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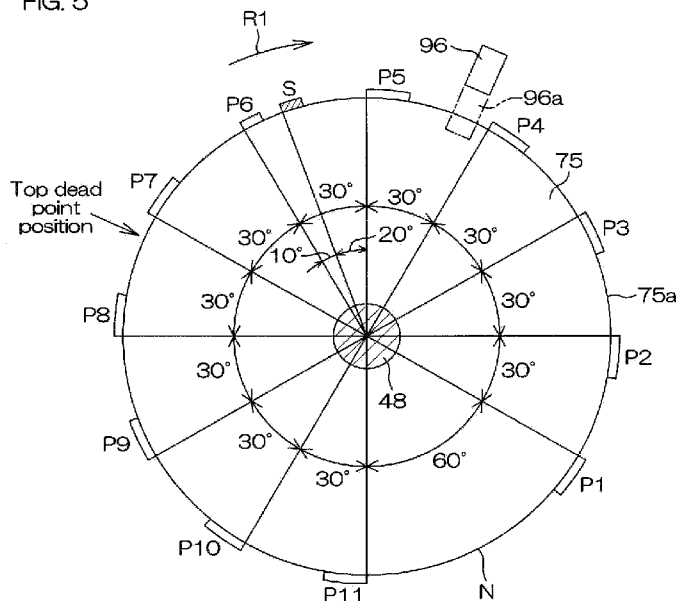
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(54) Title: SYNCHRONISATION SYSTEM FOR AN INTERNAL COMBUSTION ENGINE WITH A TOOTHED WHEEL WITH MORE THAN TWO REFERENCE POSITIONS

FIG. 5



(S) as a reference.

(57) Abstract: An engine system includes an engine having a rotary member (75) that rotates together with the crankshaft (48), a plurality of first detection bodies (P1-N) provided on the rotary member (75), a second detection body (S) provided on the same rotary member (75), a detection means (96) that detects the first (P1-N) and second detection bodies (S), a crank pulse generating means that generates crank pulses from an output signal of the detection means, a detection body identifying means, and an ignition control section. The plurality of first detection bodies (P1-N) are disposed so that their rear ends in a rotation direction of the rotary member are evenly spaced at first intervals along the rotation direction (R1), and the plurality of first detection bodies (P1-N) include an energization start detection body (P6) and an ignition detection body (P7). The second detection body (S) has a rear end disposed between a pair of the first detection bodies disposed at the first interval so that the intervals along the rotation direction between the rear end of the second detection body (S) and the rear ends of the pair of first detection bodies are second intervals different from the first interval. The detection body identifying means identifies the second detection body (S) based on intervals of crank pulses, and further, identifies the energization start detection body (P6) and the ignition detection body (P7) by using the second detection body

Description

Title of Invention: SYNCHRONISATION SYSTEM FOR AN INTERNAL COMBUSTION ENGINE WITH A TOOTHED WHEEL WITH MORE THAN TWO REFERENCE POSITIONS

Technical Field

[0001] The present invention relates to an engine system including an engine (internal combustion) that burns fuel by spark discharge of an ignition plug inside a combustion chamber, and a vehicle including the engine system.

Background Art

[0002] A fuel injection type engine includes a crank angle detection device for detecting a rotation angle of a crankshaft. The crank angle detection device includes a rotor that rotates together with the crankshaft and a pickup that generates a detection signal according to rotation of the rotor. On the outer periphery of the rotor, detection teeth are provided at even intervals. A detection signal to be output by the pickup changes according to passage of the detection tooth. By shaping the waveform of the detection signal, crank pulses are generated. At a portion on the outer periphery of the rotor, a tooth-missing position at which the detection tooth is missing is provided. At this tooth-missing position, no crank pulse is generated, so that the crank pulse interval becomes longer before and after the tooth-missing position. Accordingly, a reference rotation position of the crankshaft is obtained. By counting the crank pulses (counting the detection teeth) by using this reference rotation position as a reference, the crank angle can be obtained. Based on the crank angle thus obtained, fuel injection control and ignition control are performed.

[0003] Patent Document 1 discloses a crank angle detection device that detects a plurality of protrusions disposed on the outer peripheral surface of a rotor so that the rear end positions thereof are at even intervals. The crank angle detection device has a pickup to detect the protrusions and generates crank pulses. One of the plurality of protrusions is longer in length from the rear end to the front end than other protrusions, and is set as a protrusion indicating a reference angle of the crank angle (hereinafter, referred to as a "reference protrusion"). This reference protrusion is disposed just before the crank angle (top dead point position) corresponding to the top dead point of the piston. The pickup generates negative pulses at front ends of the protrusions, and generates positive pulses at rear ends of the protrusions. The waveforms of the negative pulses and the positive pulses are shaped and they become front end position pulses and rear end position pulses. At generation timings of the front end position pulses, a CPU is interrupted, and accordingly, the front end position pulse generation intervals are measured. The CPU is also interrupted at generation timings of the rear end position

pulses, and accordingly, the rear end position pulse generation intervals are measured. The interval between the front end position of the reference protrusion and the front end position of the protrusion just before the reference protrusion is short, so that when the ratio of the front end position pulse generation interval to the rear end position pulse generation interval is sufficiently larger than 1, the rear end position of the reference protrusion is detected. In synchronization with this, energization of the ignition coil is started. Then, when the rear end position of the next protrusion after the reference protrusion is detected, energization of the ignition coil is stopped, and spark discharge of the ignition plug is caused, and first explosion ignition is performed. Thus, an accurate crank angle can be detected before the crankshaft has rotated 360 degrees, and a proper first explosion timing can be provided.

Citation List

Patent Literature

- [0004] PTL 1: Japanese Unexamined Patent Application Publication No. 2005-291143

Summary of Invention

Solution to Problem

- [0005] In a carburetor type engine, a rotor for crank angle detection is provided with only one projection, and based on detection of this projection, energization of the ignition coil and spark discharge of the ignition plug are controlled. Therefore, when cranking is started, ignition control can be started immediately, so that the starting performance is excellent.
- [0006] On the other hand, in a fuel injection type engine, as described above, a plurality of protrusions are disposed around the rotor and are provided with functions, respectively, so that in a period before it is identified which functions the respective protrusions have, ignition control cannot be started. In detail, protrusions cannot be identified before the tooth-missing position is detected. Therefore, the time from cranking start to ignition control start becomes longer, so that the engine starting performance is poor.
- [0007] By employing the conventional technology described in Patent Document 1, the reference protrusion is disposed just before the top dead point position, so that the first explosion ignition can be started before the crankshaft has rotated 360 degrees. Accordingly, the starting performance can be improved.
- [0008] On the other hand, with the conventional technology described in Patent Document 1, not only the rear end positions of the protrusions but also the front end positions thereof must be detected, so that the configuration becomes complicated and expensive. Specifically, in the conventional technology described in Patent Document 1, the rear ends of the plurality of protrusions including the reference protrusion are disposed at even intervals, so that the reference protrusion cannot be identified only by

detection of the rear end positions. Therefore, detection of the front end positions is also essential, and a circuit for generating rear end position pulses and a circuit for generating front end position pulses are necessary. Specifically, with the conventional technology described in Patent Document 1, by utilizing the fact that the reference protrusion is longer than other protrusions, the reference protrusion is identified, and therefore, generation of front end position pulses and rear end position pulses is essential.

[0009] A preferred embodiment of the present invention provides an engine system including an engine having a crankshaft, a rotary member that rotates together with the crankshaft, a plurality of first detection bodies provided on the rotary member, a second detection body provided on the same rotary member, a detection means that detects the first and second detection bodies, a crank pulse generating means that generates crank pulses from an output signal of the detection means, a detection body identifying means, and an ignition control section. The engine includes an ignition plug that causes spark discharge in a combustion chamber, an ignition coil that stores energy to be supplied to the ignition plug, and a crankshaft. The plurality of first detection bodies are disposed so that their rear ends in a rotation direction of the rotary member are evenly spaced at first intervals along the rotation direction, and the plurality of first detection bodies include an energization start detection body that provides a timing for starting energization of the ignition coil and an ignition detection body that provides a timing of ignition of the ignition plug. The second detection body has a rear end disposed between a pair of the first detection bodies disposed at the first interval so that the intervals along the rotation direction between the rear end of the second detection body and the rear ends of the pair of first detection bodies are second intervals different from the first interval. The detection means has a detection region at a fixed position on a path that the first detection bodies and the second detection body pass through according to rotation of the rotary member, and outputs a detection signal that changes according to passages of the first detection bodies and the second detection body through the detection region. The crank pulse generating means generates crank pulses corresponding to the rear ends of the first detection bodies and the rear end of the second detection body based on the output signal of the detection means. The detection body identifying means identifies the second detection body based on intervals of crank pulses generated by the crank pulse generating means, and further, identifies the energization start detection body and the ignition detection body by using the second detection body as a reference. The ignition control section starts energization of the ignition coil in response to identification of the energization start detection body by the detection body identifying means, and stops energization of the ignition coil and makes the ignition plug cause spark discharge in response to identi-

fication of the ignition detection body by the detection body identifying means.

[0010] With this configuration, the rotary member is provided with a plurality of first detection bodies and a second detection body. The rear ends of the plurality of first detection bodies are evenly spaced at the first intervals. On the other hand, the rear end of the second detection body is disposed so that the intervals between the rear end of the second detection body and the rear ends of the first detection bodies adjacent to the second detection body are second intervals different from the first intervals (narrower than the first intervals). Therefore, when crank pulses corresponding to the rear ends of the detection bodies are generated based on an output signal of the detection means that detects the first and second detection bodies, the intervals of the crank pulses before and after the second detection body are different from the intervals of the previous or subsequent crank pulses. Accordingly, the second detection body can be identified, and by using the second detection body as a reference, the energization start detection body and the ignition detection body can be identified. Therefore, it is sufficient to provide a crank pulse generating means that generates crank pulses corresponding to the rear ends of the detection bodies, and there is no need to provide a circuit for generating crank pulses corresponding to the front ends of the detection bodies. Accordingly, the configuration is simple, and therefore, the cost can be reduced.

[0011] In a preferred embodiment of the present invention, the second detection body is disposed on the rotary member so as to pass through the detection region of the detection means when the rotation position of the crankshaft is just before a top dead point position. With this configuration, a reference of the rotation position of the crankshaft is obtained before reaching the top dead point position when the engine starts, and accordingly, it becomes possible to identify the first detection bodies. As a result, the engine can be quickly started.

[0012] When the rotation position of the crankshaft is just before the compression top dead point position, a load (cranking load) necessary for rotating the crankshaft becomes maximum. Therefore, when the engine is stopped, the crankshaft is very likely to stop at a rotation position before the compression top dead point. Therefore, the first top dead point position after the engine starts is the compression top dead point position in most cases. Therefore, when the second detection body provides a reference position just before the first top dead point position after the engine starts, and it becomes possible to identify the energization start detection body, ignition control can be quickly started and the engine can be quickly started.

[0013] The "rotation position just before the top dead point position" may be a position in a rotation position range of 180 degrees or less just before the top dead point position. Specifically, it corresponds to a rotation position of the crankshaft in a compression

stroke or an exhaust stroke in a four-stroke engine in which one cycle consists of four strokes of intake, compression, explosion, and exhaust. More preferably, the "rotation position just before the top dead point position" is a rotation position at 90 degrees or less just before the top dead point position, that is, a rotation position of the crankshaft in the latter half of the compression stroke or exhaust stroke.

[0014] In a preferred embodiment of the present invention, the second detection body is disposed so that the energization start detection body enters a detection region of the detection means before the ignition detection body enters the detection region of the detection means after the second detection body enters the detection region of the detection means according to rotation of the rotary member. With this configuration, the second detection body is disposed before the energization start detection body, so that after the second detection body is detected, by identifying the energization start detection body, ignition control including energization of the ignition coil can be started. Therefore, ignition control is started immediately after cranking starts, so that the engine can be quickly started. Specifically, the engine starting performance can be improved with the simple and inexpensive configuration.

[0015] More preferably, the second detection body may be disposed so that the energization start detection body enters the detection region next to the second detection body. With this configuration, the second detection body is disposed just before the energization start detection body, so that when the second detection body is detected, the energization start detection body is identified immediately and ignition control including energization of the ignition coil can be started. Therefore, when cranking is started, ignition control is more quickly started, so that the engine can be quickly started.

[0016] In a preferred embodiment of the present invention, the rear end of the second detection body is disposed at a position deviating from a middle position between the rear ends of the pair of first detection bodies in the rotation direction. With this configuration, the rear end of the second detection body is positioned so that the interval between the rear end of the second detection body and the rear end of the first detection body just before the second detection body and the interval between the rear end of the second detection body and the rear end of the first detection body just after the second detection body are different from each other (preferably, in a ratio of about 2 to 1). Therefore, the crank pulse interval differs before and after the second detection body, so that the second detection body can be reliably identified.

[0017] In a preferred embodiment of the present invention, the engine system further includes a reference position detection portion that is provided on the rotary member so as to pass through the detection region of the detection means, and can be identified from the first detection bodies and the second detection body based on an output signal of the detection means, and the detection body identifying means identifies the ener-

gization start detection body and the ignition detection body by using the second detection body or the reference position detection portion as a reference. With this configuration, the reference position detection portion is provided separately from the second detection body, so that when either the second detection body or the reference position detection portion is detected, it becomes possible to identify the first detection bodies.

[0018] In a preferred embodiment of the present invention, the detection body identifying means identifies the energization start detection body and the ignition detection body by using either one detected earlier of the second detection body and the reference position detection portion as a reference before starting of the engine is completed after starting of the engine is initiated. Accordingly, if the second detection body is detected earlier after the engine starting is initiated, by using the second detection body as a reference, or if the reference position detection portion is detected earlier, by using the reference position detection portion as a reference, the energization start detection body and the ignition detection body are identified. Accordingly, ignition control can be reliably started early when the engine starts.

[0019] In a preferred embodiment of the present invention, the detection body identifying means identifies the energization start detection body and the ignition detection body by using not the second detection body but the reference position detection portion as a reference after starting of the engine is completed.

[0020] According to the conventional technology described in Patent Document 1, even after starting of the engine is completed, a reference position of the crankshaft is provided by the reference protrusion, and based on this reference position, other protrusions are identified. Then, based on the identification results, various engine controls including ignition control and fuel injection control are performed.

[0021] However, the reference protrusion is provided just before the top dead point position, so that rotation of the crankshaft is not always stable when the reference projection is detected. In particular, near the compression top dead point, the intake valve and the exhaust valve are both closed and the cranking load is maximum, so that the rotation of the crankshaft is most unstable. Therefore, detection of the reference protrusion arranged at the position just before the top dead point position is not always stable, and accordingly, accurate engine control may be prevented, and eventually, the driving efficiency of the engine may be deteriorated.

[0022] In the above-described preferred embodiment of the present invention, when the second detection body is disposed near the top dead point position, the second detection body may not provide an accurate reference position. In this case, even if early start of ignition control is given priority and the second detection body is used when the engine is started, after starting of the engine is completed, not the second

detection body but the reference position detection portion is preferably used as a reference. Accordingly, the accuracy of identification of the first detection bodies can be improved, and therefore, accurate and efficient engine control can be realized.

