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(72) Inventor: **Sugimori, Shigehiko**
Takanezawa-machi
Shioya-gun
Tochigi (JP)

(74) Representative: **Tomlinson, Kerry John**
Frank B. Dehn & Co.
St Bride's House
10 Salisbury Square
London
EC4Y 8JD (GB)

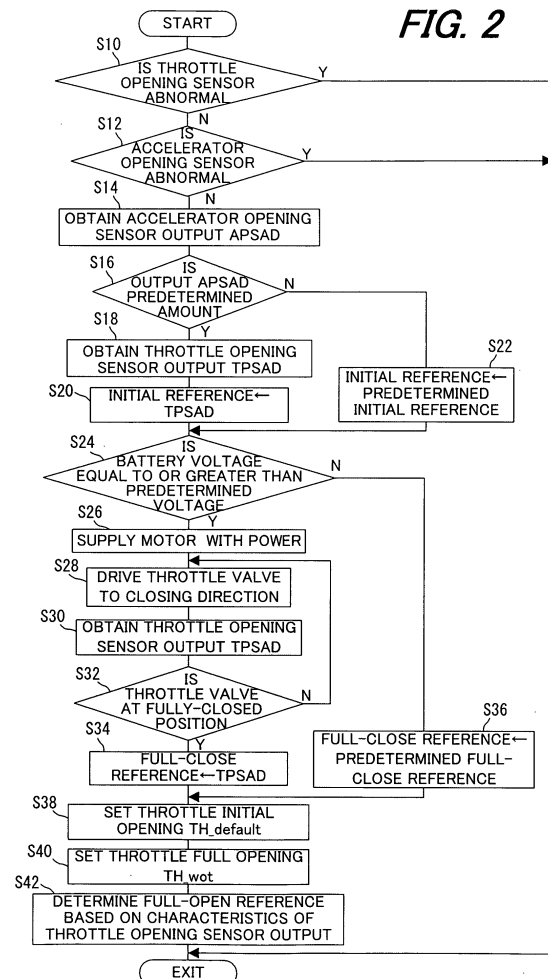
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(71) Applicant: **Keihin Corporation**
Shinjuku-ku, Tokyo (JP)

(54) **Control system for internal combustion engine**

(57) In a system for controlling an internal combustion engine (12) mounted on a vehicle (10) and having an actuator (44) that drives a throttle valve (24) installed in an intake pipe (22) of the engine, it is configured to comprise a throttle opening sensor (52) that produces an output indicative of opening of the throttle valve (24), and to determine an output of the throttle opening sensor (52) at a time when the throttle valve (24) is driven to a fully-closed position by the actuator as a full-close reference TPS_fully_close; determine a full-open reference TPS_wot corresponding to a fully-opened position of the throttle valve (24) based on the determined full-close reference; and control the operation of the actuator (44) such that the throttle valve opening becomes a desired value that is determined within a range defined by the full-close reference and the full-open reference. With this, the full-close reference and full-open reference can be determined accurately and promptly.

FIG. 2



Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] This invention relates to a control system for an internal combustion engine, particularly to a control system for an internal combustion engine that controls the operation of an actuator that drives a throttle valve installed in an intake pipe of the engine mounted on a vehicle such as a motorcycle.

Description of the Related Art

[0002] In recent years, so-called Drive-By-Wire control systems for internal combustion engines have been known in which mechanical interconnection between an accelerator and a throttle valve is omitted and the throttle valve is driven by an actuator (electric motor). Generally, such a system is equipped with a throttle opening sensor that produces an output indicative of opening of the throttle valve and based on the output, drives the throttle valve. However, outputs of the throttle opening sensor indicating the fully-closed position and fully-opened position may differ from the fully-closed and fully-opened positions of the actual throttle valve due to variation in location of installment of the throttle opening sensor, variation in outputs attributed to respective sensor circuits, or the like.

[0003] In the case where the throttle valve is driven to the fully-closed position, for example, even when the actual throttle valve has reached the fully-closed position and made a contact with a fully-closed end, if the throttle opening sensor does not produce an output indicating that the throttle valve is at the fully-closed position, the actuator further drives the throttle valve in the closing direction. It leads to increase in load current of the actuator, resulting in waste of electric power of a battery and other disadvantages. Therefore, it is necessary to accurately know reference values (full-close reference value and full-open reference value) of outputs of the throttle opening sensor corresponding to the fully-closed and fully-opened positions of the actual throttle valve. Japanese Laid-Open Patent Application No. Hei 10(1998)-169470 ('470) discloses a technique in which a throttle valve is forcibly operated to the fully-closed position and fully-opened position and based on outputs of a throttle opening sensor at that time, a full-close reference and full-open reference are determined.

[0004] However, since the technique in '470 is configured to forcibly operate the throttle valve to fully-closed and fully-opened positions to determine the full-close and full-open references, time needed to determine the reference values adversely increases by time period of the throttle valve operation.

SUMMARY OF THE INVENTION

[0005] An object of this invention is therefore to overcome the foregoing drawback by providing a control system for an internal combustion engine that can determine a full-close reference and a full-open reference of a throttle opening sensor corresponding to fully-closed and fully-opened positions of an actual throttle valve, accurately and promptly.

[0006] In order to achieve the object, this invention provides a system for controlling an internal combustion engine mounted on a vehicle and having an actuator that drives a throttle valve installed in an intake pipe of the engine, characterized by: a throttle opening sensor that produces an output indicative of opening of the throttle valve; a full-close reference determiner that determines an output of the throttle opening sensor at a time when the throttle valve is driven to a fully-closed position by the actuator as a full-close reference; a full-open reference determiner that determines a full-open reference corresponding to a fully-opened position of the throttle valve based on the determined full-close reference; and an actuator controller that controls the operation of the actuator such that the throttle valve opening becomes a desired value that is determined within a range defined by the full-close reference and the full-open reference.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The above and other objects and advantages of the invention will be more apparent from the following description and drawings in which:

FIG 1 is an overall view schematically showing a control system for an internal combustion engine according to a first embodiment of this invention;
 FIG. 2 is a flowchart showing the operation of the control system shown in FIG. 1;
 FIG. 3 is a graph showing the characteristics of an output of a throttle opening sensor with respect to throttle opening of the engine shown in FIG. 1;
 FIG. 4 is a time chart showing time period needed for determining a full-close reference and full-open reference in the control system shown in FIG. 1, in comparison with the prior art;
 FIG. 5 is a flowchart for showing the operation of a control system for an internal combustion engine according to a second embodiment of this invention;
 FIG. 6 is a flowchart similar to a part of FIG. 5 but showing the operation of a control system for an internal combustion engine according to a third embodiment;
 FIG. 7 is a former half of a flowchart for showing the operation of a control system for an internal combustion engine according to a fourth embodiment; and
 FIG. 8 is a latter half of the flowchart shown in FIG. 7.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0008] A control system for an internal combustion engine according to preferred embodiments of the present invention will now be explained with reference to the attached drawings.

[0009] FIG 1 is an overall view schematically showing a control system for an internal combustion engine according to a first embodiment of this invention.

[0010] In FIG 1, reference numeral 10 designates a saddle-seat vehicle, specifically a motorcycle. The motorcycle 10 is mounted with an internal combustion engine 12 and equipped with a handlebar 14 attached to the upper end of a telescopic fork (not shown) of a front wheel and other equipment. The engine 12 is a 4-cycle, single-cylinder, water-cooled gasoline engine having a displacement of 250 cc or thereabout.

[0011] The right end of the handlebar 14 (as viewed by the operator or driver) is equipped with an accelerator 16, precisely an accelerator 16 constituted as a throttle grip to be operable by the operator, and with a front wheel brake lever 20 to be operable by the operator. The front wheel brake lever 20 is mechanically connected to a front wheel brake through a hydraulic cylinder (neither shown). When operated (gripped) by the operator, it operates the front wheel brake to brake the front wheel. The left end of the handlebar 14 is equipped with a grip that the operator can grip and with a clutch lever, but they are neither explained nor illustrated here, since not directly related to the gist of this invention.

[0012] A throttle valve 24 installed in an air intake pipe 22 (partially shown in FIG. 1) of the engine 12 regulates the amount of intake air passing through the air intake pipe 22. A default spring (not shown) or the like is attached to the throttle valve 24 and when the throttle valve 24 is not driven by an electric motor which will be explained later (e.g., when the motor is not supplied with power), it urges the throttle valve 24 to a default opening position (initial position; about 3 degrees when full opening is about 90 degrees).

[0013] An injector (not shown) is installed downstream of the throttle valve 24 in the air intake pipe 22 for injecting gasoline fuel into the intake air regulated by the throttle valve 24. The fuel injected by the injector mixes with intake air to form an air-fuel mixture that flows into a combustion chamber 30 when an intake valve 26 opens.

[0014] The air-fuel mixture flowing into the combustion chamber 30 is ignited to burn by a spark discharge from a spark plug 32 supplied with high voltage from an ignition coil (not shown), thereby driving a piston 34 downward in FIG 1 to rotate a crankshaft 36. When an exhaust valve 40 opens, the exhaust gas produced by the combustion passes through an exhaust pipe, catalyst for removing harmful components of the exhaust gas (neither shown) and the like to be discharged outside the engine 12.

[0015] As shown in FIG 1, the throttle valve 24 is mechanically separated from the accelerator (throttle grip)

16. Specifically, the throttle valve 24 is connected to the electric motor (actuator; now assigned by 44) through a reduction gear mechanism 42 to be driven (opened/closed) by the operation of the motor 44. The motor 44 is constituted of a three-phase brushless DC motor having a rotor, stator and the like. The throttle valve 24 is thus operated by a DBW (Drive-By-Wire) system using the motor 44.

[0016] A hall sensor or rotor position sensor 50 having hall elements attached near the rotor is provided at the motor 44 and produces an output or signal in response to a position of the rotor. A throttle opening sensor 52 constituted of a variable resistance potentiometer is provided near the throttle valve 24 and produces an output TPSAD [V] indicative of the actual opening of the throttle valve 24 (hereinafter called the "actual throttle opening") between around 0 degree and around 90 degrees. The throttle opening sensor 52 is configured so that its output TPSAD increases with increasing opening of the throttle valve 24, precisely, they are directly proportional.

[0017] An accelerator opening sensor 54 similarly constituted of a variable resistance potentiometer is provided near the accelerator 16 and produces an output APSAD [V] in response to the actual opening of the accelerator 16 (more exactly, the amount of rotation of the throttle grip). The opening of the accelerator 16 is set to a value corresponding to throttle opening near 0 degree as the initial position and to throttle opening near 90 degrees at full rotation. When the accelerator 16 is at the initial position, i.e., is not operated by the operator, the accelerator opening sensor 54 outputs voltage of a predetermined amount (e.g., 0.7 [V]) and its output APSAD increases with increasing rotation amount of the accelerator 16.

