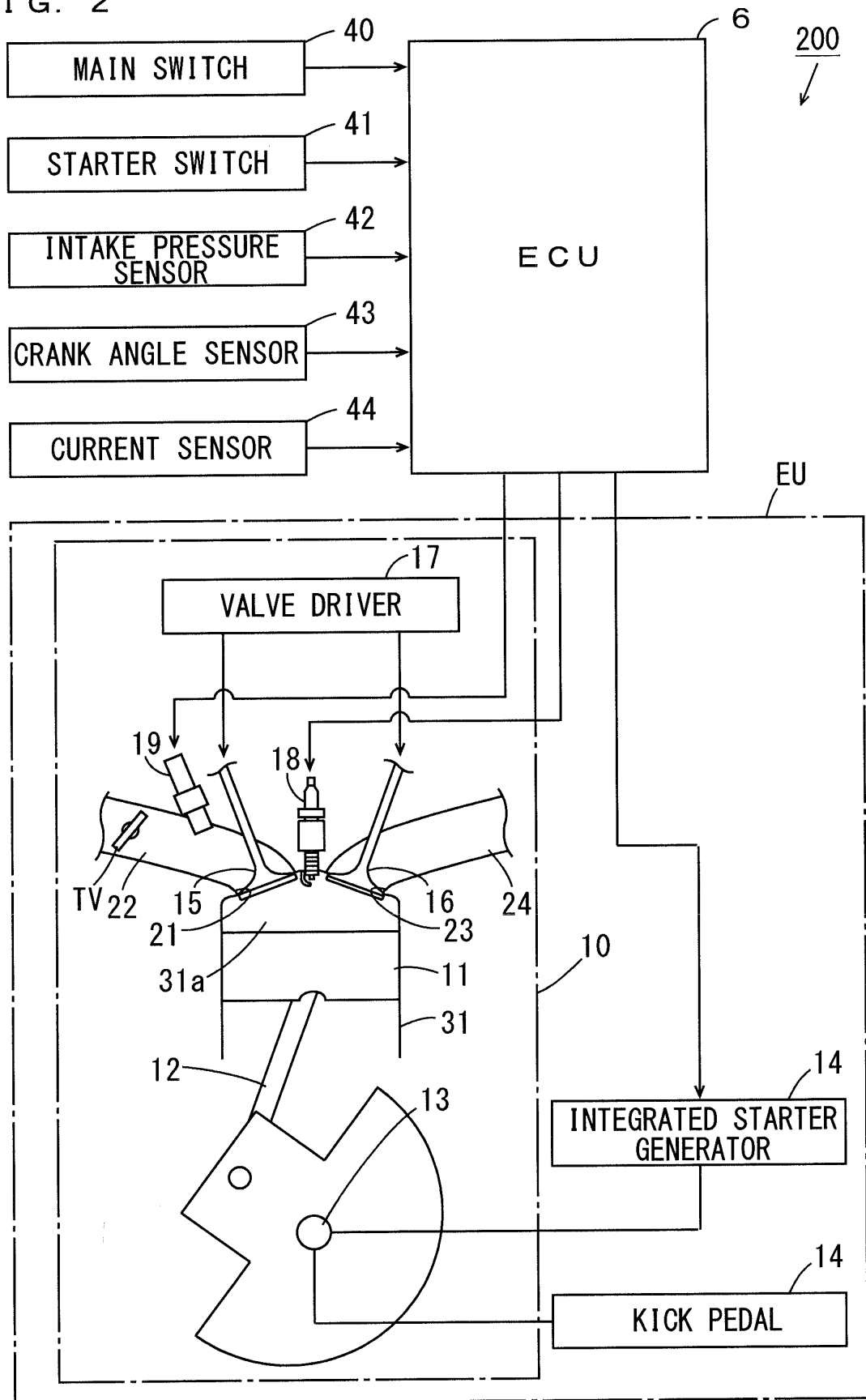


FIG. 3

