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(71) Applicant: **Yamaha Hatsudoki Kabushiki Kaisha**
Iwata-shi, Shizuoka 438-8501 (JP)

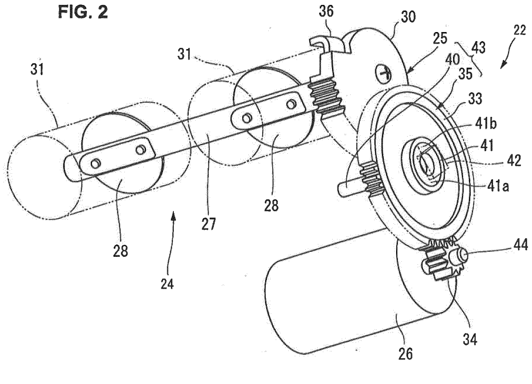
(72) Inventors:
- **FUJITO, Manabu**
  Iwata-shi
  Shizuoka 438-8501 (JP)
- **SAKAI, Kouji**
  Iwata-shi
  Shizuoka 438-8501 (JP)
- **WATANABE, Hiroto**
  Iwata-shi
  Shizuoka 438-8501 (JP)

(74) Representative: **Stöckeler, Ferdinand et al**
Schoppe, Zimmermann, Stöckeler
Zinkler, Schenk & Partner mbB
Patentanwälte
Radlkoferstrasse 2
81373 München (DE)

(54) ENGINE WITH THROTTLE DEVICE, AND ENGINE-DRIVEN VEHICLE

(57) An engine with a throttle device includes a throttle valve (24) provided in an intake passage (31) of the engine. The engine includes a throttle shaft (27) that rotates integrally with a valve element (28) of the throttle valve (24), a spring member that biases the valve element (28) in a direction to close, and a throttle valve driving motor (26) connected to the throttle shaft (27) via a gear mechanism (25). The engine includes a sensor (42) that detects the rotation angle of a rotating shaft (43) different from the throttle shaft (27) in the gear mechanism (25), and a throttle angle calculation unit that obtains the rotation angle $\theta 2$ of the throttle shaft (27) using the detection value of the sensor (42). The throttle angle calculation unit calculates the rotation angle $\theta 2$ of the throttle shaft (27) by subtracting a backlash angle α from the detection angle of the sensor (42). It is possible to provide an engine with a throttle device capable of accurately detecting the rotation angle of the throttle shaft while employing an arrangement that causes the sensor to detect the rotation angle of the rotating shaft different from the throttle shaft.

FIG. 2



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Description

Technical Field

[0001] The present invention relates to an engine with a throttle device including a sensor that detects the opening of a throttle valve, and an engine-driven vehicle.

Background Art

[0002] A conventional throttle device is described in, for example, patent literature 1. The throttle device disclosed in patent literature 1 includes a butterfly throttle valve, a motor that drives the throttle valve, and a sensor configured to detect the opening of the throttle valve.

[0003] The throttle valve includes a disc-shaped valve element and a throttle shaft that rotates integrally with the valve element.

[0004] The throttle shaft is connected to the output shaft of the motor via a gear mechanism. The gear mechanism decelerates the rotation of the motor and transfers it to the throttle shaft. The gear mechanism includes a driving gear provided on the output shaft, a driven gear provided on the throttle shaft, and a transmission gear that meshes with the gears. The transmission gear is provided on an intermediate shaft located between the output shaft and the throttle shaft.

[0005] The sensor detects the rotation angle of the intermediate shaft.

[0006] In a lightweight engine-driven vehicle such as a motorcycle, the throttle valve needs to accurately follow an accelerator handler because the power weight ratio (weight per unit horsepower) is low. To implement this, the opening of the throttle valve (the rotation angle of the throttle shaft) needs to be detected at a high accuracy.

Related Art Literature

Patent Literature

[0007] Patent Literature 1: Japanese Patent Laid-Open No. 2010-19137

Disclosure of Invention

Problem to be Solved by the Invention

[0008] In the throttle device described in patent literature 1, it is difficult to accurately obtain the rotation angle of the throttle shaft. This is because the intermediate shaft whose rotation angle is detected by the sensor is connected to the throttle shaft via the gears. That is, since a backlash exists in the meshing portion between the gears, the rotation angle of the throttle shaft with respect to the rotation angle of the intermediate shaft is unreliable.

[0009] This problem can be solved to some extent by directly detecting the rotation angle of the throttle shaft using the sensor. However, when this arrangement is employed, the sensor needs to be arranged near the end of the throttle shaft, and a projecting portion made of the sensor is formed on a side of the throttle device. That is, the throttle device becomes bulky, posing a new problem. In addition, since the rotation angle of the throttle shaft is smaller than that of the intermediate shaft, the resolution of the rotation angle detected by the sensor lowers.

[0010] The present invention has been made to solve the above-described problems, and has as its first object to provide an engine with a throttle device capable of accurately detecting the rotation angle of a throttle shaft while employing an arrangement that causes a sensor to detect the rotation angle of a rotating shaft different from the throttle shaft. It is the second object of the present invention to provide an engine-driven vehicle easy to drive because a throttle valve accurately follows a throttle handler.

Means of Solution to the Problem

[0011] In order to achieve the object, according to the present invention, there is provided an engine with a throttle device, comprising a throttle valve provided in an intake passage of the engine, a throttle shaft that rotates integrally with a valve element of the throttle valve, a spring member that biases the valve element in a direction to close, a throttle valve driving motor connected to the throttle shaft via a gear mechanism, a sensor that detects a rotation angle of a rotating shaft different from the throttle shaft in the gear mechanism, and a throttle angle calculation unit that obtains the rotation angle of the throttle shaft using a detection value of the sensor, wherein the rotation angle of the rotating shaft detected by the sensor is defined as a detection angle, the rotation angle of the rotating shaft corresponding to an amount of backlash involved in a meshing portion of gears provided between the rotating shaft and the throttle shaft is defined as a backlash angle, and the throttle angle calculation unit calculates the rotation angle of the throttle shaft based on the rotation angle obtained by subtracting the backlash angle from the detection angle.

[0012] According to the present invention, there is also provided an engine-driven vehicle including an engine with a throttle device according to the above-described invention.

Effects of the Invention

[0013] According to the present invention, the backlash involved in the meshing portion between the gears located between the rotating shaft and the throttle shaft is substantially removed. For this reason, since the rotating shaft and the throttle shaft substantially integrally rotate, the rotation angle of the throttle shaft can accurately be obtained.

[0014] Hence, according to the present invention, it is possible to provide an engine with a throttle device capable of accurately detecting the rotation angle of a throttle shaft while employing an arrangement that causes a sensor to detect the rotation angle of a rotating shaft different from the throttle shaft.

[0015] The engine-driven vehicle according to the present invention is easy to drive because it includes the above-described throttle device, and the throttle valve accurately follows the throttle handler.

Brief Description of Drawings

[0016]

Fig. 1 is a side view of a motorcycle including an engine with a throttle device according to the first embodiment of the present invention;

Fig. 2 is a perspective view showing the arrangement of a throttle valve driving unit according to the first embodiment of the present invention;

Fig. 3 is a side view showing the main portion of a throttle device according to the first embodiment of the present invention;

Fig. 4 is a side view of a valve gear according to the first embodiment of the present invention;

Fig. 5 is an enlarged side view showing the meshing portion between the valve gear and a pinion gear according to the first embodiment of the present invention;

Fig. 6 is a block diagram showing the arrangement of a throttle angle calculation unit according to the first embodiment of the present invention;

Fig. 7 is a flowchart for explaining a throttle angle calculation program according to the first embodiment of the present invention;

Fig. 8 is a graph showing the relationship between the output value of an angle sensor and the rotation angle of the throttle shaft according to the first embodiment of the present invention;

Fig. 9 is a flowchart for explaining the operation of a CPU according to the first embodiment of the present invention;

Fig. 10 is a flowchart for explaining a throttle angle calculation program according to the second embodiment of the present invention;

Fig. 11 is a flowchart for explaining the operation of a CPU according to the second embodiment of the present invention; and

Fig. 12 is a sectional view for explaining a technique as a reference to the present invention.

Best Mode for Carrying Out the Invention

(First Embodiment)

[0017] An engine with a throttle device and an engine-driven vehicle according to an embodiment of the present invention will now be described in detail with reference to Figs. 1 to 9. Here, an embodiment when applying the present invention to a motorcycle will be explained. The first embodiment is an embodiment of the present invention described in claims 1 to 4 and 7.

[0018] In a motorcycle 1 shown in Fig. 1, a driver (not shown) sits astride a seat 2 and drives while gripping a steering handlebar 3 with hands. Reference numeral 4 denotes a front wheel; 5, a front fork; 6, an engine; and 7, a rear wheel. The steering handlebar 3 is provided with an accelerator handler (not shown) to be operated by the driver.

[0019] The engine 6 is a four-stroke engine, and includes a crank case 11, and a cylinder body 12 and a cylinder head 13 attached on the crank case 11. The cylinder body 12 is attached on the crank case 11 such that the axis points the upper front side of the motorcycle 1.

[0020] An inlet pipe 14 is attached to the rear surface of the cylinder head 13. A throttle valve driving unit 22 of an electric throttle device 21 to be described later is attached to the upstream end of the inlet pipe 14.