[0018] An intake air pressure sensor or absolute pressure sensor 56 installed at an appropriate position of the air intake pipe 22 produces an output or signal indicative of the absolute pressure in the air intake pipe 22 (engine load). A coolant temperature sensor 60 attached to a coolant passage (not shown) of the cylinder block of the engine 12 produces an output or signal corresponding to the engine coolant temperature. A crank angle sensor 62 installed near the crankshaft 36 of the engine 12 outputs a pulse signal at a predetermined crank angle.

[0019] The motorcycle 10 is further equipped with an engine controller 64 that controls fuel injection and the like of the engine 12 and a throttle valve controller 66 that controls the operation of the throttle valve 24, precisely, the motor 44. The controllers 64, 66 are connected to a battery 72 through an ignition switch 70 to be supplied with operating power.

[0020] The engine controller 64 comprises a plurality of detection circuits electrically connected to the above-mentioned accelerator opening sensor 54 and the like for detecting sensor outputs and a microprocessor (MPU) 64a that produces an output or signal used for controlling the operation of the injector and other outputs based on the sensor outputs detected by the detection circuits.

[0021] As shown in FIG. 1, the output APSAD of the

accelerator opening sensor 54 is inputted to the MPU 64a through an accelerator opening sensor output detection circuit 64b and is Analog-to-Digital converted. The A/D converted value is transformed using a suitable characteristic curve to obtain a value corresponding to a throttle opening value between about 0 degree and about 90 degrees, specifically transformed to accelerator opening APS (i.e., the accelerator opening APS is calculated or detected).

[0022] The output TPSAD of the throttle opening sensor 52 is inputted to the MPU 64a through a throttle opening sensor output detection circuit 64c and is Analog-to-Digital converted. The A/D converted value is transformed using a suitable characteristic curve to obtain a value corresponding to the opening of the throttle valve 24 between about 0 degree and about 90 degrees, specifically transformed to actual throttle opening TPS (i.e., the actual throttle opening TPS is calculated or detected).

[0023] The MPU 64a is also inputted with the output of the intake air pressure sensor 56 through an intake air pressure sensor output detection circuit 64d and with the output of the coolant temperature sensor 60 through a coolant temperature sensor output detection circuit 64e, and the inputted outputs are Analog-to-Digital converted to be transformed to an intake air pressure PBA and coolant temperature (engine temperature) TW, respectively (i.e., the intake air pressure PBA and coolant temperature TW are calculated). Further, the output of the crank angle sensor 62 is inputted to the MPU 64a through a crank angle sensor output detection circuit 64f and the inputted output is counted to calculate engine speed NE.

[0024] Upon turning-on of the ignition switch 70 by the operator, the battery 72 is connected to a battery voltage detection circuit 64h through a power circuit 64g that supplies operating power to the MPU 64a. The output of the battery voltage detection circuit 64h is also sent to the MPU 64a. Based on the outputs of the battery voltage detection circuit 64h and the like, the MPU 64a determines whether the battery 72 is capable of driving the motor 44, e.g., whether the voltage of the battery 72 is equal to or greater than predetermined voltage, and when it is discriminated to be capable, outputs an enable signal.

[0025] On the other hand, the throttle valve controller 66 comprises a MPU 66a that produces an output or signal used for controlling the operation of the motor 44 and other outputs based on the outputs of the rotor position sensor 50 and the like. As illustrated, the MPU 66a is connected to the MPU 64a of the engine controller 64 to be able to communicate each other through a CAN (Controller Area Network), specifically, connected so as to enable communication of the output APSAD of the accelerator opening sensor 54, output TPSAD of the throttle opening sensor 52 and signals indicative of the calculated accelerator opening APS, actual throttle opening TPS and the like.

[0026] The outputs of the rotor position sensor 50 (i.e., hall sensor outputs of U-phase, V-phase and W-phase) are inputted to the MPU 66a through a rotor position sen-

sor output detection circuit 66b. Based on the output of the rotor position sensor output detection circuit 66b, the accelerator opening APS forwarded from the MPU 64a and the like, the MPU 66a outputs signals (i.e., U-phase, V-phase and W-phase outputs) used for controlling the operation of the motor 44 to the motor drive circuit 66c. Specifically, the MPU 66a determines or calculates desired throttle opening (desired value) of the throttle valve 24 based on operating condition such as the accelerator opening APS and produces the signals for controlling the operation of the motor 44.

[0027] The throttle valve controller 66 is further equipped with a power circuit 66d that supplies operating power from the battery 72 to the MPU 66a and motor 44 upon turning-on of the ignition switch 70, and a battery voltage detection circuit 66e connected to the power circuit 66d to detect the voltage of the battery 72. The output of the battery voltage detection circuit 66e is sent to the MPU 66a. Based on the inputted output and the like, the MPU 66a determines whether the battery 72 is capable of driving the motor 44, e.g., whether the voltage of the battery 72 is equal to or greater than the predetermined voltage, and when it is discriminated to be capable, outputs an enable signal.

[0028] The enable signal from the MPU 66a and the above-mentioned enable signal from the MPU 64a are sent to an AND circuit 66f. When the two enable signals are inputted, specifically when it is discriminated in the both MPUs 64a, 66a that the battery 72 is capable of driving the motor 44, the AND circuit 66f outputs a Hi-level signal to close an enable relay 66g and supplies motor drive voltage from the power circuit 66d to the motor drive circuit 66c.

[0029] When supplied with the motor drive voltage from the power circuit 66d, i.e., when the enable relay 66g is closed, based on the outputs of the MPU 66a, the motor drive circuit 66c sends outputs to the coil (U-, V-, W-phases) of the motor 44.

[0030] FIG. 2 is a flowchart showing the operation of the control system according to the first embodiment. The illustrated program is executed only once by the throttle valve controller 66 or the like upon starting of the engine 12 (precisely, turning-on of the ignition switch 70 by the operator).

[0031] In S10, it is determined whether the throttle opening sensor 52 is abnormal. This determination is made based on the outputs of the throttle opening sensor output detection circuit 64c and the like. When the result in S10 is YES, the remaining steps are skipped and when the result is NO, the program proceeds to S12, in which it is determined whether the accelerator opening sensor 54 is abnormal. This determination is made based on the outputs of the accelerator opening sensor output detection circuit 64b and the like. When the result in S12 is YES, the remaining steps are skipped and when the result is NO, the program proceeds to S14.

[0032] In S 14, the output APSAD of the accelerator opening sensor 54 is obtained or detected and in S16, it

is determined whether the obtained output APSAD is the predetermined amount. Since, as explained above, the predetermined amount is voltage outputted at the time when the accelerator 16 is not operated by the operator and remains at the initial position, the processing of S 16 amounts to determining whether the accelerator 16 is at an accelerator fully-closed position (initial position).

[0033] When the result in S16 is YES, the program proceeds to S 18, in which the output TPSAD of the throttle opening sensor 52 is obtained or detected. Precisely, in S 18, the output TPSAD of the throttle opening sensor 52 corresponding to a position of the throttle valve 24 at the time when the throttle valve 24 is not driven by the motor 44 (the motor 44 is not supplied with power) and the accelerator 16 is at the accelerator fully-closed position, in other words, when the throttle valve 24 is at the initial opening (default opening), is obtained.

[0034] Next, in S20, the obtained output TPSAD is determined as an initial reference (TPS default value) TPS_default. In the output of the throttle opening sensor 52, the initial reference means a reference value that corresponds to the initial opening (initial position) of the throttle valve 24. Thus the output TPSAD of the throttle opening sensor 52 corresponding to a position of the throttle valve 24 when not driven by the motor 44 is defined as the initial reference TPS_default.

[0035] On the other hand, when the result in S16 is NO, i.e., the output APSAD is greater than the predetermined amount and the accelerator 16 is discriminated not to be at the accelerator fully-closed position, the program proceeds to S22, in which a predetermined initial reference (i.e., an initial reference determined in the preceding loop or a default value (initial value)) stored in the MPU 66a is defined as the initial reference TPS_default.

[0036] In S24, it is determined whether voltage of the battery 72 is equal to or greater than the predetermined voltage. This determination is made based on the presence/absence of the enable signal from the MPUs 64a, 66a.

[0037] When the result in S24 is YES, the program proceeds to S26, in which the motor 44 is supplied with the motor drive voltage of the battery 72, i.e., the motor 44 is supplied with power, to S28, in which the throttle valve 24 is forcibly driven to the closing direction, specifically the motor 44 is operated to drive the throttle valve 24 in the closing direction, and to S30, in which the output TPSAD of the throttle opening sensor 52 is obtained.

[0038] In S32, it is determined whether the throttle valve 24 has reached the fully-closed position, i.e., has been driven to the fully-closed position by the motor 44. This determination is made by checking whether a minimum value TPSADmin of the output of the throttle opening sensor 52 is updated. Specifically, the (latest) output TPSAD of the throttle opening sensor 52 obtained last time and the minimum value TPSADmin among the outputs of the throttle opening sensor 52 obtained up to that time are compared in an unshown program and when the output TPSAD is less than the minimum value TP-

SADmin, the latest output TPSAD is newly defined as the minimum value TPSADmin. An initial value of the minimum value TPSADmin is experimentally defined beforehand.

[0039] With this, when the minimum value TPSADmin is updated, it means that the throttle valve 24 is driven to the closing direction, so it can be discriminated to have not reached the fully-closed position and when the minimum value TPSADmin is not updated, it means that movement of the throttle valve 24 to the closing direction is stopped, so it can be discriminated to have reached the fully-closed position and made a contact with a fully-closed end. Thus determination whether the throttle valve 24 is driven to the fully-closed position is made not by using a current sensor detecting current of the motor 44 or the like, but based on the output TPSAD of the throttle opening sensor 52.

[0040] When the result in S32 is NO, i.e., the throttle valve 24 has not reached the fully-closed position yet, the program returns to the steps of S28 and S30, in which the throttle valve 24 is driven to the closing direction further and the output TPSAD of the throttle opening sensor 52 is obtained again. When the result in S32 is YES, the program proceeds to S34, in which the (latest) output TPSAD of the throttle opening sensor 52 obtained last time is defined as a full-close reference (a reference value of the throttle opening sensor 52 corresponding to the fully-closed position of the throttle valve 24; TPS lower limit value) TPS_fully_close. Thus the output TPSAD of the throttle opening sensor 52 when the throttle valve 24 is driven to the fully-closed position by the motor 44 is determined as the full-close reference TPS_fully_close.