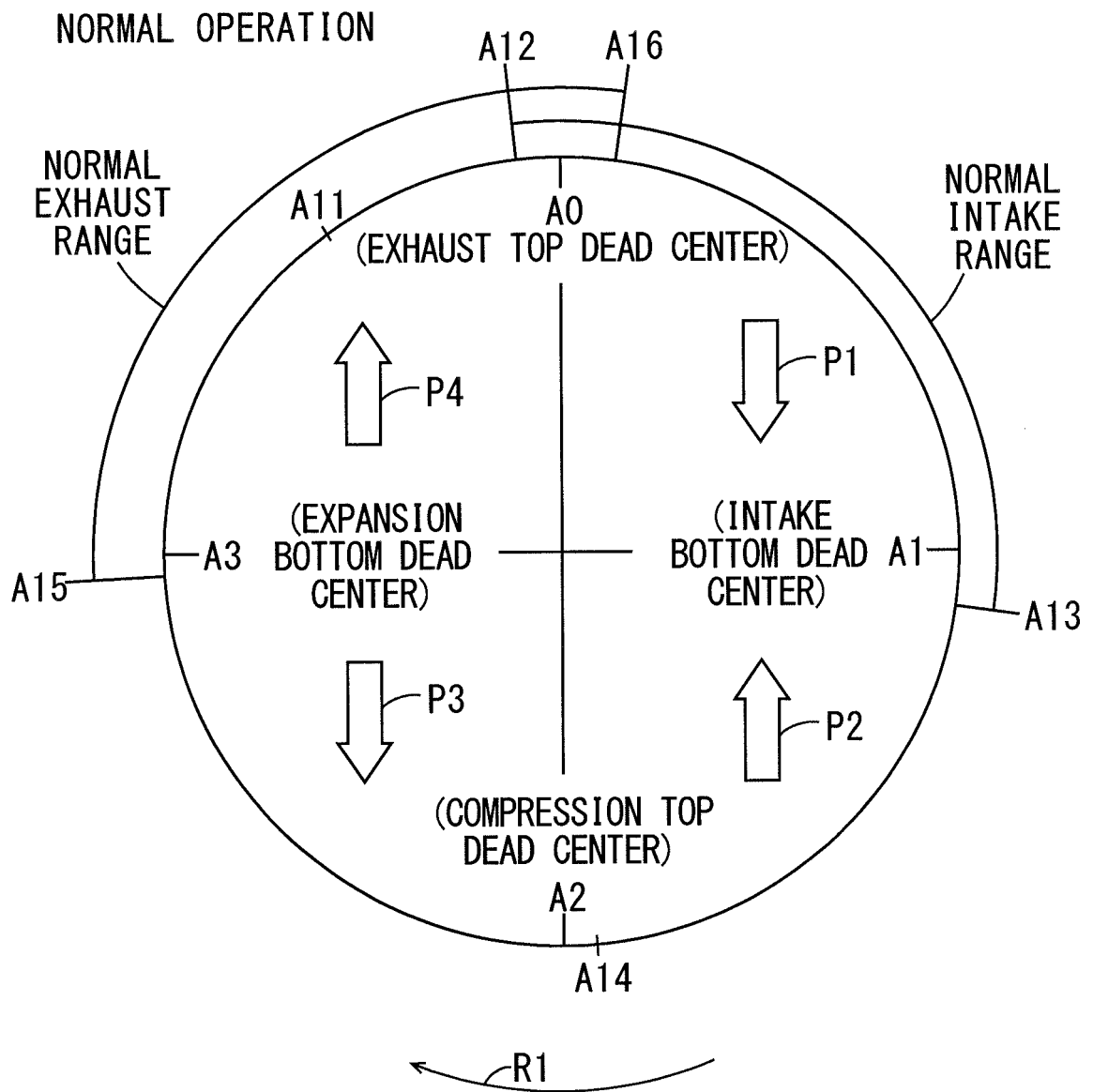


FIG. 4

FORWARD ROTATION
POSITIONING OPERATION