[0021] The throttle device 21 is formed from the throttle valve driving unit 22 shown in Fig. 2 and a throttle angle calculation unit 23 shown in Fig. 6.

[0022] The throttle valve driving unit 22 includes a butterfly throttle valve 24, a throttle valve driving motor 26 connected to the throttle valve 24 via a gear mechanism 25, and the like. Fig. 2 illustrates only the main members of the throttle valve driving unit 22 while omitting members such a throttle body. The throttle valve 24 includes one throttle shaft 27, and a plurality of disc-shaped valve elements 28 attached to the throttle shaft 27.

[0023] The throttle shaft 27 is rotatably supported by the throttle body (not shown) while extending in the width direction of the motorcycle 1. The throttle shaft 27 rotates integrally with the valve elements 28. The throttle shaft 27 extends through a torsion coil spring 29 (see Fig. 3). The torsion coil spring 29 biases the valve elements 28 in the closing direction. One end of the torsion coil spring 29 is hooked on a valve gear 30 attached to the throttle shaft 27, and the other end is hooked on the throttle body. The throttle shaft 27 rotates integrally with the valve gear 30.

[0024] As shown in Fig. 2, the valve elements 28 are provided in an intake passage 31. The intake passage 31 extends from an air cleaner (not shown) into the cylinder head 13 via the throttle body and the inlet pipe 14.

[0025] As shown in Fig. 3, the gear mechanism 25 forms a two-stage gear reducer, and is formed from four gears including the valve gear 30. The four gears include the valve gear 30, a pinion gear 32 that meshes with the valve gear 30, a wheel gear 33 that rotates integrally with the pinion gear 32, and a motor gear 34 that meshes with the wheel gear 33. These gears are made of plastic. The pinion gear 32 and the wheel gear 33 are integrally formed so as to form one intermediate gear 35.

[0026] The valve gear 30 is formed from a so-called sector gear, and includes a fan-shaped gear forming portion 30a. As shown in Fig. 4, the valve gear 30 includes a full close stopper 36 and a full open stopper 37. The full close stopper 36 is used to set the full close position of the throttle valve 24. As shown in Fig. 2, the full close stopper 36 is formed to have an L-shaped section and provided at one end of the gear forming portion 30a in the rotational direction. When the full close stopper 36 abuts against an adjusting bolt 38 (see Fig. 4) on the throttle body side, rotation of the valve gear 30 in a direction to close the throttle valve 24 is regulated.

[0027] The full open stopper 37 is formed into a plate shape standing on the valve gear 30 and provided at the other end of the gear forming portion 30a in the rotational direction. When the full open stopper 37 abuts against a pressure wall 39 of the valve body, as indicated by the alternate long and two short dashed line in Fig. 4, rotation of the valve gear 30 in a direction to open the throttle valve 24 is regulated.

[0028] That is, the valve gear 30 can rotate only by a designed rotation angle $\theta 1$ (see Fig. 4) from the full close position (full close abutting position) where the full close stopper 36 abuts against the adjusting bolt 38 to the full open position (full open abutting position) where the full open stopper 37 abuts against the pressure wall 39.

[0029] The intermediate gear 35 formed from the pinion gear 32 and the wheel gear 33 is fixed to one end of an intermediate shaft 40 (see Figs. 2 and 3) and rotatably supported by the throttle body via the intermediate shaft 40. The pinion gear 32 is provided at one end of the wheel gear 33 adjacent to the intake passage 31. Because of a backlash in the meshing portion to the valve gear 30, as shown in Fig. 5, the pinion gear 32 can rotate only by a backlash angle α with respect to the valve gear 30. Referring to Fig. 5, a line C1 indicates the pitch circle of the pinion gear 32, and a line C2 indicates the pitch circle of the wheel gear 33.

[0030] As shown in Figs. 2 and 3, a ring magnet 41 is attached to the other end of the wheel gear 33 in the axial direction. The ring magnet 41 is formed into a ring shape and fixed on the axis of the wheel gear 33 so as to be located on the same axis as the wheel gear 33. The ring magnet 41 is magnetized so as to divide magnetic poles 41a and 41b (see Fig. 2) by a virtual line perpendicular to the axis when viewed from the axial direction of the wheel gear 33.

[0031] An angle sensor 42 is arranged at a position facing the ring magnet 41. The angle sensor 42 detects the rotation angle of a rotating shaft 43 formed from the intermediate gear 35 and the intermediate shaft 40, and is formed from a vector detection hole IC. In this embodiment, the angle sensor 42 forms a "sensor" in the present invention. The angle sensor 42 is supported by the throttle body while forming a predetermined gap with respect to the ring magnet 41. That is, the angle sensor 42 detects the rotation angle of the rotating shaft 43 different from the throttle shaft 27 in the gear mechanism 25. A detection angle that is a rotation angle of the rotating shaft 43 detected by the angle sensor 42 is sent to the throttle angle calculation unit 23 (to be described later) as a signal.

[0032] The motor gear 34 is provided on an output shaft 44 of the throttle valve driving motor 26. That is, rotation of the motor 26 is transferred from the motor gear 34 to the valve gear 30 (throttle shaft 27) via the wheel gear 33 and the pinion gear 32. The motor 26 is supported by the throttle body. The operation of the motor 26 is controlled by the throttle angle calculation unit 23 to be described later.

[0033] The throttle angle calculation unit 23 obtains the rotation angle of the throttle shaft 27 using the detection angle detected by the angle sensor 42, and operates the throttle shaft 27 so as to interlock with the accelerator handler. As shown in Fig 6, the throttle angle calculation unit 23 according to this embodiment is formed from an ECU 54 (Electronic Control Unit) including a CPU 51, a nonvolatile memory 52, a motor driver 53, and the like.

[0034] The throttle angle calculation unit 23 is provided in a control device 55 (see Fig. 1) arranged under the seat 2 of the motorcycle 1. The control device 55 controls the operation of the engine 6 of the motorcycle 1.

[0035] The CPU 51 includes an AD (analog/digital converter) 56 that receives a signal. The angle sensor 42, an accelerator manipulation amount sensor 57, and the like are connected to the AD 56. The accelerator manipulation amount sensor 57 detects the manipulation amount of the accelerator handler and sends it to the AD 56 as a signal.

[0036] The nonvolatile memory 52 is used to store programs to be used by the CPU 51, numerical data calculated by the CPU 51, and the like. In this embodiment, the nonvolatile memory 52 corresponds to a "storage device" in the present invention. The motor driver 53 is used to drive the throttle valve driving motor 26.

[0037] The CPU 51 according to this embodiment calculates the rotation angle of the throttle shaft 27 using a throttle angle calculation program to be described later.

[0038] When the throttle angle calculation program is executed, a rotation angle $\theta 2$ of the throttle shaft 27 is calculated by calculation using the detection angle of the angle sensor 42, the backlash angle α, the designed rotation angle $\theta 1$, and the like.

[0039] The CPU 51 sends a control signal to the motor driver 53 to operate the throttle valve driving motor 26 such that the difference between the rotation angle $\theta 2$ of the throttle shaft 27 calculated by executing the throttle angle calculation program and a target rotation angle $\theta 3$ corresponding to the manipulation amount of the accelerator handler becomes 0.

[0040] The throttle angle calculation program is configured as shown in the flowchart of Fig. 7, and recorded in the nonvolatile memory 52. The CPU 51 reads out the throttle angle calculation program from the nonvolatile memory 52 as needed and uses it.

[0041] The throttle angle calculation program according to this embodiment employs a configuration for calculating the actual backlash angle α and then calculating the rotation angle $\theta 2$ of the throttle shaft 27. The backlash angle α is assumed to be calculated upon shipment from the factory or upon power-on.

[0042] Calculation of the backlash angle α is performed in steps S1 to S3 of the flowchart shown in Fig. 7. Calculation of the rotation angle $\theta 2$ of the throttle shaft 27 is performed in step S4. In step S1, first, the CPU 51 causes the throttle valve driving motor 26 to close the throttle valve 24. The CPU 51 acquires an output value A of the angle sensor 42 in a state in which the throttle valve 24 is at the full close abutting position. The full close abutting position is the position of the throttle valve 24 when the full close stopper 36 abuts against the adjusting bolt 38.

[0043] In step S2, first, the CPU 51 causes the throttle valve driving motor 26 to open the throttle valve 24. The CPU 51 acquires an output value B of the angle sensor 42 in a state in which the throttle valve 24 is at the full open abutting position. The full open abutting position is the position of the throttle valve 24 when the full open stopper 37 abuts against the pressure wall 39 of the throttle body. When the motor operates the throttle valve 24 from the full close abutting position to the full open abutting position in this way, the rotation angle $\theta 2$ of the throttle shaft 27 increases, as shown in Fig. 8.

[0044] The abscissa of Fig. 8 represents the output value of the angle sensor 42, and the ordinate represents the rotation angle $\theta 2$ of the throttle shaft 27. When the motor 26 is operated as described above, the output value of the angle sensor 42 increases from the output value A to an output value C only by the amount of backlash, and after that, the throttle shaft 27 starts rotating. That is, the output value of the angle sensor 42 acquired at the full open abutting position includes the backlash.