[0041] When the result in S24 is NO, i.e., the voltage of the battery 72 is below the predetermined voltage, since the battery 72 cannot drive the throttle valve 24 to the closing direction, the program proceeds to S36, in which a predetermined full-close reference (i.e., a full-close reference determined in the preceding loop or a default value (initial value)) stored in the MPU 66a is defined as the full-close reference TPS_fully_close.

[0042] Next, in S38, the initial opening (about 3 degrees) of the throttle valve 24 is set or determined as throttle initial opening TH_default, and in S40, the full opening (about 90 degrees) of the throttle valve 24 is set as throttle full opening TH_wot. The foregoing initial opening and full opening of the throttle valve 24 are set values (characteristic values) uniquely owned by the throttle body including the throttle valve 24 and stored in the MPU 66a.

[0043] The program proceeds to S42, in which, based on the characteristics of the throttle opening sensor 52 obtained from the determined initial reference TPS_default and full-close reference TPS_fully_close, a full-open reference (a reference value of the throttle opening sensor 52 corresponding to the fully-opened position of the throttle valve 24; TPS upper limit value) TPS_wot corresponding to the fully-opened position (TH_wot) of the throttle valve 24 is determined.

[0044] The determination of the full-open reference TPS_wot is explained. Since the output of the throttle opening sensor 52 is directly proportional to a position of the throttle valve 24 (i.e., the throttle opening), as shown in FIG. 3, if the initial reference TPS_default that is the sensor output when the throttle valve 24 is at the throttle initial opening TH_default and the full-close reference TPS_fully_close that is the sensor output when the throttle valve 24 is at the fully-closed position (when the throttle opening is zero in FIG. 3) are determined, the output characteristics (sensor model) of the throttle opening sensor 52 can be obtained as indicated by the dashed-dotted line in FIG. 3.

[0045] Therefore, applying the throttle full opening TH_wot defined in S40 to the output characteristics of the throttle opening sensor 52, the full-open reference TPS_wot corresponding to the fully-opened position (throttle full opening TH_wot) of the throttle valve 24 can be determined or estimated. More specifically, the full-open reference TPS_wot is obtained in accordance with the following Equation 1.

$$\text{TPS_wot [V]} = ((\text{TPS_default} - \text{TPS_fully_close}) / \text{TH_default}) \times \text{TH_wot} + \text{TPS_fully_close} \dots \text{Eq. 1}$$

[0046] Specifically, a difference obtained by subtracting the full-close reference TPS_fully_close from the initial reference TPS_default is divided by the throttle initial opening TH_default (i.e., a change amount of the sensor output is divided by a change amount of the throttle opening), and a value obtained by multiplying the result by the throttle full opening TH_wot is added with the full-close reference TPS_fully_close, whereby the full-open reference TPS_wot is obtained. In Equation 1, although the throttle initial opening TH_default is used as a change amount of the throttle opening, it is only because the fully-closed opening of the throttle valve 24 is 0 degree and in other cases, a difference obtained by subtracting the fully-closed opening of the throttle valve 24 from the throttle initial opening TH_default should be used as a change amount of the throttle opening.

[0047] Following determination of the full-close reference and full-open reference of the throttle opening sensor 52 as stated in the foregoing, based on the operating condition such as the accelerator opening APS, the desired throttle opening (desired value) of the throttle valve 24 is determined within a range defined by the full-close reference and full-open reference in an unshown program. Then the operation of the motor 44 is controlled such that the opening of the throttle valve 24 becomes the desired throttle opening. Thus the motor 44 is operated such that the opening of the throttle valve 24 becomes the desired throttle opening that is determined within a range defined by the full-close reference TPS_fully_close and full-open reference TPS_wot.

[0048] FIG. 4 is a time chart showing time period needed for determining the full-close reference and full-open reference in the control system according to the first embodiment, in comparison with the prior art.

[0049] As shown in FIG. 4, in the system according to

this embodiment, when the ignition switch 70 is turned on by the operator at a time point t_1 , as explained, the output of the throttle opening sensor 52 corresponding to a position of the throttle valve 24 when not driven by the motor 44 (i.e., when the throttle valve 24 is at the initial opening (default position)) is defined as the initial reference TPS_default during time period from t_1 to t_2 .

[0050] From a time point t_2 to t_3 , the throttle valve 24 is forcibly driven to the closing direction. When the throttle valve 24 has reached the fully-closed position (t_3), the full-close reference TPS_fully_close is determined and based on the determined initial reference TPS_default and full-close reference TPS_fully_close, the full-open reference TPS_wot is determined. The throttle valve 24 driven to the fully-closed position is, after that, driven in the opening direction to start opening which is appropriately set. At a time point t_4 , the processing for determining the full-close reference TPS_fully_close and full-open reference TPS_wot is completed.

[0051] In contrast, the prior art (a technique disclosed by '470) is configured to conduct the same processing as that in this embodiment from the time point t_1 to t_3 and at t_3 , the full-close reference is determined. From the time point t_3 to t_5 , the throttle valve 24 is forcibly driven to the opening direction and when the throttle valve 24 has reached the fully-opened position (t_5), the full-open reference is determined. After that, the throttle valve 24 is driven in the closing direction to start opening and at t_6 , the processing for determining the full-close and full-open references finishes. Thus, in the system according to the first embodiment, since the throttle valve 24 is not operated to the fully-opened position, the time period needed to determine the full-close and full-open references can be shortened by a period for conducting extra operation (i.e., time period from t_4 to t_6).

[0052] As stated in the foregoing, the first embodiment is configured to have a system for (and method of) controlling an internal combustion engine (12) mounted on a vehicle (10) and having an actuator (44) that drives a throttle valve (24) installed in an intake pipe (22) of the engine, characterized by: a throttle opening sensor (52) that produces an output indicative of opening of the throttle valve (24); a full-close reference determiner that determines an output of the throttle opening sensor at a time when the throttle valve is driven to a fully-closed position by the actuator as a full-close reference TPS_fully_close (throttle valve controller 66, S34); a full-open reference determiner that determines a full-open reference TPS_wot corresponding to a fully-opened position (throttle full opening TH_wot) of the throttle valve based on the determined full-close reference (throttle valve controller 66, S42); and an actuator controller that controls the operation of the actuator such that the throttle valve opening becomes a desired value (desired throttle opening) that is determined within a range defined by the full-close reference and the full-open reference (throttle valve controller 66).

[0053] Since the both full-close reference TPS_fully_

close and full-open reference TPS_wot are determined by driving the throttle valve 24 to the fully-closed position only, i.e., the throttle valve 24 is not driven to the fully-opened position as in the prior art, the reference values can be determined accurately and promptly, thereby improving start-up performance of the engine 12. Further, the motor 44 is operated such that the opening of the throttle valve 24 becomes the desired throttle opening that is determined within a range defined by the full-close reference TPS_fully_close and full-open reference TPS_wot. With this, when, for example, the throttle valve 24 has reached the fully-closed position and made a contact with the fully-closed end, the motor 44 does not drive the throttle valve 24 to the closing direction further, thereby preventing disadvantages such as increase in load current of the motor 44 and waste of electric power.

[0054] The system further includes an initial reference determiner that determines an output of the throttle opening sensor (52) corresponding to a position (throttle initial opening TH_default) of the throttle valve when not operated by the actuator (44) as an initial reference TPS_default (throttle valve controller 66, S20), and the full-open reference determiner determines the full-open reference TPS_wot based on characteristics of the throttle opening sensor (52) obtained from the determined initial reference TPS_default and the full-close reference TPS_fully_close (S42). With this, in addition to the above effects, the full-open reference TPS_wot can be determined further accurately.

[0055] FIG. 5 is a flowchart similar to FIG. 2 but showing the operation of a control system for an internal combustion engine according to a second embodiment of this invention. The illustrated program is executed only once by the throttle valve controller 66 or the like upon starting of the engine 12 (precisely, turning-on of the ignition switch 70 by the operator).

[0056] In S100, it is determined whether the throttle opening sensor 52 is abnormal. This determination is made based on the outputs of the throttle opening sensor output detection circuit 64c and the like. When the result in S100 is YES, the remaining steps are skipped and when the result is NO, the program proceeds to S102, in which it is determined whether voltage of the battery 72 is equal to or greater than the predetermined voltage. This determination is made based on the presence/absence of the enable signal from the MPUs 64a, 66a.

[0057] When the result in S102 is YES, the program proceeds to S104, in which the motor 44 is supplied with the motor drive voltage of the battery 72, i.e., the motor 44 is supplied with power, to S106, in which the throttle valve 24 is forcibly driven to the closing direction, specifically the motor 44 is controlled to drive the throttle valve 24 in the closing direction, and to S108, in which the output TPSAD of the throttle opening sensor 52 is obtained or detected.

[0058] In S110, it is determined whether the throttle valve 24 has reached the fully-closed position, i.e., has been driven to the fully-closed position by the motor 44.

This determination is made, similarly to the processing of S32 explained above, by checking whether the minimum value TPSADmin of the output of the throttle opening sensor 52 is updated.

5 **[0059]** When the result in S110 is NO, i.e., the throttle valve 24 has not reached the fully-closed position yet, the program returns to the steps of S 106 and S108, in which the throttle valve 24 is driven to the closing direction further and the output TPSAD of the throttle opening sensor 52 is obtained again. When the result in S110 is YES, the program proceeds to S112, in which the (latest) output TPSAD of the throttle opening sensor 52 obtained last time is defined as a full-close reference (a reference value of the throttle opening sensor 52 corresponding to the fully-closed position of the throttle valve 24; TPS lower limit value). Thus the output TPSAD of the throttle opening sensor 52 when the throttle valve 24 is driven to the fully-closed position by the motor 44 is determined as the full-close reference.

20 **[0060]** Next, in S 114, a value obtained by adding a first predetermined value to the determined full-close reference is defined as a full-open reference (a reference value of the throttle opening sensor 52 corresponding to the fully-opened position of the throttle valve 24; TPS upper limit value) and then the program is terminated. The first predetermined value is information on a difference (offset value) between the fully-closed position and fully-opened position of the throttle valve 24, which is experimentally defined beforehand, e.g., 3.6 [V].

30 **[0061]** When the result in S 102 is NO, i.e., the voltage of the battery 72 is below the predetermined voltage, since the battery 72 cannot drive the throttle valve 24 to the closing direction, the program proceeds to S 116, in which a predetermined full-close reference (i.e., the full-close reference determined in the preceding loop or a default value (initial value)) stored in the MPU 66a is defined as the full-close reference. Then the processing of S 114 is conducted, whereafter the program is terminated.

40 **[0062]** Next, time period needed for determining the full-close reference and full-open reference in the control system according to the second embodiment will be explained in reference to FIG. 4.

