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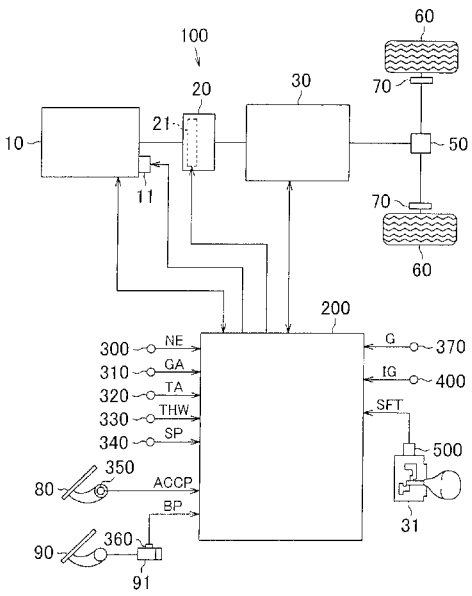
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(54) **Title**: CONTROL DEVICE AND CONTROL METHOD FOR VEHICLE

FIG. 1



(57) **Abstract**: A control device for a vehicle in which an internal combustion engine is mounted, the control device includes an electronic control unit. The electronic control unit is configured to (i) start the internal combustion engine in the event of an engine stall, and (ii) permit the start of the internal combustion engine in the event of the engine stall on condition that a braking force is equal to or higher than a predetermined value and the braking force acts against a driving force that is applied to the vehicle when the internal combustion engine is started.

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CONTROL DEVICE AND CONTROL METHOD FOR VEHICLE

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a control device and a control method for a vehicle.

2. Description of Related Art

[0002] A technology that improves convenience by restarting (automatically starting) the internal combustion engine mounted in a vehicle by driving a starter motor in the event of an engine stall has been proposed. For example, a device that is disclosed in Japanese Patent Application Publication No. 2001-200739 (JP 2001-200739 A) permits restart of the internal combustion engine in the event of an engine stall on condition, for example, that an ON signal is being output from a brake switch that detects depression of the brake pedal.

[0003] When restart of the internal combustion engine is permitted on condition that an ON signal is being output from a brake switch, the starter motor is driven with a low braking force being applied to the vehicle when an ON signal is being output from the brake switch even when the amount of depression of the brake pedal is relatively small. Thus, in such a case, the vehicle can be moved by the driving force that is produced when the internal combustion engine is restarted even when the driver is depressing the brake pedal.

SUMMARY OF THE INVENTION

[0004] The present invention provides a control device for a vehicle that can restrain the vehicle from moving when the internal combustion engine is automatically started in the event of an engine stall.

[0005] A first aspect of the present invention provides a control device for a vehicle in which an internal combustion engine is mounted. The control device includes an electronic control unit. The electronic control unit is configured to (i) start the internal combustion engine in the event of an engine stall, and (ii) permit the start of the internal combustion engine in the event of the engine stall on condition that a braking force is equal to or higher than a predetermined value. The braking force acts against a driving force that is applied to the vehicle when the internal combustion engine is started.

[0006] According to the above configuration, the start of the internal combustion engine in the event of an engine stall is permitted on condition that a braking force that is equal to or higher than a predetermined value can act against the driving force that is applied to the vehicle when the internal combustion engine is started. Therefore, by setting the predetermined value appropriately, the start of the internal combustion engine can be permitted when the braking force is higher than the driving force that is produced when internal combustion engine is started (automatically started). Thus, the vehicle can be restrained from moving when the internal combustion engine is started in the event of an engine stall.

[0007] The vehicle further includes a brake operating member. In the control device, the electronic control unit may be configured to permit the start of the internal combustion engine in the event of an engine stall on condition that the braking force is equal to or higher than the predetermined value and the braking force is produced by the operation of the brake operating member. In the control device, the predetermined value may correspond to a braking force that is high enough to hold the vehicle stationary when the internal combustion engine is started.

[0008] According to the above configuration, because the vehicle can be held stationary when the internal combustion engine is started in the event of an engine stall, the vehicle can be restrained from moving more reliably when the internal combustion engine is started. The vehicle may further include a starter motor that is configured to start the internal combustion engine. In the control device, the predetermined value may

correspond to a braking force that is high enough to hold the vehicle stationary when the starter motor is driven.

[0009] In the control device, the electronic control unit may be configured to permit the start of the internal combustion engine in the event of the engine stall on condition that the braking force is equal to or higher than the driving force.

[0010] In the case of a hydraulic brake, the hydraulic pressure that is supplied to the brake increases and a higher braking force is applied to the vehicle as the displacement of a brake operating member is increased. The vehicle may further include a hydraulic brake that is activated when a brake operating member is operated. In the control device, the electronic control unit may be configured to use the hydraulic pressure that is being supplied to the brake as a value that indicates the braking force.

[0011] When an engine stall occurs on a road with a gradient that is greater than that of a flat road, such as on an ascending or descending slope, a higher braking force is necessary to hold the vehicle stationary. Thus, to make it possible for the start of the internal combustion engine to be permitted even when an engine stall occurs on a road with a large gradient, the abovementioned predetermined value must have been set to a sufficiently large value.

[0012] On the other hand, when the vehicle is on a flat road, for example, the braking force necessary to hold the vehicle stationary is lower as compared to that which is necessary when the vehicle is on an ascending or descending slope. Thus, when the vehicle is on a flat road, the vehicle can be restrained from moving when the internal combustion engine is started even when the braking force is relatively low. However, when the predetermined value has been set to a large value in view of the occurrence of an engine stall on a road with a large gradient as described above, the start of the internal combustion engine may not be permitted when the vehicle can be held stationary with a low braking force as in the case where the vehicle is on a flat road because the brake pressure does not exceed the predetermined value. When the predetermined value has been set to a sufficiently large value in view of the occurrence of an engine stall on a road with a large gradient as described above, the start of the internal combustion engine may

not be permitted even when a braking force that is high enough to restrain the vehicle from moving when the internal combustion is started is being produced. This leads to a decrease of opportunities for the engine to be started.