[0023] In a preferred embodiment of the present invention, the reference position detection portion is disposed on the rotary member so as to pass through the detection region of the detection means when the rotation position of the crankshaft is near a bottom dead point position. Near the bottom dead point position, rotation of the crankshaft is stable, so that the reference position detection portion can be reliably detected.

[0024] A preferred embodiment of the present invention provides a vehicle that includes an engine system having the above-described features and uses the above-described engine as a power source.

[0025] Other elements, features, steps, characteristics and advantages of the present invention will more apparent from the following detailed description of the preferred embodiments with reference to the attached drawings.

Brief Description of Drawings

[0026] [fig.1]Fig. 1 is an illustrative side view for describing a configuration of a motorcycle as an example of a saddle type vehicle to which an engine system according to a preferred embodiment of the present invention is applied.

[fig.2]Fig. 2 is a perspective view showing a configuration example of a handle of the motorcycle.

[fig.3]Fig. 3 is a horizontal sectional view of a power unit of the motorcycle.

[fig.4]Fig. 4 is a schematic view for describing a configuration relating to an engine installed in the power unit.

[fig.5]Fig. 5 is a schematic view for describing a configuration for detecting a rotation position or a crank angle of the crankshaft of the engine.

[fig.6]Fig. 6 is a block diagram for describing an electrical configuration relating to control of the engine.

[fig.7]Fig. 7 is a block diagram for describing a functional configuration of an ECU (Electronic Control Unit) that controls the engine.

[fig.8]Fig. 8 is a flowchart for describing a flow from start of the engine to switching into an idling-stop state.

[fig.9]Fig. 9 is a flowchart for describing the details of engine start control.

[fig.10]Fig. 10 is a flowchart for describing a detailed example of judgment on deterioration of the battery.

[fig.11]Fig. 11 is a waveform chart showing waveform examples of crank pulses and an ignition signal when the engine starts.

[fig.12]Fig. 12 is a flowchart for describing a detailed example of judgment (Step S5 in

Fig. 8) of idling-stop conditions.

[fig.13]Fig. 13 is a flowchart for describing an example of control for restarting the engine in an idling-stop state.

Description of Embodiments

- [0027] Fig. 1 is an illustrative side view for describing a configuration of a saddle type vehicle to which an engine system according to a preferred embodiment of the present invention is applied. Fig. 1 shows a scooter type motorcycle 1 as an example of a saddle type vehicle. In the following description, for convenience, based on the point of view of a rider (driver) getting on the motorcycle 1, the front-rear, left-right, and up-down directions of the motorcycle 1 are defined.
- [0028] A motorcycle 1 includes a vehicle main body 2, a front wheel 3, and a rear wheel 4. The vehicle main body 2 includes a vehicle body frame 5, a handle 6, a seat 7, and a power unit 8. The vehicle body frame 5 includes a down tube 9 disposed on the front side, and a pair of left and right side frames 10 disposed at the rear of the down tube 9. The down tube 9 extends forward to the diagonally upper side, and to an upper end portion thereof, a head pipe 11 is fixed. On this head pipe 11, a steering shaft 20 is supported turnably. To the lower end of the steering shaft 20, a pair of left and right front forks 12 are fixed. To an upper end portion of the steering shaft 20, the handle 6 is attached, and to the lower end portions of the front forks 12, a front wheel 3 is attached rotatably. The side frames 10 are curved in substantially S shapes, and extend rearward to the diagonally upper side from the lower end of the down tube 9. On the side frames 10, a seat 7 is supported. To the vicinities of the intermediate portions of the side frames 10, a bracket 13 is fixed. On the bracket 13, the power unit 8 is supported so as to swing up and down via a pivot shaft 14. The power unit 8 is a unit swing type engine unit. Above the power unit 8, an air cleaner 23 for cleaning the air to be taken into the engine is disposed. Cushion units 15 are laid between the vicinities of the rear end portions of the side frames 10 and the rear end portion of the power unit 8. On the rear end portion of the power unit 8, a rear wheel 4 is supported rotatably.
- [0029] The vehicle body frame 5 is covered by a vehicle body cover 16 made of resin. The vehicle body cover 16 includes a foot board 17 that is provided below the front side of the seat 7 and provides a foot placing portion, a front cover 18 that covers the head pipe 11, a side cover 19 that covers the region below the seat 7, and a handle cover 21 that covers the handle 6. A battery 25 is housed in a space covered by the side cover 19 below the seat 7, and is supported on the vehicle body frame 5. A headlight 22 is provided to be exposed forward from the handle cover 21, and supported on the handle 6. A main switch 40 for supplying electric power charged in the battery 25 to the motorcycle 1 is disposed on, for example, the rear surface (surface facing the seat 7) of the

front cover 18. The main switch 40 may be a key switch that is operated by using a key held by a user.

[0030] Fig. 2 is a perspective view showing a configuration example of the handle 6, and shows a configuration viewed down from a driver seated on the seat 7. The handle 6 includes a handle bar 30 extending in the left-right direction, and grips 31 and 32 provided on the left end and right end of the handle bar 30. Ahead of the left grip 31, a rear wheel brake lever 38 for actuating a rear wheel brake is disposed, and ahead of the right grip 32, a front wheel brake lever 39 for actuating a front wheel brake is disposed. The right grip 32 is attached turnably in a predetermined angle range around the axis of the handle bar 30, and is an accelerator grip for an accelerating operation. The handle bar 30 is covered by the handle cover 21. The handle cover 21 is provided with a speed meter 33 and an engine rotation speed meter 34. On the speed meter 33, an indicator 41 is disposed. The indicator 41 is turned on when the engine is switched into an idling-stop state by idling-stop control described later. Near the accelerator grip 32, a starter button 35 for starting the engine is disposed. Near the left grip 31, a turn signal switch 36, a headlight switch 37, etc., are disposed.

[0031] Fig. 3 is a horizontal sectional view of the power unit 8, and shows a section viewed from above, and the upper side corresponds to the front side of the motorcycle 1, and the lower side corresponds to the rear side of the motorcycle 1. The power unit 8 includes a starter motor 43, a power generator 44, an engine 45, a V-belt type continuously variable transmission 46, and a centrifugal clutch 47. The engine 45 is a four-stroke gasoline engine in which one cycle consists of four strokes of intake, compression, explosion, and exhaust, and is a drive source of the motorcycle 1.

[0032] The engine 45 includes a crankshaft 48 extending in the left-right direction, a crankcase 49 that houses the crankshaft 48, a cylinder block 50 extending forward from the crankcase 49, a cylinder head 51 fixed to the tip end portion of the cylinder block 50, and a head cover 52 fixed to the tip end portion of the cylinder head 51. The cylinder block 50 and the cylinder head 51 constitute a cylinder 53. Inside the cylinder block 50, a piston 54 is housed slidably. The piston 54 and the crankshaft 48 are joined by a connection rod 55. A combustion chamber 56 is defined by the cylinder block 50, the cylinder head 51, and the piston 54.

[0033] On the right of the crankcase 49, the power generator 44 is disposed. The power generator 44 includes a rotor 58 coupled to the right end portion of the crankshaft 48, and a stator coil 59 supported on the crankcase 49. When the crankshaft 48 rotates, the rotor 58 rotates around the stator coil 59, and an electromotive force is generated in the stator coil 59. By this electromotive force generated in the stator coil 59, the battery 25 (refer to Fig. 1) is charged.

[0034] The V-belt type continuously variable transmission 46 includes a transmission case

60, a drive pulley 61, a driven pulley 62, and a V-belt 63 wound around these pulleys. The drive pulley 61 is attached to the left end portion of the crankshaft 48. The driven pulley 62 is attached to a main shaft 65 rotatably around the main shaft 65. In detail, the driven pulley 62 includes a movable pulley piece 62a whose position in the axial direction of the main shaft 65 changes and a fixed pulley piece 62b whose position in the axial direction does not change. Both of the pulley pieces 62a and 62b are rotatable with respect to the main shaft 65. The main shaft 65 is held rotatably on the transmission case 60. Rotation of the main shaft 65 is transmitted to a rear wheel shaft 67 via a gear mechanism 66. The rear wheel shaft 67 is supported rotatably on the transmission case 60. To the rear wheel shaft 67, the rear wheel 4 is fixed.

[0035] Rotation of the driven pulley 62 is transmitted to the main shaft 65 via the centrifugal clutch 47. The centrifugal clutch 47 includes a primary side rotor 71 supported rotatably on the main shaft 65 and a secondary side rotor 72 as a clutch plate that is coupled to the main shaft 65 and rotates together with the main shaft 65. The secondary side rotor 72 has a tubular portion surrounding the primary side rotor 71. The driven pulley 62 is coupled to the primary side rotor 71, and the primary side rotor 71 rotates together with the driven pulley 62. However, the movable pulley piece 62a can be freely displaced along the axial direction of the main shaft 65, and a compression coil spring 70 is interposed between the movable pulley piece 62a and the primary side rotor 71. The primary side rotor 71 is provided with a shoe 73. The shoe 73 is configured to come into contact with the inner surface of the tubular portion of the secondary side rotor 72 when the rotation speed of the primary side rotor 71 increases to a predetermined speed. Therefore, when the rotation speed of the driven pulley 62 increases, the shoe 73 comes into contact with the secondary side rotor 72, and accordingly, the rotation of the driven pulley 62 is transmitted to the main shaft 65 via the centrifugal clutch 47, and a driving force is applied to the rear wheel 4.

[0036] The drive pulley 61 includes a movable pulley piece 61a disposed in the crankcase 49, and a fixed pulley piece 61b disposed on the side away from the crankcase 49. The movable pulley piece 61a is coupled to the crank shaft 48 so that the movable pulley piece 61a can be displaced in the axial direction of the crankshaft 48 with respect to the crankshaft 48, and rotates together with the crankshaft 48. The fixed pulley piece 61b is fixed to the crankshaft 48, and rotates together with the crankshaft 48 in a state where it is not displaced in the axial direction of the crankshaft 48. On the crankcase 49 side with respect to the movable pulley piece 61a, a holder plate 64 is fixed to the crankshaft 48. A roller 68 is disposed between the holder plate 64 and the movable pulley piece 61a. The roller 68 is positioned near the rotation center when the rotation speed of the crankshaft 48 is low, and the movable pulley piece 61a is positioned close to the crankcase 49 accordingly. On the other hand, as the rotation speed of the

crankshaft 48 becomes higher, the roller 68 moves away from the rotation center due to a centrifugal force, and presses the movable pulley piece 61a and brings it closer to the fixed pulley piece 61b.

[0037] When the rotation speed of the crankshaft 48, that is, the engine rotation speed is low, and the distance between the movable pulley piece 61a and the fixed pulley piece 61b is long, the V-belt 63 is positioned at a small-diameter position close to the crankshaft 48. Accordingly, on the driven pulley 62, the V-belt 63 is positioned at a large-diameter position away from the main shaft 65. This state is shown in Fig. 3. In this state, the rotation speed of the driven pulley 62 is low, so that the centrifugal clutch 47 is kept in a disconnected state. When the engine rotation speed increases, the roller 68 is displaced by a centrifugal force to move away from the crankshaft 48, and accordingly, the movable pulley piece 61a moves closer to the fixed pulley piece 61b, so that the V-belt 63 moves to a large-diameter position of the drive pulley 61. Accordingly, on the driven pulley 62, the V-belt 63 widens the distance between the movable pulley piece 62a and the fixed pulley piece 62b by pushing these against a force of the compression coil spring 70 and moves to the small-diameter position. As a result, the rotation speed of the driven pulley 62 increases, so that the centrifugal clutch 47 is switched into a connected state, and a driving force of the engine 45 is transmitted to the rear wheel 4. The centrifugal clutch 47 is a rotation speed responsive clutch that is switched into a connected state in response to an engine rotation speed. A minimum engine rotation speed when the centrifugal clutch 47 is switched into a connected state is referred to as "transmission rotation speed."

[0038] The starter motor 43 is fixed to the crankcase 49, and is actuated by electric power supplied from the battery 25. The rotative force of the starter motor 43 is transmitted to the crankshaft 48 by the gear mechanism 69 housed in the crankcase 49. Therefore, when starting the engine 45, the starter motor 43 is actuated, and accordingly, the crankshaft 48 is rotated.

[0039] Fig. 4 is a schematic view for describing a configuration relating to the engine 45. On the cylinder head 51, an intake opening 81 and an exhaust opening 82 facing the combustion chamber 56 are defined. Further, on the cylinder head 51, an ignition plug 80 is disposed to face the combustion chamber 56. An intake valve 83 is disposed in the intake opening 81, and an exhaust valve 84 is disposed in the exhaust opening 82. The intake valve 83 opens and closes the intake opening 81, and the exhaust valve 84 opens and closes the exhaust opening 82. The intake valve 83 and the exhaust valve 84 are driven by a valve gear (not illustrated) that interlocks with the crankshaft 48. The intake opening 81 is connected to the intake port 85, and the exhaust opening 82 is connected to the exhaust port 86.

[0040] The engine 45 is a fuel injection type engine in the present preferred embodiment.

Specifically, in the intake port 85, an injector 87 is disposed on the upstream side of the intake valve 83. The injector 87 is arranged to inject fuel toward the intake opening 81. The injector 87 is supplied with fuel from a fuel tank 88 via a fuel hose 89. Inside the fuel tank 88, a fuel pump 90 is disposed. The fuel pump 90 pressure-feeds fuel inside the fuel tank 88 to the fuel hose 89.

[0041] In the intake port 85, a throttle body 91 is disposed on the upstream side of the injector 87. The throttle body 91 holds a throttle valve 92, an intake pressure sensor 93, an intake temperature sensor 94, and a throttle opening degree sensor 95. The throttle valve 92 may be, for example, a butterfly valve including a plate-shaped valve element disposed turnably inside the intake port 85. The throttle valve 92 is mechanically coupled to the accelerator grip 32 via a wire 99 in the present preferred embodiment. Specifically, when the accelerator grip 32 is operated, according to the operation direction and the operation amount, the throttle valve 92 is displaced (in the present preferred embodiment, angular displacement) to change the throttle opening degree. The position of the throttle valve 92 is detected by the throttle opening degree sensor 95. The throttle valve 92 and the accelerator grip 32 are mechanically joined to each other, so that in the present preferred embodiment, the throttle opening degree sensor 95 functions as an accelerator operation detection section that detects an accelerator opening degree as an accelerator command value as well as the throttle opening degree. The accelerator opening degree is an operation amount of the accelerator grip 32. The intake pressure sensor 93 detects the pressure of the intake air. The intake temperature sensor 94 detects the temperature of the intake air.

[0042] A crank angle sensor 96 for detecting a rotation angle of the crankshaft 48 is attached to the crankcase 49. An engine temperature sensor 97 for detecting the temperature of the engine 45 is attached to the cylinder block 50.

[0043] Fig. 5 is a schematic view for describing a configuration for detecting a rotation position or a crank angle of the crankshaft 48. A rotor 75 which is a rotary member for crank angle detection is fixed to the crankshaft 48. As the rotor 75, a rotor 58 for the power generator 44 may be used in common as shown in Fig. 3. A crank angle sensor 96 is disposed to face the rotor 75, and the rotor 75 and the crank angle sensor 96 constitute a crank angle detection unit. The crank angle sensor 96 consists of, for example, an electromagnetic pickup or an optical pickup, and is a detection means that outputs an electric signal responsive to an object passing through the inside of a detection region 96a.