45 **[0063]** As shown in FIG. 4, in the system according to this embodiment, when the ignition switch 70 is turned on by the operator at the time point t_1 , the output indicative of the default opening of the throttle valve 24 is obtained or detected from of throttle opening sensor 52 during time period from t_1 to t_2 . Then, as explained, from a time point t_2 to t_3 , the throttle valve 24 is forcibly driven to the closing direction. When the throttle valve 24 has reached the fully-closed position (t_3), the full-close reference and full-open reference are determined. The throttle valve 24 driven to the fully-closed position is, after that, driven in the opening direction to the start opening which is appropriately set. At a time point t_4 , the processing for determining the full-close reference and full-open reference is completed.

[0064] In contrast, the prior art is configured to conduct the processing for determining the full-close and full-open references from t_1 to t_6 . Thus, in the system according to the second embodiment, since the throttle valve 24 is not operated to the fully-opened position, the time period needed for determining the full-close and full-open references can be shortened by a period for conducting extra operation (i.e., time period from t_4 to t_6).

[0065] The remaining configuration is the same as that in the first embodiment.

[0066] As stated in the foregoing, the system according to the second embodiment is configured such that the full-open reference determiner determines a value obtained by adding a first predetermined value (offset value) to the determined full-close reference as the full-open reference (S 114). With this, it becomes possible to achieve the same effects as in the first embodiment.

[0067] A control system for an internal combustion engine according to a third embodiment is explained.

[0068] FIG. 6 is a flowchart similar to FIG. 5 but showing the operation of the control system according to the third embodiment.

[0069] The explanation will be made with focus on points of difference from the second embodiment. As shown in FIG. 6, the third embodiment is configured to add the processing for determining an accelerator full-close reference and accelerator full-open reference of the accelerator opening sensor 54. Specifically, after the step of S 100, the program proceeds to S100a, in which it is determined whether the accelerator opening sensor 54 is abnormal. This determination is made based on the outputs of the accelerator opening sensor output detection circuit 64b and the like. When the result is YES, the remaining steps are skipped and when the result is NO, the program proceeds to S100b.

[0070] In S100b, the output APSAD of the accelerator opening sensor 54 is obtained or detected and in S100c, it is determined whether the obtained output APSAD is the predetermined amount. Since the predetermined amount is voltage outputted at the time when the accelerator 16 is not operated by the operator and remains at the initial position, the processing of S100c amounts to determining whether the accelerator 16 is at an accelerator fully-closed position (initial position).

[0071] When the result in S100c is YES, the program proceeds to S100d, in which the output APSAD obtained in S100b is defined as the accelerator full-close reference (a reference value of the accelerator opening sensor 54 corresponding to the fully-closed position of the accelerator 16; APS lower limit value). Thus the output APSAD of the accelerator opening sensor 54 when the accelerator 16 is not operated by the operator and at the fully-closed position is determined as the accelerator full-close reference.

[0072] When the result in S100c is NO, i.e., the output APSAD is greater than the predetermined amount and the accelerator 16 is discriminated not to be at the accelerator fully-closed position, the program proceeds to

S100e, in which a predetermined accelerator full-close reference (i.e., an accelerator full-close reference determined in the preceding loop or a default value (initial value)) stored in the MPU 66a is defined as the accelerator full-close reference.

[0073] Next, in S100f, a value obtained by adding an accelerator predetermined value to the accelerator full-close reference determined in S100d or S100e is defined as an accelerator full-open reference (a reference value of the accelerator opening sensor 54 corresponding to the accelerator fully-opened position of the accelerator 16; APS upper limit value) and the above-mentioned processing of S 102 onward are conducted. The accelerator predetermined value is information on a difference (offset value) between the fully-closed position and fully-opened position of the accelerator 16, which is experimentally defined beforehand, e.g., 3.6 [V].

[0074] Following determination of the accelerator full-close reference and accelerator full-open reference of the accelerator opening sensor 54 as stated in the foregoing, the operation of the motor 44 is controlled in an unshown program such that the accelerator full-close reference and accelerator full-open reference correspond to the full-close reference and full-open reference of the throttle opening sensor 52, respectively.

[0075] Thus in the control system according to the third embodiment, it is configured to have the accelerator opening sensor 54 that produces an output indicative of the opening of the accelerator 16, and such that the output APSAD of the accelerator opening sensor 54 when the accelerator 16 is at the fully-closed position is determined as the accelerator full-close reference, and a value obtained by adding the accelerator predetermined value (offset value) to the determined accelerator full-close reference is determined as the accelerator full-open reference. With this, the accelerator full-close reference and accelerator full-open reference can be determined accurately and promptly.

[0076] The remaining configuration is the same as that in the second embodiment.

[0077] FIG. 7 is a former half of a flowchart similar to FIG. 2 but showing the operation of a control system for an internal combustion engine according to a fourth embodiment and FIG. 8 is a latter half thereof. The illustrated program is executed only once by the throttle valve controller 66 or the like upon starting of the engine 12 (precisely, turning-on of the ignition switch 70 by the operator).

[0078] In S200, it is determined whether the throttle opening sensor 52 is abnormal. This determination is made based on the outputs of the throttle opening sensor output detection circuit 64c and the like. When the result in S200 is YES, the remaining steps are skipped and when the result is NO, the program proceeds to S202, in which it is determined whether the accelerator opening sensor 54 is abnormal. This determination is made based on the outputs of the accelerator opening sensor output detection circuit 64b and the like. When the result in S202

is YES, the remaining steps are skipped and when the result is NO, the program proceeds to S204.

[0079] In S204, the output APSAD of the accelerator opening sensor 54 is obtained or detected and in S206, it is determined whether the obtained output APSAD is the predetermined amount. Since, as explained above, the predetermined amount is voltage outputted at the time when the accelerator 16 is not operated by the operator and remains at the initial position, the processing of S206 amounts to determining whether the accelerator 16 is at the accelerator fully-closed position (initial position).

[0080] When the result in S206 is YES, the program proceeds to S208, in which the output TPSAD of the throttle opening sensor 52 is obtained or detected. Precisely, in S208, the output TPSAD of the throttle opening sensor 52 corresponding to a position of the throttle valve 24 at the time when the throttle valve 24 is not driven by the motor 44 (the motor 44 is not supplied with power) and the accelerator 16 is at the accelerator fully-closed position, in other words, when the throttle valve 24 is at the initial opening (default opening), is obtained.

[0081] Next, in S210, the obtained output TPSAD is defined as the initial reference (TPS default value) TPS_default. In the output of the throttle opening sensor 52, the initial reference means a reference value that corresponds to the initial opening (initial position) of the throttle valve 24. Thus the output TPSAD of the throttle opening sensor 52 corresponding to a position of the throttle valve 24 when not driven by the motor 44 is defined as the initial reference TPS_default.

[0082] On the other hand, when the result in S206 is NO, i.e., the output APSAD is greater than the predetermined amount and the accelerator 16 is discriminated not to be at the accelerator fully-closed position, the program proceeds to S212, in which the predetermined initial reference (i.e., the initial reference determined in the preceding loop or a default value (initial value)) stored in the MPU 66a is defined as the initial reference TPS_default.

[0083] Then in S214, a voltage difference between the initial reference TPS_default and a full-close reference (explained later) stored in the MPU 66a is set to a second predetermined value (TPS offset value) TPS_offset_REF. The second predetermined value TPS_offset_REF is stored in the MPU 66a beforehand and, as its initial value, a value (voltage) uniquely owned by the throttle body including the throttle valve 24 is set, but after that, a voltage value updated every time the full-close reference is newly defined (i.e., an updatable learning value) is set, as explained later.

[0084] The program proceeds to S216, in which the full-close reference (hereinafter called "full-close reference estimation value") is estimated or obtained from the initial reference TPS_default. Specifically, a value obtained by subtracting the second predetermined value TPS_offset_REF from the initial reference TPS_default is defined as the full-close reference estimation value (TPS lower limit estimation value) TPS_hat_fully_close.

[0085] In S218, a full-close reference candidate value (TPS lower limit learning value) TPS_fully_close_REF that is a candidate of the full-close reference is set. Specifically, the output of the throttle opening sensor 52 corresponding to the fully-closed position of the throttle valve 24 at engine start, which is stored in the MPU 66a, is read to be set to the full-close reference candidate value TPS_fully_close_REF.

[0086] This embodiment is characterized in that the sensor output at engine start is set to the full-close reference candidate value TPS_fully_close_REF. Since the program is executed upon starting of the engine 12, the initial reference TPS_default and full-close reference estimation value TPS_hat_fully_close are determined based on the output of the throttle opening sensor 54 under temperature environment at engine start. Here, the full-close reference candidate value TPS_fully_close_REF is set as in the foregoing, so the full-close reference candidate value TPS_fully_close_REF and full-close reference estimation value TPS_hat_fully_close can be obtained from the sensor output under the substantially same temperature environment.

[0087] Similarly to the second predetermined value TPS_offset_REF, the full-close reference candidate value TPS_fully_close_REF is also stored in the MPU 66a beforehand and, as its initial value, a value (voltage) uniquely owned by the throttle body is set, but after that, a voltage value updated every time the full-close reference is newly defined (i.e., an updatable learning value) is set, as explained later.

[0088] In S220, the determined full-close reference estimation value TPS_hat_fully_close is compared with the full-close reference candidate value TPS_fully_close_REF. Specifically, as illustrated, it is determined whether an absolute value of a difference between the full-close reference candidate value TPS_fully_close_REF and full-close reference estimation value TPS_hat_fully_close is equal to or less than a third predetermined value (e.g., 0.2 [V]), i.e., the values TPS_fully_close_REF and TPS_hat_fully_close are relatively close.

[0089] When the result in S220 is YES, i.e., the full-close reference candidate value TPS_fully_close_REF is discriminated to be relatively credible, the program proceeds to S222, in which the full-close reference candidate value TPS_fully_close_REF is determined as the full-close reference (the reference value of the throttle opening sensor 52 corresponding to the fully-closed position of the throttle valve 24; TPS lower limit value) TPS_fully_close.

[0090] When the result in S220 is NO, i.e., the absolute value of the difference between the full-close reference candidate value TPS_fully_close_REF and full-close reference estimation value TPS_hat_fully_close exceeds the third predetermined value, since it can be discriminated that credibility of the full-close reference candidate value TPS_fully_close_REF is relatively low, the program proceeds to S224 onward, in which the throttle valve 24 is actually (forcibly) driven to the fully-closed

position and the output of the throttle opening sensor 54 at that time is determined as the full-close reference TPS_fully_close.

[0091] Specifically, in S224, it is determined whether voltage of the battery 72 is equal to or greater than the predetermined voltage. This determination is made based on the presence/absence of the enable signal from the MPUs 64a, 66a.