REVERSE ROTATION
START-UP OPERATION

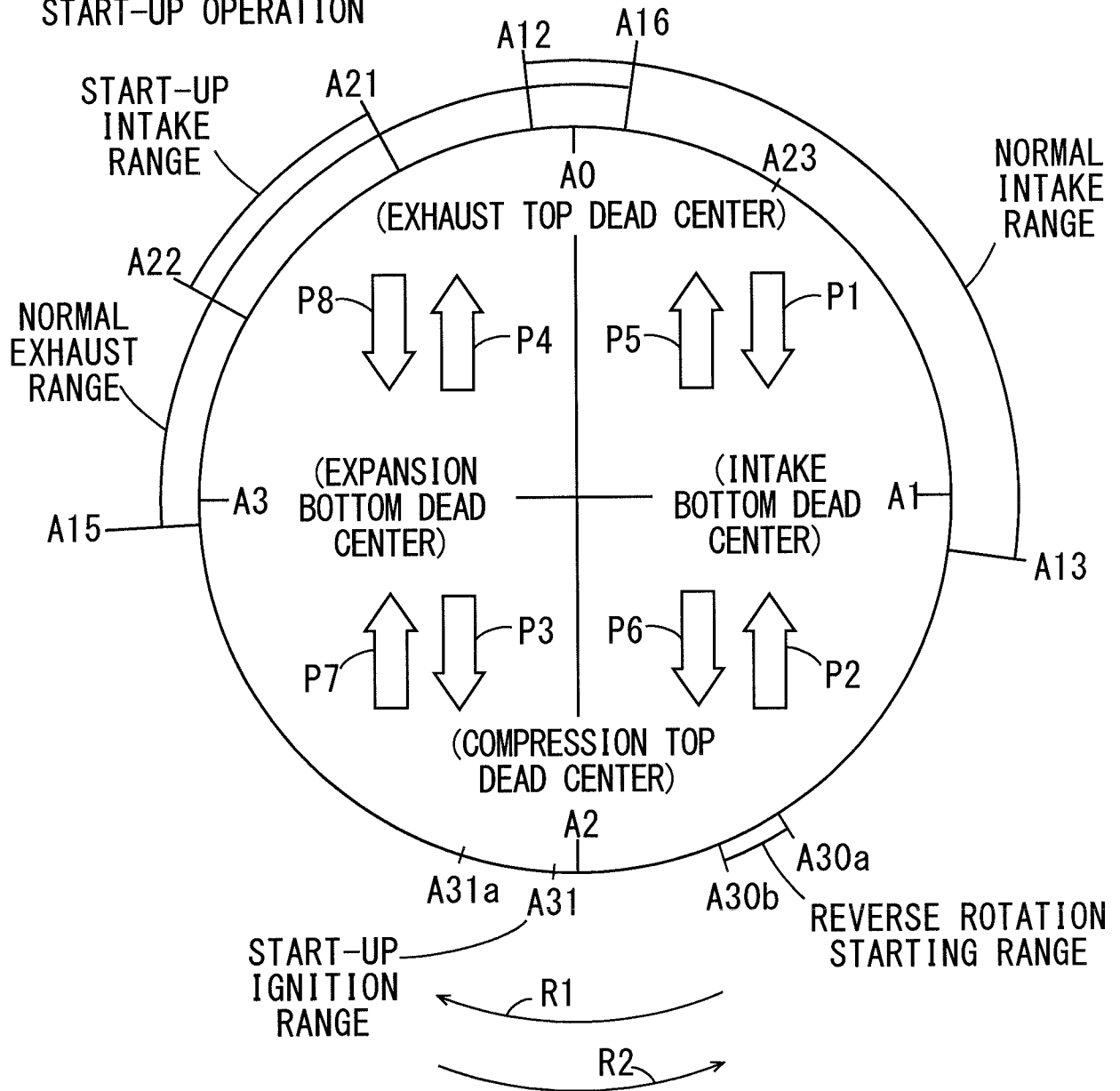