[0044] The rotor 75 has an outer peripheral surface 75a circular in a side view along the axial direction of the crankshaft 48. Specifically, the outer peripheral surface 75a has a cylindrical surface along the rotation direction R1 of the crankshaft 48. On the outer peripheral surface 75a, along its circumferential direction, that is, along the rotation

direction R1 of the crankshaft 48, first detection bodies P1, P2, ..., P11 are disposed at even intervals. In the present preferred embodiment, the first detection bodies P1, P2, ..., P11 are flat projections (detection teeth) projecting by a predetermined height from the outer peripheral surface 75a toward the outer side of the rotation radius.

[0045] The crank angle sensor 96 is disposed so that a path that the outer peripheral surface 75a of the rotor 75 and the first detection bodies P1, P2, ..., P11 pass through crosses the detection region 96a of the crank angle sensor 96. The crank angle sensor 96 outputs a detection signal that changes for each passage of the first detection bodies P1, P2, ..., P11 according to rotation of the rotor 75. Each of the first detection bodies P1, P2, ..., P11 has a front end positioned on the downstream side in the rotation direction R1 and a rear end positioned on the upstream side in the rotation direction R1. When the crankshaft 48 rotates in the rotation direction R1, the front end of each detection body enters the detection region 96a, and then the rear end of this detection body enters the detection region 96a. An output signal of the crank angle sensor 96 changes according to passage of the front end and passage of the rear end of each detection body. In the present preferred embodiment, the rear ends of the first detection bodies P1, P2, ..., P11 are used as detection edges. Specifically, from an output signal of the crank angle sensor 96, signals corresponding to the rear ends of the first detection bodies P1, P2, ..., P11 are extracted as significant signals to generate crank pulses. Therefore, the plurality of first detection bodies P1, P2, ..., P11 are disposed on the outer peripheral surface 75a of the rotor 75 so that rear ends thereof are at even intervals. In detail, eleven first detection bodies P1, P2, ..., P11 are disposed by matching the rear ends thereof with 11 positions of 12 positions arranged by dividing the full angle range of 360 degrees around the crankshaft 48 by 30 degrees into twelve. One position at which the first detection bodies P1, P2, ..., P11 are missing is a tooth-missing position N. The distance between the first detection bodies P1 and P11 before and after the tooth-missing position N is long, so that the crank pulse interval becomes long. Therefore, by detecting the tooth-missing position N, the reference position of the crankshaft 48 can be obtained, and by counting crank pulses generated according to passages of the first detection bodies P1, P2, ..., P11 from the reference position, the rotation position (crank angle) of the crankshaft 48 can be obtained. The tooth-missing position N is a reference position detection portion that provides a first reference position of the crank angle.

[0046] The tooth-missing position N is, for example, disposed at a position such that the tooth-missing position N enters the detection region 96a near a bottom dead point position (a predetermined region including the bottom dead point position). The bottom dead position is defined by a crank angle at which the piston 54 is closest to the crankshaft 48. For example, the first detection body P6 that is sixth from the tooth-

missing position N is an energization start detection body that provides a timing to start energization of the ignition coil 79, and the following seventh first detection body P7 is an ignition detection body that provides an ignition timing to cause spark discharge by the ignition plug 80. The ignition detection body P7 is, for example, disposed to face the crank angle sensor 96 just before the top dead point position which is defined by a crank angle at which the piston 54 is farthest from the crankshaft 48. Specifically, the ignition detection body P7 is a first detection body closest to the top dead point position on the downstream side in the rotation direction R1 of the top dead point position among the plurality of first detection bodies P1 to P11.

[0047] Between the energization start detection body P6 and the first detection body P5 just before the energization start detection body P6 (that is, the first detection body P5 that passes through the detection region 96a of the crank angle sensor 96 just before the energization start detection body P6), a second detection body S is disposed. Specifically, the second detection body S is disposed so as to pass through the detection region 96a of the crank angle sensor 96 when the rotation position of the crankshaft 48 is just before the top dead point position. In detail, the second detection body S is disposed at a rotation position just before the top dead point position in a rotation position range of 180 degrees or less (in the present preferred embodiment, 90 degrees or less) just before the top dead point position. Specifically, the second detection body S is disposed so as to pass through the detection region 96a of the crank angle sensor 96 in the compression stroke or exhaust stroke (in the present preferred embodiment, in a latter half of the compression stroke or latter half of the exhaust stroke). In addition, the second detection body S is disposed so that the energization start detection body P6 enters the detection region 96a before the ignition detection body P7 enters the detection region 96a after the second detection body S enters the detection region 96a. The disposition of the second detection body S is not limited to the disposition example shown in Fig. 5, and for example, the second detection body S may be disposed between the first detection bodies P4 and P5.

[0048] The second detection body S is a flat projection (detection tooth) projecting by a predetermined height from the outer peripheral surface 75a of the rotor 75 outward in the rotation radial direction like the first detection bodies P1, P2, ..., P11. The second detection body S is disposed so that the rear end (edge on the upstream side in the rotation direction R1) that is a detection edge is sufficiently separated from the rear ends of the first detection bodies P5 and P6 before and after the second detection body S. Further, in the present preferred embodiment, the rear end of the second detection body S is biased toward the side close to the sixth detection body P6 (energization start detection body) with respect to the middle position between the rear ends of the first detection bodies P5 and P6 before and after the second detection body

S. In detail, a ratio of the distance from the rear end of the first detection body P5 to the rear end of the second detection body S (angle viewed from the crankshaft 48) with respect to the distance from the rear end of the second detection body S to the rear end of the energization start detection body P6 (angle viewed from the crankshaft 48) is 2 to 1. In the present preferred embodiment, therefore, as viewed from the crankshaft 48, the angle between the rear end of the first detection body P5 and the rear end of the second detection body S is 20 degrees, and the angle between the rear end of the second detection body S and the rear end of the energization start detection body P6 is 10 degrees. Sufficient distances (for example, 5 degrees or more as angles viewed from the crankshaft 48) are secured between the rear end of the first detection body P5 and the front end of the second detection body S and between the rear end of the second detection body S and the front end of the energization start detection body P6. In order to secure this distance, in the present preferred embodiment, the length from the rear end to the front end of the energization start detection body P6 is shorter than that of other first detection bodies P1 to P5 and P7 to P11. Therefore, the front ends of the first detection bodies P1, P2, ..., P11 are not disposed at even intervals in the present preferred embodiment. For example, the first detection bodies P1 to P5 and P7 to P11 have a length of approximately 10 degrees as an angle viewed from the crankshaft 48, and on the other hand, the energization start detection body P6 has a length of approximately 5 degrees as an angle viewed from the crankshaft 48. The length along the rotation direction R1 of the second detection body S is, for example, approximately 5 degrees as an angle viewed from the crankshaft 48.

[0049] Therefore, the angle range from the rear end of the fourth detection body P4 to the rear end of the fifth detection body P5 is 30 degrees, the angle range from the rear end of the fifth detection body P5 to the rear end of the second detection body S is 20 degrees, and the angle range from the rear end of the second detection body S to the rear end of the energization start detection body P6 is 10 degrees. The time intervals of the crank pulses depend on the angle ranges, so that the second detection body S can be identified based on the crank pulses. When the second detection body S can be identified, the energization start detection body P6 just after the second detection body S can be identified, so that immediately after the second detection body S is identified, energization of the ignition coil 79 can be started. Specifically, the second detection body S provides a second reference position of the crank angle just before the energization start detection body P6.

[0050] The rotation load of the engine 45 becomes highest just before the compression top dead point. Therefore, the angle position of the crankshaft 48 when the engine 45 stops is before the compression top dead point in many cases. In detail, a load when the first detection body P7 (ignition detection body) just before the compression top dead point

faces the crank angle sensor 96 is maximum, and the engine 45 stops at an angle position about 90 degrees before the angle position corresponding to the maximum load in many cases. Specifically, as shown in Fig. 5, it is highly probable that when the engine 45 stops, the range from the fourth first detection body P4 to the fifth first detection body P5 from the tooth-missing position N is positioned in the detection region 96a of the crank angle sensor 96.

[0051] Therefore, in the present preferred embodiment, the second detection body S is disposed between the fifth first detection body P5 and the following energization start detection body P6. When cranking is started from the state shown in Fig. 5, the angle from the rear end of the fifth first detection body P5 to the rear end of the second detection body S and the angle from the second detection body S to the sixth first detection body P6 are greatly different from each other, so that the second detection body S can be identified based on the output signal of the crank angle sensor 96, and accordingly, a reference position for crank angle detection can be provided. Based on this reference position, the energization start detection body P6 and the ignition detection body P7 can be identified immediately and ignition control for engine start can be started immediately.

[0052] Fig. 6 is a block diagram for describing an electrical configuration relating to control of the engine 45. Outputs of the sensors 93 to 97 are input into the ECU (electronic control unit) 100. To the ECU 100, other sensors such as a vehicle speed sensor 98, an acceleration sensor 131, etc., may be connected as appropriate. The vehicle speed sensor 98 is a sensor that detects the vehicle speed of the motorcycle 1, and may be a wheel speed sensor that detects rotation speeds of the wheels 3 and 4. The acceleration sensor 131 is a sensor that detects the acceleration of the motorcycle 1. To the ECU 100, a getting-on detection unit 28 for detecting whether a driver has sat on the seat 7 (refer to Fig. 1), that is, whether a driver has got on the motorcycle, is connected. The getting-on detection unit 28 may be a load detection unit that detects a load (weight) applied onto the seat 7 as illustrated in Fig. 1. An example of the load detection unit is a seat switch that becomes conductive when a load of a predetermined value or more is applied onto the seat 7.

[0053] The ECU 100 includes an interface circuit for taking-in signals output from the sensors 28, 93 to 98, and 131. The interface circuit includes a one-side edge detection circuit 106, which serves as a crank pulse generating means, that shapes the waveform of the output signal of the crank angle sensor 96 and generates crank pulses. The one-side edge detection circuit 106 detects signals corresponding to the rear ends of the first detection bodies P1 to P11 and the second detection body S from the output signal of the crank angle sensor 96 and generates crank pulses.

[0054] The ECU 100 includes a CPU 110. Based on output signals of the sensors 93 to 97,

etc., the CPU 110 drives the fuel pump 90 and the injector 87 to control the fuel injection amount and the fuel injection timing. To the ECU 100, an ignition coil 79 is further connected. The ignition coil 79 stores electric power for causing spark discharge of the ignition plug 80 (refer to Fig. 4). The CPU 110 controls energization of the ignition coil 79 based on output signals of the sensors 93 to 97, etc., to control the ignition time (discharge timing of the ignition plug 80).

[0055] Further, the CPU 110 controls energization of the starter motor 43 to control the start of the engine 45.

[0056] The battery 25 is connected to a power supply line 26 via a fuse 27. The electric power stored in the battery 25 is supplied to the starter motor 43, the ECU 100, the ignition coil 79, the injector 87, the fuel pump 90, the indicator 41, etc., via the power supply line 26. The battery 25 is supplied with electric power that is generated by the power generator 44 and rectified and regulated by the regulator 78, and accordingly, during driving of the engine 45, the battery 25 is charged.

[0057] The main switch 40 is interposed in the power supply line 26. To the power supply line 26, on the side opposite to the battery 25 with respect to the main switch 40, a parallel circuit of brake switches 135 and 136 is connected. The brake switch 135 becomes conductive when the rear wheel brake lever 38 is operated, and is shut off when the rear wheel brake lever 38 is not operated. Similarly, the brake switch 136 becomes conductive when the front wheel brake lever 39 is operated, and is shut off when the front wheel brake lever 39 is not operated. The starter button 35 is connected in series to the parallel circuit of these brake switches 135 and 136, a diode 137 is connected in series to the starter button 35, and further, a coil of a relay 77 is connected to the diode 137. To the power supply line 26, the starter motor 43 is connected via the relay 77. Therefore, when the starter button 35 is turned on in a state where the rear wheel brake lever 38 or the front wheel brake lever 39 is operated, the relay 77 becomes conductive and the electric power of the battery 25 is supplied to the starter motor 43.

[0058] In the power supply line 26, to the side opposite to the battery 25 with respect to the main switch 40, the ECU 100, the ignition coil 79, the injector 87, the fuel pump 90, the indicator 41, etc., are connected. Specifically, when the main switch 40 becomes conductive, the electric power is supplied to the ECU 100, and the control operation of the ECU 100 is started.

[0059] The ECU 100 includes a drive control section 101 for driving actuators including the ignition coil 79, the injector 87, the fuel pump 90, the relay 77, the indicator 41, etc. The drive control section 101 includes a plurality of driving circuits for energizing the actuators. The plurality of driving circuits include an ignition coil driving circuit 103 for energizing the ignition coil 79 and an injector driving circuit 104 for driving the

injector 87. The CPU 110 controls energization of the actuators by controlling these driving circuits.

- [0060] Between the diode 137 and the coil of the relay 77, the drive control section 101 of the ECU 100 is connected. Therefore, the ECU 100 can actuate the starter motor 43 by driving the relay 77 even when the starter button 35 is off.
- [0061] Fig. 7 is a block diagram for describing a functional configuration of the ECU 100. The ECU 100 and the sensors 28, 93 to 98, and 131 constitute an engine control device for controlling the engine 45. An engine system is configured by including the engine control device and the engine 45. As described above, the ECU 100 includes the CPU 110 installed inside, and by execution programs by the CPU 110, the functions of the functional processing sections described as follows are realized.
- [0062] Specifically, the ECU 100 includes, as functional processing sections, an idling-stop control section 111, a start control section 112, a traveling start control section 113, an engine output control section 114, and an engine stop control section 115. Further, the ECU 100 includes an angular velocity measuring section 121, a detection body identifying section 122, and a battery deterioration judging section 123.
- [0063] The engine output control section 114 controls the output of the engine 45. In detail, the engine output control section 114 includes a fuel supply control section 116 and an ignition control section 117. The fuel supply control section 116 controls the fuel injection amount and the fuel injection timing by controlling the fuel pump 90 and the injector 87. The ignition control section 117 controls a spark discharge time (ignition time) of the ignition plug 80 by controlling energization of the ignition coil 79. By controlling one or both of the fuel injection amount and the ignition time, the output of the engine 45 can be controlled. By cutting-off the fuel by setting the fuel injection amount to zero, the engine 45 can be stopped.
- [0064] The idling-stop control section 111 stops the engine 45 and switches the engine into an idling-stop state when predetermined idling-stop conditions are satisfied during an idling state of the engine 45. The idling state is a state where the throttle opening degree is a full closing degree and the engine rotation speed is in an idling rotation speed range (for example, 2500 rpm or less). The idling-stop state is a state where the driving of the engine 45 is automatically stopped by control of the idling-stop control section 111. In detail, the idling-stop control section 111 stops fuel supply to the engine 45 by providing a fuel cut-off command to the engine output control section 114, and accordingly stops the engine 45.
- [0065] The start control section 112 judges that cranking is being performed when it receives crank pulses input in a stopped state of the engine 45, and performs control for engine start. Specifically, the start control section 112 commands the engine output control section 114 to perform fuel supply control and ignition control. Accordingly, in

synchronization with the rotation of the crankshaft 48, fuel is injected by the injector 87 and energization of the ignition coil 79 is controlled, and the engine 45 is started. The start control section 112 includes an engine restart control section 112A. The engine restart control section 112A restarts the engine 45 when a predetermined operation of the accelerator grip 32 is detected during the idling-stop state of the engine 45. Restart means restarting the engine 45 being in an idling-stop state. In detail, the engine restart control section 112 actuates the starter motor 43 by making the relay 77 (see Fig. 6) conductive by controlling the drive control section 101 and applies fuel supply control and an ignition control command to the engine output control section 114. Accordingly, the starter motor 43 is actuated and fuel is injected from the injector 87, and the ignition coil 79 spark-discharges and the engine 45 restarts.