[0013] In the control device, the electronic control unit may be configured to variably set the predetermined value based on a road gradient on which the engine stall occurred. According to the above configuration, the predetermine value is varied depending on the variation of the braking force necessary to hold the vehicle stationary which varies depending on the gradient of the road. This leads to an increase of opportunities for the internal combustion engine to be started.

[0014] The braking force that is necessary to hold the vehicle stationary increases as the road gradient (the absolute value of the angle of the road gradient) is greater. In the control device, the electronic control unit may be configured to set the predetermined value to a larger value as the road gradient is greater.

[0015] A brake switch as described above is provided to detect whether the brake pedal is being operated. In general, when an ON signal is output from the brake switch, stop lamps turn on to inform the vehicles behind that the brake pedal of the vehicle is being operated. Also, an ON signal is usually output from the brake switch when the brake pedal is slightly depressed. It is, therefore, highly possible that the braking force that is being produced when an ON signal is being output from the brake switch is not high enough to restrain the vehicle from moving when the internal combustion engine is started. Thus, when the start of the internal combustion engine is permitted when an ON signal is being output from the brake switch, the starter motor tends to be driven with a low braking force being applied to the vehicle as described above. In this respect, in each of the above configurations, the start of the internal combustion engine is permitted based on the result of comparison between the braking force that is being applied to the vehicle and a predetermined value and a necessary braking force therefore can be appropriately secured.

[0016] In each of the above configuration, the term "braking force" refers not only to a force that is used to decelerate the vehicle but also to a force that is used to hold the vehicle stationary.

[0017] A second aspect of the present invention provides a control method for a vehicle that includes an internal combustion engine. The method includes starting the internal combustion engine in the event of an engine stall, and permitting the start of the internal combustion engine in the event of the engine stall on condition that a braking force is equal to or higher than a predetermined value and the braking force acts against a driving force that is applied to the vehicle when the internal combustion engine is started. According to the above configuration, the same effects as those of the first aspect can be achieved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] 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 schematic diagram that illustrates the configuration of a vehicle in a first embodiment of the present invention;

FIG. 2 is a flowchart that illustrates a processing procedure that is performed in the first embodiment in the event of an engine stall;

FIG. 3 is a flowchart that illustrates a processing procedure that is performed in a second embodiment in the event of an engine stall; and

FIG. 4 is a conceptual diagram that illustrates the relationship between the road gradient and a threshold value in the second embodiment.

DETAILED DESCRIPTION OF EMBODIMENTS

[0019] A first embodiment that embodies a control device for a vehicle is described below with reference to FIG. 1 and FIG. 2.

[0020] As shown in FIG. 1, an engine 10, which is an internal combustion engine, is mounted in a vehicle 100. The engine 10 is equipped with a starter motor 11 that rotates the crankshaft to start the engine 10.

[0021] The crankshaft of the engine 10 is connected to an input shaft of a torque converter 20, which is a fluid coupling. The torque converter 20 has an output shaft that is connected to an input shaft of an automatic transmission 30.

[0022] The torque converter 20 is equipped with a lock-up clutch 21. The lock-up clutch 21 is a clutch that can directly couple the input and output shafts of the torque converter 20, and is engaged and disengaged depending on the running conditions of the vehicle 100.

[0023] The automatic transmission 30 has an output shaft that is connected to a differential gear 50. The differential gear 50 has an output shaft that is connected to driving wheels 60 of the vehicle. Each of the driving wheels 60 of the vehicle 100 is equipped with a hydraulic brake 70. When a brake pedal 90 as a brake operating member is operated by the driver, a hydraulic pressure in proportion to the displacement of the brake pedal 90 is produced in a master cylinder 91 that supplies a hydraulic pressure to the brakes 70. When the hydraulic pressure that is produced in the master cylinder 91 is supplied to the hydraulic cylinders of the brakes 70, the rotation of the driving wheels 60 is slowed or stopped.

[0024] A shift lever device 31 that is used to select the transmission mode of the automatic transmission 30 is provided in the cabin of the vehicle 100. The shift lever device 31 has shift positions including "P (parking)," "R (reverse)," "N (neutral)" and "D (drive)."

[0025] The conditions of the vehicle 100 and the engine 10 are detected by various sensors and so on. For example, an engine speed NE is detected by a crank angle sensor 300; an intake air amount GA is detected by an intake air amount sensor 310; a throttle opening TA that indicates the opening of throttle valve is detected by a throttle opening sensor 320; a coolant temperature THW of the engine 10 is detected by a coolant temperature sensor 330; a vehicle speed SP of the vehicle is detected by a vehicle

speed sensor 340; an accelerator operation amount ACCP that indicates the displacement of an accelerator pedal 80 is detected by an accelerator sensor 350; the pressure in the master cylinder 91 (brake pressure BP) is detected by a brake pressure sensor 360; an acceleration G of the vehicle 100 is detected by an acceleration sensor 370; a request to start the engine, a request to stop the engine and so on from the driver are received by an ignition switch 400; and a shift position SFT of the shift lever device 31 is detected by a shift position sensor 500.