FIG. 5

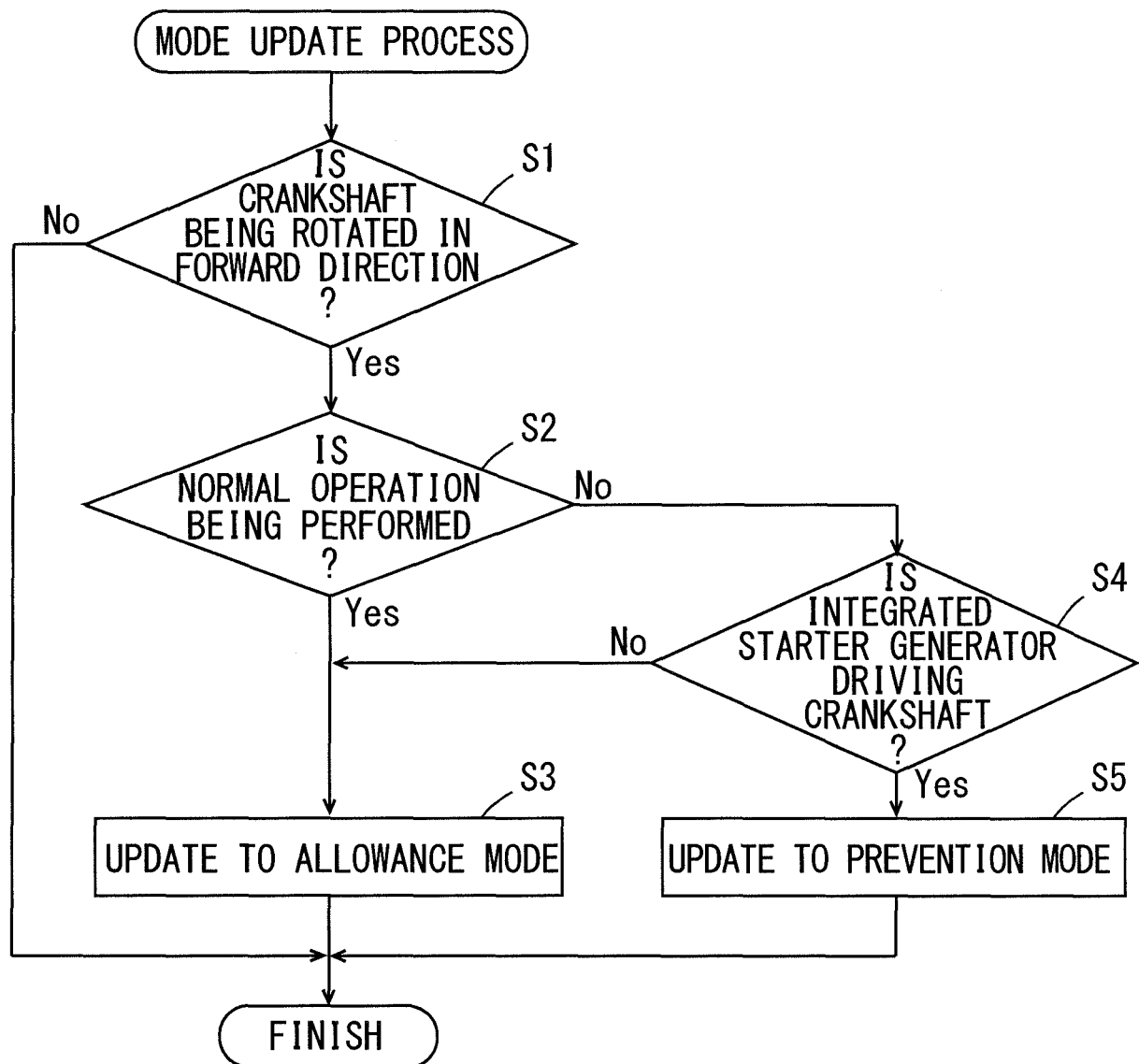