[0066] The traveling start control section 113 permits the motorcycle 1 to start traveling on the condition that getting-on of a driver has been detected by the getting-on detection unit 28 after the engine 45 is restarted. In other words, the traveling start control section 113 prohibits traveling start of the motorcycle 1 unless getting-on of a driver is detected by the getting-on detection unit 28. In detail, prohibiting traveling start means a state where a driving force of the engine 45 is not transmitted to the rear wheel 4. Therefore, permitting traveling start means a state where transmission of a driving force of the engine 45 to the rear wheel 4 is permitted.

[0067] In detail, the traveling start control section 113 provides a command (output inhibiting command) to inhibit an output of the engine 45 to the engine output control section 114. The engine output control section 114 that received the output inhibiting command controls the output of the engine 45 so that the rotation speed of the engine 45 becomes lower than a predetermined transmission rotation speed. As described above, the transmission rotation speed is a lowest engine rotation speed for switching the centrifugal clutch 47 (see Fig. 3) as an example of a rotation speed responsive clutch into a connected state where the centrifugal clutch 47 transmits the rotation of the primary side rotor 71 to the secondary side rotor 72. Therefore, when the engine rotation speed is kept lower than the transmission rotation speed, the centrifugal clutch 47 is kept in a shut-off state where the primary side rotor 71 and the secondary side rotor 72 rotate independently of each other, and the driving force of the engine 45 is not transmitted to the rear wheel 4. The engine output control section 114 keeps the engine rotation speed lower than the transmission rotation speed regardless of the throttle opening degree by inhibiting the output of the engine 45 by performing one or both of control of the fuel injection amount and control of the ignition time when the engine output control section 114 receives an output inhibiting command.

[0068] After the engine 45 is restarted by the engine restart control section 112A, when the

traveling start control section 113 does not permit the motorcycle 1 to start traveling, the engine stop control section 115 stops the engine 45 in response to detection of a predetermined engine stop trigger operation. An example of the engine stop trigger operation may be an operation of the accelerator grip 32 for quickly closing or quickly opening the throttle. This operation can be detected by monitoring the output of the throttle opening degree sensor 95 that also serves as an accelerator operation detection section. Specifically, when the throttle opening degree change rate is a predetermined value or more, it can be judged that an accelerator operation for quickly closing or quickly opening the throttle has been performed. Another example of the engine stop trigger operation may be a predetermined amount or more of operation of the accelerator grip 32. For example, by judging that the throttle opening degree has reached a predetermined value or more from the output of the throttle opening degree sensor 95, it can be judged that the predetermined amount or more of operation of the accelerator grip 32 has been performed. When an engine stop trigger operation is detected, the engine stop control section 115 provides a fuel cut-off command to the engine output control section 114. In response to this, the engine output control section 114 sets the fuel injection amount to zero, and accordingly, the fuel supply to the engine 45 is cut off and driving of the engine 45 is stopped.

[0069] The detection body identifying section 122 is a detection body identifying means that identifies the detection bodies P1 to P11 and S detected by the crank angle sensor 96 based on crank pulses generated by the one-side edge detection circuit 106 (refer to Fig. 6) based on an output signal of the crank angle sensor 96. In detail, based on intervals of the crank pulses generated responsive to passages of the rear ends of the detection bodies P1 to P11 and S, the detection body identifying section 122 detects the tooth-missing position N or the second detection body S as a reference position. Then, by counting crank pulses from the reference position, the detection body identifying section 122 identifies the energization start detection body P6 and the ignition detection body P7. The identification results are given to the ignition control section 117.

[0070] When the energization start detection body P6 is detected, the ignition control section 117 starts energization of the ignition coil 79. When the ignition detection body P7 is detected, the ignition control section 117 cuts-off energization of the ignition coil 79. Accordingly, energy stored in the ignition coil 79 is supplied to the ignition plug 80, and the ignition plug 80 causes spark discharge inside the combustion chamber 56. When ignition time control (retarding control) is performed, the ignition control section 117 stops energization of the ignition coil 79 at a timing shifted from the detection timing of the ignition detection body P7, and causes spark discharge of the ignition plug 80 at this shifted timing.

[0071] The angular velocity measuring section 121 is an angular velocity measuring means that measures an angular velocity of the crankshaft 48 at the time of start (including restart) of the engine 45. In detail, at the time of cranking of the engine 45, the angular velocity measuring section 121 measures an angular velocity of the crankshaft 48 just before the top dead point position (preferably, just before the compression top dead point position). In detail, in the present preferred embodiment, the angular velocity measuring section 121 measures a time during which the ignition coil 79 is energized (ignition coil energization time) as an index that indicates the angular velocity. The angular velocity measuring section 121 may measure the time from detection of the energization start detection body P6 by the detection body identifying section 122 to detection of the ignition detection body P7. This time corresponds to the ignition coil energization time. The distance between the energization start detection body P6 and the ignition detection body P7 is fixed, so that the time from detection of the energization start detection body P6 to the detection of the ignition detection body P7 is in inverse proportion to the angular velocity of the crankshaft 48. Therefore, this time can be used as an index that indicates the angular velocity of the crankshaft 48 just before the top dead point position. The angular velocity measuring section 121 may measure a time during which the ignition control section 117 generates a command of energization of the ignition coil 79 as an ignition coil energization time. The ignition control section 117 generates an energization command during the time from detection of the energization start detection body P6 to detection of the ignition detection body P7. The distance between the energization start detection body P6 and the ignition detection body P7 is fixed, so that the time during which an energization command is issued is in inverse proportion to the angular velocity of the crankshaft 48. Therefore, the time during which the energization command is issued can be used as an index that indicates an angular velocity of the crankshaft 48 just before the top dead point position. For the same reason, the angular velocity measuring section 121 may measure a time during which the ECU 100 actually energizes the ignition coil 79 (an actual ignition coil energization time). This actual ignition coil energization time can also be used as an index that indicates the angular velocity of the crankshaft 48 just before the top dead point position.

[0072] The battery deterioration judging section 123 is a battery deterioration judging means that judges whether the battery 25 has deteriorated based on an angular velocity (ignition coil energization time) measured by the angular velocity measuring section 121. When the battery 25 deteriorates, the angular velocity of the crankshaft 48 becomes smaller due to a cranking load when starting. Therefore, the battery deterioration judging section 123 judges that the battery 25 has deteriorated when the angular velocity of the crankshaft 48 when starting is smaller than a predetermined

threshold.

- [0073] Fig. 8 is a flowchart for describing the flow from the start of the engine 45 to switching into the idling-stop state. In the case where the main switch 40 is conductive, when the starter button 35 is operated (Step S2) while the rear wheel brake lever 38 or the front wheel brake lever 39 is gripped (step S1), the relay 77 becomes conductive to supply the electric power of the battery 25 to the starter motor 43. Accordingly, the starter motor 43 is driven, and crank pulses from the crank angle sensor 96 are input into the ECU 100. Based on the crank pulses, the ECU 100 identifies the energization start detection body P6 and the ignition detection body P7, and based on the identification results, performs fuel injection control and ignition control. Accordingly, the engine 45 starts and enters a driving state (Step S3).
- [0074] The ECU 100 judges whether the battery 25 has been deteriorated in a period during which the starter motor 43 is energized and a cranking operation is performed, and writes a battery deterioration judgment flag that indicates whether the battery has been deteriorated in a memory installed inside (Step S4). The state where the battery 25 has deteriorated is a state where electric power sufficient for enabling the starter motor 43 to start the engine 45 cannot be supplied from the battery 45. Specifically, not only the case where the battery 25 has deteriorated in performance due to aging, etc., but also the case where the output voltage of the battery 25 decreases due to discharge of the battery 25 are also included in the state where the battery 25 has deteriorated. The process in Step S4 is a process of writing a judgment flag indicating the battery deterioration state in a memory installed inside.
- [0075] When the engine 45 is in a driving state, the ECU 100 judges whether predetermined idling-stop conditions are satisfied (Step S5). When the idling-stop conditions are satisfied, the ECU 100 switches the engine 45 into an idling-stop state (Step S6). Specifically, fuel supply to the engine 45 is stopped and the fuel injection control and ignition control are stopped.
- [0076] Fig. 9 is a flowchart for describing details of engine start control. The CPU 110 executes an interrupting process for each input of a crank pulse. First, the CPU 110 judges whether the tooth-missing position N has already been detected (Step S51). When the tooth-missing position N has already been detected (Step S51: YES), the CPU 110 judges whether the crank pulse corresponds to the energization start detection body P6 (Step S53). That is, the CPU 110 judges whether the detection body detected by the crank angle sensor 96 is the energization start detection body P6. When it is the energization start detection body P6 (Step S53: YES), the CPU 110 starts energization of the ignition coil 79 (Step S54), and otherwise (Step S53: NO), the CPU 110 cuts-off energization of the ignition coil 79 (Step S55). That is, when energization of the ignition coil 79 has already been cut off, the CPU 110 keeps this cut-off state, and

when the ignition coil 79 is being energized, the CPU 110 cuts-off the energization. By cutting-off the energization, the energy stored in the ignition coil 79 is supplied to the ignition plug 80, and spark discharge occurs on the ignition plug 80. Thereafter, other interrupting processes are further performed (Step S56).

[0077] Other interrupting processes (Step S56) include identifications of the detection bodies P1 to P5, P7 to P11, and S corresponding to crank pulses that caused the interruptions, detection of the tooth-missing position N, fuel injection control, etc. The identifications of the detection bodies include identification of the second detection body S.

[0078] When the tooth-missing position N has not been detected yet (Step S51: NO), the second detection body S may be identified earlier than the tooth-missing position N (Step S52). In this case, by using the position of the second detection body S as a reference position, the energization start detection body P6 is identified (Step S53). Therefore, without waiting for detection of the tooth-missing position N, the energization of the ignition coil 79 can be controlled. Specifically, when the engine starts, by using either one detected earlier of the tooth-missing position N and the second detection body S as a reference, the energization start detection body P6, etc., are identified.

[0079] On the other hand, after the tooth-missing position N is detected (Step S51: YES), the interrupting process in response to a crank pulse corresponding to the second detection body S is omitted. Therefore, when the tooth-missing position N is detected earlier than the second detection body S when the engine starts, by using the tooth-missing position N exclusively as a reference, ignition control, fuel injection control, and other interrupting processes are performed. When the second detection body S is detected earlier than the tooth-missing position N when the engine starts, identification of the energization start detection body P6 just after the detection of the second detection body S is performed by using the position of the second detection body S as a reference. However, the tooth-missing position N is detected earlier than the next detection of the second detection body S, so that after this, the first detection bodies P1 to P11 are identified by using the tooth-missing position N as a reference.

[0080] The second detection body S is disposed just before the energization start detection body P6, so that when the engine starts, the second detection body S can reliably provide a reference position before the energization start detection body P6 passes through the detection region 96a of the crank angle sensor 96 for the first time. Accordingly, ignition control can be quickly started when the engine starts. On the other hand, after the engine starts, it is more proper that the reference position for identifying the first detection bodies P1 to P11 is provided not by the second detection body S but by the tooth-missing position N. The reason for this is that the second detection body S

is disposed so as to be detected at a position near the top dead point position by the crank angle sensor 96, and the tooth-missing position N is disposed so as to be detected at a position near the bottom dead point position by the crank angle sensor 96. Specifically, the rotation of the crankshaft 48 is more stable when the tooth-missing position N is detected by the crank angle sensor 96 than when the second detection body S is detected by the crank angle sensor 96. Therefore, after starting of the engine 45 is completed, by using the tooth-missing position N as a reference position, the detection bodies P1 to P11 can be identified more accurately, so that the engine 45 can be controlled more accurately.

[0081] Further, when it is tried to perform control after starting of the engine is completed based on a reference position provided by the second detection body S, the existing system in which the tooth-missing position is set near the bottom dead point position must be greatly changed. Therefore, by performing the control after starting of the engine is completed by using the tooth-missing position as a reference, the cost required to change the system can be minimized.

[0082] Fig. 10 is a flowchart for describing a detailed example of judgment on deterioration of the battery 25. This process is performed when starting the engine 45 and when restarting the engine 45 (refer to Step S4 in Fig. 8 and Step S33 in Fig. 13 described later). The CPU 110 resets the battery deterioration flag (Step S61), and waits for detection of the energization start detection body P6 (Step S62). When the energization start detection body P6 is detected, the CPU 110 starts the angular velocity measuring timer (Step S63). Then, the CPU 110 waits for detection of the ignition detection body P7 (Step S64). When the ignition detection body P7 is detected, the CPU 110 stops the angular velocity measuring timer (Step S65). Therefore, the angular velocity measuring timer measures the time from detection of the energization start detection body P6 to detection of the ignition detection body P7 by the crank angle sensor 96. This time corresponds to the angular velocity of the crankshaft 48 as described above. This time also corresponds to an energization time of the ignition coil 79 as described above.

[0083] The CPU 110 compares a measured value measured by the angular velocity measuring timer with a predetermined battery deterioration judgment threshold (Step S66). When the measured value measured by the angular velocity measuring timer is equal to or more than the battery deterioration judgment threshold (Step S66: YES), the angular velocity of the crankshaft 48 when cranking is equal to or less than an angular velocity threshold corresponding to the battery deterioration judgment threshold. Then, the CPU 110 raises a battery deterioration flag (Step S67). When the measured value measured by the angular velocity measuring timer is less than the battery deterioration judgment threshold (Step S66: NO), the angular velocity of the

crankshaft 48 when cranking is sufficient, so that the battery deterioration flag is kept in a reset state.

[0084] Thus, when the battery 25 has deteriorated and cannot supply sufficient electric power, the rotation speed of the crankshaft 48 that is rotated by the starter motor 43 decreases, so that by utilizing this phenomenon, deterioration of the battery 25 can be judged.

[0085] Fig. 11 is a waveform chart showing waveform examples of crank pulses and an ignition signal when the engine starts. The main switch 40 is made conductive at the timing t1, and the starter button 35 is operated at the timing t2. Accordingly, rotation of the crankshaft 48 starts, and according to passages of the detection bodies P1 to P11 and S, crank pulses are generated. In the example of Fig. 11, a crank pulse corresponding to the rear end of the first detection body P3 that is third from the tooth-missing position N is generated first. After crank pulses corresponding to the rear ends of the fourth first detection body P4 and the fifth first detection body P5 are generated, a crank pulse corresponding to the rear end of the second detection body S is generated, and subsequently, a crank pulse corresponding to the rear end of the energization start detection body P6 is generated. For example, the CPU 110 identifies the second detection body S based on intervals between crank pulses before and after each crank pulse. Specifically, the second detection body S is biased toward the first detection body P6 side between the first detection bodies P5 and P6. Therefore, the magnitude relationship between the crank pulse intervals s1 and s2 before and after the crank pulse corresponding to the second detection body S can be distinguished from the magnitude relationships between the crank pulse intervals before and after other crank pulses. Accordingly, the second detection body S can be identified.