[0026] Various signals from the above sensors, switch and so on are input into an electronic control unit 200. Based on the various signals, the electronic control unit 200 controls the engine 10, the lock-up clutch 21, the automatic transmission 30 and so on.

[0027] When a temporary failure occurs in the fuel injection or fuel ignition system of the engine 10 or the rotational load on the crankshaft excessively increases, the engine 10 may stall. An excessive increase of rotational load on the crankshaft tends to occur when the disengaging operation of the lock-up clutch 21 is late when the vehicle 100 is stopped or when the shift position of the shift lever device 31 is changed from "D" to "R" or from "R" to "D" while the vehicle is running.

[0028] In this embodiment, when an engine stall occurs as described above, the engine 10 is restarted (automatically started). In the following, a processing procedure that is performed to start the engine 10 in the event of an engine stall is described with reference to FIG. 2. A series of processing that is shown in FIG. 2 is executed at predetermined intervals by the electronic control unit 200.

[0029] As shown in FIG. 2, when this processing is started, it is first determined whether an engine stall has occurred (S100). The engine stall determination in step S100 can be arbitrarily performed. For example, it can be determined that an engine stall has occurred when there is a transition from a state where the condition that the ignition switch 400 has been operated to the ON position and "engine speed NE > 0" is fulfilled to a state where the condition that the ignition switch 400 has been operated to the ON position and the "engine speed NE = 0" is fulfilled, for example.

[0030] Then, when an engine stall has not occurred (S100: NO), the current processing is terminated. On the other hand, when an engine stall has occurred (S100: YES), the current road gradient S is calculated (S110). In this embodiment, the gradient S is the absolute value of the angle of road gradient. For example, a gradient S of "10°" is employed when the angle of gradient of an ascending slope is "+10°," and a gradient S of "10°" is employed when the angle of gradient of a descending slope is "-10°." The output value from the acceleration sensor 370 changes depending not only on the acceleration of the vehicle 100 but also on the degree of the gradient S. While the gradient S is calculated based on the output value from the acceleration sensor 370 in this embodiment, the gradient S may be obtained in a different way. For example, another sensor may be used to detect the gradient S, or the gradient S may be estimated from the relationship between the output torque from the engine 10 and the vehicle acceleration. Alternatively, the gradient S may be obtained based on the map information from a car navigation system or a change in the altitude information from a global positioning system (GPS).

[0031] Next, it is determined whether the gradient S is equal to or smaller than a permissible gradient Smax (S120). The permissible gradient Smax has been set to a value that is slightly smaller than the maximum gradient at which the vehicle 100 may be moved by the driving force that is produced when the engine 10 is automatically started, more specifically, the driving force that is produced when the starter motor 11 is driven, even when the brake pedal 90 is depressed sufficiently.

[0032] When the gradient S is greater than the permissible gradient Smax (S120: NO), the current processing is terminated. On the other hand, when the gradient S is equal to or smaller than the permissible gradient Smax (S120: YES), it is determined whether the current brake pressure BP is equal to or higher than a predetermined threshold value H (S130). The threshold value H is a fixed value that has been set in advance to the minimum value of brake pressure BP at which the vehicle 100 can be held stationary even when the starter motor 11 is driven to start the engine 10 after the vehicle 100 has been stopped by activating the brakes 70 on a road with a gradient S which is

equal to the permissible gradient Smax. As the displacement of the brake pedal 90 is increased, the brake pressure BP increases and the braking force that is produced by the brakes 70 increases. In step S130, therefore, the brake pressure BP is used as a value that indicates the braking force that is being applied to the vehicle 100. In this embodiment, the term "braking force" refers not only to a force that is used to decelerate the vehicle but also to a force that is used to hold the vehicle stationary.

[0033] When the brake pressure BP is lower than the threshold value H (S130: NO), the current processing is terminated. On the other hand, when the brake pressure BP is equal to or higher than the threshold value H (S130: YES), it is determined whether all the conditions for permitting the start of the internal combustion engine except the brake pressure BP are fulfilled (S140). For example, the following conditions are set as the conditions for permitting the start of the internal combustion engine except the brake pressure BP. The conditions, however, may be changed as needed.

[0034] (i) The vehicle speed SP is "0."

(ii) No failure has occurred in the fuel system, the ignition system, the starting system and so on.

(iii) The bonnet and doors of the vehicle are closed.

(iv) The ignition switch 400 has been operated to the ON position.

[0035] When at least one of the conditions (i) to (iv) for permitting the start of the internal combustion engine except the brake pressure BP is not fulfilled (S140: NO), the current processing is terminated.

[0036] On the other hand, when all the conditions for permitting the start of the internal combustion engine except the brake pressure BP are fulfilled (S140: YES), the start of the internal combustion engine is permitted (S150). When the start of the internal combustion engine is permitted in this way, driving of the starter motor 11, fuel injection, ignition and so on are started to start the engine 10 and the current processing is terminated.

[0037] The processing in step S140 as described above may be omitted and the processing in step S150 may be executed when the brake pressure BP is equal to or

higher than the threshold value H (S130: YES). The effects of this embodiment are next described.

[0038] In the event of an engine stall, the engine 10 is automatically started. The convenience for the vehicle driver is therefore improved. Here, the start of the internal combustion engine is permitted on condition that a braking force that is equal to or higher than a predetermined value can act against the driving force that is applied to the vehicle 100 when the internal combustion engine is started. In other words, the start of the engine 10 is permitted when the brake pressure BP that is equal to or higher than the threshold value H is being produced by the operation of the brake pedal 90. As the threshold value H, a brake pressure BP that is high enough to hold the vehicle 100 stationary even when the starter motor 11 is driven to start the engine 10 is set. Thus, the start of the engine 10 is permitted when the braking force that is being applied to the vehicle 100 by the brakes 70 is higher than the driving force that is applied to the vehicle 100 when the starter motor 11 is driven to start the engine 10.