FIG. 6

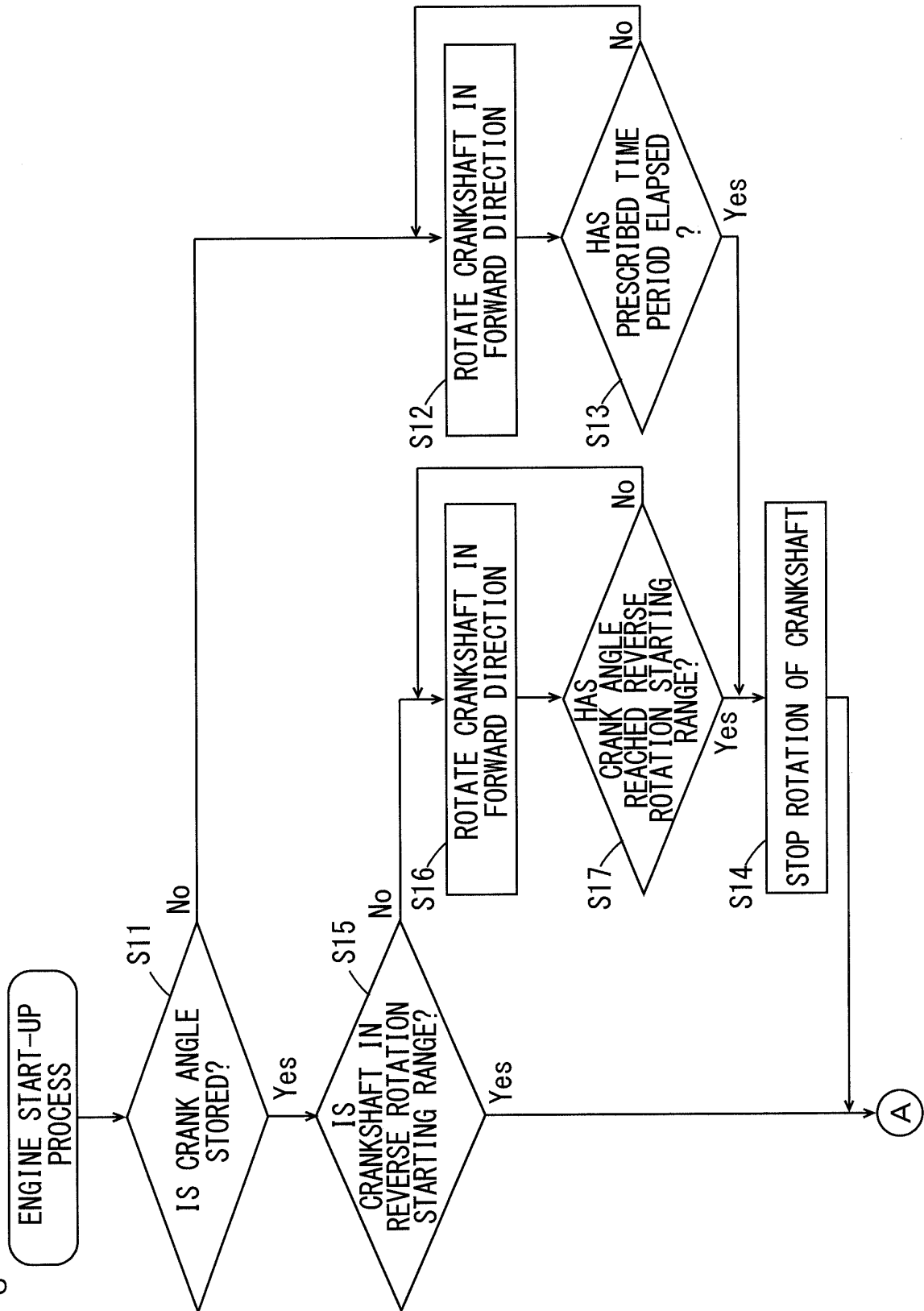


FIG. 7