[0086] After the second detection body S is identified, the CPU 110 starts energization of the ignition coil 79 at the timing t3 in synchronization with a crank pulse corresponding to the energization start detection body P6. Then, in synchronization with a crank pulse corresponding to the ignition detection body P7 that is detected next to the energization start detection body P6, the CPU 110 stops the energization of the ignition coil 79 at the timing t4. Further, the CPU 110 measures the energization time of the ignition coil 79 by starting the angular velocity measuring timer at the timing t3 and stopping the angular velocity measuring timer at the timing t4.

[0087] Thereafter, crank pulses corresponding to the first detection bodies P8 to P11 are generated, and the CPU 110 performs necessary processes at the respective angle positions. After the first detection body P11, the tooth-missing position N faces the crank angle sensor 96, so that until the crank pulse of the first detection body P1 to be detected next, a long time interval is generated. By monitoring the time intervals of the crank pulses, the CPU 110 detects the tooth-missing position N. Thereafter, by using

the tooth-missing position N as a reference position, crank pulses corresponding to the first detection bodies P1 to P11 are counted, and at angle positions corresponding to the first detection bodies P1 to P11, necessary processes are performed.

[0088] Unless the second detection body S is provided, the first detection bodies P1 to P11 cannot be identified until the tooth-missing position N is detected. Therefore, the energization start detection body P6 is identified for the first time after the crankshaft 48 has rotated substantially 360 degrees, and then ignition control is started. Therefore, the time until the engine 45 starts becomes long. On the other hand, in the configuration of the present preferred embodiment in which the second detection body S is provided, the ignition control can be started by identifying the energization start detection body P6 before the crankshaft 48 rotates 360 degrees, so that the starting performance of the engine 45 can be improved.

[0089] In addition, the energization start detection body P6 can be quickly identified, so that the angular velocity measurement for battery deterioration judgment can be quickly started. Therefore, the angular velocity of the crankshaft 48 immediately after the starter motor 43 is actuated can be measured, so that deterioration of the battery 25 can be properly judged. After the crankshaft 48 rotates 360 degrees, the rotation of the crankshaft 48 becomes faster, so that the accuracy of the battery deterioration judgment based on the angular velocity measurement results may be deteriorated.

[0090] Fig. 12 is a flowchart for describing a detailed example of judgment of idling-stop conditions (Step S5 in Fig. 8). The CPU 110 judges whether the following conditions A1 to A7 are all satisfied (Steps S11 to S17).

[0091] Condition A1: The accelerator grip 32 is at a full-closing position. This condition is for confirming that a driver does not intend to transmit a driving force of the engine 45 to the rear wheel 4 that is a drive wheel. In the present preferred embodiment, the accelerator grip 32 and the throttle valve 92 are mechanically interlocked with each other by the wire 99, so that when the throttle opening degree sensor 95 detects full closing of the throttle valve 92, the accelerator grip 32 is at a full-closing position.

[0092] Condition A2: The vehicle speed is a predetermined value (for example, 3 km/h) or less. This condition is for confirming that the motorcycle 1 has stopped. In detail, the condition is that the vehicle speed sensor 98 detects a vehicle speed of a predetermined value or less.

[0093] Condition A3: Getting-on of a driver has been detected. Getting-on of a driver is detected by the getting-on detection unit 28. If the getting-on detection unit 28 malfunctions and the output thereof is not supplied to the ECU 100, getting-on of a driver is not detected. As described above, to restart the engine 45 in an idling-stop state, getting-on of a driver must be detected. If the getting-on detection unit 28 malfunctions and cannot detect getting-on of a driver, after the engine is switched into an idling-stop

state, the engine 45 cannot be restarted. This failure can be avoided by the condition A3. Specifically, when the getting-on detection unit 28 malfunctions, the engine is not switched into an idling-stop state, so that a restart failure from the idling-stop state does not occur.

[0094] Condition A4: The engine rotation speed is a predetermined value (for example, 2500 rpm) or less. This condition is for confirming that the engine rotation speed is in an idling rotation speed range. The ECU 100 calculates an engine rotation speed based on a crank pulse generation period output by the crank angle sensor 96, for example.

[0095] Condition A5: The engine temperature is a predetermined value (for example, 60 degree) or more. This condition is for confirming that the engine 45 has been sufficiently warmed up, and can be easily restarted after the driving thereof is stopped. The ECU 100 judges the engine temperature based on an output signal of the engine temperature sensor 97.

[0096] Condition A6: The battery has not been deteriorated. Specifically, the judgment of the condition A6 may be judgment as to whether a battery deterioration judgment flag has been raised.

[0097] Condition A7: A ratio of an idling-stop time to an energization time is a predetermined value (for example, 40%) or less. The energization time is a time during which the main switch 40 is conductive, the motorcycle 1 is powered on, and the electric system of the motorcycle 1 is energized. The idling-stop time is a cumulative time during which the engine 45 is in an idling-stop state. In the present preferred embodiment, an idling-stop time in an energization time of the last 20 minutes, approximately, is measured, and based on this, a ratio of the idling-stop time to the energization time (approximately 20 minutes) is calculated.

[0098] When all of the conditions A1 to A7 are satisfied (YES in all of Steps S11 to S17), the CPU 110 increments a timer installed inside (Step S18) and judges whether the value of the timer has reached a predetermined value (for example, a value corresponding to 3 seconds) (Step S19). The timer measures a duration of a state where all of the conditions A1 to A7 are satisfied. When at least one of the conditions A1 to A7 is not satisfied (NO in any of Steps S11 to S17), the CPU 110 resets the timer to zero (Step S20). When the time measured by the timer reaches the predetermined value (for example, a value corresponding to 3 seconds), the CPU 110 judges that the idling-stop conditions have been satisfied and switches the engine 45 into an idling-stop state (Step S6). Specifically, the idling-stop condition is continuation of a state where all of the conditions A1 to A7 are satisfied for a predetermined time. In the idling-stop state, the ECU 110 turns the indicator 41 on.

[0099] Fig. 13 is a flowchart for describing an example of control for restarting the engine 45 being in an idling-stop state. The CPU 110 judges whether the operation amount of

the accelerator grip 32, that is, the accelerator opening degree has exceeded a predetermined value by monitoring the output of the throttle opening degree sensor 95 (Step S31). When the accelerator opening degree does not exceed the predetermined value, the idling-stop state is continued. When the accelerator opening degree exceeds the predetermined value, the CPU 110 restarts the engine 45 (Step S32). Specifically, the CPU 110 actuates the starter motor 43 by making the relay 77 conductive, and starts the fuel injection control and ignition control. Accordingly, the engine 45 restarts.

[0100] The CPU 110 judges whether the battery 25 has been deteriorated during a period in which the starter motor 43 is energized and a cranking operation is performed, and writes a battery deterioration judgment flag indicating whether the battery has been deteriorated in the memory installed inside (Step S33). Details of this operation are the same as those in Step S4 of Fig. 8 (see Fig. 10).

[0101] After restarting the engine 45, the CPU 110 judges whether a driver has got on the vehicle, that is, whether a driver has sat on the seat 7 by referring to the output of the getting-on detection unit 28 (Step S34). When a driver gets on the vehicle (Step S34: YES), the CPU 110 establishes a traveling start permitting state (Step S35). Specifically, the CPU 110 permits the engine rotation speed to increase over the transmission rotation speed. Therefore, the accelerator opening degree is increased by the operation of the accelerator grip 32, and in response to this, the throttle opening degree increases and the output of the engine 45 increases, and then, the engine rotation speed reaches the transmission rotation speed. Accordingly, the centrifugal clutch 47 is switched into a connected state, and the driving force of the engine 45 is transmitted to the rear wheel 4.

[0102] On the other hand, when getting-on of a driver is not detected by the getting-on detection unit 28 (Step S34: NO), the CPU 110 establishes a traveling start prohibiting state (Step S36). In the traveling start prohibiting state, even when the driver increases the accelerator opening degree and the throttle opening degree accordingly increases, the output of the engine 45 is limited, and the engine rotation speed does not reach the transmission rotation speed. Specifically, the CPU 110 limits the output of the engine 45 by reducing the fuel injection amount according to the engine rotation speed and retarding the ignition time (regarding control) so that the engine rotation speed does not increase even if the throttle opening degree increases. Accordingly, the engine rotation speed does not reach the transmission rotation speed, so that the centrifugal clutch 47 is kept in a disconnected state, and the driving force of the engine 45 is not transmitted to the rear wheel 4. Therefore, the motorcycle 1 is prevented from unintentionally starting traveling in a state where a driver does not get on it.

[0103] In the traveling start prohibiting state, in response to a predetermined engine stop trigger operation performed by a driver (Step S37), the CPU 110 stops the engine 45

(Step S38). For example, when the accelerator opening degree reaches a predetermined value or more, this is detected by the throttle opening degree sensor 95, and in response to this detection, the CPU 110 stops the engine 45 by stopping fuel supply to the engine 45. Therefore, when a driver does not sit on the seat 7, if the engine is restarted unintentionally, by increasing the accelerator opening degree, the engine 45 can be stopped immediately without shutting-off the main switch 40.

[0104] As described above, according to the present preferred embodiment, the rotor 75 is provided with the plurality of first detection bodies P1 to P11 and the second detection body S. The rear ends of the plurality of first detection bodies P1 to P11 are evenly spaced from each other at first intervals (intervals of 30 degrees as angles viewed from the crankshaft 48). On the other hand, the rear end of the second detection body S is disposed so that the intervals between the rear end of the second detection body S and the rear ends of the adjacent first detection bodies P5 and P6 are second intervals (intervals of 10 degrees and 20 degrees as angles viewed from the crankshaft 48) different from the first intervals. Therefore, based on an output signal of the crank angle sensor 96 that detects the first and second detection bodies P1 to P11 and S, when crank pulses corresponding to the rear ends of the detection bodies P1 to P11 and S are generated, the intervals of the crank pulses before and after the second detection body S are different from the intervals between crank pulses previous to or subsequent to the crank pulses before and after the second detection body S. Accordingly, the second detection body S can be identified, and by using this second detection body S as a reference, the energization start detection body P6 and the ignition detection body P7 can be identified. Therefore, it is sufficient to provide the one-side edge detection circuit 106 that generates crank pulses corresponding to the rear ends of the detection bodies P1 to P11 and S, so that there is no need to provide a circuit that generates crank pulses corresponding to the front ends of the detection bodies P1 to P11 and S. Accordingly, the configuration becomes simple, and accordingly, the cost can be reduced.

[0105] As another configuration (Comparative example), a configuration may be possible in which, instead of adding the second detection body in the row of the plurality of first detection bodies P1 to P11 having rear ends disposed at even intervals, the interval between the rear ends of a pair of first detection bodies P_i and $P_{(i+1)}$ ($i = 1, 2, 3, \dots, 10$) adjacent to each other among the first detection bodies P1 to P11 is made different from the intervals between the rear ends of other first detection bodies adjacent to each other. Even in the configuration of this Comparative example, a reference position can be provided by the detection body $P_{(i+1)}$ by using an output of the one-side edge detection circuit. However, in this case, a control program using the detection body $P_{(i+1)}$ as a trigger must be greatly changed. Therefore, the existing control program on

the assumption that the detection bodies are provided at even intervals on the rotor that rotates together with the crankshaft must be greatly changed. The control program change may widely influence not only the control portion using the detection body $P(i+1)$ as a trigger but also the entirety of engine control, and the development cost is accordingly increased.

[0106] On the other hand, in the configuration according to the present preferred embodiment, the rear ends of the first detection bodies P1 to P11 provided on the rotor 75 are disposed at even intervals, so that there is no need to greatly change the existing control program that works on the assumption that the detection bodies are provided at even intervals on the rotor that rotates together with the crankshaft.

[0107] In addition, in the present preferred embodiment, the second detection body S is disposed just before the top dead point position, so that when the engine starts, a reference of the rotation position of the crankshaft 48 is obtained before the top dead point position is reached, so that the first detection body S can be accordingly identified. As a result, the engine 45 can be quickly started.

[0108] In the present preferred embodiment, the second detection body S is disposed between the energization start detection body P6 and the detection body P5 that passes through the detection region 96a of the crank angle sensor 96 just before the energization start detection body P6. Therefore, the possibility that the energization of the ignition coil 79 can be started when the energization start detection body P6 passes through the detection region 96a of the crank angle sensor 96 for the first time after the starter motor 43 is started increases. Accordingly, after the starter motor 43 is started, ignition control can be quickly started, so that the engine starting performance can be improved.

[0109] Further, in the present preferred embodiment, the rear end of the second detection body S is disposed at a position deviating in the rotation direction R1 from the middle position between the first detection bodies P5 and P6 before and after the second detection body S. Accordingly, the rear end of the second detection body S is disposed so that the interval between the rear end of the second detection body S and the rear end of the first detection body P5 just before the second detection body S (the interval of 20 degrees as an angle viewed from the crankshaft 48) and the interval between the rear end of the second detection body S and the rear end of the first detection body P6 just after the second detection body S (the interval of 10 degrees as an angle viewed from the crankshaft 48) become different from each other. In detail, the ratio of these intervals is 2 to 1. Therefore, the crank pulse interval changes before and after the second detection body S, so that the second detection body S can be reliably identified.

[0110] Further, in the present preferred embodiment, a reference position is set based on either one detected earlier of the second detection body S and the tooth-missing

position N, and based on the reference position thus set, the energization start detection body P6 and the ignition detection body P7 are identified. Therefore, after the starter motor 43 is started, the energization start detection body P6 can be quickly identified, that is, identified before the crankshaft 48 has rotated 360 degrees. Therefore, after the starter motor 43 is started, ignition control can be quickly started, and the engine 45 can be quickly started.

[0111] In the present preferred embodiment, after starting of the engine 45 is completed, by using not the second detection body S but the tooth-missing position N as a reference, the energization start detection body P6 and the ignition detection body P7 are identified. The second detection body S is positioned near the top dead point position, so that it enters the detection region 96a when the rotation of the crankshaft 48 is unstable. Therefore, the reference position provided by the second detection body S is not always accurate. Therefore, in the present preferred embodiment, when starting the engine, quick start of ignition control is given priority and the second detection body S is used; however, when starting of the engine is completed, the first detection bodies P1 to P11 are identified by using not the second detection body S but the tooth-missing position N disposed near the bottom dead point position as a reference. Accordingly, the identification accuracy for the first detection bodies P1 to P11 is increased, and accordingly, accurate and efficient engine control is realized.

[0112] A preferred embodiment of the present invention is described above; however, the present invention can also be carried out in other modes. For example, the above-described preferred embodiment shows an example in which the first detection bodies P1 to P11 and the second detection body S are formed of projections provided on the outer peripheral surface 75a of the rotor 75. However, these detection bodies may be recess portions formed on the outer peripheral surface 75a, or magnetic bodies embedded in the outer peripheral surface 75a. Similarly, in the above-described preferred embodiment, the first reference position detection portion is defined by the tooth-missing position N; however, it is also possible that the first reference position detection portion may be formed of a projection, a recess portion, or a magnetic body. Further, the above-described embodiment shows an example in which the rear ends of the first detection bodies P1 to P11 are disposed at even intervals; however, it is also possible that the front ends of the first detection bodies P1 to P11 are disposed at even intervals, and the front ends of the detection bodies P1 to P11 and S are used as detection edges. However, the output signal of the crank angle sensor 96 is more stable in the case where the rear end positioned on the upstream side in the rotation direction R1 is used as a detection edge, and accordingly, stable detection is realized.