[0039] As described above, this embodiment provides the following effects. (1) The start of the engine 10 in the event of an engine stall is permitted on condition that a braking force that is equal to or higher than a predetermined value can act against the driving force that is applied to the vehicle 100 when the internal combustion engine is started. More specifically, the start of the engine 10 is permitted when the brake pressure BP, which is used in place of the braking force on the vehicle 100, has been increased to be equal to or higher than the threshold value H by the operation of the brake pedal 90. Therefore, by setting the threshold value H appropriately, the start of the engine 10 can be permitted when the braking force is higher than the driving force that is produced when the engine 10 is started. Thus, the vehicle 100 can be restrained from moving when the engine 10 is started in the event of an engine stall.

[0040] (2) To set the threshold value H appropriately, a brake pressure BP that is high enough to hold the vehicle 100 stationary when the engine 10 is started is set as the threshold value H. More specifically, a brake pressure BP that is high enough to hold the vehicle 100 stationary even when the starter motor 11 is driven to start the

engine 10 is set as the threshold value H. Thus, because the vehicle 100 can be held stationary when the engine 10 is started, the vehicle 100 can be restrained from moving more reliably when the engine 10 is started.

[0041] A second embodiment that embodies a control device for a vehicle is next described with reference to FIG. 3 and FIG. 4. The threshold value H is a fixed value in the first embodiment, whereas the threshold value H is variably set depending on the gradient S in this embodiment. In this embodiment, a new step S200 is added between step S120 and step S130 of the series of processing that is shown in FIG. 2. The control device according to this embodiment is described below with a focus on the difference from the first embodiment.

[0042] FIG. 3 shows a processing procedure that is performed to start the engine 10 in the event of an engine stall. A series of processing that is shown in FIG. 3 is also executed at predetermined intervals by the electronic control unit 200. The same processing steps as those which are shown in FIG. 2 are designated by the same step numbers.

[0043] In this embodiment, when the gradient S is determined to be equal to or smaller than the permissible gradient Smax in step S120 (S120: YES), a threshold value H is set based on the gradient S (S200) as shown in FIG. 3.

[0044] As shown in FIG. 4, in step S200, the threshold value H is variably set to a greater value as the gradient S is greater. As shown in FIG. 4, the threshold value H takes the maximum value when the gradient S is equal to the above-mentioned permissible gradient Smax.

[0045] When the threshold value H is set based on the gradient S in this way, the processing in and after step S130 as described above is serially performed. The effects of this embodiment are next described.

[0046] When an engine stall occurs on a road with a gradient that is greater than that of a flat road, such as on an ascending or descending slope, a higher braking force is necessary to hold the vehicle 100 stationary. Thus, to make it possible for the automatic start of the engine 10 to be permitted even when an engine stall occurs on a road with a

large gradient, the abovementioned threshold value H must have been set to a sufficiently large value.

[0047] On the other hand, when the vehicle 100 is on a flat road, for example, the braking force necessary to hold the vehicle 100 stationary is lower as compared to that which is necessary when the vehicle 100 is on an ascending or descending slope. Thus, when the vehicle 100 is on a flat road, the vehicle 100 can be restrained from moving when the engine 10 is started even when the braking force is relatively low. However, when the braking force is low, the start of the engine 10 is not permitted because the brake pressure BP does not exceed the threshold value H, which has been set to a large value. When the threshold value H has been set to a sufficiently large value in view of the occurrence of an engine stall on a road with a large gradient as described above, the start of the engine 10 may not be permitted even when a braking force that is high enough to restrain the vehicle 100 from moving when the engine 10 is started is being produced. This may lead to a decrease of opportunities for the engine 10 to be started.

[0048] In this respect, in this embodiment, the threshold value H is variably set based on the gradient S of the road on which the engine stall occurred. More specifically, because a higher braking force is necessary to hold the vehicle 100 stationary as the gradient S is greater, the threshold value H is variably set to a greater value as the gradient S is greater.

[0049] Thus, the braking force that is necessary to hold the vehicle 100 stationary varies depending on the gradient S of the road, and the threshold value H is also varied depending on the variation of the braking force. This leads to an increase of opportunities for the engine 10 to be started in the event of an engine stall.

[0050] In other words, in the above first embodiment, the threshold value H is fixed at a certain value based on the permissible gradient Smax as indicated by a chain double-dashed line in FIG. 4. Thus, when the brake pressure BP is lower than the threshold value H (fixed value), the engine 10 is not started irrespective of the gradient S.

[0051] On the other hand, in this embodiment, as indicated by a solid line in FIG. 4, the threshold value H is set to take the maximum value when the gradient S is equal to the permissible gradient Smax and to be smaller as the gradient S decreases from the permissible gradient Smax. Thus, the start of the engine 10 is permitted as long as the brake pressure BP is equal to or greater than the threshold value H that is variably set depending on the gradient S even when it is smaller than the threshold value H that is set as a fixed value in the first embodiment. In other words, because the region in which the automatic start of the engine 10 is permitted in the event of an engine stall is increased by the hatched area I in FIG. 4, the opportunities for the engine 10 to be started increase.

[0052] As described above, this embodiment provides the following effects in addition to the abovementioned effects (1) and (2). (3) The threshold value H that is used to determine whether to start the engine 10 in the event of an engine stall is variably set based on the gradient S of the road on which the engine stall occurred. Thus, it is possible to increase opportunities for the engine 10 to be started.

