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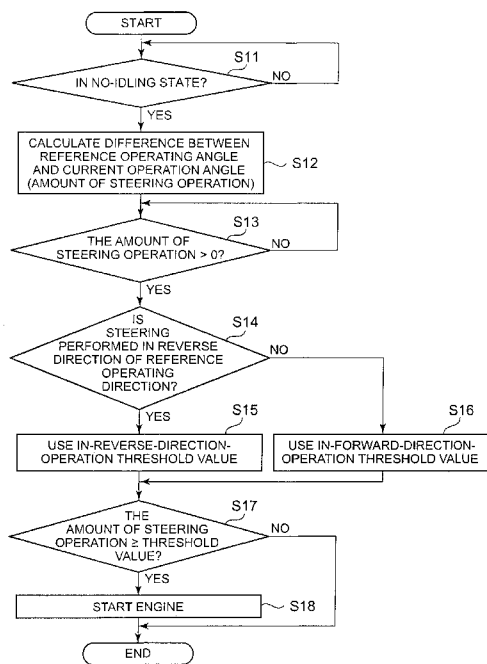
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FIG. 4



(57) Abstract: A vehicle controller is configured to start an engine when an operation of a steering wheel by a prescribed operation angle is detected after the engine is automatically stopped by an idle reduction function. The vehicle controller includes a steering operation detecting unit configured to detect an operation angle and an operation direction of the steering wheel. In order to take into consideration the restoring force of a tire that is twisted by a friction against a road surface, the prescribed operation angle in a case where the operation direction of the steering wheel after the engine is automatically stopped differs from that before the engine is automatically stopped, is larger than the prescribed operation angle in a case where the operation direction of the steering wheel after the engine is automatically stopped coincides with that before the engine is automatically stopped.

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START-STOP SYSTEM FOR AN INTERNAL COMBUSTION ENGINE WITH A  
CHANGE OF STEERING ANGLE AS AUTOMATIC START CONDITION

BACKGROUND OF THE INVENTION

1. Field of the Invention

5       **[0001]**     The present invention relates to a vehicle controller having an engine automatic starting function.

2. Description of Related Art

10       **[0002]**     The idle reduction (i.e., no-idling) function of automatically stopping an engine has come into widespread use in order to increase the vehicle fuel efficiency. In addition, there are known vehicle controllers that restart an engine when the amount of change in the steering angle of a steering wheel becomes equal to or larger than a prescribed angle while the engine is in the idle reduction mode (refer to, for example, Japanese Patent Application Publication No. 2013-133719 (JP 2013-133719 A)). JP 2013-133719 A describes that the prescribed angle is set larger as the steering angle of the steering wheel at the time when the engine is automatically stopped is closer to the neutral point (steering angle = 0°).

15       **[0003]**     However, the technique described in JP 2013-133719 A does not take into account twisting of a tire due to friction between the tire and a road surface. Thus, the vehicle controller in JP 2013-133719 A may start the engine against the intention of a driver when the steering wheel is turned toward the neutral position due to restoring force of the twisted tire as a result of the fact that steering assist force generated by power steering is reduced or lost while the engine is in the idle reduction mode.

SUMMARY OF THE INVENTION

25       **[0004]**     The present invention provides a vehicle controller capable of reducing the occurrence of a driver's unintended start of an engine.

**[0005]**     An aspect of the invention relates to a vehicle controller configured to start an engine when an operation of a steering wheel by a prescribed operation degree is detected after the engine is automatically stopped by an idle reduction function. The

vehicle controller includes a steering operation detecting unit configured to detect an operation degree and an operation direction of the steering wheel. The operation degree of the steering wheel includes an operation degree due to a restoring force of a tire that is twisted by a friction against a road surface. The prescribed operation degree in a case where the operation direction of the steering wheel after the engine is automatically stopped differs from the operation direction of the steering wheel before the engine is automatically stopped, is larger than the prescribed operation degree in a case where the operation direction of the steering wheel after the engine is automatically stopped coincides with the operation direction of the steering wheel before the engine is automatically stopped.

[0006] According to the above aspect of the invention, a vehicle controller capable of reducing the occurrence of a driver's unintended start of an engine is provided.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Features, advantages, and technical and industrial significance of exemplary embodiments of the invention will be described below with reference to the accompanying drawings, in which like numerals denote like elements, and wherein:

FIG. 1 is a block diagram showing a configuration example of an onboard system including a vehicle controller according to an embodiment of the present invention;

FIG. 2 is a block diagram showing a configuration example of the vehicle controller in FIG. 1;

FIG. 3 is a flowchart of a reference value storing process; and

FIG. 4 is a flowchart of an automatic starting process.

#### DETAILED DESCRIPTION OF EMBODIMENTS

[0008] FIG. 1 is a block diagram showing a configuration example of an onboard system 100 including a vehicle controller 10 according to an embodiment of the present invention. In FIG. 1, bold solid lines denote electric power supply lines, broken lines denote signal lines, and double lines denote a communication network 55. The

communication network 55 is, for example, an onboard communication network formed of a controller area network (CAN).

[0009] The onboard system 100 mainly includes the vehicle controller 10, an engine electronic control unit (ECU) 20, a brake ECU 30, a power steering ECU 40, an onboard ECU 50, an electrical load 60, a steering angle sensor 61, a battery 70, a battery sensor 71, an alternator 72, a starter 73, a starter relay 74, a boosting transformer 75, and an ignition switch 76.

[0010] The vehicle controller 10 is a device that controls starting of an engine. The vehicle controller 10 is, for example, a computer including a CPU, a RAM, a ROM, and the like. In the present embodiment, the vehicle controller 10 is a stop-and-start ECU that has an engine idle reduction function (engine automatic stopping function) and an automatic restarting function (automatic starting function).

[0011] The automatic stopping function is a function of automatically stopping the engine when a prescribed vehicle state is detected. Specifically, the vehicle controller 10 automatically stops the engine, for example, when the vehicle speed becomes equal to or lower than a prescribed speed. The automatic starting function is a function of automatically starting the engine when a prescribed vehicle state is detected after the engine is stopped. Specifically, the vehicle controller 10 automatically starts the engine, for example, when the depression of a brake pedal is cancelled or when a steering wheel is operated. Note that the automatic stopping function and the automatic starting function will be described later in detail.