[0045] After the throttle valve 24 opens up to the full open abutting position, the CPU 51 subtracts a second operation angle from a first operation angle to be described later to obtain the backlash angle α in step S3. The first operation angle is a rotation angle of the throttle valve 24 including the backlash. The "rotation angle of the throttle valve 24 including a backlash" can be obtained by subtracting the output value A of the angle sensor 42 when the throttle valve 24 is fully closed by driving of the motor 26 from the output value B of the angle sensor 42 when the throttle valve 24 is fully opened by driving of the motor 26.

[0046] The second operation angle is the true rotation angle of the throttle valve 24 and corresponds to the rotation angle $\theta 2$ of the throttle valve 24 throttle shaft 27 when the valve elements 28 of the throttle valve 24 are moved from the full close position to the full open position. As the second operation angle, a designed value such as the designed rotation angle $\theta 1$ shown in Fig. 4 or a measured value obtained by performing measurement while actually operating the throttle valve 24 can be used.

[0047] When step S3 is executed, the backlash angle α corresponding to the difference between the output value C and the output value A shown in Fig. 8 is calculated. In step S3, the CPU 51 stores, in the nonvolatile memory 52, the backlash angle α calculated in the above-described way.

[0048] In step S4, the CPU 51 calculates the rotation angle $\theta 2$ of the throttle shaft 27 based on the rotation angle obtained by subtracting the backlash angle α from the detection angle of the angle sensor 42. The detection angle is a rotation angle of the rotating shaft 43 detected by the angle sensor 42.

[0049] The CPU 51 according to this embodiment executes steps S1 to S3 at the time of shipment from the factory and executes step S4 after power-on. The backlash angle α to be used when executing step S4 is read out from the nonvolatile memory 52 and used. After power-on, the CPU 51 operates based on an operation program shown in the flowchart of Fig. 9.

[0050] More specifically, after power-on in step P1 of the flowchart shown in Fig. 9, the CPU 51 reads out the backlash angle α from the nonvolatile memory 52 in step P2. In step P3, the CPU 51 acquires the current rotation angle, that is, the detection angle of the rotating shaft 43 using the angle sensor 42.

[0051] In step P4, the CPU 51 determines whether the detection angle is smaller than the backlash angle α. In other words, the CPU 51 determines whether the rotation angle of the rotating shaft 43 detected by the angle sensor 42 is a rotation angle between the backlash angle α and the rotation angle at the time of fully closing the throttle. If this determination results in YES, that is, when the detection angle is smaller than the backlash angle α, the process advances to step P5, and the CPU 51 sets the rotation angle $\theta 2$ of the throttle shaft 27 as the rotation angle at the time of fully closing the throttle.

[0052] When the detection angle is equal to or larger than the backlash angle α, the process advances to step P6 to execute step S4 described above. That is, in step P6, the CPU 51 calculates the rotation angle $\theta 2$ of the throttle shaft 27 based on the value obtained by subtracting the backlash angle α from the detection angle.

[0053] After that, in step P7, the CPU 51 operates the motor 26 such that the rotation angle $\theta 2$ of the throttle shaft 27 matches the target rotation angle.

[0054] Steps P3 to P7 are repetitively executed until power-off in step P8.

[0055] According to the engine with a throttle device having the above-described arrangement, the backlash involved in the meshing portion of the gears located between the rotating shaft 43 and the throttle shaft 27 is substantially removed. For this reason, since the rotating shaft 43 and the throttle shaft 27 substantially integrally pivot, the rotation angle $\theta 2$ of the throttle shaft 27 can accurately be obtained.

[0056] Hence, according to this embodiment, it is possible to provide an engine with a throttle device capable of accurately detecting the rotation angle $\theta 2$ of the throttle shaft 27 while employing an arrangement that causes the angle sensor 42 to detect the rotation angle of the rotating shaft 43 different from the throttle shaft 27.

[0057] The throttle angle calculation unit 23 according to this embodiment sets the rotation angle θ2 of the throttle shaft 27 as the rotation angle at the time of fully closing the throttle when the rotation angle of the rotating shaft 43 detected by the angle sensor 42 is a rotation angle between the backlash angle α and the rotation angle at the time of fully closing the throttle.

[0058] Hence, according to this embodiment, it is possible to accurately detect the fully closed state of the throttle valve 24.

[0059] The throttle angle calculation unit 23 according to this embodiment calculates the backlash angle α by subtracting the true second operation angle of the throttle valve 24 from the first operation angle of the throttle valve 24 including the backlash obtained based on the detection value of the angle sensor 42.

[0060] Hence, according to this embodiment, since the backlash is obtained by subtracting the second operation angle including no backlash from the first operation angle including the backlash in the meshing portion between the gears, the backlash angle α can easily and accurately be calculated by calculation.

[0061] In this embodiment, the device includes the nonvolatile memory 52 that stores the backlash angle α calculated by the throttle angle calculation unit 23. The throttle angle calculation unit 23 according to this embodiment calculates the backlash angle α upon shipment from the factory and stores it in the nonvolatile memory 52. After that, when operating the engine, the throttle angle calculation unit 23 calculates the rotation angle θ2 of the throttle shaft 27 using the backlash angle α read out from the nonvolatile memory 52.

[0062] Hence, according to this embodiment, the backlash angle α need not be calculated every time the device is powered on. That is, according to this embodiment, it is possible to provide an engine with a throttle device capable of quickly starting.

[0063] The motorcycle 1 according to this embodiment includes the above-described throttle device 21 and is easy to drive because the throttle valve 24 accurately follows the throttle handler.

(Second Embodiment)

[0064] A throttle angle calculation program and an operation program can be configured as shown in Figs. 10 and 11. The same reference numerals as described in Figs. 1 to 9 denote the same or similar members in Figs. 10 and 11, and a detailed description thereof will be omitted.

[0065] The throttle angle calculation program according to this embodiment employs a configuration that rotates a rotating shaft 43 until the teeth of a pinion gear 32 hit those of a valve gear 30, and detects a backlash angle α based on the rotation angle at this time, although details will be described later.

[0066] In step S1 of the flowchart shown in Fig. 10, a CPU 51 of a throttle angle calculation unit 23 according to this embodiment causes a throttle valve driving motor 26 to close a throttle valve 24. The CPU 51 acquires an output value A of an angle sensor 42 in a state in which the throttle valve 24 is at the full close abutting position. In this embodiment, the output value A corresponds to a "first output value" in the invention described in claim 5.

[0067] In step S20, the CPU 51 acquires an output value D of the angle sensor 42 in a state in which the rotating shaft 43 is at a control full close position to be described later. The control full close position is the position of the rotating shaft 43 when the pinion gear 32 rotates only by the amount of backlash with respect to the valve gear 30. To locate the rotating shaft 43 at the control full close position, the throttle valve driving motor 26 applies a predetermined small torque to a throttle shaft 27.

[0068] The predetermined small torque here is a torque smaller than the initial torque of a torsion coil spring 29. That is, the torque rotates only the rotating shaft 43 without rotating the throttle shaft 27 against the spring force of the torsion coil spring 29. When the small torque is applied to the rotating shaft 43, the rotating shaft 43 rotates only by the amount of backlash. The output value D is the detection angle of the angle sensor 42 when the rotating shaft 43 rotates in this way. In this embodiment, the output value D corresponds to a "second output value" in the invention described in claim 5.

[0069] In step S30, the CPU 51 subtracts the output value A (first output value) from the output value D (second output value), thereby calculating a backlash angle α. After that, the CPU 51 calculates a rotation angle θ2 of the throttle shaft 27 in step S4, as in the first embodiment.

[0070] The throttle angle calculation program shown in Fig. 10 is incorporated in the operation program shown in Fig. 11 and executed after power-on. That is, after power-on in step P1 of the flowchart shown in Fig. 11, the CPU 51 executes steps S1, S20 and S30 of the throttle angle calculation program to obtain the backlash angle α. The backlash angle α is stored in a nonvolatile memory 52 by the CPU 51.

[0071] In step P2, the CPU 51 reads out the backlash angle α from the nonvolatile memory 52. In step P3, the CPU 51 acquires the current rotation angle, that is, the detection angle of the rotating shaft 43 using the angle sensor 42.

[0072] In step P4, the CPU 51 determines whether the detection angle is smaller than the backlash angle α.
In other words, the CPU 51 determines whether the rotation angle of the rotating shaft 43 detected by the angle sensor 42 is a rotation angle between the backlash angle α and the rotation angle at the time of fully closing the throttle.

[0073] If this determination results in YES, that is, when the detection angle is smaller than the backlash angle α, the process advances to step P5, and the CPU 51 sets the rotation angle θ2 of the throttle shaft 27 as the rotation angle at the time of fully closing the throttle.

[0074] When the detection angle is equal to or larger than the backlash angle α, the process advances to step

P6 to execute step S4 described above. That is, in step P6, the CPU 51 calculates the rotation angle θ2 of the throttle shaft 27 based on the value obtained by subtracting the backlash angle α from the detection angle.

[0075] After that, in step P7, the CPU 51 operates the motor 26 such that the rotation angle θ2 of the throttle shaft 27 matches the target rotation angle.