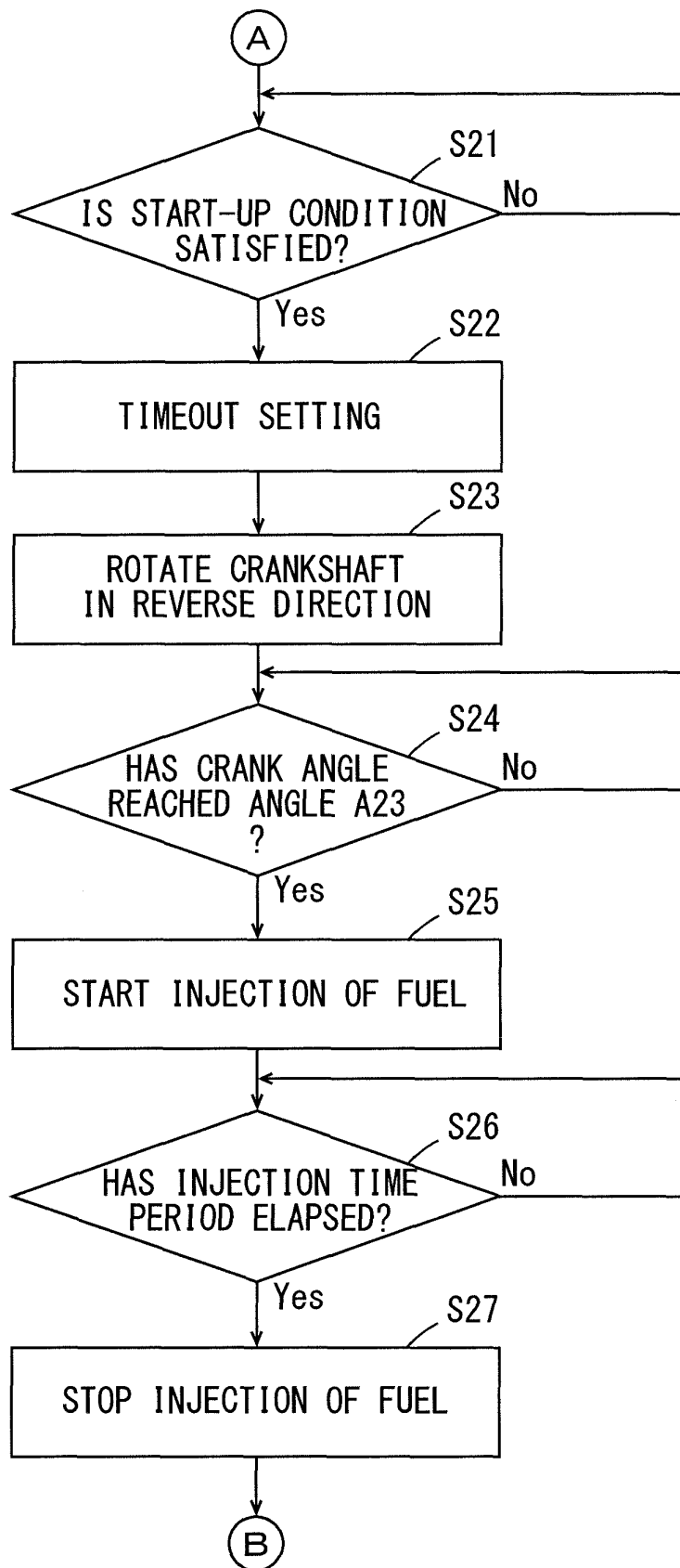


FIG. 8