[0113] Further, in the above-described preferred embodiments, a configuration in which the power transmission path between the engine 45 and the drive wheel (rear wheel 4) is

connected/disconnected by the centrifugal clutch 47 is shown; however, the clutch that connects/disconnects the power transmission path may be realized by other modes such as a hydraulic clutch or an electromagnetic clutch. By controlling the hydraulic clutch or the electromagnetic clutch, etc., according to an engine rotation speed, etc., the same operation as in the case where the centrifugal clutch 47 is used can be realized.

[0114] In the above-described preferred embodiment, the configuration in which the throttle valve 92 is mechanically interlocked with the accelerator grip 32 by the wire 99 is described; however, instead of this configuration, a so-called electronic throttle device may be applied. Specifically, while the throttle valve 92 is driven by a throttle actuator such as an electric motor, an accelerator opening degree sensor that detects the operation amount of the accelerator grip 32 (accelerator opening degree) may be provided. In this case, an output signal of the accelerator opening degree sensor is input into the ECU 100. The ECU 100 drives the throttle actuator and adjusts the throttle opening degree according to the output signal of the accelerator opening degree sensor. In this configuration, control in which the throttle opening degree does not depend on the accelerator opening degree can also be performed. Specifically, for example, even when the accelerator opening degree is not changed, the throttle opening degree can be changed. Therefore, for example, even if an increase in accelerator opening degree is detected in a traveling start prohibiting state (refer to Step S36 in Fig. 13), the throttle opening degree is not increased, and the engine rotation speed can be prevented from increasing. Specifically, in the traveling start prohibiting state, even if the accelerator grip 32 is operated, the engine output control section 114 does not actuate the throttle actuator, and keeps the throttle opening degree at a full closing degree (or equal to or less than a value at which the engine rotation speed does not reach the transmission rotation speed). Thus, by adjusting the intake air amount to be taken into the engine 45, the driving force of the engine 45 can be prevented from being transmitted to the rear wheel 4 (refer to Fig. 1). Further, the engine restart control section 112A may perform engine restart control based on an output of the accelerator opening degree sensor (Step S31 in Fig. 13). The engine stop control section 115 may judge whether a predetermined engine stop trigger operation has been performed based on an output signal not of the throttle opening degree sensor 95 but of the output signal of the accelerator opening degree sensor (Step S37 in Fig. 13).

[0115] In the above-described preferred embodiment, a scooter type motorcycle 1 is described by way of example; however, the present invention is also applicable to other motorcycles such as a moped type, a sport type, etc. Further, not only to motorcycles, the present invention is also applicable to other saddle type vehicles such as all-terrain vehicles and snowmobiles. Further, the present invention is also applicable

not only to engines for saddle type vehicles but also to engines for other types of vehicles and engines to be used for a purpose other than vehicles, such as power generators.

[0116] The present application corresponds to Japanese Patent Application No. 2012-153928 filed in the Japan Patent Office on July 9, 2012, and the entire disclosure of the application is incorporated herein by reference.

[0117] While preferred embodiments of the present invention have been described above, it is to be understood that variations and modifications will be apparent to those skilled in the art without departing the scope of the present invention. The scope of the present invention, therefore, is to be determined solely by the following claims.

Reference Signs List

- [0118] 1 Motorcycle
8 Power unit
25 Battery
43 Starter motor
44 Power generator
45 Engine
48 Crankshaft
R1 Rotation direction
49 Crankcase
53 Cylinder
54 Piston
58 Rotor
59 Stator coil
75 Rotor (for crank angle detection)
75a Outer peripheral surface
P1 to P11 First detection body
S Second detection body
N Tooth-missing position
77 Relay
78 Regulator
79 Ignition coil
80 Ignition plug
87 Injector
92 Throttle valve
95 Throttle opening degree sensor
96 Crank angle sensor

96a Detection region
100 ECU
101 Drive control section
103 Ignition coil driving circuit
104 Injector driving circuit
106 One-side edge detection circuit
110 CPU
111 Idling-stop control section
112 Start control section
112A Engine restart control section
113 Traveling start control section
114 Engine output control section
115 Engine stop control section
116 Fuel supply control section
117 Ignition control section
121 Angular velocity measuring section
122 Detection body identifying section
123 Battery deterioration judging section
140 Stroke identifying sensor

Claims

[Claim 1]

An engine system comprising:

an engine having an ignition plug that causes spark discharge inside a combustion chamber, an ignition coil that stores energy to be supplied to the ignition plug, and a crankshaft;

a rotary member that rotates together with the crankshaft;

a plurality of first detection bodies that are provided on the rotary member and disposed so that rear ends thereof in a rotation direction of the rotary member are evenly spaced at first intervals along the rotation direction, the plurality of first detection bodies including an energization start detection body that provides a timing for starting energization of the ignition coil and an ignition detection body that provides a timing of ignition of the ignition plug;

a second detection body that is provided on the rotary member, and has a rear end disposed between a pair of the first detection bodies disposed at the first interval so that the intervals along the rotation direction between the rear end and the rear ends of the pair of first detection bodies are second intervals different from the first interval;

a detection means that has a detection region at a fixed position on a path that the first detection bodies and the second detection body pass through according to rotation of the rotary member, and outputs a detection signal that changes according to passages of the first detection bodies and the second detection body through the detection region;

a crank pulse generating means that generates crank pulses corresponding to the rear ends of the first detection bodies and the rear end of the second detection body based on an output signal of the detection means;

a detection body identifying means that identifies the second detection body based on intervals of crank pulses generated by the crank pulse generating means, and further, identifies the energization start detection body and the ignition detection body by using the second detection body as a reference; and

an ignition control section that starts energization of the ignition coil in response to identification of the energization start detection body by the detection body identifying means, and stops energization of the ignition coil and makes the ignition plug cause spark discharge in response to

identification of the ignition detection body by the detection body identifying means.

[Claim 2] The engine system according to Claim 1, wherein the second detection body is disposed on the rotary member so as to pass through the detection region of the detection means when the rotation position of the crankshaft is just before a top dead point position.

[Claim 3] The engine system according to Claim 1 or 2, wherein the second detection body is disposed so that the energization start detection body enters the detection region before the ignition detection body enters a detection region of the detection means after the second detection body enters the detection region of the detection means according to rotation of the rotary member.

[Claim 4] The engine system according to Claim 3, wherein the second detection body is disposed so that the energization start detection body enters the detection region next to the second detection body according to rotation of the rotary member.

[Claim 5] The engine system according to any one of Claims 1 to 4, wherein the rear end of the second detection body is disposed at a position deviating from a middle position between the rear ends of the pair of first detection bodies in the rotation direction.

[Claim 6] The engine system according to any one of Claims 1 to 5, further comprising:
a reference position detection portion that is provided on the rotary member so as to pass through the detection region of the detection means, and can be identified from the first detection bodies and the second detection body based on an output signal of the detection means, wherein
the detection body identifying means identifies the energization start detection body and the ignition detection body by using the second detection body or the reference position detection portion as a reference.

[Claim 7] The engine system according to Claim 6, wherein the detection body identifying means identifies the energization start detection body and the ignition detection body by using either one detected earlier of the second detection body and the reference position detection portion as a reference before starting of the engine is completed after starting of the engine is initiated.

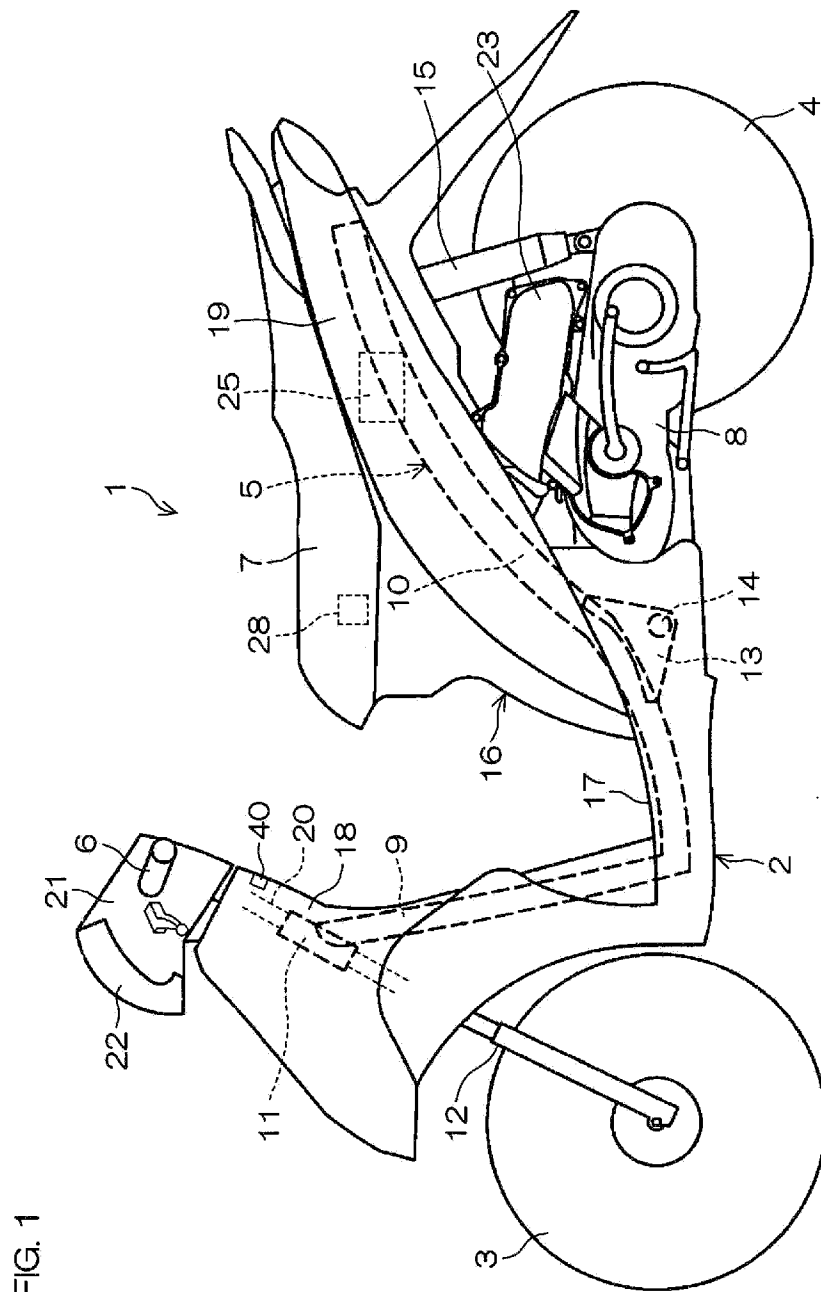
[Claim 8] The engine system according to Claim 6 or 7, wherein the detection

body identifying means identifies the energization start detection body and the ignition detection body by using not the second detection body but the reference position detection portion as a reference after starting of the engine is completed.

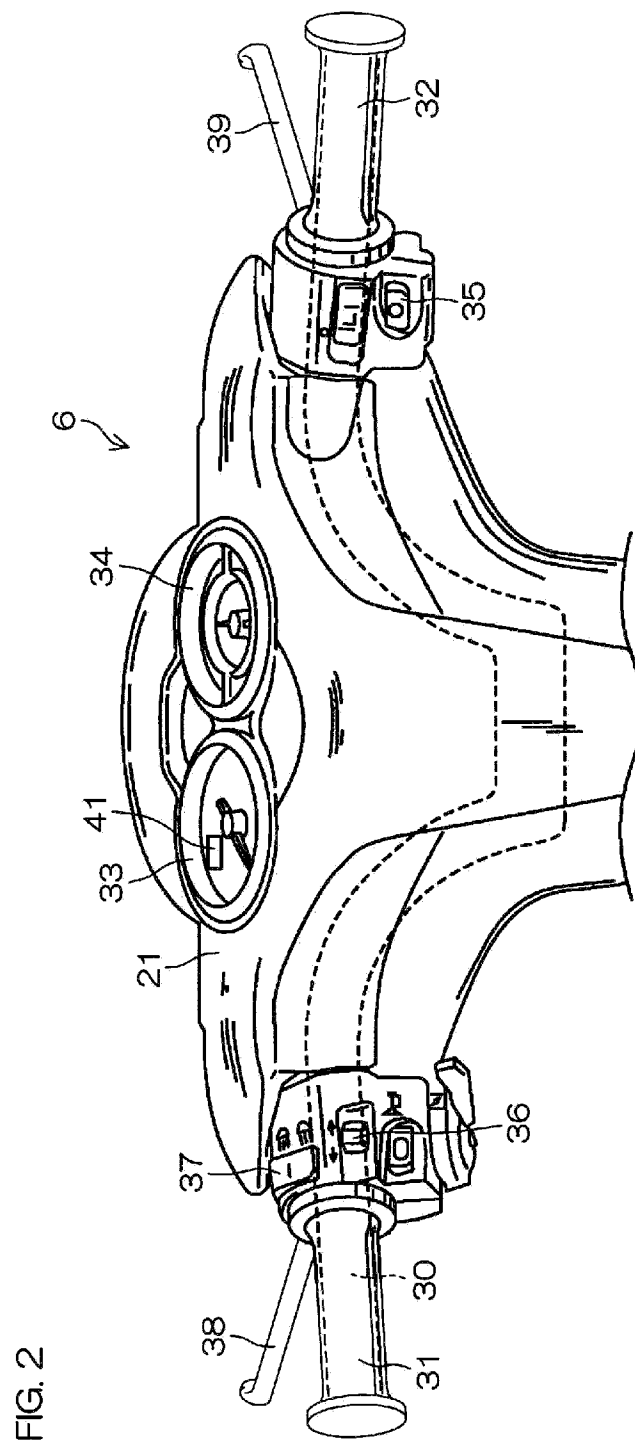
[Claim 9] The engine system according to any one of Claims 6 to 8, wherein the reference position detection portion is disposed on the rotary member so as to pass through the detection region of the detection means when the rotation position of the crankshaft is near a bottom dead point position.

[Claim 10] A vehicle comprising the engine system set forth in any one of Claims 1 to 9, and using the engine as a power source.