[0076] The operation program according to this embodiment is repetitively executed until power-off in step P8. That is, the CPU 51 calculates the rotation angle θ2 of the throttle shaft 27 using the backlash angle α read out from the nonvolatile memory 52 until power-off.

[0077] The CPU 51 of the throttle angle calculation unit 23 according to this embodiment detects the first output value (output value A) of the angle sensor 42 when the throttle valve 24 is fully closed by driving of the throttle valve driving motor 26. In addition, the CPU 51 detects the second output value (output value D) of the angle sensor 42 when the throttle valve driving motor 26 applies a torque smaller than the initial torque of the torsion coil spring 29 to the throttle shaft 27 in a direction to open the throttle valve 24. The CPU 51 subtracts the first output value from the second output value, thereby calculating the backlash angle α.

[0078] Hence, according to this embodiment, the backlash angle α can be calculated every time the device is powered on. It is therefore possible to remove an increase in the backlash angle α caused by aging as well and more accurately obtain the rotation angle θ2 of the throttle shaft 27.

[0079] In this embodiment, the device includes the nonvolatile memory 52 that stores the backlash angle α calculated by the throttle angle calculation unit 23. The throttle angle calculation unit 23 calculates the backlash angle α upon power-on and stores it in the nonvolatile memory 52. In addition, the throttle angle calculation unit 23 calculates the rotation angle θ2 of the throttle shaft 27 using the backlash angle α read out from the nonvolatile memory 52 until power-off.

[0080] Hence, according to this embodiment, when operating an engine 6, calculation of the backlash angle α can be done only once upon power-on. Hence, according to this embodiment, it is possible to provide an engine with a throttle device capable of avoiding waste in unnecessarily calculating the backlash angle α during an operation.

(Reference Technique)

[0081] The rotating shaft 43 whose rotation angle is detected by the angle sensor 42 can be formed as shown in Fig. 12. The same reference numerals as described in Figs. 1 to 11 denote the same or similar members in Fig. 12, and a detailed description thereof will be omitted.

[0082] The pinion gear 32 of the rotating shaft 43 shown in Fig. 12 is formed from a fixed portion 61 formed integrally with the wheel gear 33, a movable portion 62 that is rotatable with respect to the fixed portion 61, and a torsion coil spring 63 that biases the movable portion 62 in one direction toward the fixed portion 61. The movable portion 62 is rotatably supported by the intermediate shaft 40 while being arranged on a side of the fixed portion 61 in the axial direction.

[0083] According to this embodiment, since the pinion gear 32 forms a so-called scissors gear, an error caused by the backlash can be solved. The throttle device 21 described in the first or second embodiment can obtain the same effects using a simple gear, unlike the case where the scissors gear is used. Hence, when the first or second embodiment is employed, the manufacturing cost can be suppressed low as compared to the case where the scissors gear is used.

[0084] In the above-described embodiments, an example in which the present invention is applied to a motorcycle has been explained. However, the present invention is applicable to any vehicle as long as it includes an engine with a throttle device. The present invention is applicable to, for example, a scooter, a motor tricycle, a four wheel vehicle, an off-road vehicle, a snowmobile, a small planning boat, and the like.

Explanation of the Reference Numerals and Signs

[0085] 1...motorcycle, 6...engine, 21...throttle device, 23...throttle angle calculation unit, 24...throttle valve, 25...gear mechanism, 26...throttle valve driving motor, 28...valve element, 27...throttle shaft, 29...torsion coil spring (spring member), 31...intake passage, 42...angle sensor, 43...rotating shaft, α...backlash angle

Claims

1. An engine with a throttle device, comprising:

a throttle valve provided in an intake passage of the engine;
a throttle shaft that rotates integrally with a valve element of the throttle valve;
a spring member that biases the valve element in a direction to close;
a throttle valve driving motor connected to the throttle shaft via a gear mechanism;
a sensor that detects a rotation angle of a rotating shaft different from the throttle shaft in the gear mechanism; and
a throttle angle calculation unit that obtains a rotation angle of the throttle shaft using a detection value of the sensor, the throttle angle calculation unit calculating the rotation angle of the throttle shaft based on the rotation angle obtained by subtracting a backlash angle from a detection angle,
wherein the detection angle is defined as the rotation angle of the rotating shaft detected by the sensor, and

the a backlash angle is defined as the rotation angle of the rotating shaft corresponding to an amount of backlash involved in a meshing portion of gears provided between the rotating shaft and the throttle shaft.

2. The engine with the throttle device according to claim 1, wherein the throttle angle calculation unit sets the rotation angle of the throttle shaft as the rotation angle at a time of fully closing the throttle when the rotation angle of the rotating shaft detected by the sensor is a rotation angle between the backlash angle and the rotation angle at the time of fully closing the throttle.

3. The engine with the throttle device according to claim 1 or 2, wherein the throttle angle calculation unit calculates the backlash angle by subtracting a true second operation angle of the throttle valve from a first operation angle of the throttle valve including the backlash obtained based on the detection value of the sensor,
wherein the first operation angle is a rotation angle of the throttle shaft obtained by subtracting an output value of the sensor when the throttle valve is fully closed by driving of the throttle valve driving motor from the output value of the sensor when the throttle valve fully opened by driving of the throttle valve driving motor, and
the second operation angle is a rotation angle of the throttle shaft based on one of a designed value and a measured value when the valve element of the throttle valve is moved from a full close position to a full open position.

4. The engine with the throttle device according to claim 3, further comprising a storage device that stores the backlash angle calculated by the throttle angle calculation unit,
wherein the throttle angle calculation unit calculates the backlash angle upon shipment from a factory, stores the backlash angle in the storage device, and when operating the engine later, calculates the rotation angle of the throttle shaft using the backlash angle read out from the storage device.

5. The engine with the throttle device according to claim 1 or 2, wherein the throttle angle calculation unit detects
a first output value of the sensor when the throttle valve is fully closed by driving of the throttle valve driving motor, and
a second output value of the sensor when the throttle valve driving motor applies a torque smaller than an initial torque of the spring member to the throttle shaft in a direction to open the throttle valve, and
calculates the backlash angle by subtracting the first output value from the second output value.

6. The engine with the throttle device according to claim 5, further comprising a storage device that stores the backlash angle calculated by the throttle angle calculation unit,
wherein the throttle angle calculation unit calculates the backlash angle upon power-on, stores the backlash angle in the storage device, and calculates the rotation angle of the throttle shaft using the backlash angle read out from the storage device until power-off.