[0053] Each of the above embodiments may be implemented with any of the following modifications. In step S130 that is shown in FIG. 2 and FIG. 3, it is determined whether a brake pressure BP that is equal to or higher than the threshold value H is being produced by the operation of the brake pedal 90. Alternatively, in the case of a vehicle in which the brakes 70 are automatically activated by a control device, it may be determined whether the brake pressure BP is equal to or greater than the threshold value H not only when the brakes 70 are activated by the operation of the brake pedal 90 but also when the brakes 70 are automatically activated.

[0054] In each of the above embodiments, the brake pressure BP is used as a value that indicates the braking force that is being applied to the vehicle 100. Alternatively, the displacement of the brake pedal 90 may be directly detected by a sensor or the like. In this case, it may be determined, in step S130, whether the displacement of the brake pedal 90 that is detected by a sensor or the like is equal to or greater than a displacement corresponding to the threshold value H.

[0055] In each of the above embodiments, the brakes 70 are hydraulic brakes. Alternatively, mechanical brakes that are operated by a wire or link mechanism may be employed. In this case, the displacement of the brake pedal 90 is directly detected with a sensor or the like instead of the brake pressure BP that indicates the braking force that is being applied to the vehicle 100. In step S130, it may be determined whether the displacement of the brake pedal 90 that is detected by a sensor or the like is equal to or greater than a displacement corresponding to the threshold value H.

[0056] As another example, electrically-operated brakes may be employed. Again in this case, the displacement of the brake pedal 90 is directly detected with a sensor or the like instead of the brake pressure BP that indicates the braking force that is being applied to the vehicle 100. In step S130, it may be determined whether the displacement of the brake pedal 90 that is detected by a sensor or the like is equal to or greater than a displacement corresponding to the threshold value H.

[0057] In the case of electrically-operated brakes, the electric power that is being supplied to the brakes, which varies depending on the displacement of the brake pedal 90, may be detected instead of the brake pressure BP that indicates the braking force that is being applied to the vehicle 100. In this case, it may be determined, in step S130, whether the detected power supply is equal to or higher than an electric power corresponding to the threshold value H.

[0058] In each of the above embodiments, the threshold value H is set to a value corresponding to a braking force that is high enough to hold the vehicle 100 stationary when the engine 10 is started. More specifically, the threshold value H is a value corresponding to a braking force that is high enough to hold the vehicle 100 stationary even when the starter motor 11 is driven to start the engine 10.

[0059] Alternatively, as the threshold value H, a value corresponding to a braking force that is high enough to hold the vehicle 100 stationary against the driving force that is produced by combustion of air-fuel mixture when the engine 10 is automatically started may be set. For example, as the threshold value H, a value corresponding to a braking force that is high enough to hold the vehicle 100 stationary

even when the engine speed suddenly increases immediately after the engine 10 is automatically started may be set. Alternatively, as the threshold value H, a value corresponding to a braking force that is high enough to hold the vehicle 100 stationary when the engine 10 is idling after the automatic start of the engine 10 has been completed may be set.

[0060] In each of the above embodiments, the threshold value H is a value corresponding to a braking force that is high enough to hold the vehicle 100 stationary when the engine 10 is started. Alternatively, the threshold value H may be a value corresponding to a braking force that is high enough to reduce the movement of the vehicle 100, in other words, a braking force that is high enough to restrain the vehicle 100 from moving, when the engine 10 is started. Again in this case, the vehicle 100 can be restrained from moving when the engine 10 is automatically started in the event of an engine stall.

[0061] In each of the above embodiments, the brakes 70 are operated by depressing the brake pedal 90. However, the brakes 70 may be configured to be activated by means other than depressing a pedal. For example, the brakes 70 may be configured to be activated when a lever is manually operated.

[0062] The vehicle 100 is equipped with a lock-up clutch 21. In addition, each of the above embodiments or modifications can be applied to a vehicle that is equipped with a manual transmission and an automatic clutch or a vehicle that is equipped with a transmission which is similar in structure to a manual transmission and in which gears are automatically shifted and an automatic clutch. Even when each of the above embodiments or modifications is applied to such a vehicle, the same effects as those of each of the above embodiments and modifications can be achieved.

CLAIMS

1. A control device for a vehicle in which an internal combustion engine is mounted, the control device comprising:

an electronic control unit configured to

(i) start the internal combustion engine in an event of an engine stall, and

(ii) permit the start of the internal combustion engine in the event of the engine stall on condition that a braking force is equal to or higher than a predetermined value and the braking force acts against a driving force that is applied to the vehicle when the internal combustion engine is started.

2. The control device according to claim 1, the vehicle further comprising a brake operating member, wherein

the electronic control unit is configured to permit the start of the internal combustion engine in the event of the engine stall on condition that the braking force is equal to or higher than the predetermined value and the braking force is produced by the operation of the brake operating member.

3. The control device according to claim 1 or 2, wherein the predetermined value corresponds to the braking force that is high enough to hold the vehicle stationary when the internal combustion engine is started.

4. The control device according to claim 3, the vehicle further comprising a starter motor configured to start the internal combustion engine, wherein the predetermined value corresponds to the braking force that is high enough to hold the vehicle stationary when the starter motor is driven.

5. The control device according to any one of claims 1 to 4 wherein

the electronic control unit is configured to permit the start of the internal combustion engine in the event of the engine stall on condition that the braking force is equal to or higher than the driving force.

6. The control device according any one of claims 2 to 5, the vehicle further comprising a hydraulic brake that is activated when a brake operating member is operated, wherein

the electronic control unit is configured to use a hydraulic pressure that is being supplied to the brake as a value that indicates the braking force.