[0012] The engine ECU 20 is a device that controls the operation of the engine. The engine ECU 20 is, for example, a computer including a CPU, a RAM, a ROM, and the like. In the present embodiment, the engine ECU 20 controls the fuel injection amount, the fuel injection timing, the ignition timing, and the like based on various kinds of information such as the engine speed, the vehicle speed, the battery state, and the accelerator position.

[0013] The brake ECU 30 is a device that controls the operation of a brake. The brake ECU 30 is, for example, a computer including a CPU, a RAM, a ROM, and the like.

In the present embodiment, the brake ECU 30 controls the brake boost pressure and the like based on various kinds of information such as the vehicle speed, the steering angle, the road surface friction coefficient (road surface  $\mu$  value), and the brake pedal depression degree.

5           [0014]    The power steering ECU 40 is a device that controls the operation of a power steering system. The power steering ECU 40 is, for example, a computer including a CPU, a RAM, a ROM, and the like. In the present embodiment, the power steering ECU 40 controls a hydraulic power steering system that generates steering assist force, based on various kinds of information such as the steering angle, the steering angular velocity, and the steering direction. Specifically, the power steering ECU 40 controls the hydraulic power steering system that generates steering assist force using hydraulic fluid discharged from a hydraulic pump driven by the engine. Alternatively, the power steering ECU 40 may be a device that controls the operation of an electric power steering system that generates steering assist force using an electric motor.

10           [0015]    The onboard ECU 50 is a device that controls the operations of the other onboard devices. The onboard ECU 50 is, for example, a computer including a CPU, a RAM, a ROM, and the like. In the present embodiment, the onboard ECU 50 includes, for example, a driving support ECU, a pre-crash seatbelt ECU, and an airbag ECU.

15           [0016]    The electrical load 60 is an electrical load installed in the vehicle. In the present embodiment, the electrical load 60 includes, for example, lamps (e.g., headlamps), windshield wipers, and a navigation system.

20           [0017]    The steering angle sensor 61 is a sensor that detects the steering angle of the steering wheel. In the present embodiment, the steering angle sensor 61 repeatedly detects information on the steering angle on a prescribed sampling cycle, and outputs the information on the steering angle to the vehicle controller 10 through the communication network 55.

25           [0018]    The battery 70 is an electricity storage device installed in the vehicle. In the present embodiment, the battery 70 is a lead-acid battery, and supplies electric power to the various ECUs and the various electrical loads. Alternatively, the battery 70 may be a

single electric power supply source installed in the vehicle, or may be one of multiple electric power supply sources installed in the vehicle.

[0019] The battery sensor 71 is a sensor that detects the state of the battery 70. In the present embodiment, the battery sensor 71 detects, for example, the voltage, the state of charge (SOC), the state of health (SOH) of the battery 70.

[0020] The alternator 72 is an electricity generator installed in the vehicle. In the present embodiment, the alternator 72 is driven by the engine, and supplies the generated electric power to the various ECUs, the various electrical loads, and the battery 70.

10 [0021] The starter 73 is a device that starts the engine. In the present embodiment, the starter 73 is an electric motor that rotates a crankshaft of the engine at the time of starting the engine.

[0022] The starter relay 74 is a relay that is disposed between the battery 70 and the starter 73. In the present embodiment, the starter relay 74 is an electromagnetic relay that operates in response to a control signal from the vehicle controller 10.

[0023] The boosting transformer 75 is a device that maintains the output voltage at a constant level. In the present embodiment, the boosting transformer 75 is a DC-DC (DC-to-DC) converter. Even when the input voltage (battery voltage) drops, the boosting transformer 75 boosts the input voltage and outputs the boosted voltage to maintain the output voltage at a constant level (e.g., 12.5 V). Specifically, the boosting transformer 75 is disposed between and connected to the battery 70 and the ECUs that are susceptible to voltage fluctuations, and controls the output voltage in response to a control signal from the vehicle controller 10. The boosting transformer 75 prevents the ECUs from being reset due to a drop in the output voltage. The ECUs susceptible to voltage fluctuations include the brake ECU 30 and the power steering ECU 40. The vehicle controller 10 determines the contents of the control signal for the boosting transformer 75 based on the information on the battery state that is obtained from the battery sensor 71 via the engine ECU 20. The information on the battery state includes the battery voltage, and the contents of the control signal for the boosting transformer 75 include a duty cycle of the

DC-DC converter. The vehicle controller 10 determines the contents of the control signal such that the duty cycle (boost ratio) increases as the battery voltage becomes lower.

[0024] The ignition switch 76 is a switch that starts the various onboard devices. In the present embodiment, the ignition switch 76 is switched among four states, that is, "OFF," "ACC," "ON," and "START." In the "OFF" state, the ignition switch 76 cuts off the supply of electric power to the various ECUs and the various electrical loads. In the "ACC" state, the ignition switch 76 allows a supply of electric power to some of the various ECUs and various electrical loads. In the "ON" state, the ignition switch 76 allows a supply of electric power to all of the various ECUs and various electrical loads. In the "START" state, the ignition switch 76 starts the engine using the starter 73. Specifically, when detecting the fact that the ignition switch 76 is brought into the "START" state, the vehicle controller 10 outputs a control signal to the starter relay 74. The starter relay 74 provides electrical connection between the battery 70 and the starter 73 in response to the control signal from the vehicle controller 10 to rotate the starter 73, thereby starting the engine.

[0025] FIG. 2 is a block diagram showing a configuration example of the vehicle controller 10. In the present embodiment, the vehicle controller 10 mainly includes an automatic engine stopping unit 11 and an automatic engine starting unit 12.

[0026] The automatic engine stopping unit 11 is a functional element that executes the automatic stopping function. Specifically, the automatic engine stopping unit 11 obtains information on the vehicle speed that a vehicle speed sensor (not shown) repeatedly outputs on a prescribed sampling cycle, through the communication network 55. The automatic engine stopping unit 11 obtains information on the battery state that the battery sensor 71 repeatedly outputs on a prescribed sampling cycle, via the engine ECU 20. Alternatively, the automatic engine stopping unit 11 may obtain the information on the battery state directly from the battery sensor 71 instead of obtaining the information on the battery state via the engine ECU 20. The automatic engine stopping unit 11 outputs a stop signal to the engine ECU 20 when determining that, for example, the vehicle speed is equal to or lower than the prescribed speed and the battery voltage is equal to or higher

than a prescribed voltage. Upon reception of the stop signal from the automatic engine stopping unit 11, the engine ECU 20 stops the engine. Note that, it is confirmed that the battery voltage is equal to or higher than the prescribed voltage before the engine is automatically stopped, in order to reliably start the engine with the automatic starting  
5 function to be subsequently executed.