7. An engine-driven vehicle including an engine with a throttle device according to any one of claims 1 to 6.

FIG. 1

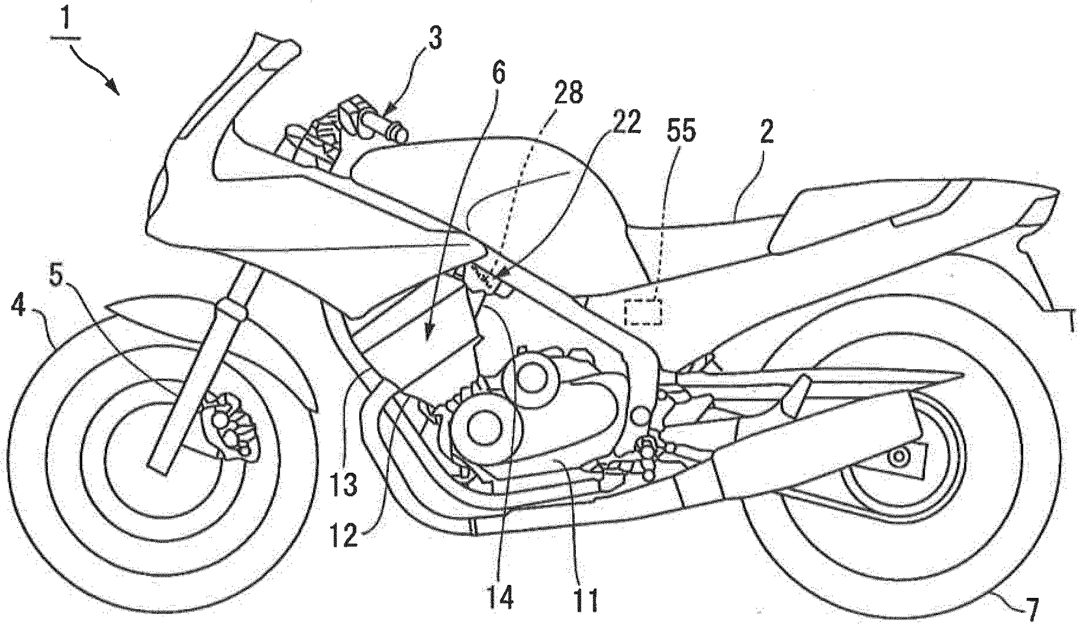

1
3
6
28
22
55
2
5
4
13
12
14
11
7

FIG. 2

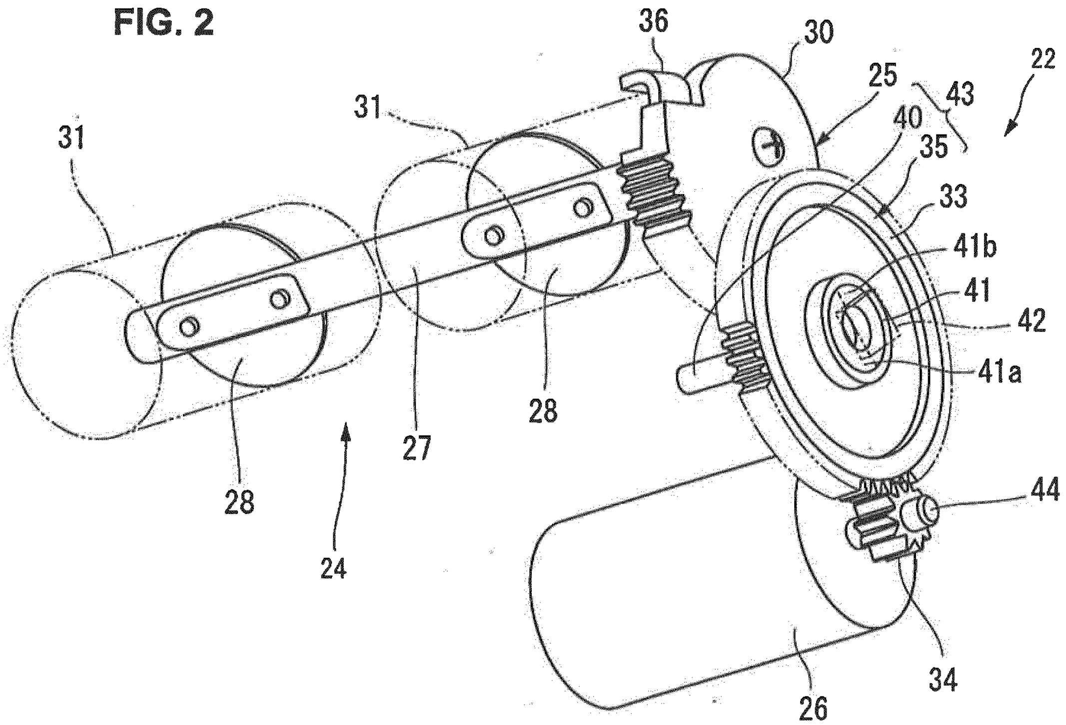

36
30
25
43
22
31
31
40
35
33
41b
41
42
41a
28
27
28
24
44
34
26

FIG. 3

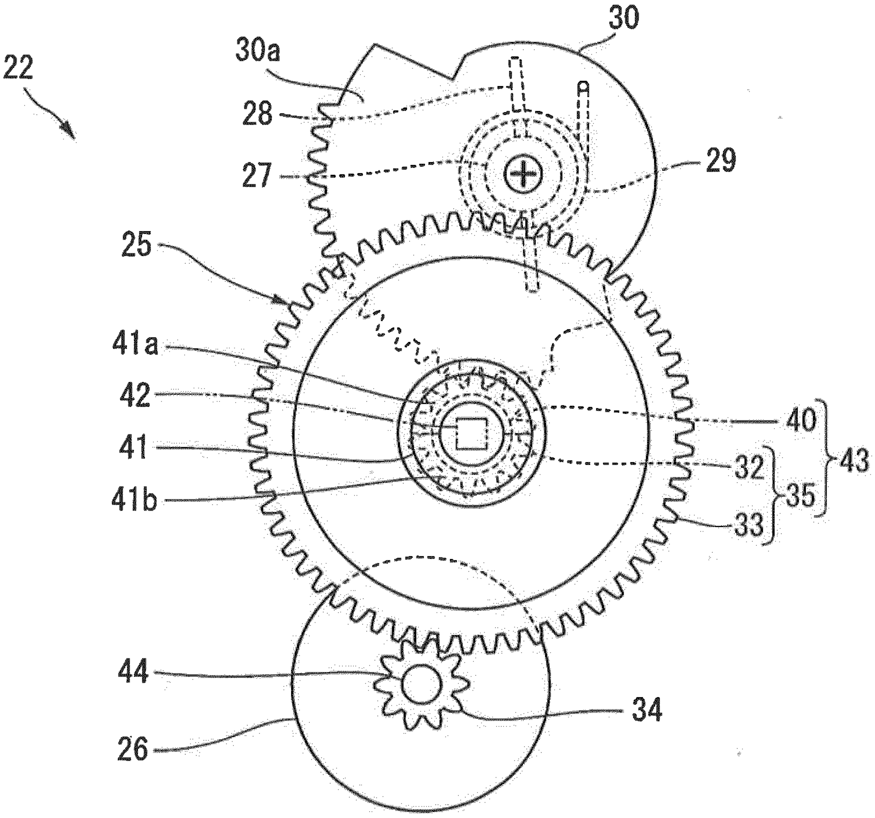

22
30a
30
28
27
29
25
41a
42
41
41b
40
32
33
35
43
44
34
26

FIG. 4

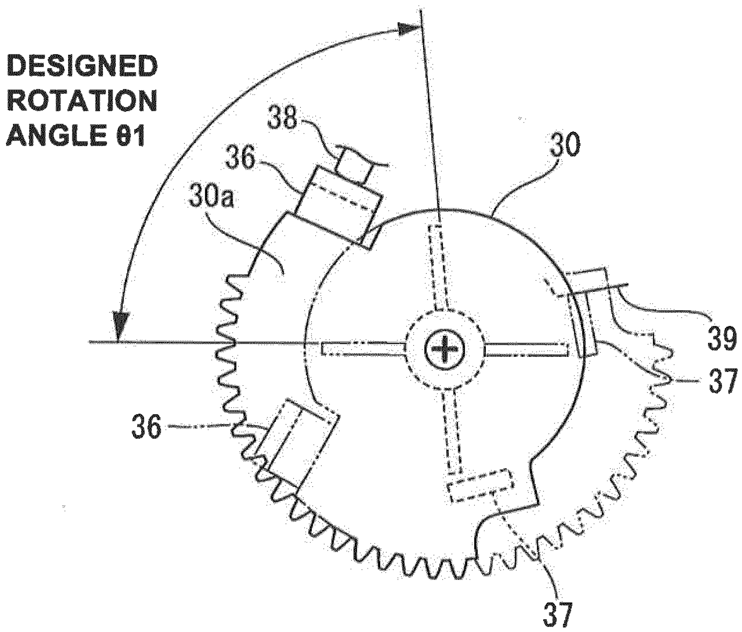

DESIGNED
ROTATION
ANGLE θ1
38
36
30a
30
39
37
36
37

FIG. 5

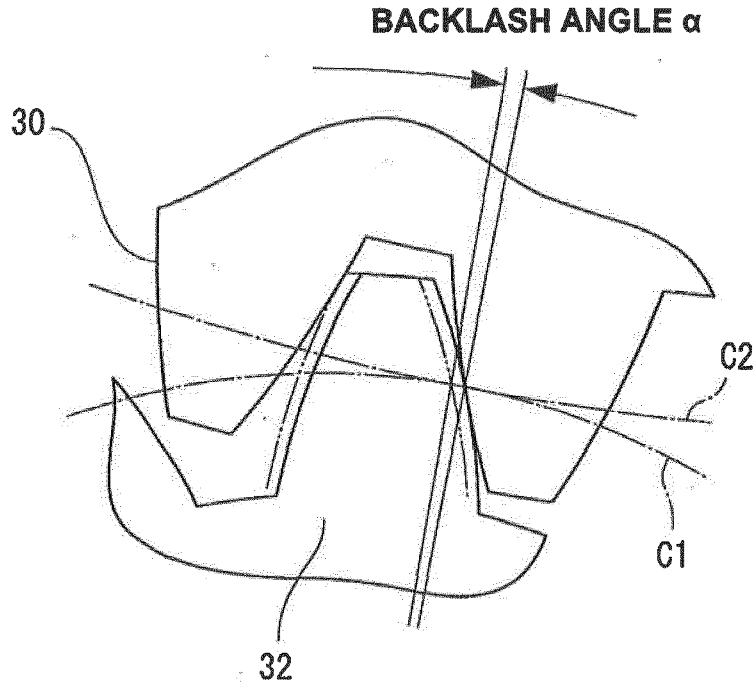


FIG. 6

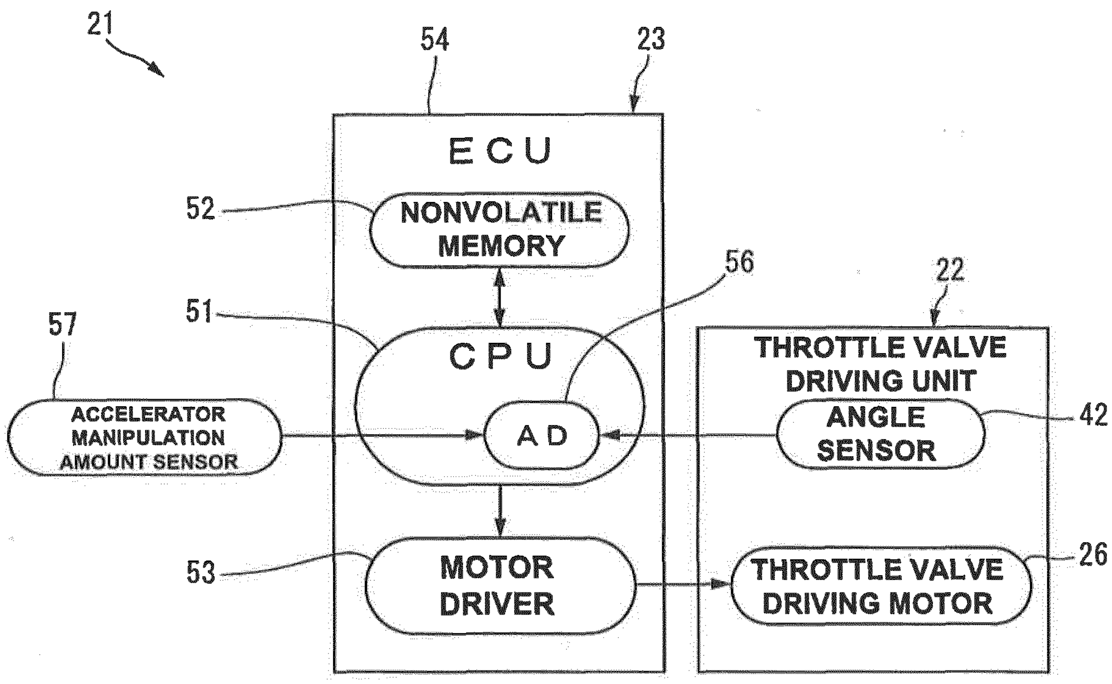

21
54
23
ECU
52
NONVOLATILE MEMORY
56
22
51
57
CPU
THROTTLE VALVE DRIVING UNIT