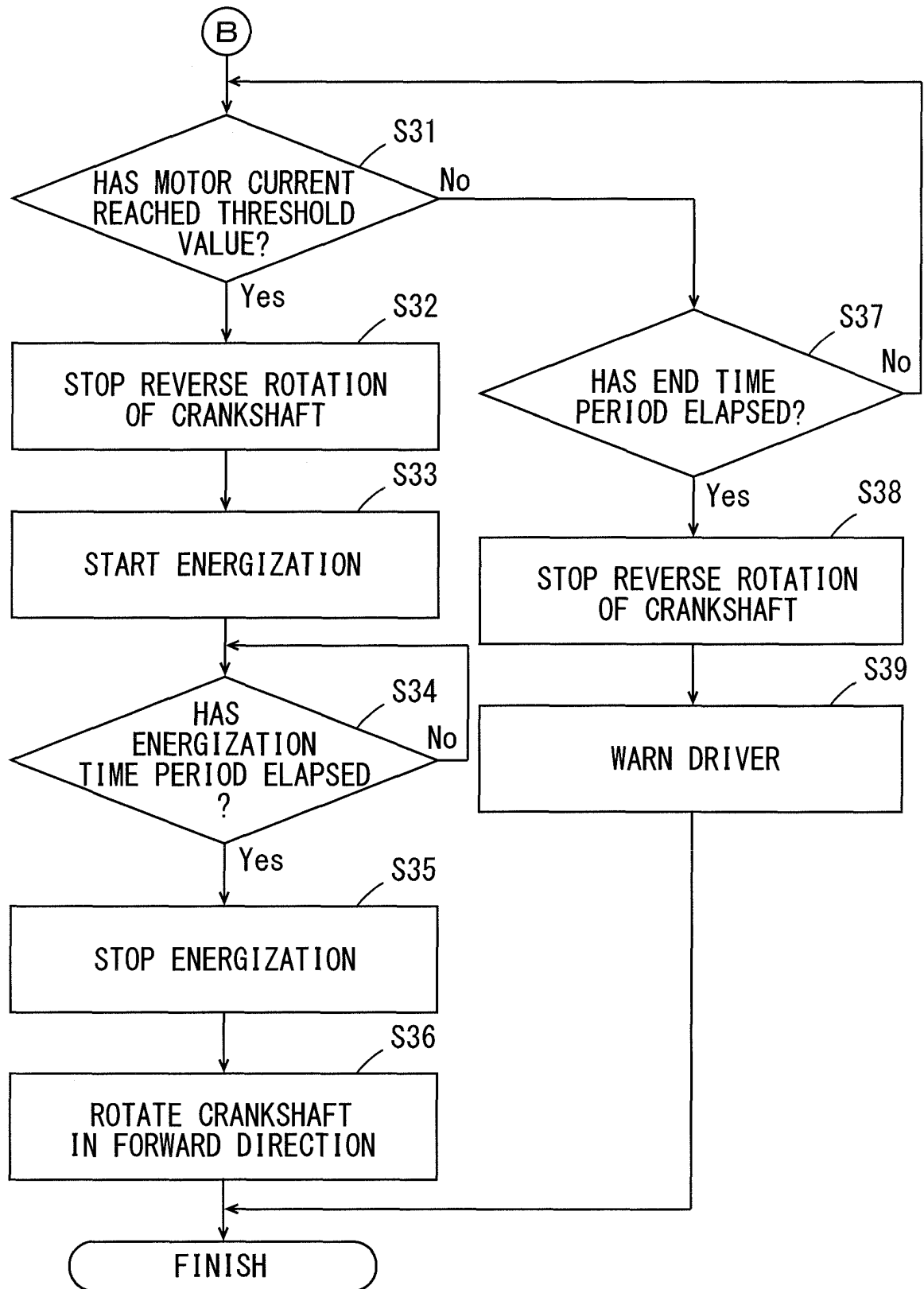
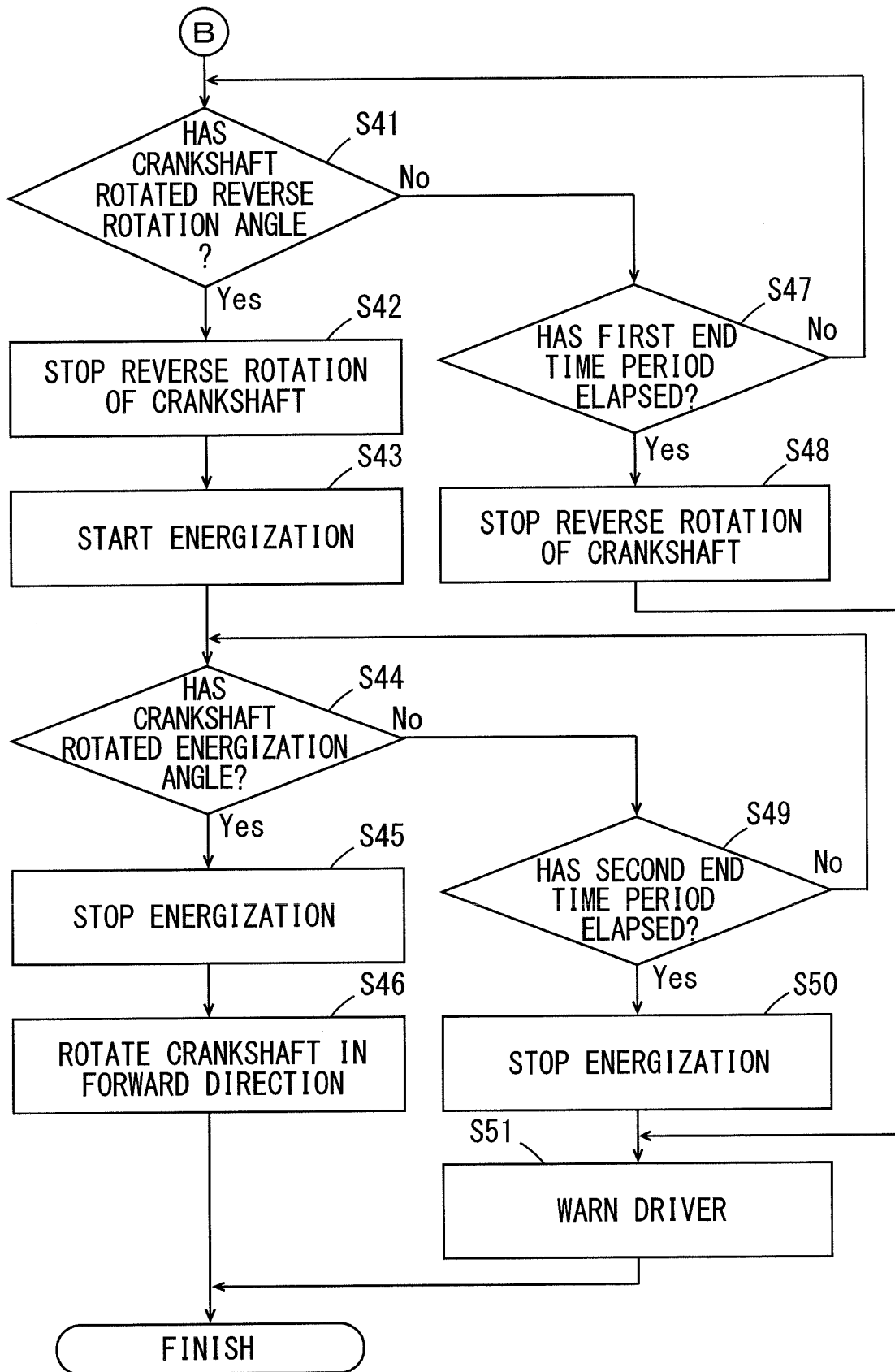


