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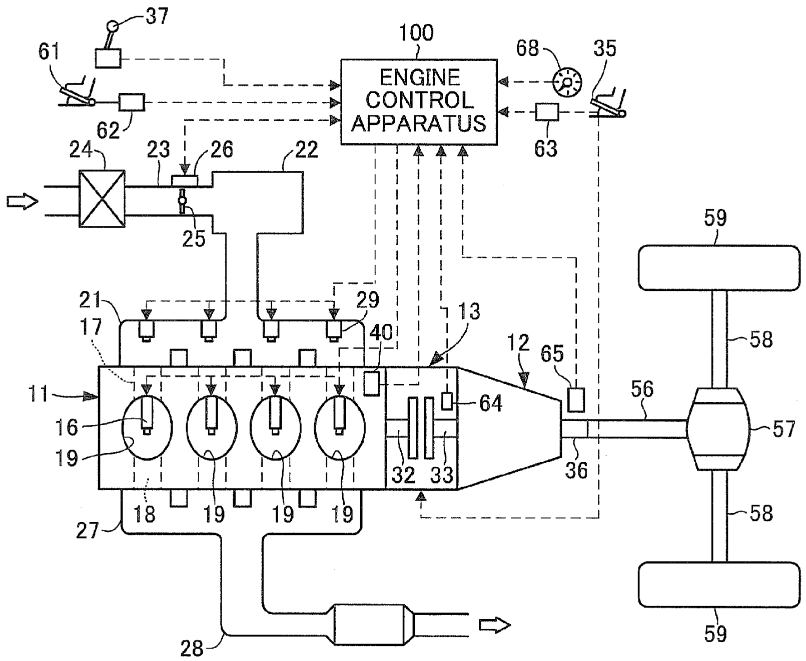
(54) **Vehicular control apparatus**

(57) A vehicular control apparatus for a vehicle having an accelerator pedal for increasing and decreasing an engine output, and a clutch pedal for changing between a transmission state transmitting a driving force outputted from the engine and a non-transmission state not transmitting the driving force, in which a vehicle speed, an accelerator pedal operation, and whether the clutch pedal starts changing from the non-transmission state to the transmission state are detected and, when the vehicle speed being below a predetermined value, the operation of the accelerator pedal, and the start of changing the non-transmission state into the transmission state are detected, the engine is controlled based on a control amount including a first control amount corresponding to the accelerator pedal operation amount and a second control amount having a larger value when the accelerator pedal operation amount is large than when the accelerator pedal operation amount is small.

FIG.1



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Description

{Technical Field}

[0001] The present invention relates to a vehicular control apparatus for controlling a vehicle having an internal combustion engine mounted thereon to transmit a driving force to a manual transmission.

{Background Art}

[0002] In general, the vehicle of this kind is provided with a manual transmission and a clutch mounted thereon. The manual clutch (hereinafter simply referred to as "clutch") is capable of transmitting a driving force outputted from an engine serving as an internal combustion engine to a transmission mechanism forming part of the manual transmission.

[0003] The clutch is usually constituted by a friction clutch of a single dry plate type which comprises a flywheel connected with an output shaft of the engine, and a clutch disc connected with an input shaft of the manual transmission. The clutch is operative to have the flywheel engaged with and disengaged from the clutch disc in response to the operation of a clutch pedal. The engagement and disengagement of the flywheel and the clutch disc by the operation of the clutch pedal ensure that the clutch is changed between a transmission state and a non-transmission state. In the transmission state, the output shaft of the engine is connected with the input shaft of the transmission to have the driving force from the output shaft of the engine transmitted to the input shaft of the transmission. In the non-transmission state, the output shaft of the engine is disconnected from the input shaft of the transmission to have the driving force from the output shaft of the engine not transmitted to the input shaft of the transmission.