7. The control device according any one of claims 1 to 6, wherein the electronic control unit is configured to variably set the predetermined value based on a road gradient on which the engine stall occurred.

8. The control device according to claim 7, wherein

the electronic control unit is configured to set the predetermined value to a greater value as the road gradient is greater.

9. A control method for a vehicle that includes an internal combustion engine, the method comprising:

starting the internal combustion engine in an event of an engine stall, and

permitting the start of the internal combustion engine in the event of the engine stall on condition that a braking force is equal to or higher than a predetermined value and the braking force acts against a driving force that is applied to the vehicle when the internal combustion engine is started.

FIG. 1

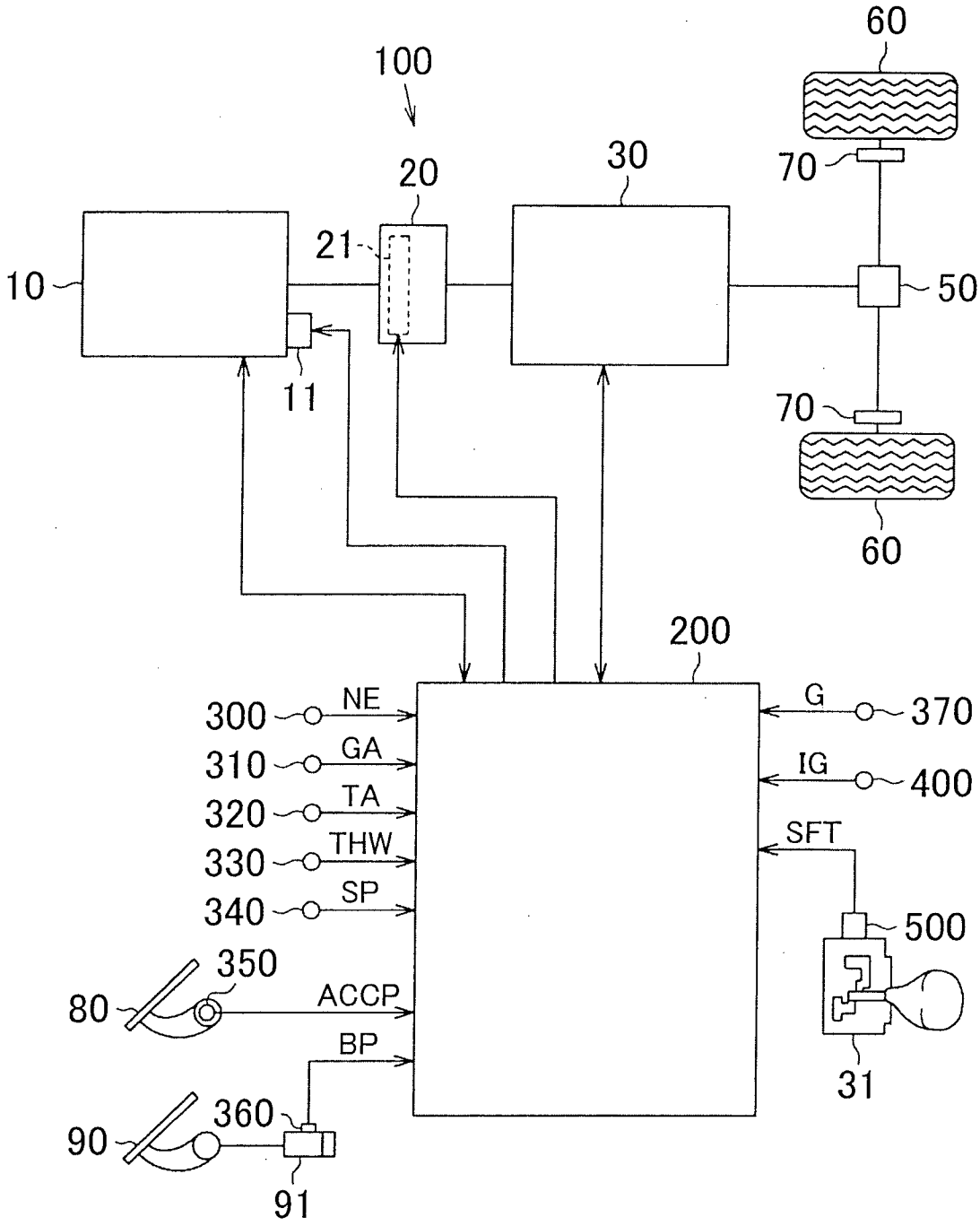

60
100
70
20
30
21
10
50
11
70
60
200
300
NE
G
370
310
GA
IG
400
320
TA
SFT
330
THW
500
340
SP
350
80
ACCP
BP
360
90
31
91