FIG. 9



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/003881

A. CLASSIFICATION OF SUBJECT MATTER

F02D29/02(2006.01)i, F02D13/02(2006.01)i, F02D41/06(2006.01)i, F02P5/15
(2006.01)i, F02D43/00(2006.01)i, F02D45/00(2006.01)i, F02N11/08(2006.01)i

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)

F02D29/00-29/02, F02D13/02, F02D41/00-41/40, F02P5/145-5/155,
F02D43/00-45/00, F02N11/08

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2014
Kokai Jitsuyo Shinan Koho 1971-2014 Toroku Jitsuyo Shinan Koho 1994-2014

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2014-77405 A (Yamaha Motor Co., Ltd.), 01 May 2014 (01.05.2014), entire text & EP 2719883 A1	1-8
A	JP 2004-176709 A (Toyota Motor Corp.), 24 June 2004 (24.06.2004), entire text & US 2004/0060530 A1 & DE 10345153 A1 & FR 2846055 A1	1-8
A	JP 2005-315231 A (Mazda Motor Corp.), 10 November 2005 (10.11.2005), entire text (Family: none)	1-8

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

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"&" document member of the same patent family

Date of the actual completion of the international search
20 October, 2014 (20.10.14)

Date of mailing of the international search report
28 October, 2014 (28.10.14)

Name and mailing address of the ISA/
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/003881

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2004-339952 A (Toyota Motor Corp.), 02 December 2004 (02.12.2004), entire text & US 2004/0226530 A1 & EP 1486667 A2	1-8

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2014077405 A [0005]