[0004] Generally, the manual transmissions are of two types such as a constant-mesh type and a synchro-mesh type. The transmissions of these types each comprises a main shaft and a counter shaft having a plurality of gears supported thereon and held in mesh with one another, respectively, to constitute a plurality of gear pairs. The main shaft has a main input shaft and a main output shaft. The plurality of gear pairs is supported on the main input shaft, the main output shaft, and the counter shaft. The plurality of gears supported on the main input shaft and the main output shaft is rotatable with respect to the main input shaft and the main output shaft. Each of the main input shaft and the main output shaft has a sleeve or sleeves splined to the main input shaft and the main output shaft and supported on the side of each of the gears on the main input shaft and the main output shaft. The sleeve or sleeves are movable with respect to the main input shaft and the main output shaft to have the sleeve selectively brought into mesh with one of the gears on the main input shaft and the main output shaft so that the gears on the main input shaft can selectively be rotated together with the main input shaft and the gears on the main output shaft can selectively be rotated together with the main output shaft. A shift lever is drivably connected with a plurality of control shafts each having a shift fork so that one of the shift forks can be selected when the shift lever is operated by a driver.

[0005] At this time, the sleeve corresponding to the shift fork thus selected can be moved in axes direction of the main input and main output shafts. As a result, the operation of the shift lever can change one of the gear pairs to the other of the gear pairs to transmit the torque of the main input shaft to the main output shaft through the counter shaft. Therefore, it will be understood that the previously mentioned gear pairs constitute as a whole a plurality of speed stages of the transmission desired by the driver, and that the main input shaft constitutes a power input shaft, while the main output shaft constitutes a power output shaft.

[0006] The operation of the vehicle provided with the manual transmission and the manual clutch at the start of the vehicle will then be explained hereinafter. The clutch pedal is operated to be depressed by the driver to have the transmission state changed to the non-transmission state. The shift lever is then operated by the driver to establish the first speed stage of the transmission. The clutch is then operated to be gradually returned to its original position by the driver to have the non-transmission state gradually returned to the transmission state while the accelerator pedal is being depressed to increase the rotation speed of the engine. When the clutch is brought into the transmission state, the driving force of the engine can be transmitted to the drive wheels through the transmission. At this time, the operation of the accelerator pedal is carried out by the driver together with the operation of the clutch pedal to increase the rotation speed of the engine to harmonize the engine torque corresponding to the rotation speed of the engine with the clutch torque in response to the operation of the clutch, thereby enabling a smooth driving feeling to the driver.

[0007] The previously mentioned vehicle provided with the manual transmission is required to harmonize the both operations of the clutch pedal and the accelerator pedal by the driver at the start of the vehicle. The harmonization operation is apt to make it not only difficult but also laborious for the driver to start moving the vehicle.

[0008] For example, when the engagement of the clutch is fast in timing with respect to the depression of the accelerator pedal at the start of the vehicle, the load on the engine is increased, thereby resulting in a high possibility to give rise to an engine stall. On the contrary, when the engagement of the clutch is delayed in timing with respect to the depression of the accelerator pedal at the start of the vehicle, there causes a slipping in the clutch, thereby resulting in abrasions of the clutch as well as deteriorated fuel efficiency. Under this condition, the engine is increased in rotation, thereby possibly causing abrupt movement of the vehicle.

[0009] In view of these problems, there has so far been proposed a vehicular control apparatus that can facilitate the operation of the clutch pedal at the start of the vehicle. The known vehicular control apparatus is disclosed for example in the Japanese Patent Publication No. 2001-263138.

[0010] The known vehicular control apparatus disclosed in the Japanese Patent Publication No. 2001-263138 is provided with a manual transmission and a manual clutch and is adapted to control the engine. The above vehicular control apparatus is provided with a control unit for controlling the engine with a target rotation speed larger than the rotation speed at the time of an idling operation of the engine in accordance with the position of the clutch when the vehicle speed is below a predetermined value, the manual transmission has a predetermined gear shift state, and the accelerator pedal is not depressed with a throttle valve being smaller in opening degree than a predetermined value.

[0011] The above vehicular control apparatus thus constructed is adapted to control the engine with the target rotation speed of the engine in response to the position of the clutch at the start of the vehicle so that the vehicle can smoothly be started without any depression of the accelerator pedal.

[0012] Japanese Patent Publication No. H06-146945 discloses a vehicle having a manual transmission and a manual clutch, and another vehicular control apparatus for lessening load on a driver at the hill start of the vehicle.

[0013] The above vehicular control apparatus disclosed in Japanese Patent Publication No. H06-146945 comprises stop state detection means for detecting a stopped state of the vehicle, slope detection means for detecting an inclination of a road surface, start operation detection means for detecting a start operation by the driver, cruising state detection means for detecting cruising state being transferred to a predetermined cruising state, and torque control means for controlling the engine to increase the torque at the time of an idling operation of the engine in response to the inclination of the road surface from the starting operation in the stop state of the vehicle is detected by the start operation detection means until the cruising state is detected by the cruising state detection means.