[0092] When the result in S224 is YES, the program proceeds to S226, in which the motor 44 is supplied with the motor drive voltage of the battery 72, i.e., the motor 44 is supplied with power, to S228, in which the throttle valve 24 is forcibly driven to the closing direction, specifically the motor 44 is controlled to drive the throttle valve 24 in the closing direction, and to S230, in which the output TPSAD of the throttle opening sensor 52 is obtained.

[0093] In S232, it is determined whether the throttle valve 24 has reached the fully-closed position, i.e., has been driven to the fully-closed position by the motor 44. This determination is made, similarly to the processing of S32 explained above, by checking whether the minimum value TPSADmin of the output of the throttle opening sensor 52 is updated.

[0094] When the result in S232 is NO, i.e., the throttle valve 24 has not reached the fully-closed position yet, the program returns to the steps of S228 and S230, in which the throttle valve 24 is driven to the closing direction further and the output TPSAD of the throttle opening sensor 52 is obtained again. When the result in S232 is YES, the program proceeds to S234, in which the (latest) output TPSAD of the throttle opening sensor 52 obtained last time is defined as the full-close reference TPS_fully_close. Thus, when the absolute value of the difference between the full-close reference candidate value TPS_fully_close_REF and full-close reference estimation value TPS_hat_fully_close exceeds the third predetermined value, the output TPSAD of the throttle opening sensor 52 when the throttle valve 24 is driven to the fully-closed position by the motor 44 is determined as the full-close reference TPS_fully_close.

[0095] Upon newly determining of the full-close reference TPS_fully_close in S234, as explained above, the full-close reference candidate value TPS_fully_close_REF and second predetermined value TPS_offset_REF are updated. Specifically, in S236, the full-close reference candidate value TPS_fully_close_REF is updated with the full-close reference TPS_fully_close newly determined and in S238, the second predetermined value TPS_offset_REF is updated with a value obtained by subtracting the newly-determined full-close reference TPS_fully_close from the initial reference TPS_default, thereby preparing for the next program. Thus, when the absolute value of the difference between the full-close reference candidate value TPS_fully_close_REF and full-close reference estimation value TPS_hat_fully_close exceeds the third predetermined value, the second predetermined value TPS_offset_REF is updated.

[0096] When the result in S224 is NO, i.e., the voltage of the battery 72 is below the predetermined voltage, since the battery 72 cannot drive the throttle valve 24 to the closing direction, the program proceeds to S222, in which the full-close reference candidate value TPS_fully_close_REF stored in the MPU 66a is determined as the full-close reference TPS_fully_close.

[0097] Next, in S240, the initial opening (about 3 degrees) of the throttle valve 24 is set or determined as the throttle initial opening TH_default, and in S242, the full opening (about 90 degrees) of the throttle valve 24 is set as the throttle full opening TH_wot. The foregoing initial opening and full opening of the throttle valve 24 are set values (characteristic values) uniquely owned by the throttle body and stored in the MPU 66a.

[0098] The program proceeds to S244, in which, based at least on the determined full-close reference TPS_fully_close, more precisely, based on the characteristics of the throttle opening sensor 52 obtained from the initial reference TPS_default and full-close reference TPS_fully_close, the full-open reference (the reference value of the throttle opening sensor 52 corresponding to the fully-opened position of the throttle valve 24; TPS upper limit value) TPS_wot corresponding to the fully-opened position (TH_wot) of the throttle valve 24 is determined.

[0099] The explanation on determination of the full-open reference TPS_wot is omitted as the processing is similar to the step of S42.

[0100] The remaining configuration is the same as that in the foregoing embodiments.

[0101] As stated in the foregoing, the system according to the fourth embodiment includes a full-close reference estimation value determiner that determines an output of the throttle opening sensor (52) corresponding to a position (throttle initial opening TH_default) of the throttle valve (24) when not operated by the actuator or electric motor (44) as an initial reference TPS_default (S210) and determines a value obtained by subtracting a second predetermined value TPS_offset_REF from the determined initial reference as a full-close reference estimation value TPS_hat_fully_close (throttle valve controller 66, S216); and a comparator that compares the determined full-close reference estimation value with a full-close reference candidate value TPS_fully_close_REF corresponding to the fully-closed position of the throttle valve (24) at starting of the engine (12) (throttle valve controller 66, S220), and the full-close reference determiner determines the full-close reference candidate value as the full-close reference TPS_fully_close when a difference between the full-close reference estimation value and the full-close reference candidate value is equal to or less than a third predetermined value (S222), and determines an output of the throttle opening sensor (52) at a time when the throttle valve (24) is driven to the fully-closed position by the actuator (44) as the full-close reference when the difference is greater than the third predetermined value (S234).

[0102] Since the full-close reference estimation value

TPS_hat_fully_close is compared with the full-close reference candidate value (which is stored beforehand and is the sensor output under the substantially same temperature environment (operating condition) where the full-close reference estimation value is determined) TPS_fully_close_REF at engine start, it becomes possible to prevent the output of the throttle opening sensor 52 from being affected by variance in temperature environment. Further, it is configured such that, when a difference between the full-close reference candidate value and full-close reference estimation value is equal to or less than the third predetermined value, the full-close reference candidate value is determined as the full-close reference TPS_fully_close. In other words, when the difference is at or below the third predetermined value, the full-close reference candidate value is discriminated to be relatively credible and is determined as the full-close reference without driving the throttle valve 24 to the fully-closed position. With this, the full-close reference can be determined accurately and promptly and, compared to a technique that drives a throttle valve every time ignition is turned off, power consumption can be reduced.

[0103] Further, it is configured such that, when the difference exceeds the third predetermined value, credibility of the full-close reference candidate value is discriminated to be relatively low and, only in this case, throttle valve 24 is driven to the fully-closed position to determine the full-close reference. With this, the full-close reference can be determined further accurately.

[0104] The system further includes a second predetermined value updater that updates the second predetermined value TPS_offset_REF with a value obtained by subtracting the full-close reference TPS_fully_close from the initial reference TPS_default when the difference between the full-close reference estimation value TPS_hat_fully_close and the full-close reference candidate value TPS_fully_close_REF is greater than the third predetermined value (throttle valve controller 66, S238). With this, the second predetermined value can be updated to correspond to the full-close reference newly determined, thereby enabling to accurately determine the full-close reference estimation value that is obtained based on the second predetermined value.

[0105] Further, the full-open reference determiner determines the full-open reference TPS_wot corresponding to the fully-opened position (throttle full opening TH_wot) of the throttle valve (24) based on characteristics of the throttle opening sensor (52) obtained from the initial reference TPS_default and the full-close reference TPS_fully_close (S244). Since it is configured such that the full-open reference is determined without driving the throttle valve to the fully-opened position as in the technique of '470, due to cutting of the time taken to drive the throttle valve to the fully-opened position, the full-opening reference can be promptly determined.

[0106] It should be noted that the motorcycle 10 is used as an example of a saddle-seat vehicle on which the engine 12 is mounted, but it is not limited thereto and can

be another type of saddle-seat vehicle such as a scooter, ATV (All Terrain Vehicle) or the like, a seat or saddle of which the operator straddles, or any other type of vehicle.

[0107] It should also be noted that the engine 12 can be a multi-cylinder engine such as a twin-cylinder engine in place of a single-cylinder engine.

[0108] It should also be noted that, although the displacement of the engine 12, throttle initial opening TH_default, throttle full opening TH_wot, first and third predetermined values and the like are indicated with specific values, they are only examples and not limited thereto.

[0109] It should further be noted that, in the first to third embodiments, although the full-close and full-open references and accelerator full-close and full-open references are determined upon starting of the engine 12, they can be determined upon stopping of the engine 12 or at another timing.

[0110] It should further be noted that, in the fourth embodiment, although the full-open reference TPS_wot is determined based on the characteristics of the throttle opening sensor 52 obtained from the initial reference TPS_default and full-close reference TPS_fully_close, a value obtained by adding a predetermined value to the full-close reference TPS_fully_close can be used as the full-open preference TPS_wot instead, for example.

Claims

1. A system for controlling an internal combustion engine (12) mounted on a vehicle (10) and having an actuator (44) that drives a throttle valve (24) installed in an intake pipe (22) of the engine, **characterized by:**

a throttle opening sensor (52) that produces an output indicative of opening of the throttle valve; a full-close reference determiner that determines an output of the throttle opening sensor at a time when the throttle valve is driven to a fully-closed position by the actuator as a full-close reference TPS_fully_close (66, S34); a full-open reference determiner that determines a full-open reference TPS_wot corresponding to a fully-opened position of the throttle valve based on the determined full-close reference (66, S42); and an actuator controller that controls the operation of the actuator such that the throttle valve opening becomes a desired value that is determined within a range defined by the full-close reference and the full-open reference (66).

2. The system according to claim 1, further including:

an initial reference determiner that determines an output of the throttle opening sensor corresponding to a position of the throttle valve when

- not operated by the actuator as an initial reference TPS_default (66, S20),
and the full-open reference determiner determines the full-open reference based on characteristics of the throttle opening sensor obtained from the determined initial reference and the full-close reference (S42).
3. The system according to claim 1, wherein the full-open reference determiner determines a value obtained by adding a first predetermined value to the determined full-close reference as the full-open reference (S 114).
4. The system according to claim 1, further including:
- a full-close reference estimation value determiner that determines an output of the throttle opening sensor corresponding to a position of the throttle valve when not operated by the actuator as an initial reference TPS_default (S210) and determining a value obtained by subtracting a second predetermined value TPS_offset_REF from the determined initial reference as a full-close reference estimation value TPS_hat_fully_close (66, S216); and
- a comparator that compares the determined full-close reference estimation value with a full-close reference candidate value TPS_fully_close_REF corresponding to the fully-closed position of the throttle valve at starting of the engine (66, S220),
and the full-close reference determiner determines the full-close reference candidate value as the full-close reference when a difference between the full-close reference estimation value and the full-close reference candidate value is equal to or less than a third predetermined value (S222), and determines an output of the throttle opening sensor at a time when the throttle valve is driven to the fully-closed position by the actuator as the full-close reference when the difference is greater than the third predetermined value (S234).
5. The system according to claim 4, further including:
- a second predetermined value updater that updates the second predetermined value with a value obtained by subtracting the full-close reference from the initial reference when the difference between the full-close reference estimation value and the full-close reference candidate value is greater than the third predetermined value (66, S238).
6. The system according to claim 4 or 5, wherein the full-open reference determiner determines the full-open reference based on characteristics of the throttle opening sensor obtained from the initial reference and the full-close reference (S244).
7. A method of controlling an internal combustion engine (12) mounted on a vehicle (10) and having an actuator (44) that drives a throttle valve (24) installed in an intake pipe (22) of the engine and a throttle opening sensor (52) that produces an output indicative of opening of the throttle valve, **characterized by:**
- determining an output of the throttle opening sensor at a time when the throttle valve is driven to a fully-closed position by the actuator as a full-close reference TPS_fully_close (66, S34);
determining a full-open reference TPS_wot corresponding to a fully-opened position of the throttle valve based on the determined full-close reference (66, S42); and
controlling the operation of the actuator such that the throttle valve opening becomes a desired value that is determined within a range defined by the full-close reference and the full-open reference (66).
8. The method according to claim 7, further including the step of:
- determining an output of the throttle opening sensor corresponding to a position of the throttle valve when not operated by the actuator as an initial reference TPS_default (66, S20),
and the step of full-open reference determining determines the full-open reference based on characteristics of the throttle opening sensor obtained from the determined initial reference and the full-close reference (S42).
9. The method according to claim 7, wherein the step of full-open reference determining determines a value obtained by adding a first predetermined value to the determined full-close reference as the full-open reference (S 114).
10. The method according to claim 7, further including the steps of:
- determining an output of the throttle opening sensor corresponding to a position of the throttle valve when not operated by the actuator as an initial reference TPS_default (S210) and determining a value obtained by subtracting a second predetermined value TPS_offset_REF from the determined initial reference as a full-close reference estimation value TPS_hat_fully_close (66, S216); and
comparing the determined full-close reference