[0027] The automatic engine stopping unit 11 may be configured not to execute the automatic stopping function when a prescribed condition is satisfied. For example, the automatic engine stopping unit 11 obtains information on the steering angle that the steering angle sensor 61 repeatedly outputs on a prescribed sampling cycle, through the  
10 communication network 55. When determining that the steering angle of the steering wheel is equal to or larger than a prescribed angle, the automatic engine stopping unit 11 does not execute the automatic stopping function even if the other conditions for automatically stopping the engine are satisfied, for the following reason. A driver largely turns the steering wheel, for example, in order to make a lane change over multiple lanes.  
15 Therefore, it is deemed that the driver does not intend to execute the automatic stopping function even when the vehicle speed becomes equal to or lower than the prescribed speed.

[0028] The automatic engine starting unit 12 is a functional element that executes the automatic starting function. Specifically, the automatic engine starting unit 12 obtains information on the steering angle that the steering angle sensor 61 repeatedly outputs on a  
20 prescribed sampling cycle, through the communication network 55. The automatic engine starting unit 12 then outputs a start signal to the starter relay 74 when determining, for example, that the degree of steering of the steering wheel is equal to or larger than a prescribed steering degree. Upon reception of the start signal from the automatic engine starting unit 12, the starter relay 74 provides electrical connection between the battery 70  
25 and the starter 73. The starter 73 connected to the battery 70 is rotated upon reception of the electric power supplied from the battery 70, thereby rotating the crankshaft of the engine to start the engine.

[0029] More specifically, the automatic engine starting unit 12 mainly includes a steering operation detecting unit 120 and a friction state detecting unit 121. However, the

friction state detecting unit 121 may be omitted.

[0030] The steering operation detecting unit 120 is a functional element that detects a movement of the steering wheel. In the present embodiment, the steering operation detecting unit 120 obtains information on the movement of the steering wheel such as the operation angle, the operation velocity, the operation direction, and the operation degree of the steering wheel. Note that "movement of the steering wheel" includes both the movement caused by a steering operation performed by a driver and the movement caused by external forces such as the restoring force of a twisted tire.

[0031] The operation angle is, for example, a steering angle output from the steering angle sensor 61. The operation velocity is, for example, a steering angular velocity that is an amount of change in the steering angle per unit time. The operation direction is, for example, a steering direction represented by a sign of the most recent steering angular velocity.

[0032] Specifically, the operation velocity is represented by, for example, a positive value when the steering wheel is turned to the left (counterclockwise), whereas it is represented by, for example, a negative value when the steering wheel is turned to the right (clockwise). In this case, the operation direction is represented by "+1," which is a value representing counterclockwise turning, when the most recent steering angular velocity is a positive value, the operation direction is represented by "-1," which is a value representing clockwise turning, when the most recent steering angular velocity is a negative value, and the operation direction is represented by a value of "0" when the most recent steering angular velocity is zero.

[0033] The operation degree is the degree of steering that is represented by, for example, the difference between the reference steering angle and the present steering angle. The reference steering angle is a steering angle that is stored when a prescribed event occurs. The reference steering angle is, for example, a steering angle that is stored in a RAM when the engine is stopped by the automatic engine stopping unit 11.

[0034] In the present embodiment, the steering angular velocity, the steering direction, and the steering degree are derived by the steering angle sensor 61, and

transmitted together with the steering angle detected by the steering angle sensor 61, to the steering operation detecting unit 120 through the communication network 55. Alternatively, the steering operation detecting unit 120 may derive the steering angular velocity, the steering direction, and the steering degree based on the steering angle output  
5 from the steering angle sensor 61.

[0035] The friction state detecting unit 121 is a functional element that detects a friction state. In the present embodiment, the friction state detecting unit 121 obtains information on the friction state of a road surface, such as a road surface  $\mu$  value.

[0036] The road surface  $\mu$  value is derived by, for example, the brake ECU 30,  
10 and is transmitted to the friction state detecting unit 121 through the communication network 55. Alternatively, the friction state detecting unit 121 may derive the road surface  $\mu$  value based on various kinds of information obtained through the communication network 55. The road surface  $\mu$  value is derived based on a known technique.

[0037] The friction state detecting unit 121 then determines whether the friction  
15 state of the road surface is a low-friction state based on the obtained road surface  $\mu$  value. That is, the friction state detecting unit 121 determines which of the two levels, that is, the low-friction state and the high-friction state, corresponds to the present friction state of the road surface. In other words, the friction state detecting unit 121 determines whether or not the present friction state of the road surface is the low-friction state. Note that the  
20 friction state of the road surface may be classified into three or more levels, and the friction state detecting unit 121 may determine which of these levels corresponds to the present friction state of the road surface. Further, the friction state detecting unit 121 need not determine the road surface  $\mu$  value as long as whether or not the friction state of the road surface is the low-friction state can be determined.

[0038] In the present embodiment, the automatic engine stopping unit 11 stores  
25 the operation angle and the operation direction of the steering wheel at the moment when the engine is stopped by the automatic stopping function, in a RAM as a reference operation angle and a reference operation direction, respectively.

[0039] The automatic engine starting unit 12 then determines whether to execute

the automatic starting function based on the detection result obtained by the steering operation detecting unit 120. Specifically, the automatic engine starting unit 12 starts the engine when the operation degree, which is the difference between the present operation angle of the steering wheel and the reference operation angle, becomes equal to or larger than a prescribed operation degree (threshold value).

[0040] The automatic engine starting unit 12 changes the prescribed operation degree (threshold value) based on the relationship between the present operation direction of the steering wheel and the reference operation direction. In the present embodiment, the automatic engine starting unit 12 sets the prescribed operation degree in the case where the operation direction of the steering wheel after the engine is stopped differs from that before the engine is stopped (hereafter, referred to as "reverse-direction-operation-time threshold value") to be larger than the prescribed operation degree in the case where the operation direction of the steering wheel after the engine is stopped coincides with that before the engine is stopped (hereafter, referred to as "forward-direction-operation-time threshold value"). Specifically, the reverse-direction-operation-time threshold value is a threshold value used in the case where the present operation direction of the steering wheel differs from the reference operation direction, that is, the steering wheel is turned in the reverse direction (negative direction) after the engine is stopped. The forward-direction-operation-time threshold value is a threshold value used in the case where the present operation direction of the steering wheel coincides with the reference operation direction, that is, the steering wheel is further turned in the forward direction (positive direction) after the engine is stopped. The forward-direction-operation-time threshold value is set to, for example, six degrees.