ACCELERATOR MANIPULATION AMOUNT SENSOR
AD
ANGLE SENSOR
42
53
MOTOR DRIVER
THROTTLE VALVE DRIVING MOTOR
26

FIG. 7

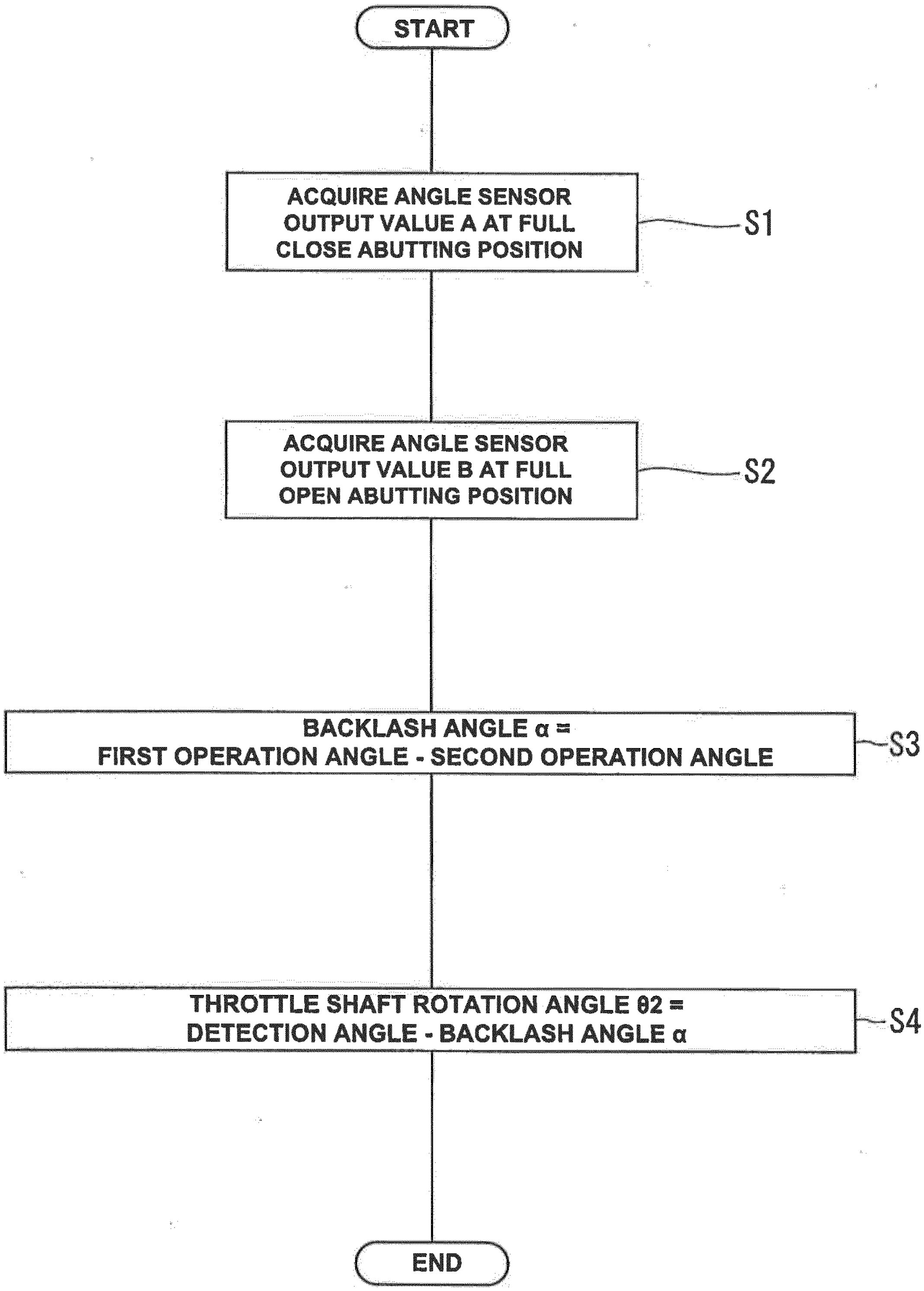

START
ACQUIRE ANGLE SENSOR OUTPUT VALUE A AT FULL CLOSE ABUTTING POSITION
S1
ACQUIRE ANGLE SENSOR OUTPUT VALUE B AT FULL OPEN ABUTTING POSITION
S2
BACKLASH ANGLE α = FIRST OPERATION ANGLE - SECOND OPERATION ANGLE
S3
THROTTLE SHAFT ROTATION ANGLE θ2 = DETECTION ANGLE - BACKLASH ANGLE α
S4
END

FIG. 8

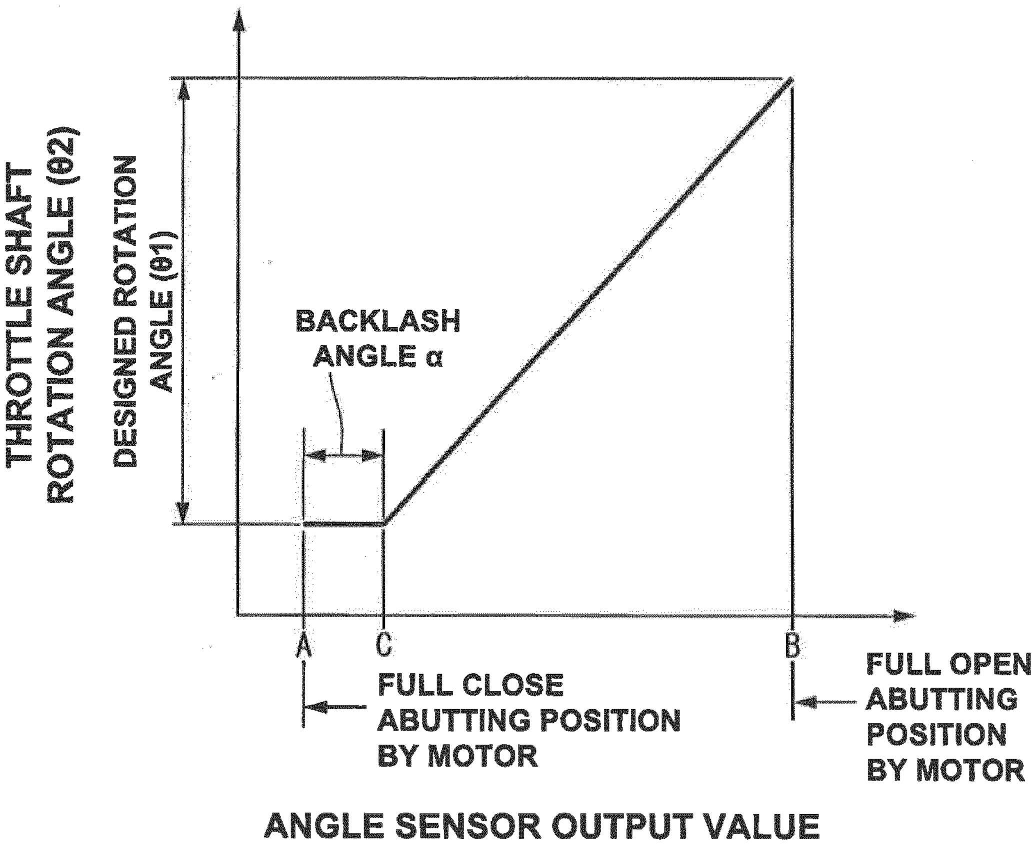

THROTTLE SHAFT
ROTATION ANGLE (θ2)
DESIGNED ROTATION
ANGLE (θ1)
BACKLASH
ANGLE α
A
C
B
FULL CLOSE
ABUTTING POSITION
BY MOTOR
FULL OPEN
ABUTTING
POSITION
BY MOTOR
ANGLE SENSOR OUTPUT VALUE