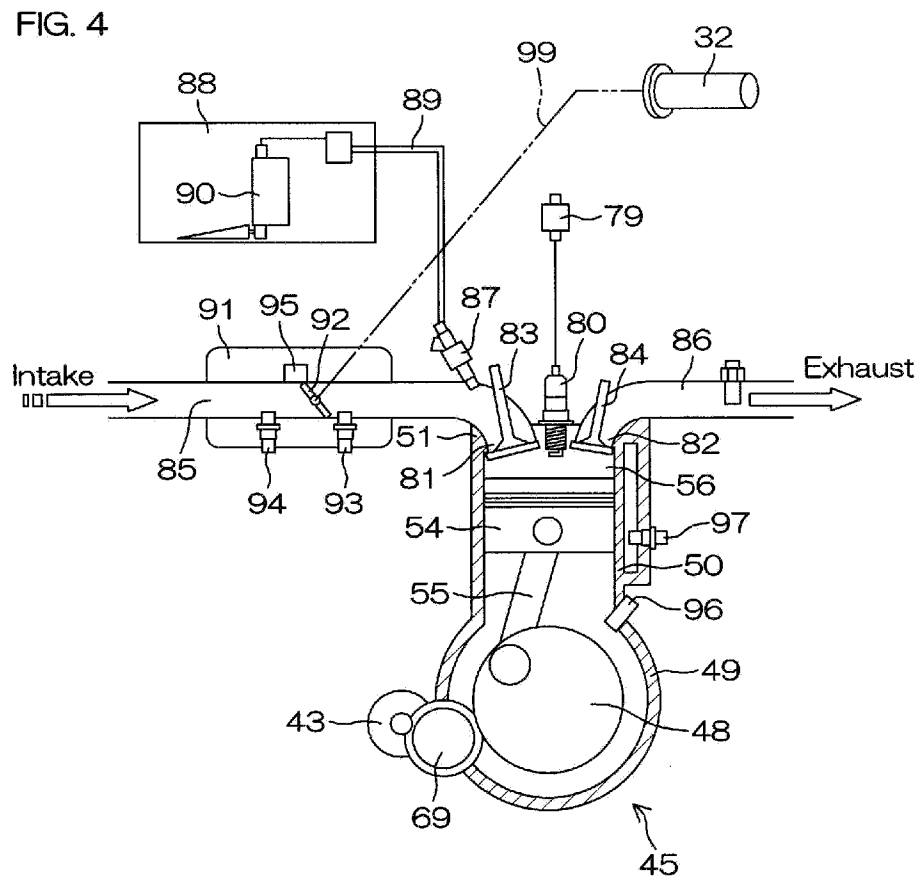
[Fig. 1]



[Fig. 2]

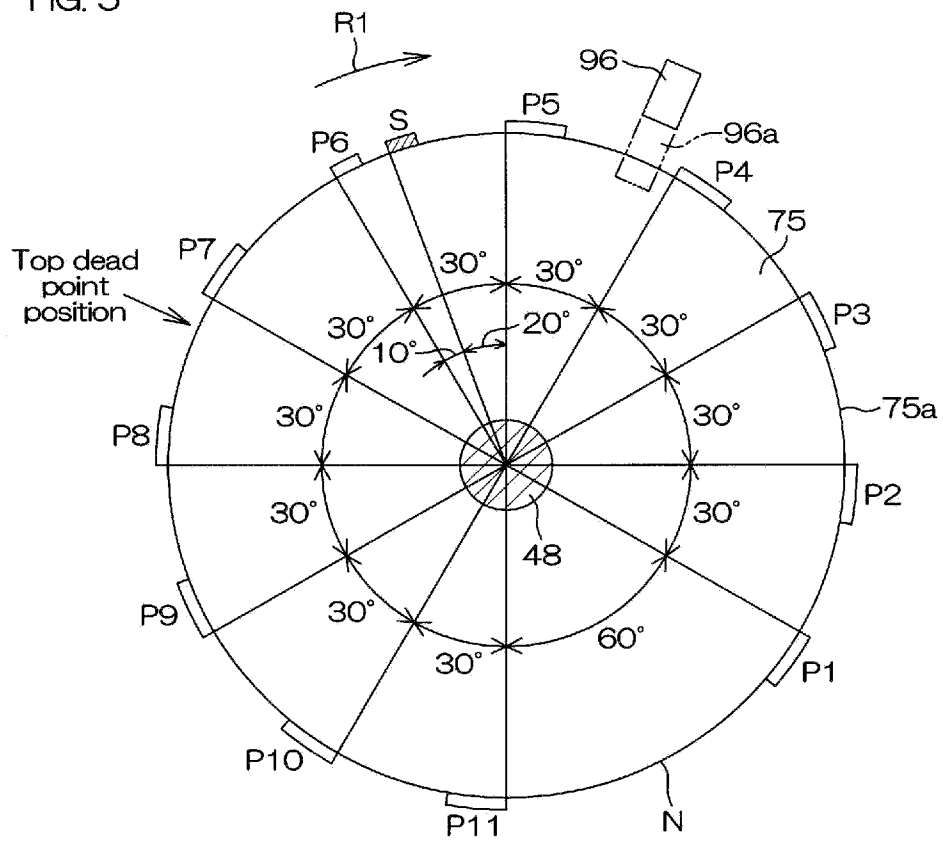


[Fig. 4]

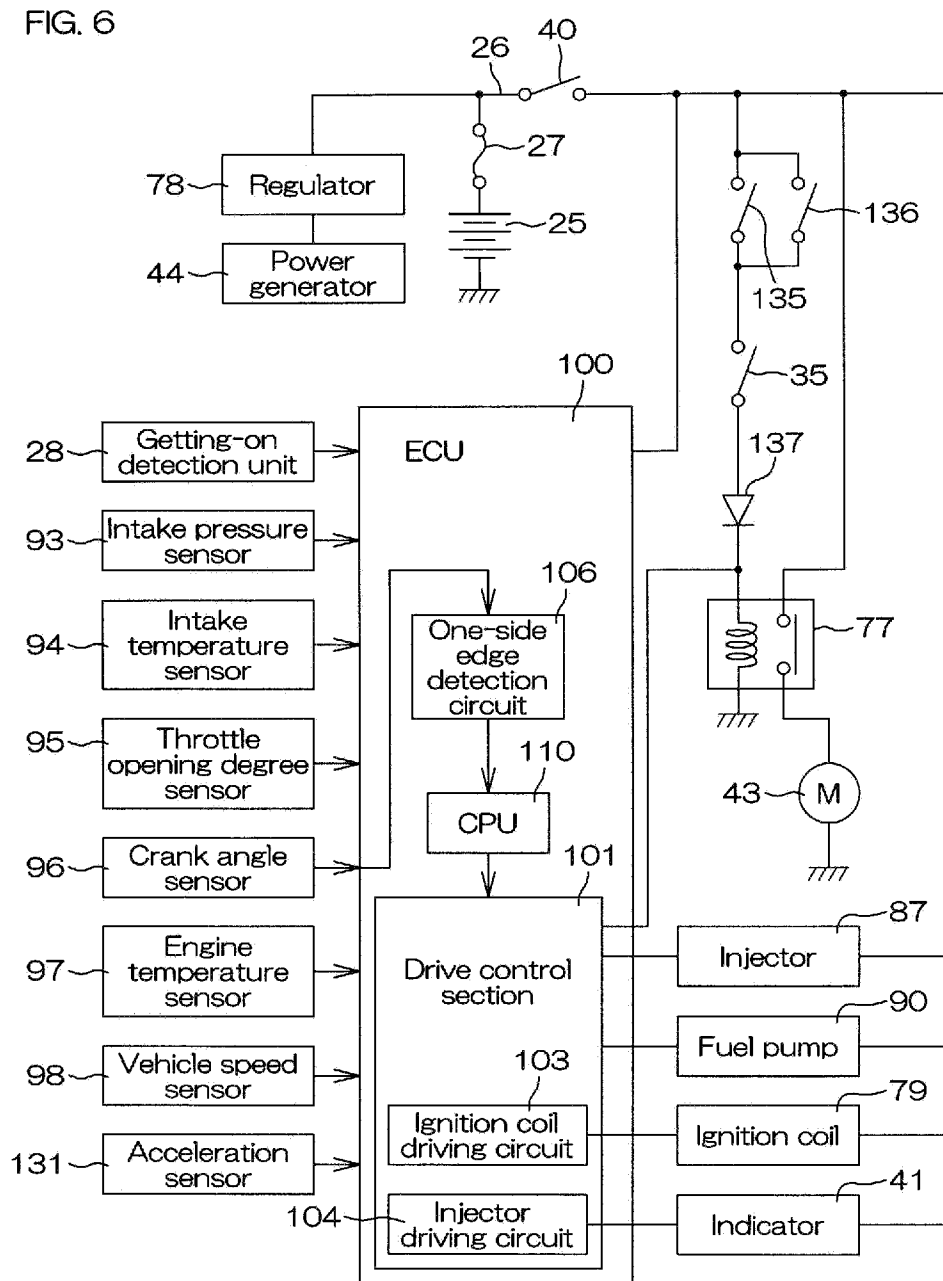


[Fig. 5]

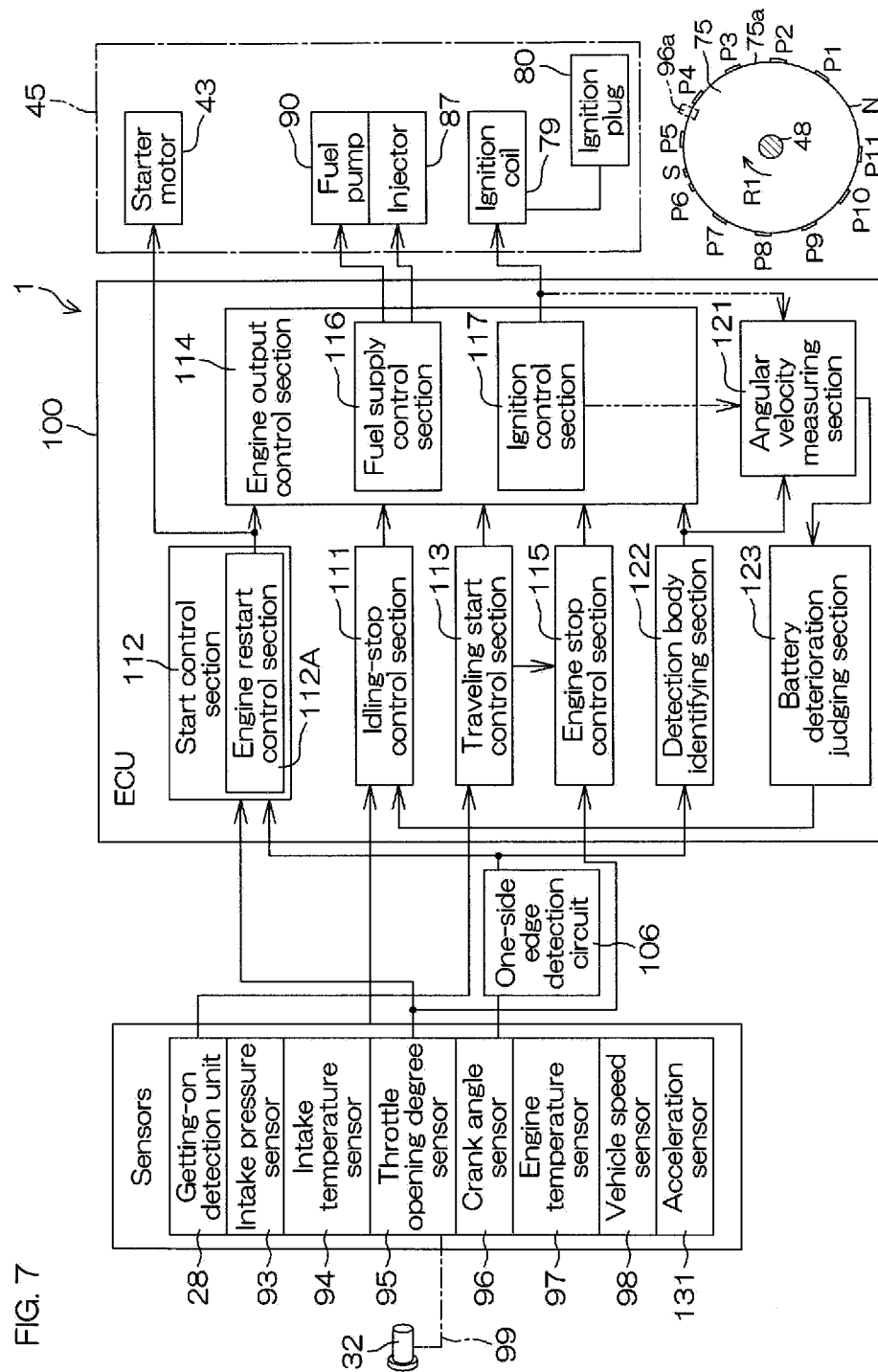
FIG. 5



[Fig. 6]

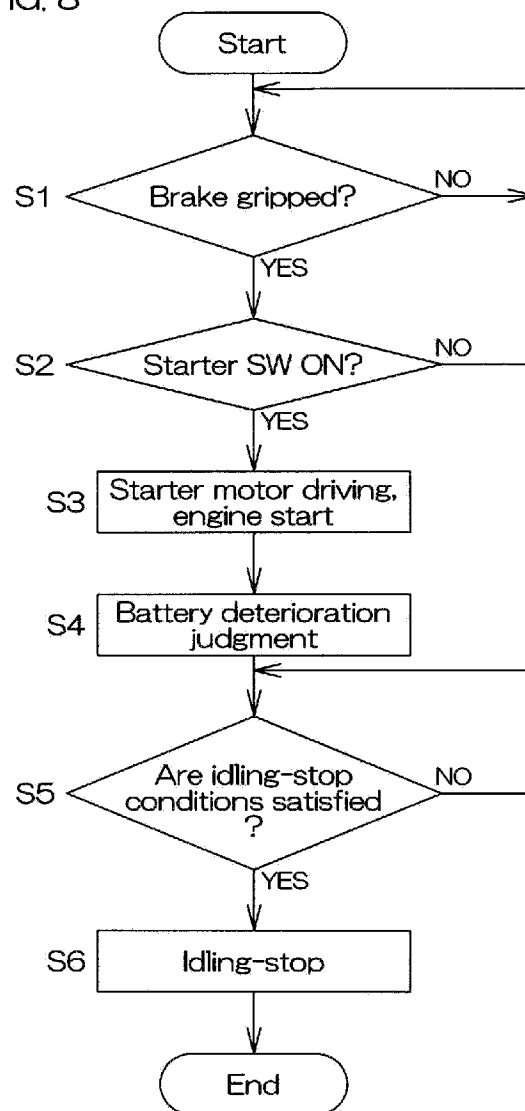


[Fig. 7]



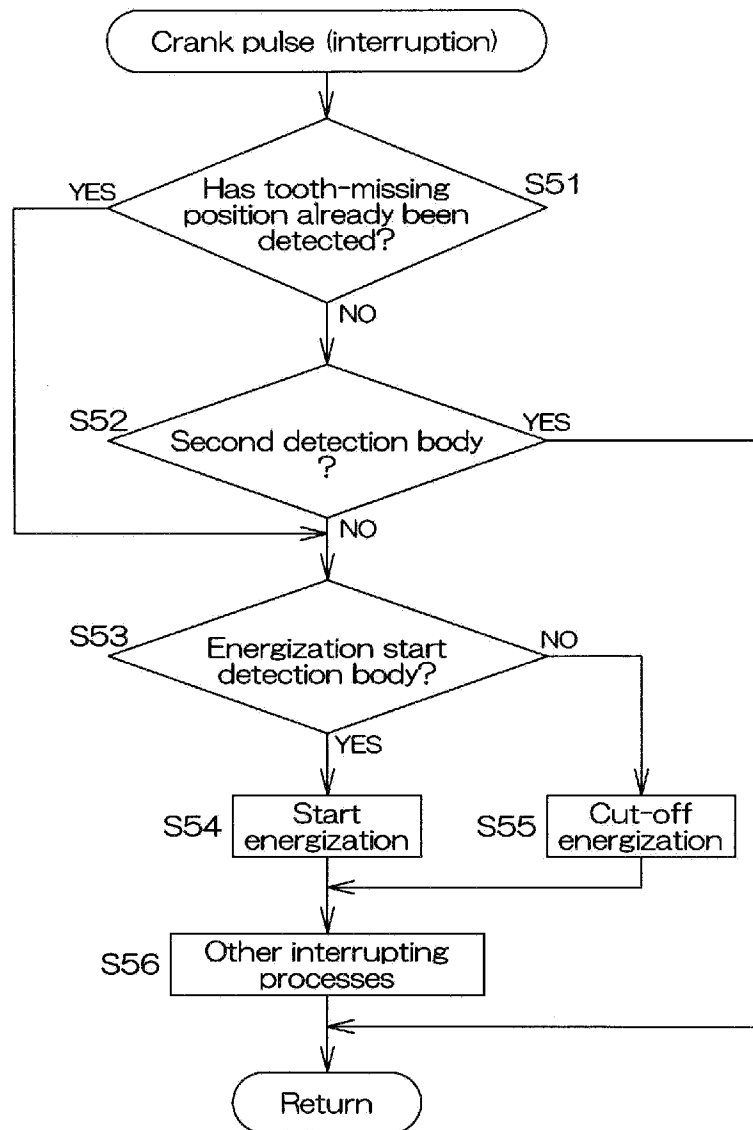
[Fig. 8]