[0041] For example, in the case where the present operation direction of the steering wheel is "+1," which is a value representing the counterclockwise turning, and the reference operation direction is "+1," which is the value representing the counterclockwise turning, the automatic engine starting unit 12 determines whether the operation degree of the steering wheel is equal to or larger than the forward-direction-operation-time threshold value. When determining that the operation degree of the steering wheel is equal to or

larger than the forward-direction-operation-time threshold value, the automatic engine starting unit 12 starts the engine. This applies to the case where the present operation direction of the steering wheel is "-1," which is a value representing the clockwise turning, and the reference operation direction is "-1," which is the value representing the clockwise turning.

[0042] In the case where the present operation direction of the steering wheel is "+1," which is the value representing the counterclockwise turning, and the reference operation direction is "-1," which is the value representing the clockwise turning, the automatic engine starting unit 12 determines whether the operation degree of the steering wheel is equal to or larger than the reverse-direction-operation-time threshold value (> the forward-direction-operation-time threshold value). When determining that the operation degree of the steering wheel is equal to or larger than the reverse-direction-operation-time threshold value, the automatic engine starting unit 12 starts the engine. This applies to the case where the present operation direction of the steering wheel is "-1," which is the value representing the clockwise turning, and the reference operation direction is "+1," which is the value representing the counterclockwise turning.

[0043] In the case where the reference operation direction is a value of "0," the automatic engine starting unit 12 determines whether the operation degree of the steering wheel is equal to or larger than the forward-direction-operation-time threshold value regardless of whether the present operation direction of the steering wheel is "+1," which is the value representing the counterclockwise turning, or "-1," which is the value representing the clockwise turning. This is because it is deemed that twisting of the tire has not occurred. In this case, the automatic engine starting unit 12 may use a value that differs from both of the forward-direction-operation-time threshold value and the reverse-direction-operation-time threshold value, as the threshold value.

[0044] As described above, when the steering wheel is turned in the reverse direction after the engine is stopped, the vehicle controller 10 determines whether to start the engine based on the reverse-direction-operation-time threshold value that is larger than the forward-direction-operation-time threshold value. Thus, it is possible to prevent the

engine from being started against the intention of a driver, even when the steering wheel is turned in the reverse direction due to restoring force of the twisted tire as a result of the fact that the hydraulic pump of the hydraulic power steering system is stopped and thus steering assist force is reduced or lost after the engine is stopped. This is because it is possible to determine whether a prescribed degree of steering operation is performed by the driver, under the condition that the degree of turning of the steering wheel in the reverse direction due to the restoring force of the tire is substantially subtracted from the operation degree of the steering wheel. The difference between the reverse-direction-operation-time threshold value and the forward-direction-operation-time threshold value is determined in advance in consideration of the degree of turning of the steering wheel in the reverse direction due to the restoring force of the tire.

[0045] The automatic engine starting unit 12 may adjust the reverse-direction-operation-time threshold value based on the detection result obtained from the friction state detecting unit 121. In the present embodiment, when the steering operation detecting unit 120 determines that the operation direction of the steering wheel after the engine is stopped differs from that before the engine is stopped, the automatic engine starting unit 12 sets the reverse-direction-operation-time threshold value in the case where the friction state of the road surface is not the low-friction state (high-friction-time threshold value) to be larger than the reverse-direction-operation-time threshold value in the case where the friction state of the road surface is the low-friction state (low-friction-time threshold value). The high-friction-time threshold value is a threshold value used in the case where the road surface  $\mu$  value is equal to or larger than a prescribed  $\mu$  value, that is, in the case where the steering wheel is turned by a large amount in the reverse direction due to the restoring force of the twisted tire. In contrast, the low-friction-time threshold value is a threshold value used in the case where the road surface  $\mu$  value is smaller than the prescribed  $\mu$  value, that is, in the case where the steering wheel is turned by a small amount in the reverse direction due to the restoring force of the twisted tire. Specifically, the automatic engine starting unit 12 derives the low-friction-time threshold value by adding a prescribed low-friction-time increment to the

forward-direction-operation-time threshold value, and derives the high-friction-time threshold value by adding a prescribed high-friction-time increment (> low-friction-time increment) to the forward-direction-operation-time threshold value. Thus, the low-friction-time threshold value is larger than the forward-direction-operation-time threshold value, but smaller than the high-friction-time threshold value.

[0046] As described above, in the case where the steering wheel is turned in the reverse direction after the engine is stopped, when the friction state of the road surface is the low-friction state, the vehicle controller 10 determines whether to start the engine based on the low-friction-time threshold value that is smaller than the high-friction-time threshold value. Thus, even in the case where the reverse-direction-operation-time threshold value is set larger than the forward-direction-operation-time threshold value in consideration of the degree of rotation of the steering wheel in the reverse direction due to the restoring force of the tire, it is possible to prevent excessive loads from being placed on a driver who operates the steering wheel in order to automatically start the engine. This is because it is possible to determine whether a prescribed degree of steering operation is performed by the driver in the state where the degree of rotation of the steering wheel in the reverse direction in the low-friction state is regarded as being smaller than that in the high-friction state.

[0047] Next, with reference to FIG. 3, description will be provided on a process in which the vehicle controller 10 stores the reference operation direction and the reference operation angle at the time of executing the automatic stopping function (hereafter, referred to as "reference value storing process"). Note that FIG. 3 is a flowchart of the reference value storing process. The vehicle controller 10 repeatedly executes the reference value storing process while the engine is operating.

[0048] First, the vehicle controller 10 determines whether the vehicle speed is equal to or lower than a prescribed value based on the information on the vehicle speed output from the vehicle speed sensor (step S1).

[0049] When determining that vehicle speed exceeds the prescribed value (NO in step S1), the vehicle controller 10 ends the present reference value storing process.

[0050] On the other hand, when determining that the vehicle speed is equal to or lower than the prescribed value (YES in step S1), the vehicle controller 10 computes an operation direction based on the operation velocity of the steering wheel (step S2).

[0051] In the present embodiment, the vehicle controller 10 receives the steering angular velocity and the steering direction that are derived by the steering angle sensor 61, from the steering angle sensor 61. Note that the vehicle controller 10 may derive the steering angular velocity based on the information on the steering angle output from the steering angle sensor 61, and then derive the steering direction based on the steering angular velocity. Alternatively, the vehicle controller 10 may derive the steering direction based on the steering angular velocity output from the steering angle sensor 61.