FIG. 9

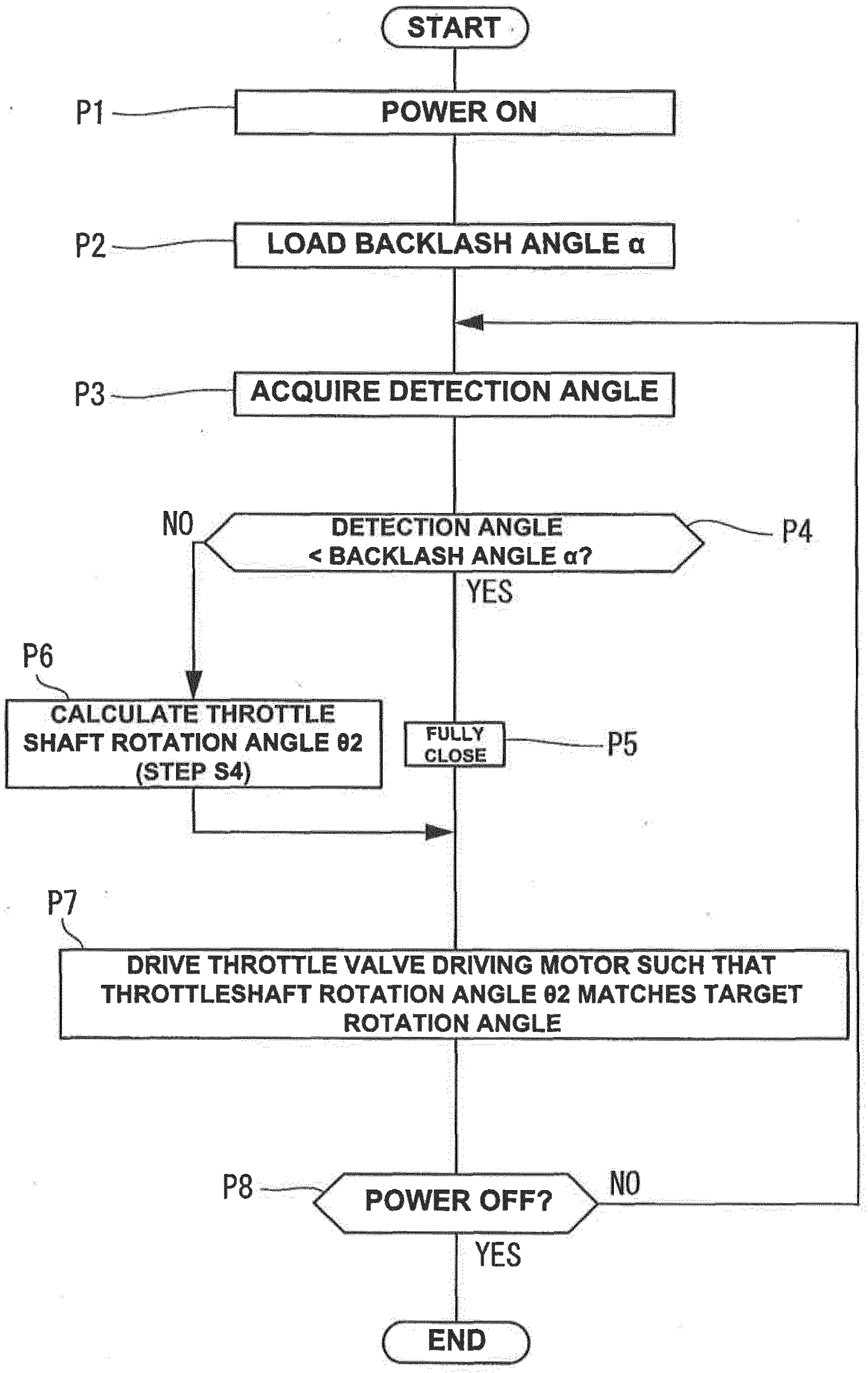

START
P1
POWER ON
P2
LOAD BACKLASH ANGLE α
P3
ACQUIRE DETECTION ANGLE
NO
DETECTION ANGLE
< BACKLASH ANGLE α?
P4
YES
P6
CALCULATE THROTTLE
SHAFT ROTATION ANGLE θ2
(STEP S4)
FULLY
CLOSE
P5
P7
DRIVE THROTTLE VALVE DRIVING MOTOR SUCH THAT
THROTTLESHAFT ROTATION ANGLE θ2 MATCHES TARGET
ROTATION ANGLE
P8
POWER OFF?
NO
YES
END

FIG. 10

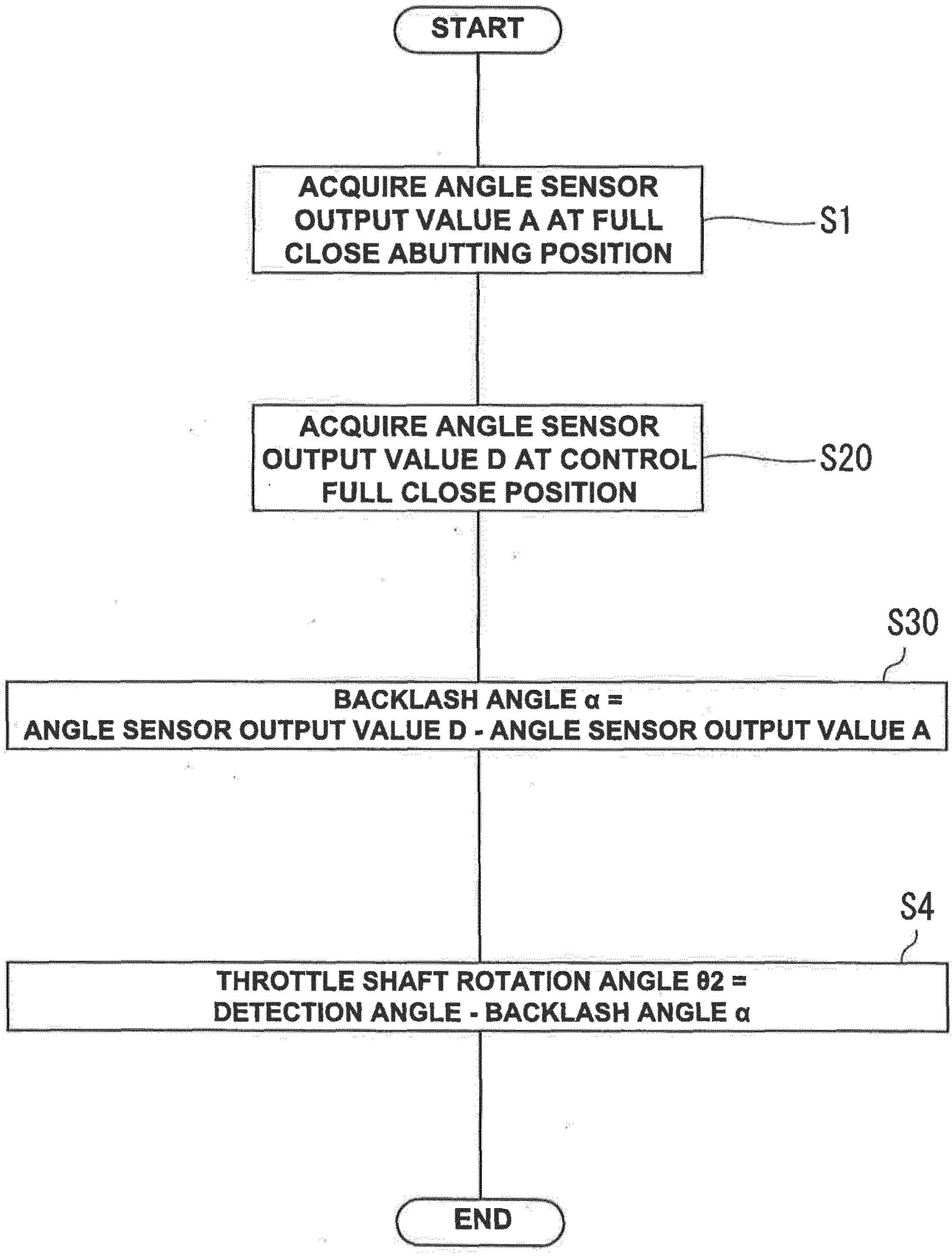

START
ACQUIRE ANGLE SENSOR OUTPUT VALUE A AT FULL CLOSE ABUTTING POSITION
S1
ACQUIRE ANGLE SENSOR OUTPUT VALUE D AT CONTROL FULL CLOSE POSITION
S20
S30
BACKLASH ANGLE α = ANGLE SENSOR OUTPUT VALUE D - ANGLE SENSOR OUTPUT VALUE A
S4
THROTTLE SHAFT ROTATION ANGLE θ2 = DETECTION ANGLE - BACKLASH ANGLE α
END