FIG. 8



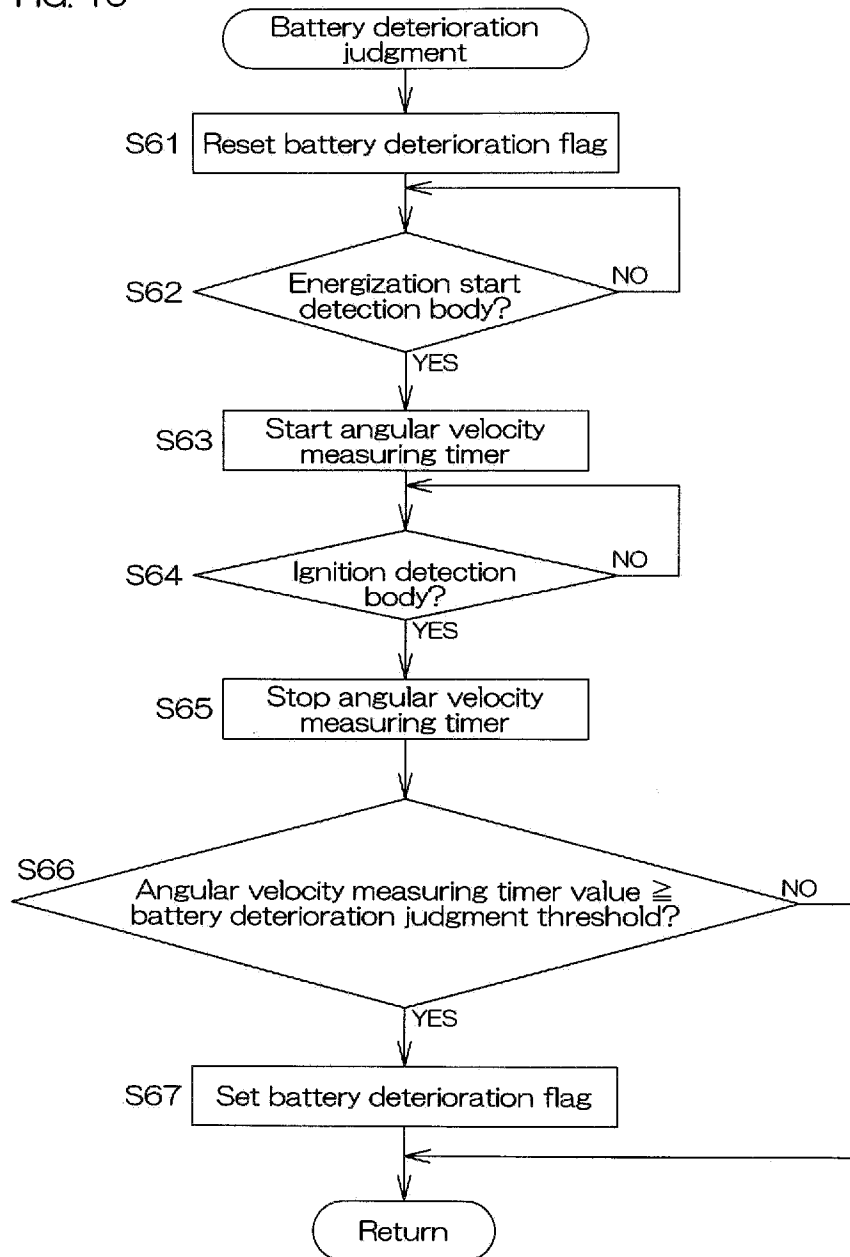
[Fig. 9]

FIG. 9

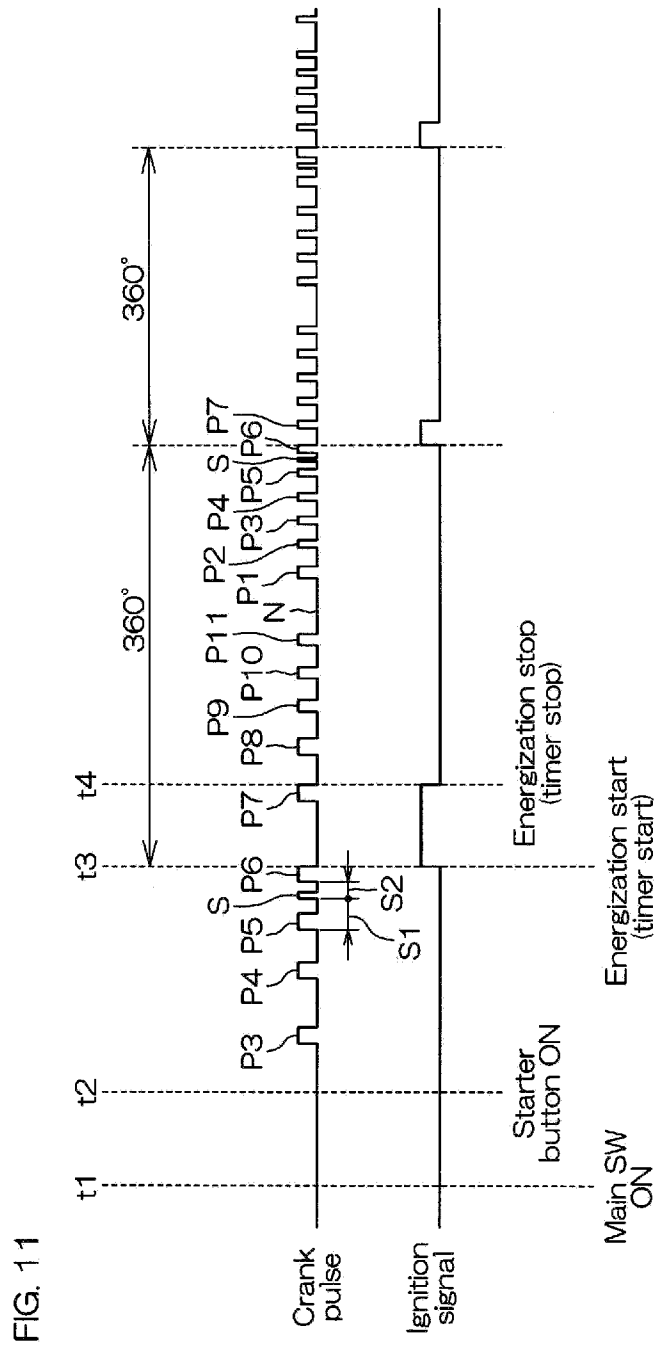


[Fig. 10]

FIG. 10

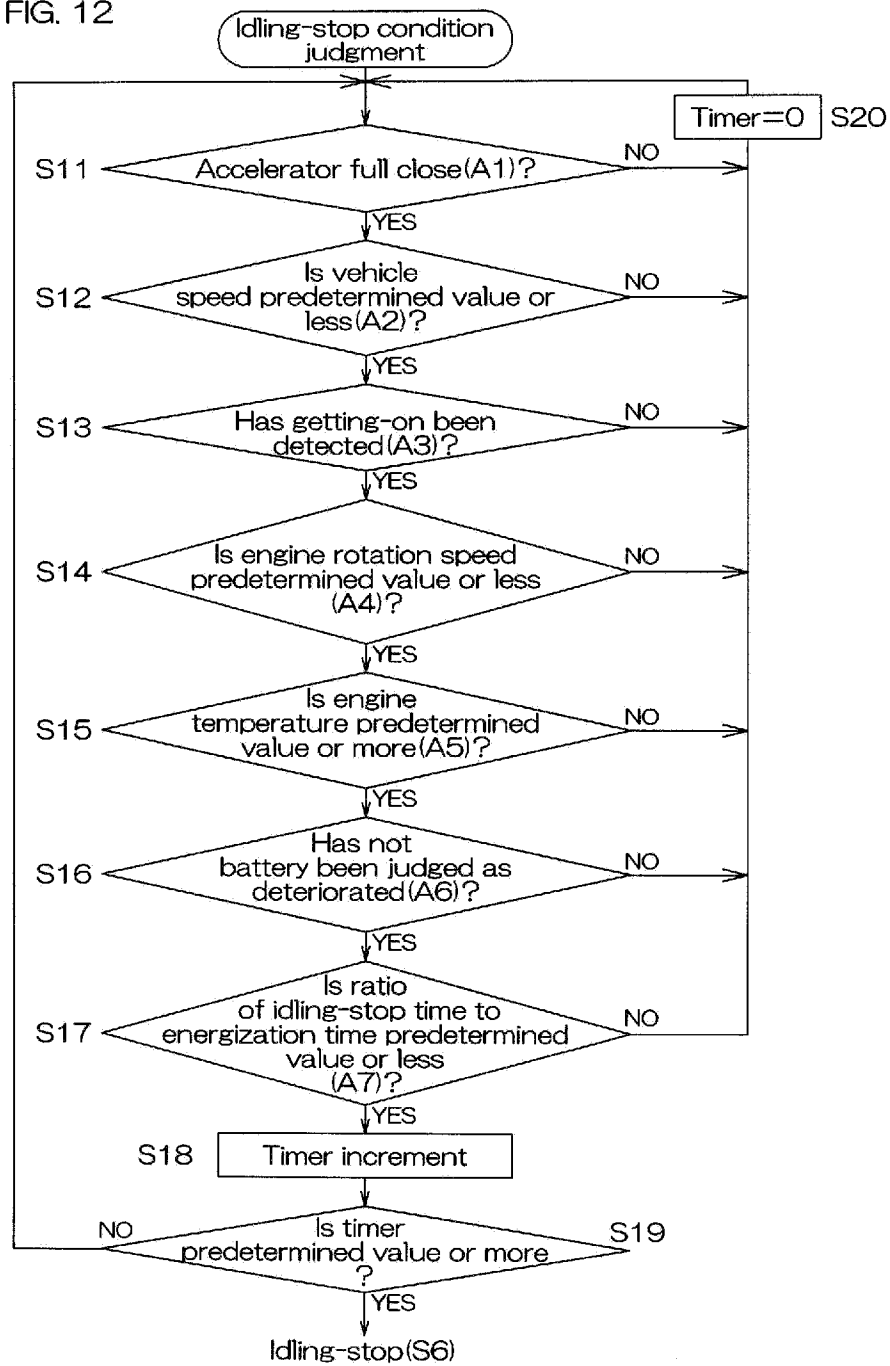


[Fig. 11]



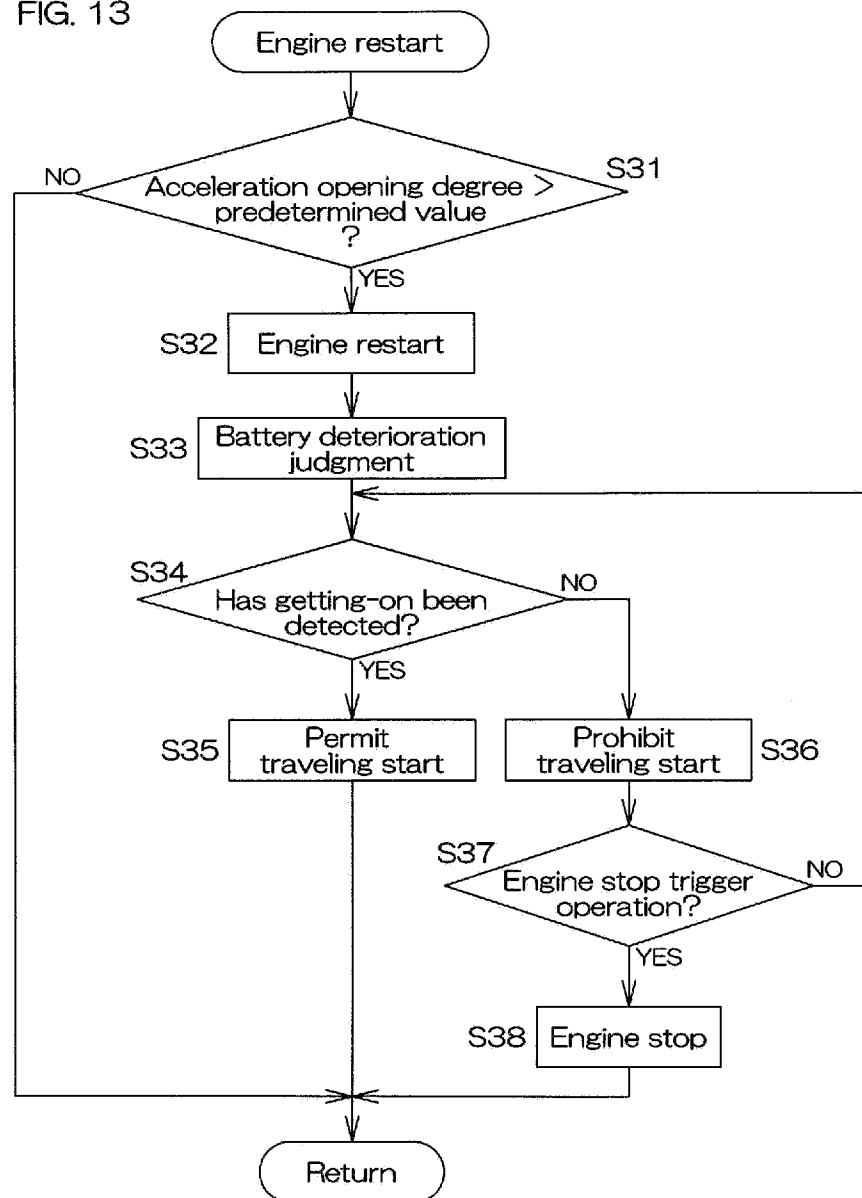
[Fig. 12]

FIG. 12



[Fig. 13]

FIG. 13



INTERNATIONAL SEARCH REPORT

International application No

PCT/JP2013/003448

A. CLASSIFICATION OF SUBJECT MATTER		
INV.	F02D41/06 G01D5/245	F02P5/15 F02P7/067
	F02D35/02	F02D41/00
		G01P3/481
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 G01M F02P G01D G01P F01B		
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		
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A	US 2008/295803 A1 (SNOPKO MICHAEL [US] ET AL) 4 December 2008 (2008-12-04) the whole document	1-10
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☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
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Date of the actual completion of the international search		Date of mailing of the international search report
8 November 2013		18/11/2013
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Mineau, Christophe

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