[0052] Subsequently, the vehicle controller 10 determines whether idle reduction is executed (step S3). In the present embodiment, the vehicle controller 10 determines whether the automatic stopping function is executed by the automatic engine stopping unit 11.

[0053] When determining that idle reduction is not executed (NO in step S3), the vehicle controller 10 returns to step S1. The vehicle controller 10 repeats these steps until determining that idle reduction is executed.

[0054] When determining that idle reduction is executed (YES in step S3), the vehicle controller 10 stores the most recent operation direction and operation angle of the steering wheel in the RAM as the reference operation direction and the reference operation angle, respectively (step S4), and ends the present reference value storing process.

[0055] In the present embodiment, the automatic engine stopping unit 11 stores the steering angle and the steering direction of the steering wheel at the moment when the engine is stopped by the automatic stopping function, in the RAM as the reference steering angle and the reference steering direction, respectively.

[0056] Next, with reference to FIG. 4, description will be provided on a process in which the vehicle controller 10 starts the engine in the idle reduction mode (hereafter, referred to as "automatic starting process"). FIG. 4 is a flowchart of the automatic starting process. The vehicle controller 10 repeatedly executes the automatic starting process on a

prescribed cycle.

[0057] First, the automatic engine starting unit 12 of the vehicle controller 10 determines whether the engine is in the idle reduction mode (step S11). In the present embodiment, the automatic engine starting unit 12 determines whether the engine is stopped by the automatic stopping function executed by the automatic engine stopping unit 11.

[0058] When determining that the engine is not in the idle reduction mode (NO in step S11), the automatic engine starting unit 12 repeatedly executes the process in step S11 until determining that the engine is in the idle reduction mode.

10 [0059] On the other hand, when determining that the engine is in the idle reduction mode (YES in step S11), the automatic engine starting unit 12 computes the steering operation degree, which is the difference between the reference operation angle and the present operation angle (step S12).

[0060] In the present embodiment, the steering operation detecting unit 120 of the automatic engine starting unit 12 reads the reference steering angle, which is stored in the RAM by the automatic engine stopping unit 11 when the engine is stopped by the automatic stopping function (the engine is placed in the idle reduction mode). In addition, the steering operation detecting unit 120 obtains the information on the most recent steering angle output from the steering angle sensor 61. The steering operation detecting unit 120 then derives the difference between the reference steering angle and the present steering angle, as the steering operation degree.

[0061] Subsequently, the automatic engine starting unit 12 determines whether the derived steering operation degree is zero (step S13).

[0062] When determining that the steering operation degree is zero (NO in step S13), the automatic engine starting unit 12 repeats the process in step S13 until determining that the steering operation degree is not zero.

[0063] On the other hand, when determining that the steering operation degree is not zero (YES in step S13), the automatic engine starting unit 12 determines whether steering is performed in a direction opposite to the reference operation direction (step S14).

[0064] In the present embodiment, the steering operation detecting unit 120 of the automatic engine starting unit 12 reads the reference steering direction that is stored in the RAM by the automatic engine stopping unit 11 when the engine is stopped by the automatic stopping function (the engine is placed in the idle reduction mode). In addition, the steering operation detecting unit 120 obtains the information on the most recent steering direction output from the steering angle sensor 61. The steering operation detecting unit 120 then determines that the steering is performed in the direction opposite to the reference operation direction when the reference steering direction differs from the present steering direction.

[0065] Specifically, in the case where the reference steering direction is "+1," which is the value representing the counterclockwise turning, and the present steering direction is "-1," which is the value representing the clockwise turning, the steering operation detecting unit 120 determines that the steering is performed in the direction opposite to the reference operation direction. Alternatively, in the case where reference steering direction is "-1," which is the value representing the clockwise turning, and the present steering direction is "+1," which is the value representing the counterclockwise turning, the steering operation detecting unit 120 determines that the steering is performed in the direction opposite to the reference operation direction.

[0066] When determining that the steering is performed in the direction opposite to the reference operation direction (YES in step S14), the steering operation detecting unit 120 uses the reverse-direction-operation-time threshold value (step S15).

[0067] On the other hand, when determining that the steering is performed in the same direction as the reference operation direction (NO in step S14), the steering operation detecting unit 120 uses the forward-direction-operation-time threshold value (step S16).

[0068] When using reverse-direction-operation-time threshold value, the automatic engine starting unit 12 may adjust the reverse-direction-operation-time threshold value based on the friction state of the road surface. Specifically, the friction state detecting unit 121 of the automatic engine starting unit 12 may detect whether the friction state of the road surface is in the low-friction state based on the most recent road surface  $\mu$

value output from the brake ECU 30. When detecting the low-friction state, the friction state detecting unit 121 may use the low-friction-time threshold value that is stored in the ROM in advance, as the reverse-direction-operation-time threshold value. On the other hand, when the low-friction state is not detected, the friction state detecting unit 121 may use the high-friction-time threshold value that is stored in the ROM in advance, as the reverse-direction-operation-time threshold value.

[0069] Subsequently, the automatic engine starting unit 12 determines whether the steering operation degree is equal to or larger than a threshold value (step S17). Specifically, when determining that the steering is performed in the same direction as the reference operation direction, the automatic engine starting unit 12 determines whether the steering operation degree is equal to or larger than the forward-direction-operation-time threshold value. When determining that the steering is performed in the direction opposite to the reference operation direction, the automatic engine starting unit 12 determines whether the steering operation degree is equal to or larger than the reverse-direction-operation-time threshold value. When determining that the steering is performed in the direction opposite to the reference operation direction and, in addition, detecting the low-friction state, the automatic engine starting unit 12 may determine whether the steering operation degree is equal to or larger than the low-friction-time threshold value. When it is determined that the steering is performed in the direction opposite to the reference operation direction and, in addition, the low-friction state is not detected, the automatic engine starting unit 12 may determine whether the steering operation degree is equal to or larger than the high-friction-time threshold value.

[0070] When determining that the steering operation degree is equal to or larger than the threshold value (YES in step S17), the automatic engine starting unit 12 starts the engine (step S18). Specifically, the automatic engine starting unit 12 outputs a start signal to the starter relay 74. Upon reception of the start signal from the automatic engine starting unit 12, the starter relay 74 provides electrical connection between the battery 70 and the starter 73. The starter 73 connected to the battery 70 rotates upon reception of electric power from the battery 70, and rotates the crankshaft of the engine to start engine.