FIG. 2

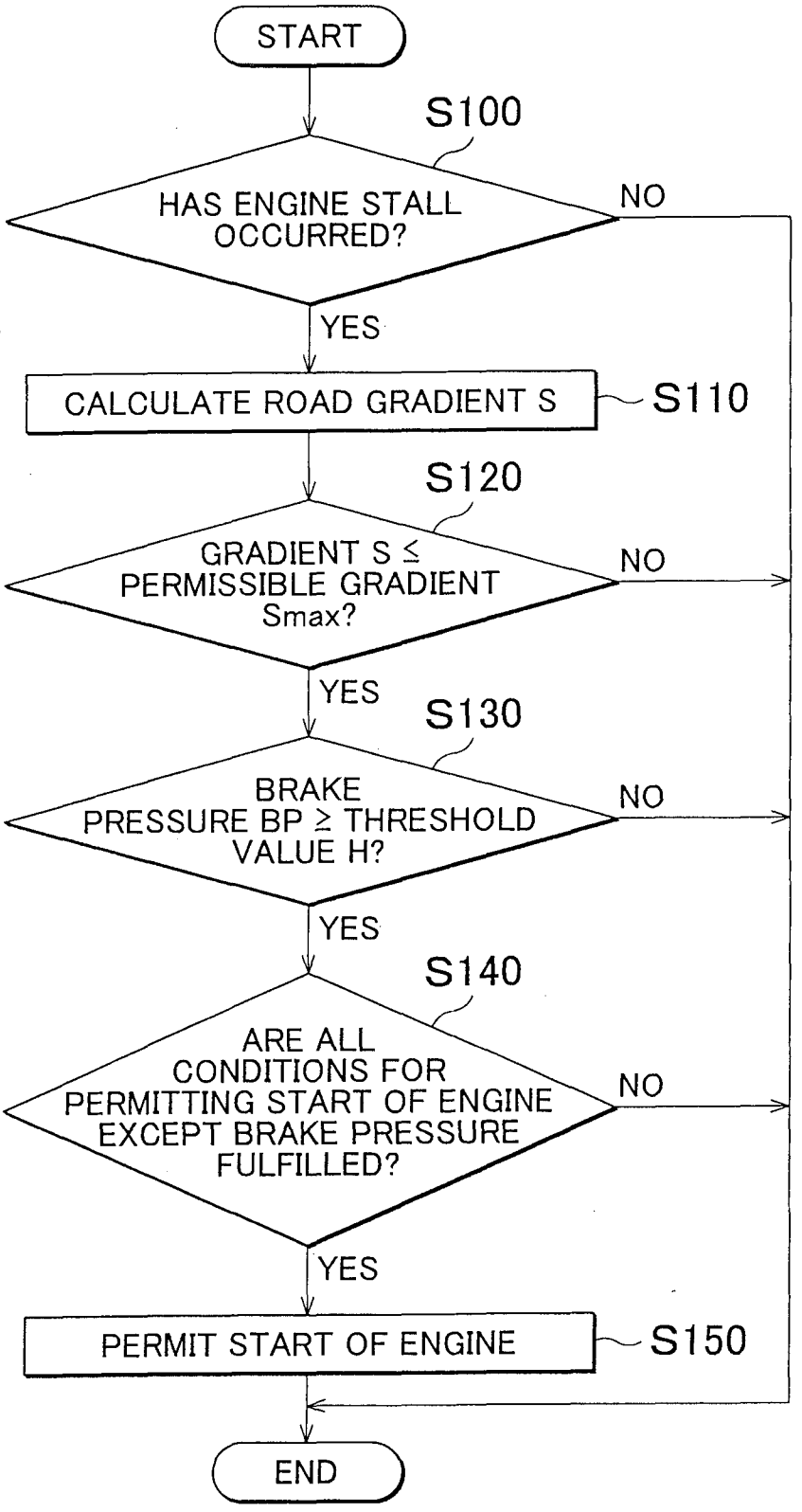

START
S100
HAS ENGINE STALL OCCURRED?
NO
YES
CALCULATE ROAD GRADIENT S
S110
S120
GRADIENT S ≤ PERMISSIBLE GRADIENT Smax?
NO
YES
S130
BRAKE PRESSURE BP ≥ THRESHOLD VALUE H?
NO
YES
S140
ARE ALL CONDITIONS FOR PERMITTING START OF ENGINE EXCEPT BRAKE PRESSURE FULFILLED?
NO
YES
PERMIT START OF ENGINE
S150
END