estimation value with a full-close reference candidate value TPS_fully_close_REF corresponding to the fully-closed position of the throttle valve at starting of the engine (66, S220), and the step of full-close reference determining determines the full-close reference candidate value as the full-close reference when a difference between the full-close reference estimation value and the full-close reference candidate value is equal to or less than a third predetermined value (S222), and determines an output of the throttle opening sensor at a time when the throttle valve is driven to the fully-closed position by the actuator as the full-close reference when the difference is greater than the third predetermined value (S234).

11. The method according to claim 10, further including the step of:

updating the second predetermined value with a value obtained by subtracting the full-close reference from the initial reference when the difference between the full-close reference estimation value and the full-close reference candidate value is greater than the third predetermined value (66, 5238).

12. The method according to claim 10 or 11, wherein the step of full-open reference determining determines the full-open reference based on characteristics of the throttle opening sensor obtained from the initial reference and the full-close reference (S244).

FIG. 1

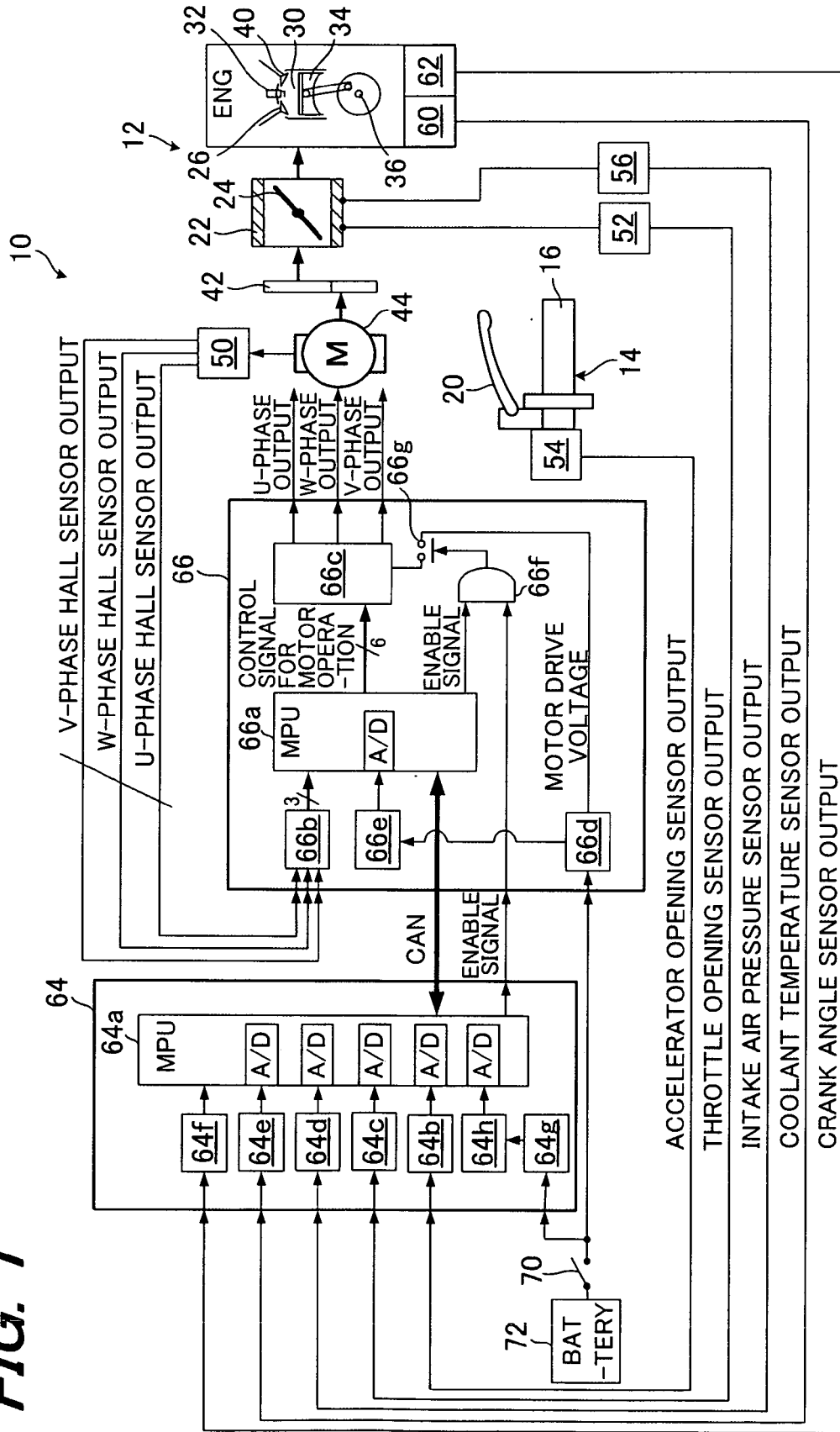


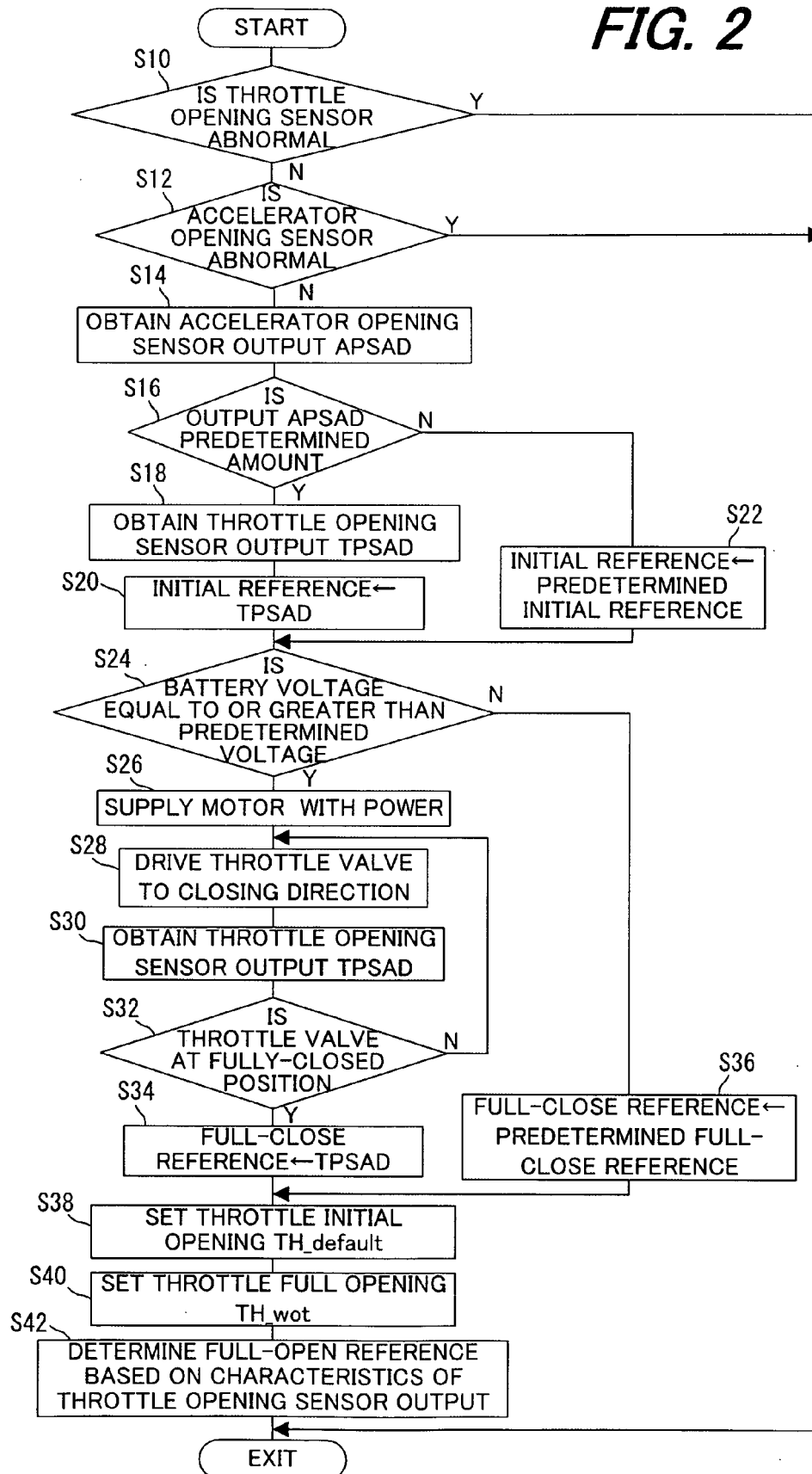
FIG. 2

FIG. 3

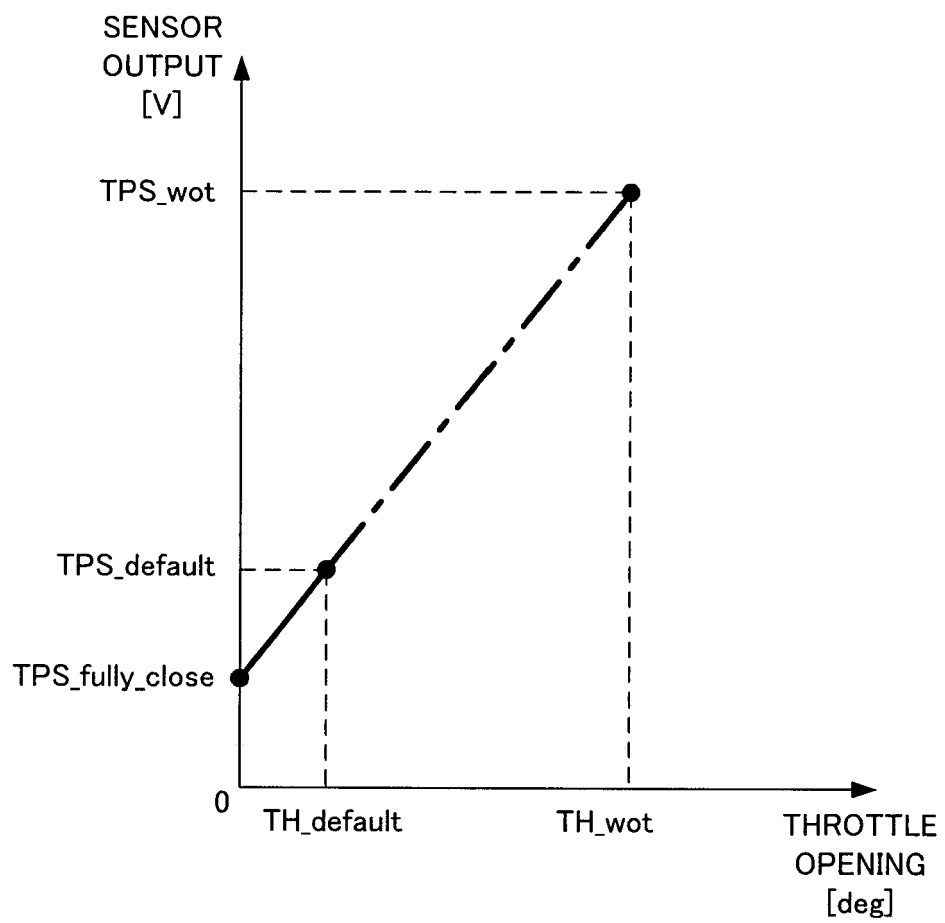


FIG. 4

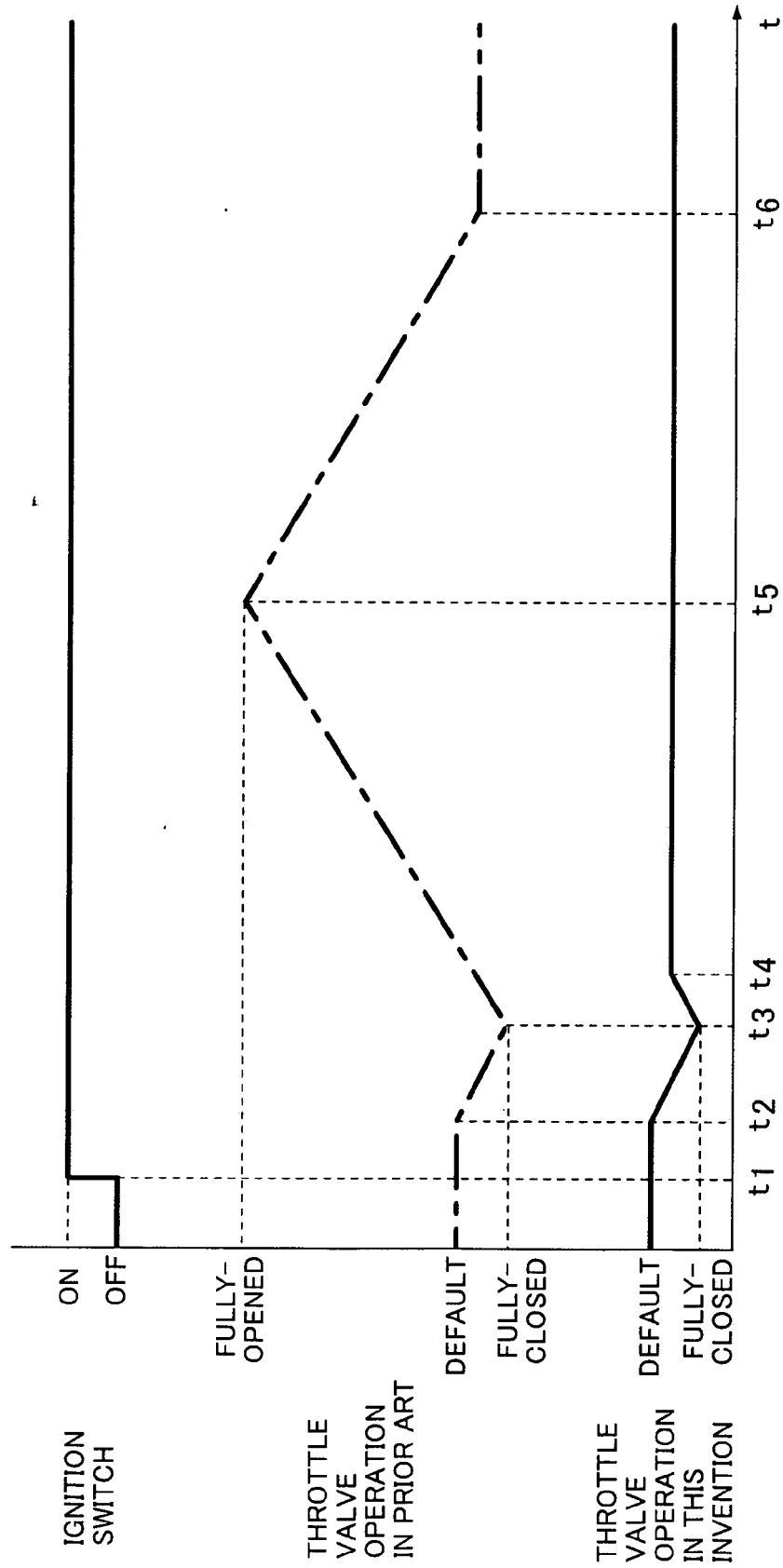


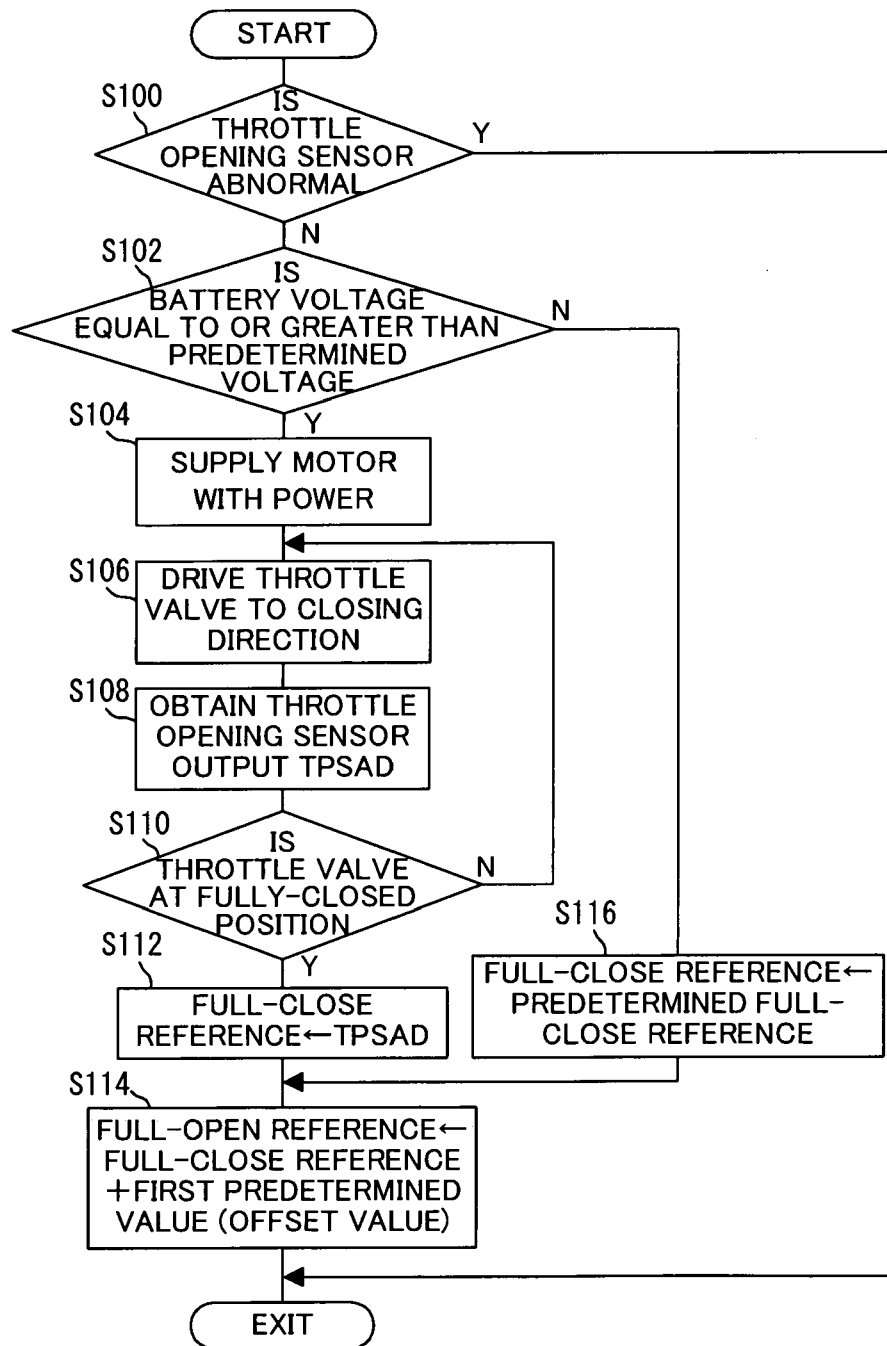
FIG. 5

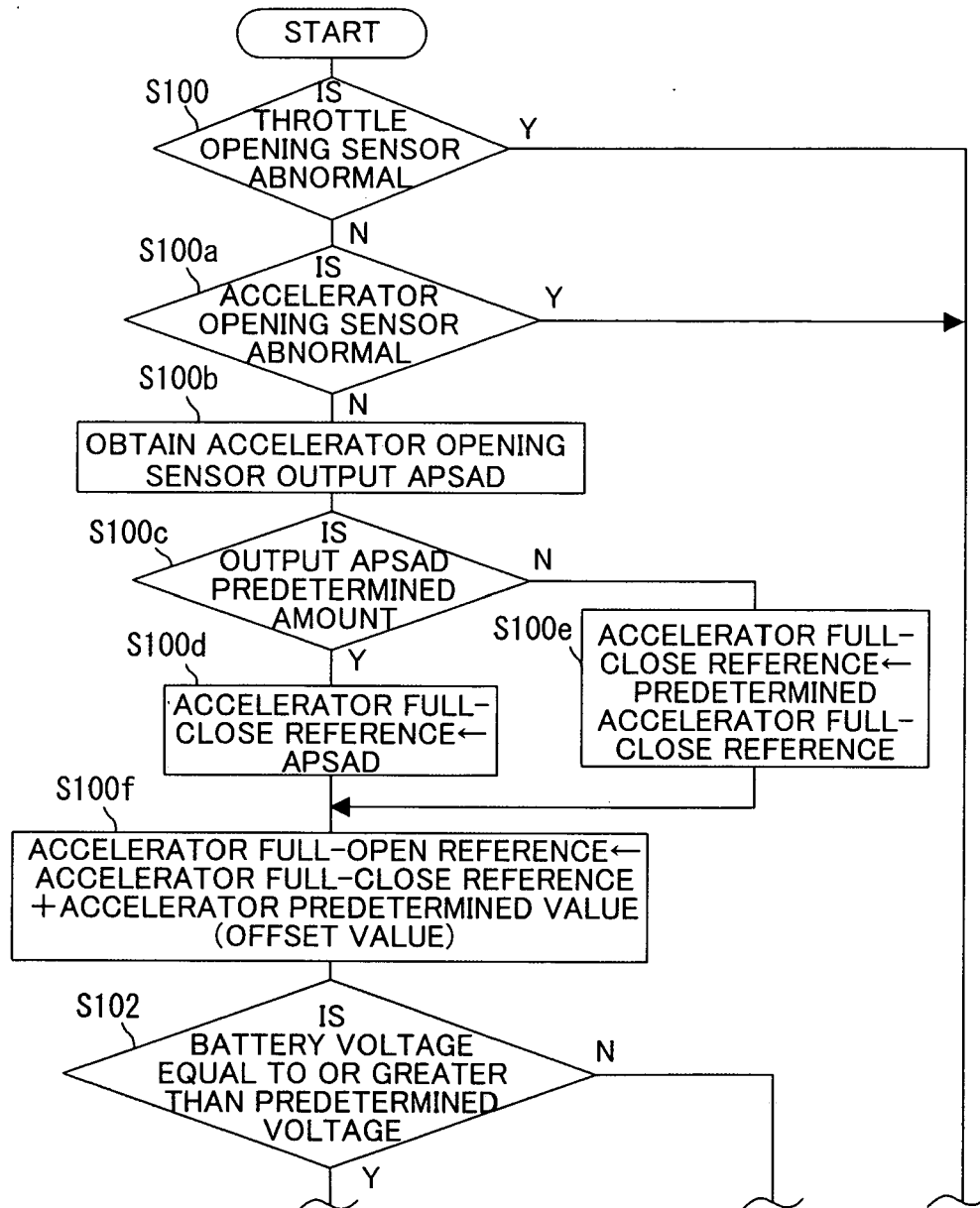
FIG. 6

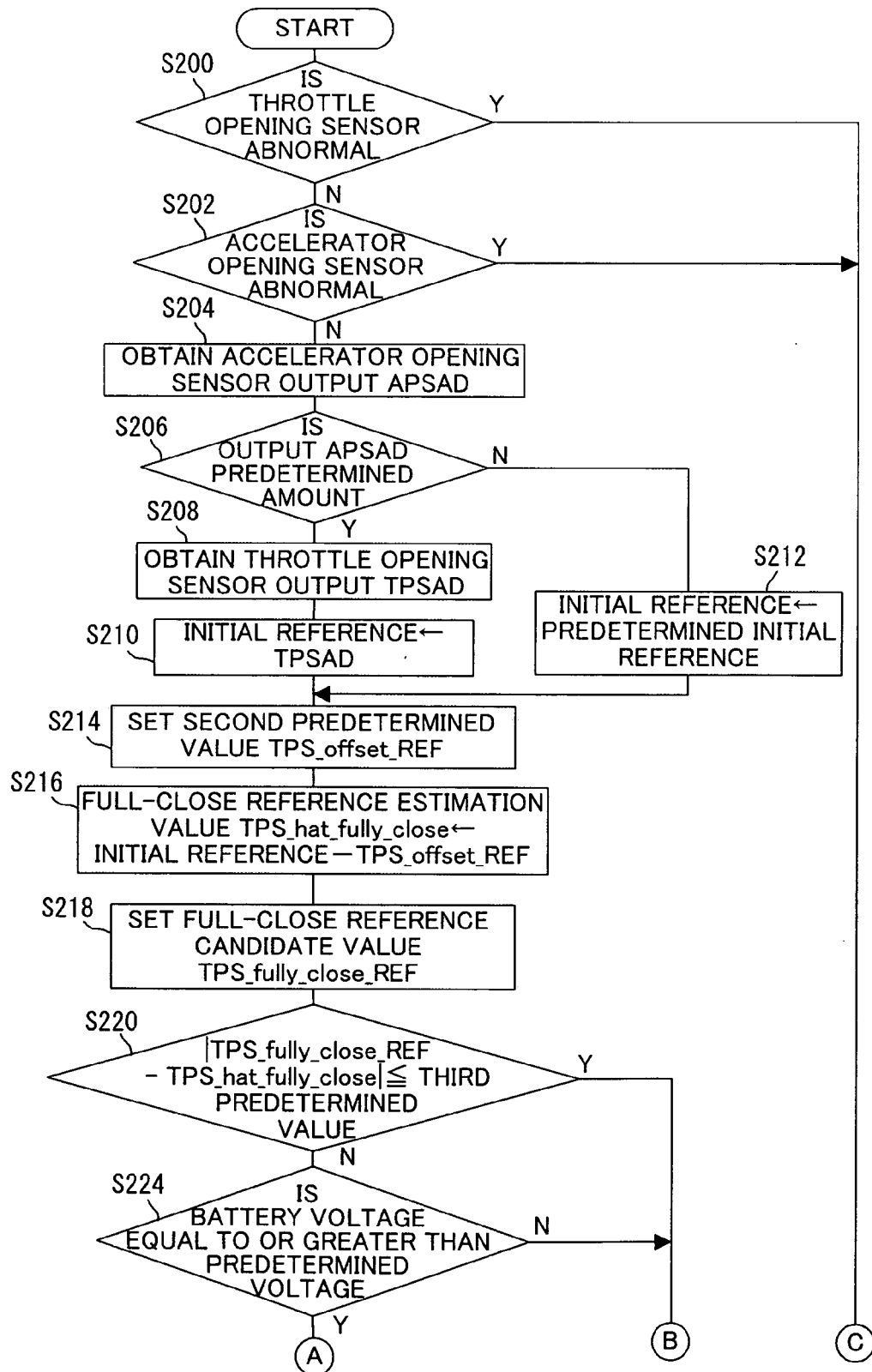
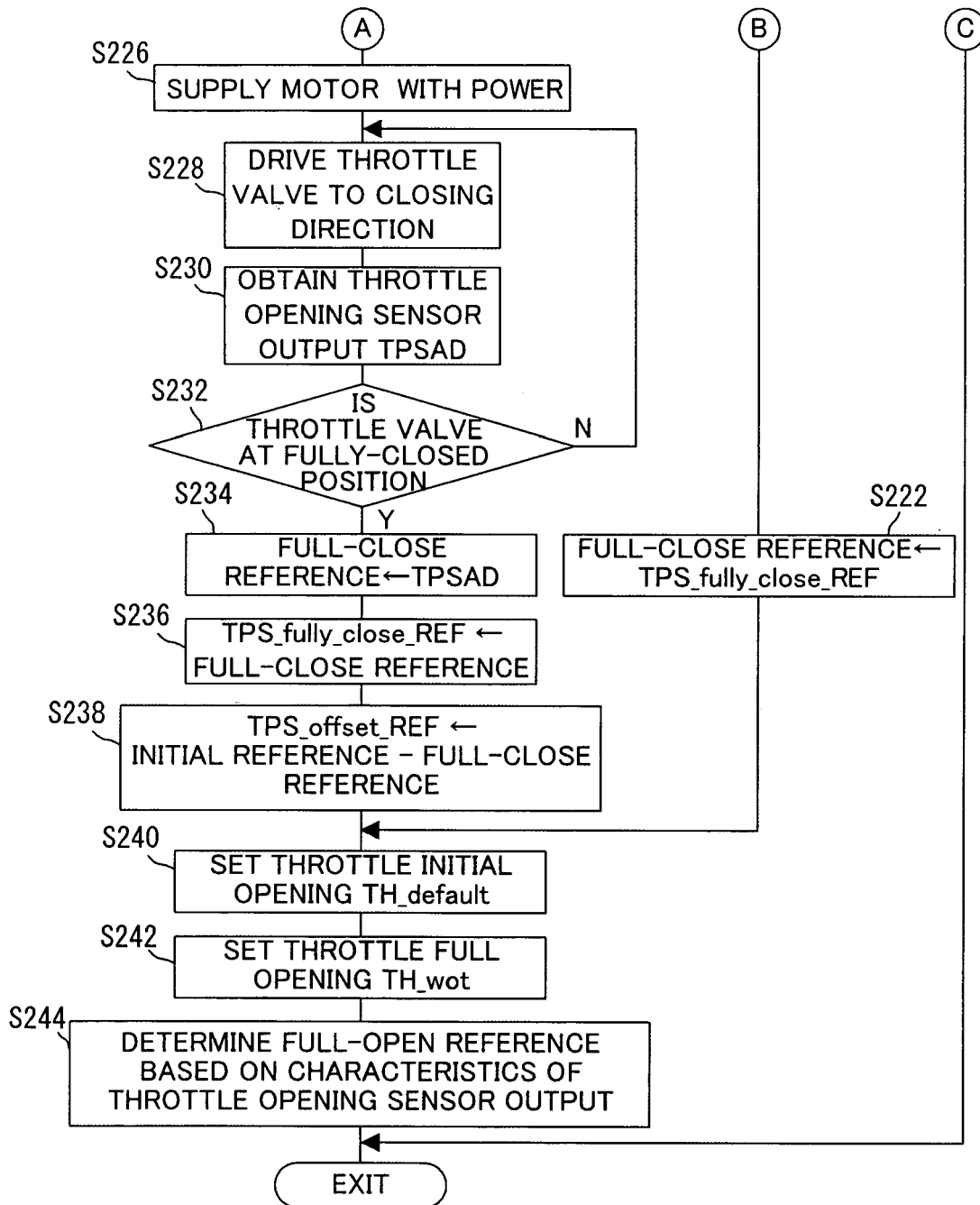
FIG. 7

FIG. 8

REFERENCES CITED IN THE DESCRIPTION

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