[0071] On the other hand, when determining that the steering operation degree is smaller than the threshold value (NO in step S17), the automatic engine starting unit 12 ends the present automatic starting process without starting the engine.

[0072] With the above-described configuration, the vehicle controller 10 starts the engine when the operation degree of the steering wheel after the engine is stopped becomes equal to or larger than the threshold value. In addition, it is possible to set the threshold value in the case where the operation direction of the steering wheel after the engine is stopped differs from that before the engine is stopped to be larger than the threshold value in the case where the operation direction of the steering wheel after the engine is stopped coincides with that before the engine is stopped. Thus, it is possible to inhibit the engine from being started against the intention of a driver, even when the steering wheel is turned in the reverse direction due to restoring force of the twisted tire as a result of the fact that steering assist force generated by the hydraulic power steering system is reduced or lost in the idle reduction mode. In addition, it is possible to prevent an excessive increase in the operation degree at the time when a driver further turns the steering wheel in order to start the engine. As a result, it is possible to more appropriately carry out the start of the engine as intended by the driver.

[0073] When the operation direction of the steering wheel after the engine is stopped differs from that before the engine is stopped, the vehicle controller 10 sets the threshold value in the case where the friction state of the road surface is the low-friction state smaller than the threshold value in the case where the friction state of the road surface is not the low-friction state. Thus, it is possible to prevent an excessive increase in the threshold value in the case where a road surface is in the low-friction state and the steering wheel is turned by a small amount in the reverse direction due to the restoring force of the twisted tire. As a result, it is possible to more appropriately carry out the start of the engine that conforms to the driver's feeling.

[0074] In addition, the vehicle controller 10 adjusts the threshold value in the case where the operation direction of the steering wheel after the engine is stopped differs from that before the engine is stopped, based on the friction state of the road surface. It is thus

possible to set the threshold value that is suitable for, for example, the road surface  $\mu$  value. As a result, it is possible to more appropriately carry out the start of the engine that conforms to the driver's feeling.

[0075] While the invention has been described with reference to an example  
5 embodiment thereof, it is to be understood that the invention is not limited to the above-described embodiment, and various modifications and changes may be made to the above-described embodiment within the scope of the invention.

[0076] For example, in the above-described embodiment, the vehicle controller  
10 adjusts the reverse-direction-operation-time threshold value in the case where the operation direction of the steering wheel after the engine is stopped differs from that before the engine is stopped, based on the friction state of the road surface. The present invention is however not limited to this configuration. For example, the vehicle controller 10 may adjust the reverse-direction-operation-time threshold value based on the reference operation velocity in addition to or instead of the friction state of the road surface.  
15 In this case, the vehicle controller 10 stores the operation velocity of the steering wheel at the moment when the engine is stopped by the automatic stopping function, as the reference operation velocity. The vehicle controller 10 sets the reverse-direction-operation-time threshold value to be greater as the reference operation velocity is higher. Specifically, when the operation direction of the steering wheel after  
20 the engine is stopped differs from that before the engine is stopped, the vehicle controller 10 sets the reverse-direction-operation-time threshold value in the case where the operation velocity of the steering wheel at the engine stop time is high, to be larger than the reverse-direction-operation-time threshold value in the case where the operation velocity of the steering wheel at the engine stop time is low. This is because it is deemed that the  
25 steering wheel is turned by a larger amount in the reverse direction due to the restoring force of the twisted tire as the reference operation velocity is higher.

## CLAIMS:

1. A vehicle controller configured to start an engine when an operation of a steering wheel by a prescribed operation degree is detected after the engine is automatically stopped by an idle reduction function, the vehicle controller comprising a steering operation detecting unit configured to detect an operation degree and an operation direction of the steering wheel, wherein:

the operation degree of the steering wheel includes an operation degree due to a restoring force of a tire that is twisted by a friction against a road surface; and

the prescribed operation degree in a case where the operation direction of the steering wheel after the engine is automatically stopped differs from the operation direction of the steering wheel before the engine is automatically stopped, is larger than the prescribed operation degree in a case where the operation direction of the steering wheel after the engine is automatically stopped coincides with the operation direction of the steering wheel before the engine is automatically stopped.

2. The vehicle controller according to claim 1, further comprising a friction state detecting unit configured to detect a friction state of the road surface, wherein

when the operation direction of the steering wheel after the engine is automatically stopped differs from the operation direction of the steering wheel before the engine is automatically stopped, the prescribed operation degree in a case where the friction state of the road surface is a low-friction state is smaller than the prescribed operation degree in a case where the friction state of the road surface is not the low-friction state.

3. The vehicle controller according to claim 1 or 2, wherein:

the steering operation detecting unit is configured to detect an operation velocity of the steering wheel; and

when the operation direction of the steering wheel after the engine is automatically stopped differs from the operation direction of the steering wheel before the engine is

automatically stopped, the prescribed operation degree in a case where the operation velocity of the steering wheel at the engine automatic stop time is high is larger than the prescribed operation degree in a case where the operation velocity of the steering wheel at the engine automatic stop time is low.