FIG. 3

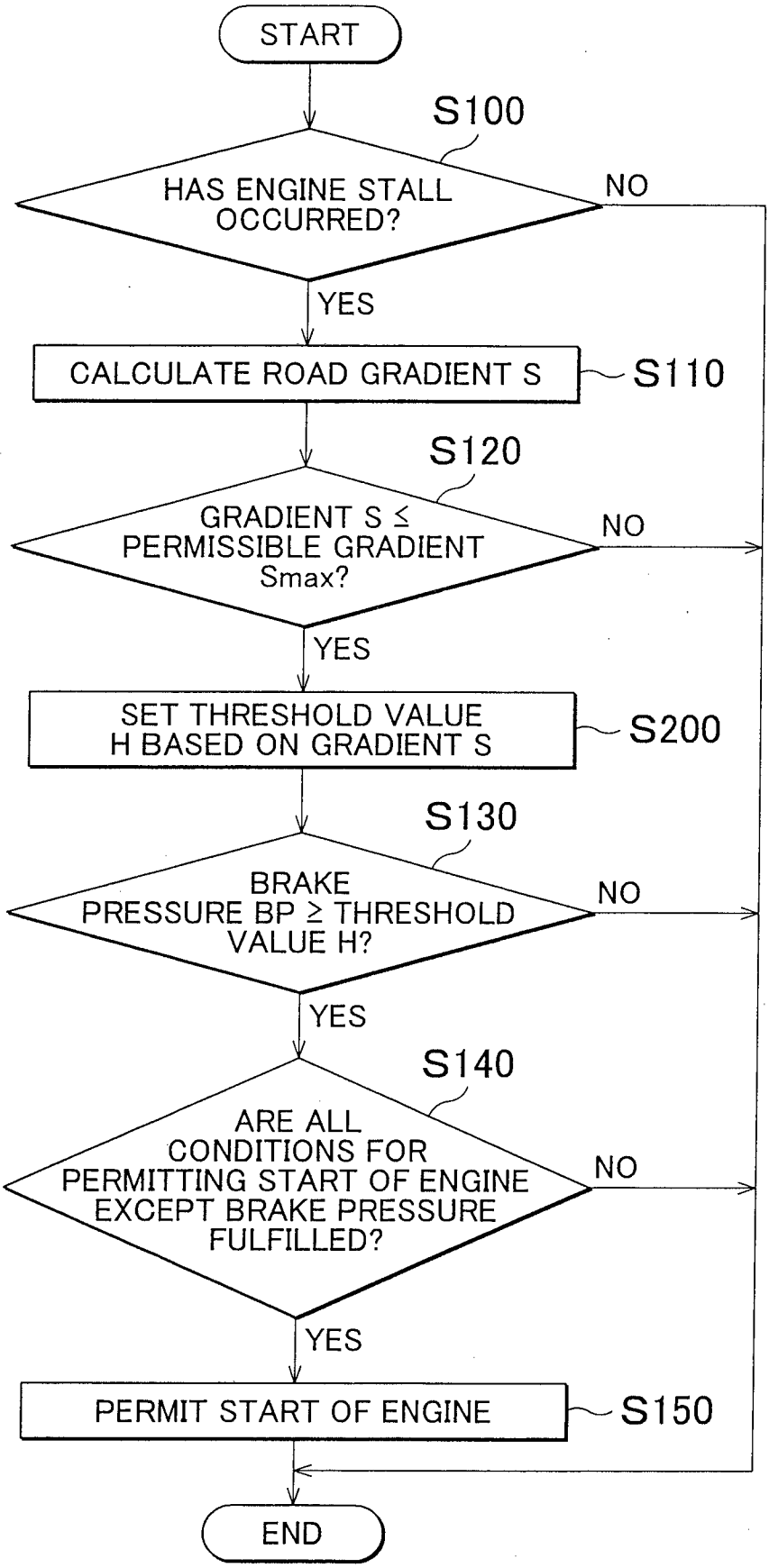
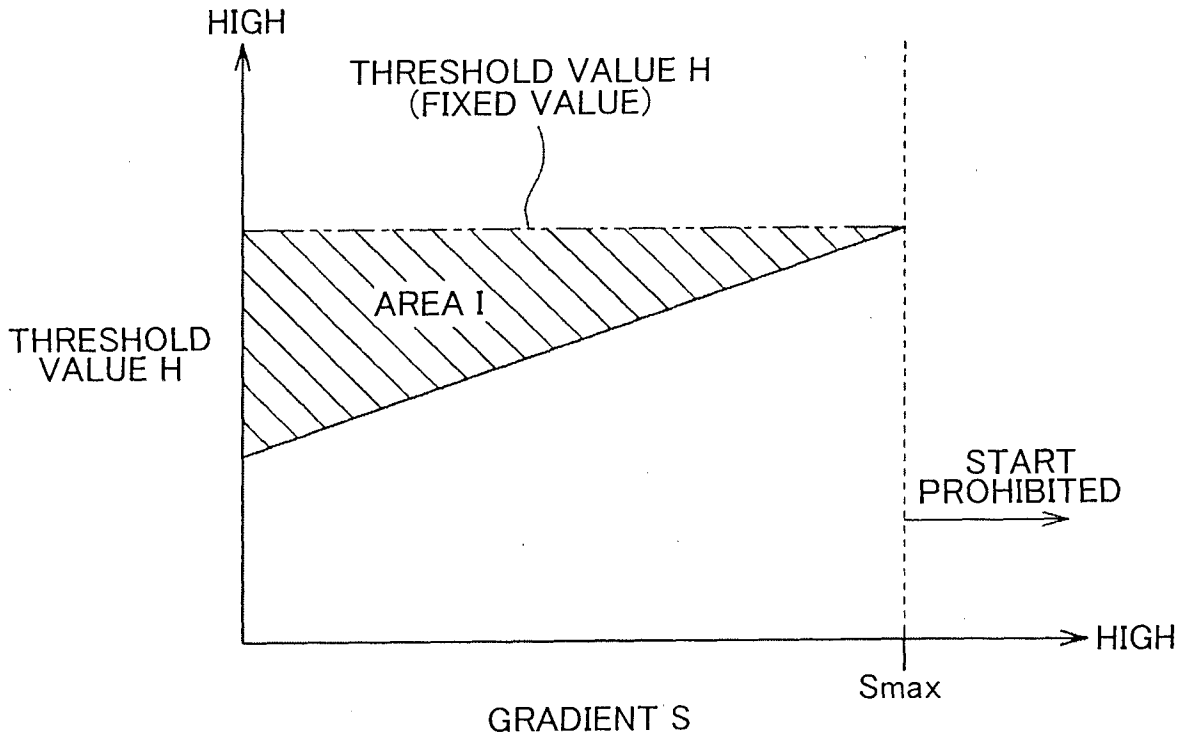

START
S100
HAS ENGINE STALL OCCURRED?
NO
YES
CALCULATE ROAD GRADIENT S
S110
S120
GRADIENT S ≤ PERMISSIBLE GRADIENT Smax?
NO
YES
SET THRESHOLD VALUE H BASED ON GRADIENT S
S200
S130
BRAKE PRESSURE BP ≥ THRESHOLD VALUE H?
NO
YES
S140
ARE ALL CONDITIONS FOR PERMITTING START OF ENGINE EXCEPT BRAKE PRESSURE FULFILLED?
NO
YES
PERMIT START OF ENGINE
S150
END

FIG. 4


HIGH
THRESHOLD VALUE H
(FIXED VALUE)
AREA I
THRESHOLD
VALUE H
START
PROHIBITED
HIGH
Smax
GRADIENT S