FIG. 11

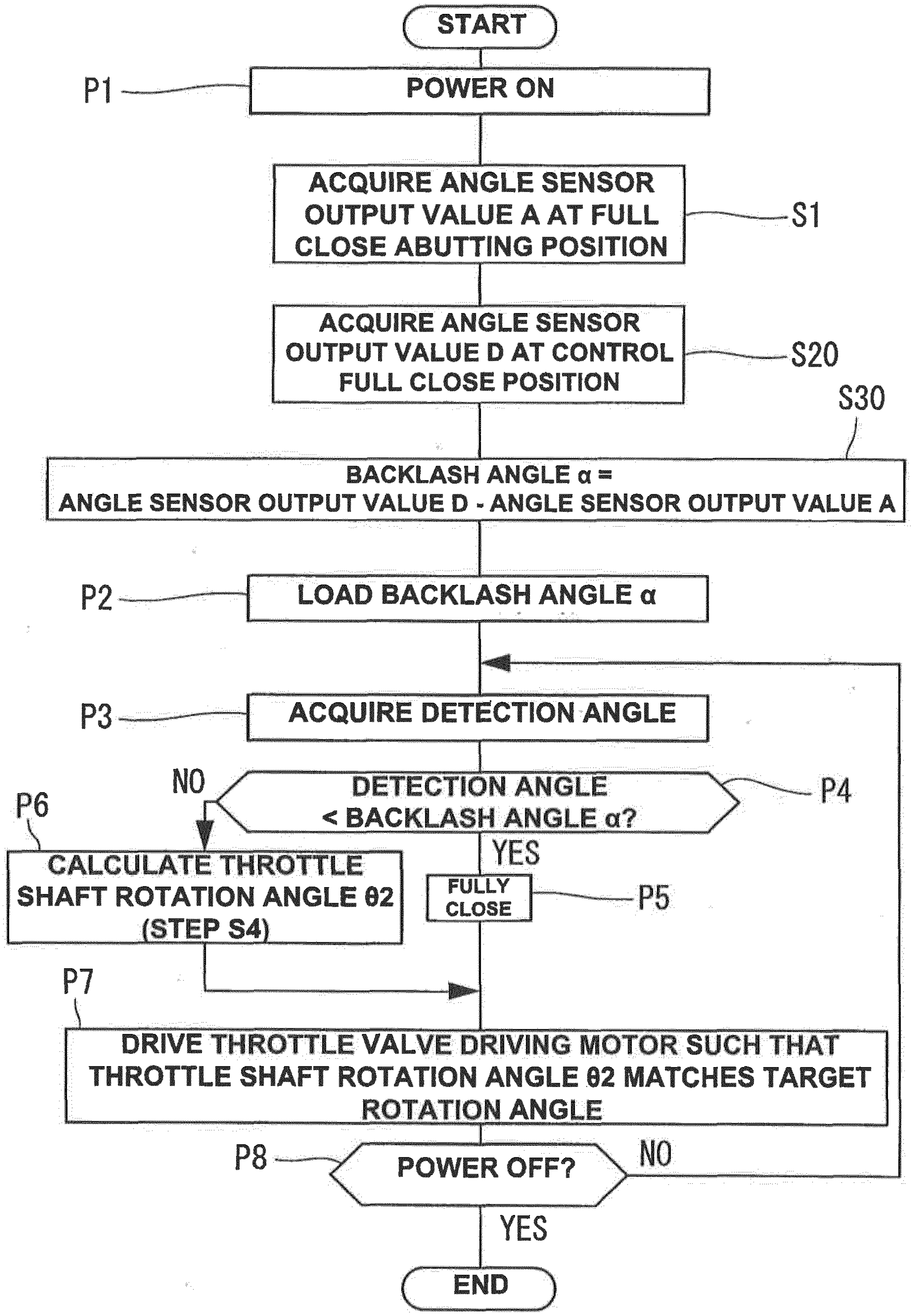
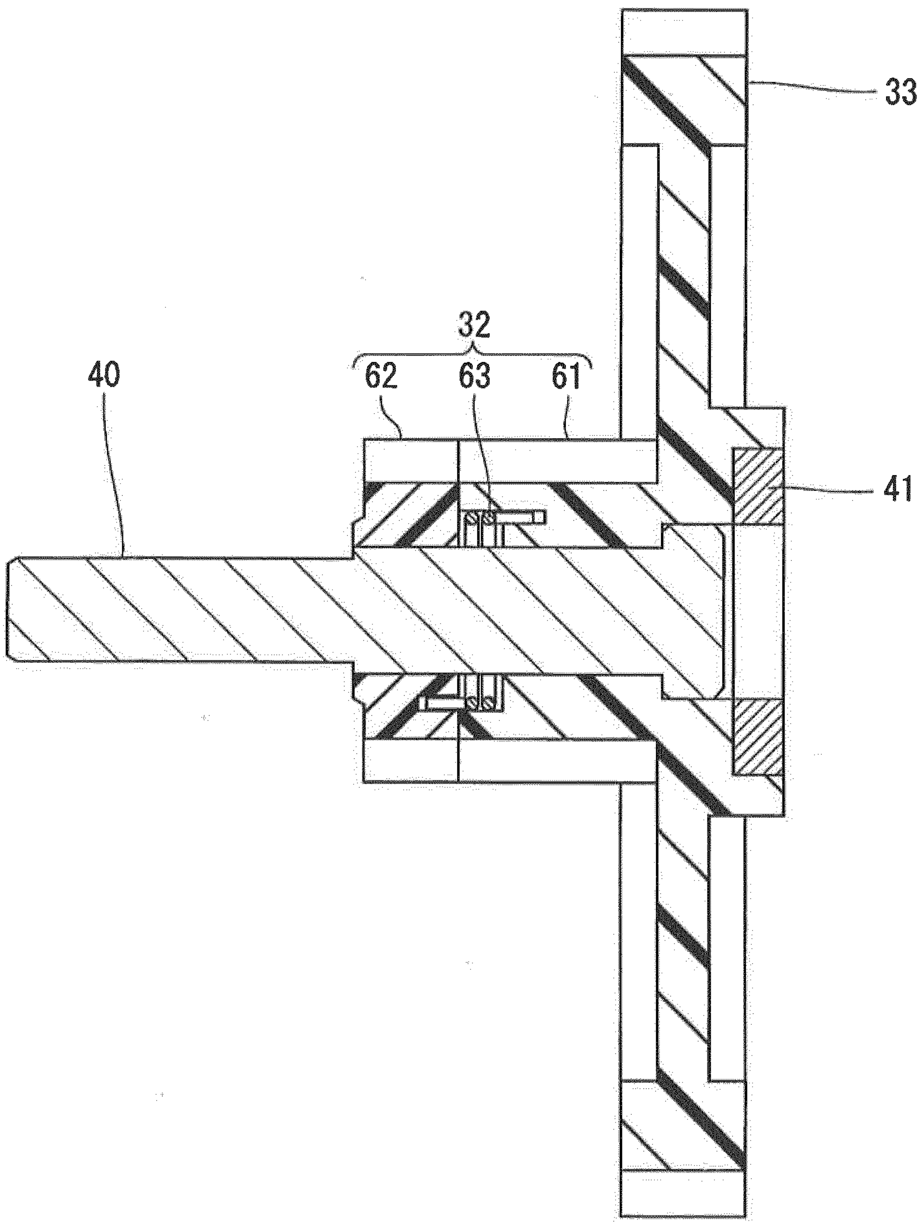

START
P1
POWER ON
ACQUIRE ANGLE SENSOR OUTPUT VALUE A AT FULL CLOSE ABUTTING POSITION
S1
ACQUIRE ANGLE SENSOR OUTPUT VALUE D AT CONTROL FULL CLOSE POSITION
S20
S30
BACKLASH ANGLE α = ANGLE SENSOR OUTPUT VALUE D - ANGLE SENSOR OUTPUT VALUE A
P2
LOAD BACKLASH ANGLE α
P3
ACQUIRE DETECTION ANGLE
NO
P6
DETECTION ANGLE < BACKLASH ANGLE α?
P4
CALCULATE THROTTLE SHAFT ROTATION ANGLE θ2 (STEP S4)
YES
FULLY CLOSE
P5
P7
DRIVE THROTTLE VALVE DRIVING MOTOR SUCH THAT THROTTLE SHAFT ROTATION ANGLE θ2 MATCHES TARGET ROTATION ANGLE
P8
POWER OFF?
NO
YES
END

FIG. 12



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2014/051264

A. CLASSIFICATION OF SUBJECT MATTER
F02D9/00(2006.01)i, *F02D9/02*(2006.01)i, *F02D11/10*(2006.01)i, *F02D45/00* (2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F02D9/00-9/02, F02D11/10, F02D45/00

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

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2010-19137 A (Yamaha Motor Co., Ltd.), 28 January 2010 (28.01.2010), claims; paragraphs [0043] to [0059]; fig. 4 to 7 & EP 2143914 A1	1-7
A	JP 2010-174729 A (Fuji Heavy Industries Ltd.), 12 August 2010 (12.08.2010), claims; paragraphs [0008], [0035] (Family: none)	1-7
A	JP 2010-174847 A (Fuji Heavy Industries Ltd.), 12 August 2010 (12.08.2010), claims; paragraphs [0008], [0035] (Family: none)	1-7

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

* Special categories of cited documents:
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- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 April, 2014 (22.04.14)	28 April, 2014 (28.04.14)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

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Patent documents cited in the description

- JP 2010019137 A **[0007]**