FIG. 1

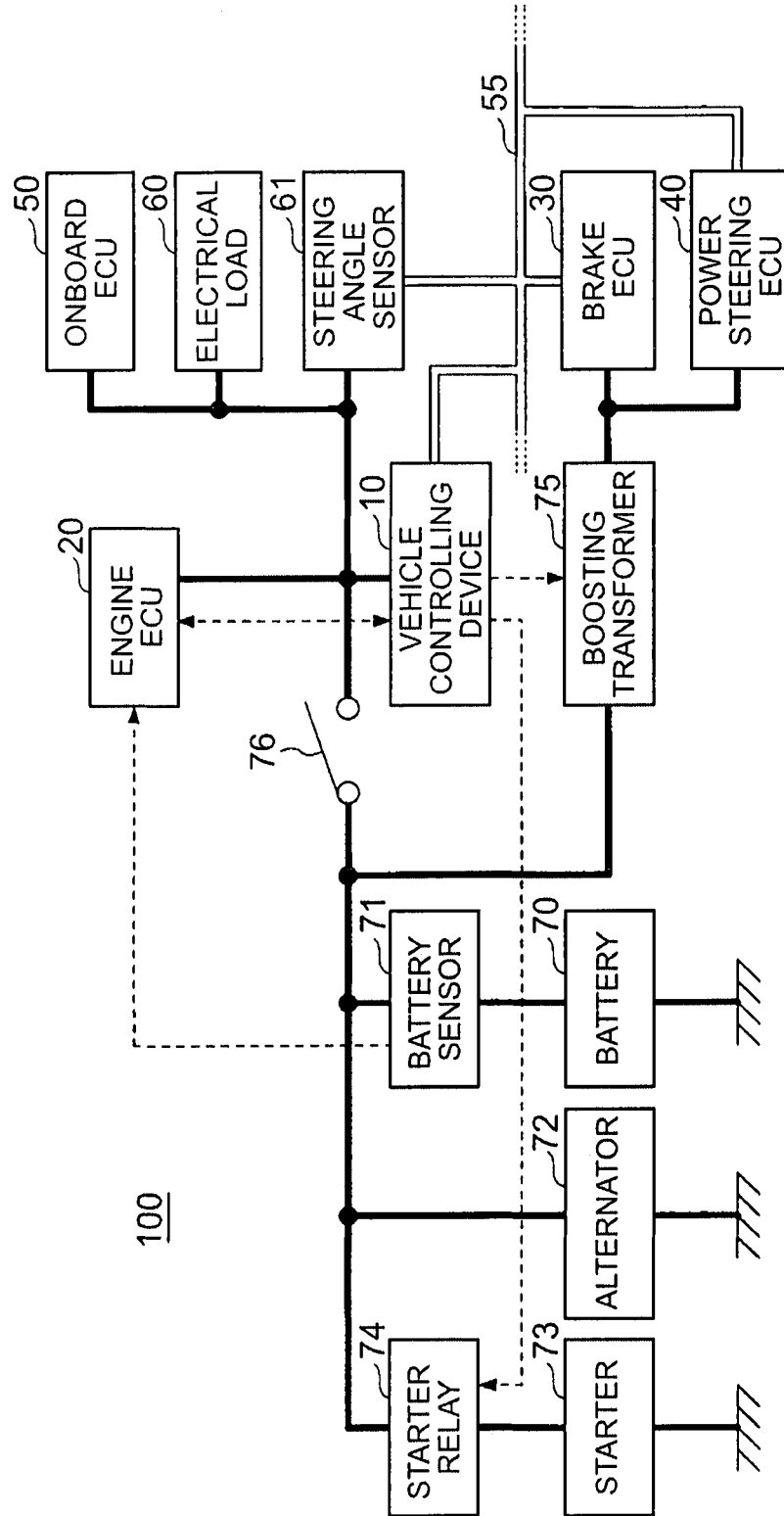


FIG. 2

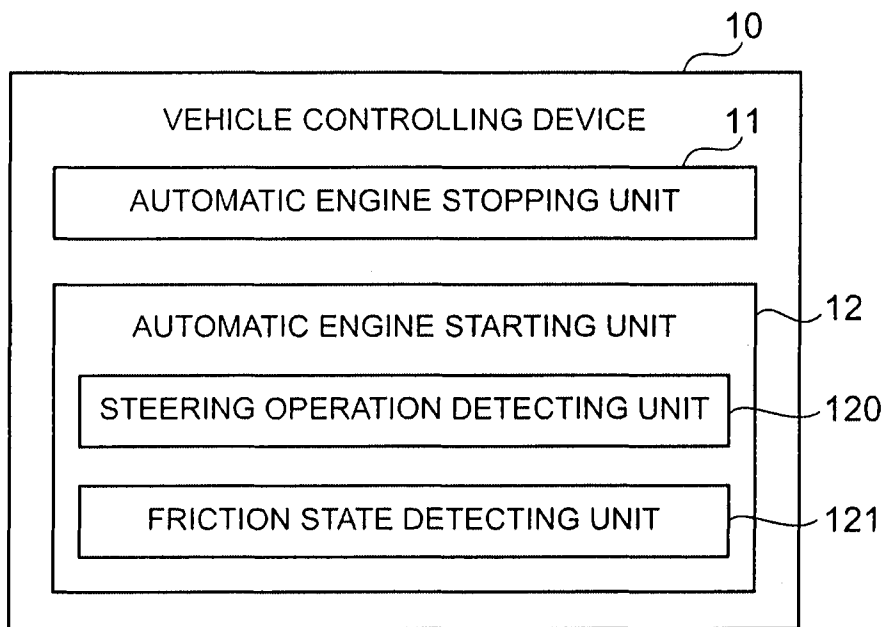


FIG. 3

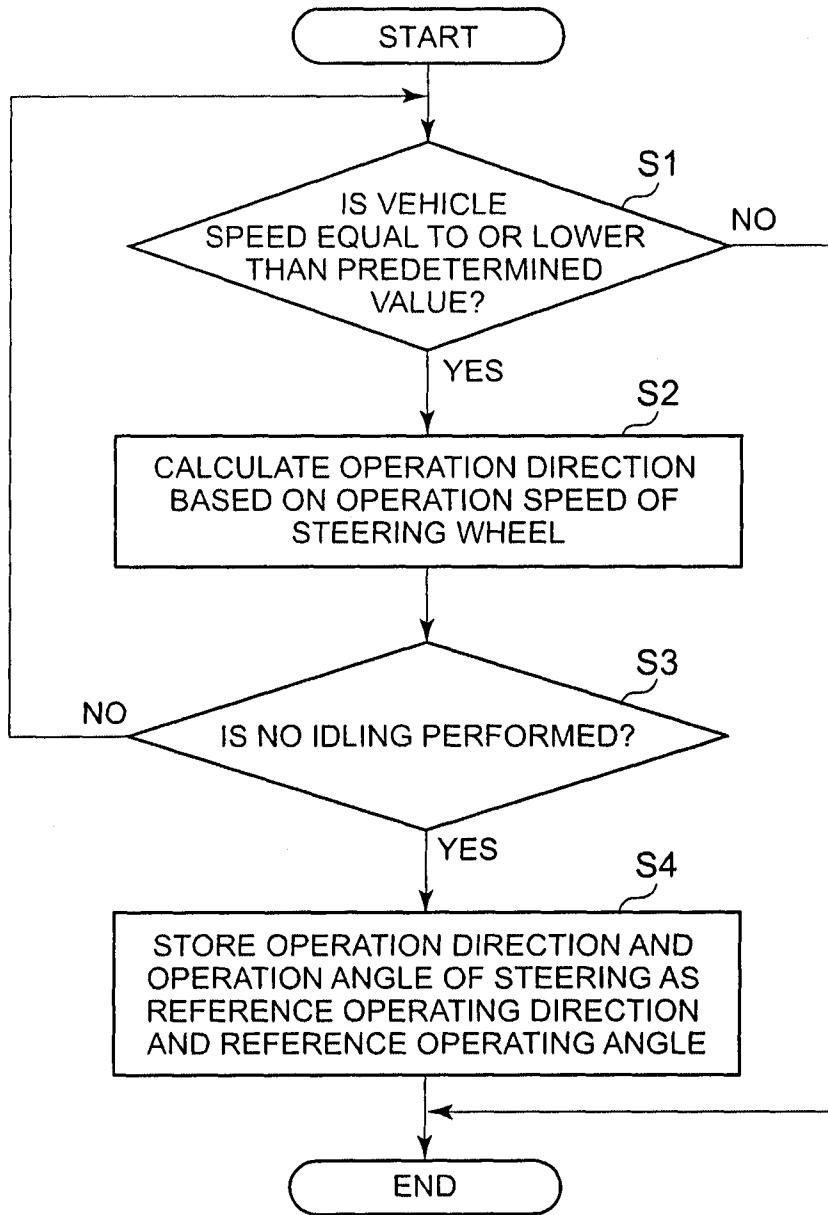
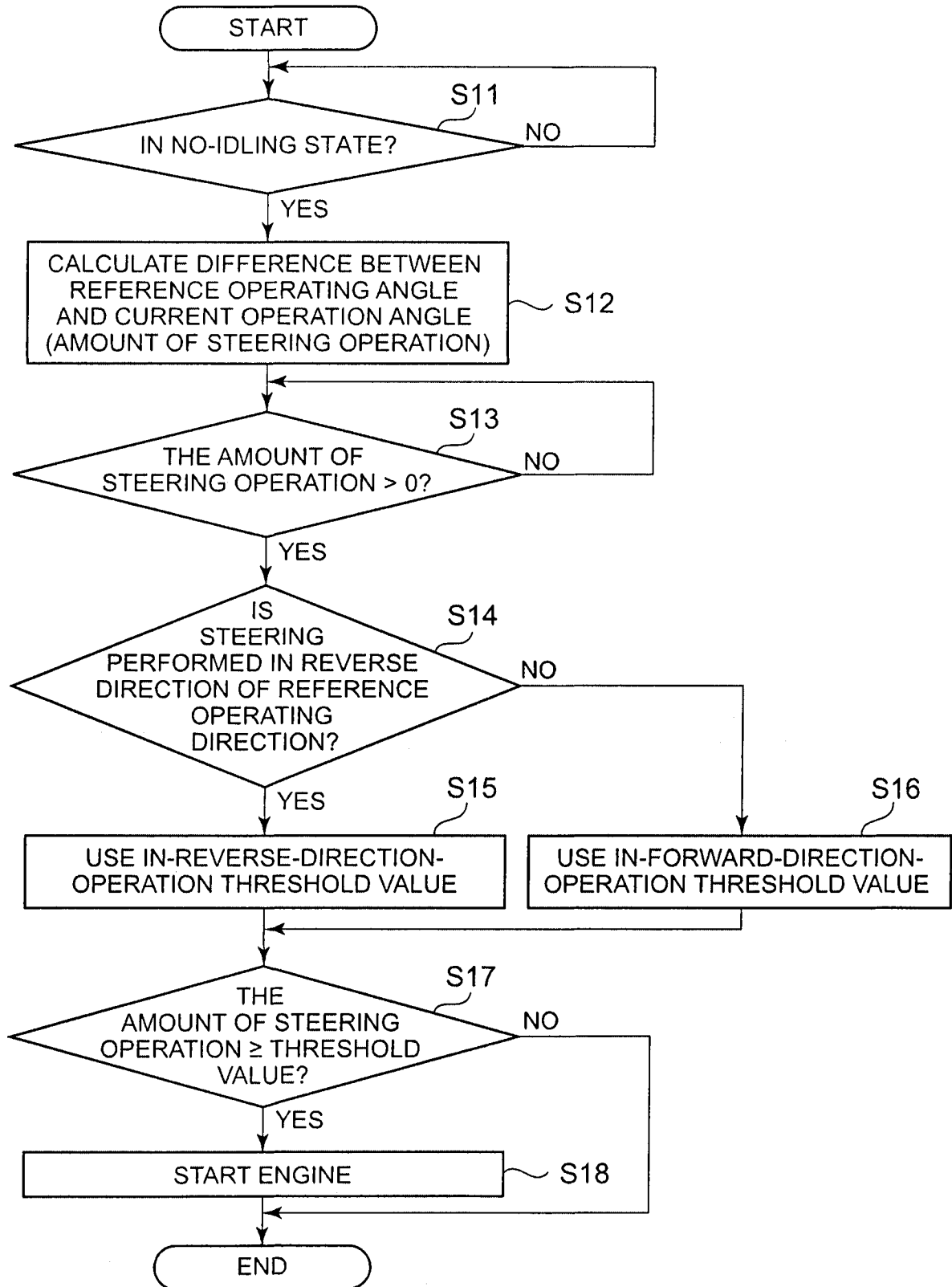


FIG. 4



INTERNATIONAL SEARCH REPORT

International application No  
PCT/IB2015/000251

A. CLASSIFICATION OF SUBJECT MATTER  
INV. F02N11/08 B60W30/18  
ADD.  
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED  
Minimum documentation searched (classification system followed by classification symbols)  
F02N B60W G01N B62D

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2013/197787 A1 (URABE HIROSHI [JP]) 1 August 2013 (2013-08-01) abstract; figures 1-17 paragraphs [0011] - [0013], [0022], [0038], [0067] - [0073], [0132] - [0137] -----	1-3
A	DE 10 2010 013180 A1 (DAIMLER AG [DE]) 29 September 2011 (2011-09-29) abstract; figure 1 paragraphs [0003] - [0021], [0031] -----	1-3
A	US 2013/311072 A1 (TOCHIHARA SEIJI [JP] ET AL) 21 November 2013 (2013-11-21) abstract; figures 1-2 paragraphs [0004], [0009] - [0019] ----- -/--	1-3

Further documents are listed in the continuation of Box C.

See patent family annex.

\* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search  20 May 2015	Date of mailing of the international search report  23/06/2015
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Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer  Mineau, Christophe
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## INTERNATIONAL SEARCH REPORT

International application No  
PCT/IB2015/000251

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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