[0014] The above vehicular control apparatus can increase the torque at the time of the idling operation of the engine in response to the inclination of the road surface, thereby making it possible to prevent an engine stall and the backward movement of the vehicle even if the clutch comes to be engaged while the accelerator pedal remains lacking the operation amount of the accelerator pedal at the start of the vehicle.

[0015] The conventional vehicular apparatus, however, is considered with respect to the idle starting operation, i.e., the starting operation only with the clutch pedal operated, but not considered with respect to the concurrent operations of the accelerator pedal and the clutch pedal at the start of the vehicle. Therefore, the clutch pedal operation at the time of the ordinary starting operation of the vehicle with the accelerator pedal depressed to increase the rotation number of the engine tends to become more rough than the operation to be performed only with the clutch pedal and thus without the accelerator pedal, thereby resulting in a high possibility in giving rise to an engine stall.

[0016] The clutch can be brought into the transmission state by synchronizing the rotation speeds of the output shaft of the engine and the input shaft of the transmission at the stroke position of the clutch pedal returned slightly from the maximum clutch stroke position at the time of the idle starting operation. In contrast, at the time of the ordinary starting operation, the rotation speeds of the output shaft of the engine and the input shaft of the transmission come to be synchronized with each other at the stroke position of the clutch pedal returned considerably from the maximum clutch stroke position, resulting from the high rotation speed of the engine and the large output torque. For this reason, the clutch is required to be operated at a small clutch stroke position at the time of the ordinary starting operation as compared with at the time of the idle starting operation. At this small clutch stroke position, the varied amount of the torque with respect to the varied stroke of the clutch pedal position becomes large. This makes it difficult to harmonize the operations of the clutch pedal and the accelerator pedal, thereby resulting in a high probability in giving rise to an engine stall.

[0017] As has been understood from the foregoing description, the vehicular control apparatuses disclosed in the above Japanese Patent Publications encounter such problems that an engine stall cannot be completely prevented from occurring at the time of the starting operation of the vehicle with the operations of the clutch pedal and the accelerator pedal.

{Summary of Invention}

[0018] The present invention is made for solving the above problems encountered by the conventional vehicular control apparatuses. It is, therefore, an object of the present invention to provide a vehicular control apparatus which can prevent an engine stall without unnecessarily increasing the rotation number of the engine at the time of starting operation with the accelerator pedal and the clutch pedal.

[0019] In view of the problems described above, a vehicular control apparatus (1) according to the present invention includes increasing and decreasing means for increasing and decreasing an output of an internal combustion engine, changing means for changing one of a transmission state and a non-transmission state into the other of the transmission state and the non-transmission state, the transmission state allowing a driving force outputted from the internal combustion engine to be transmitted while the non-transmission state allowing the driving force from the internal combustion engine to be not transmitted, speed detecting means for detecting a speed of a vehicle, operation detecting means for detecting an operation of the increasing and decreasing means and an operation amount thereof, state detecting means for detecting whether or not the changing means starts changing the non-transmission state into the transmission state, and control means for controlling the internal combustion engine in accordance with a control amount in a case that the speed of the vehicle detected by the speed detecting means is less than a predetermined value, the operation of the increasing and decreasing means is detected by the operation detecting means, and a start of changing the non-transmission state into the transmission state by the changing means is detected by the state detecting means, in which the control amount including a first control amount defined in response to the operation amount of the increasing and decreasing means and a second control amount having a value larger when the operation detecting means detects a large operation amount than when the operation detecting means detects a small operation amount.

[0020] With the structure thus described, even if the operation of the changing means becomes rough due to the concurrent operations of the increasing and decreasing means and the changing means, the fact that the control means sets the second control amount in response to the possibility of an engine stall makes it possible to reliably prevent an engine stall from occurring without unnecessarily increasing the engine rotation number.

[0021] In the vehicular control apparatus (1), as an additional feature (2), the control means may have a maximum value larger when the operation detecting means detects a large operation amount than when the operation detecting means detects a small operation amount.

[0022] Accordingly, even if the operation of the changing means becomes rough due to the concurrent operations of the increasing and decreasing means and the changing means, the fact that the control means sets the second control amount in response to the possibility of an engine stall makes it possible to reliably prevent the engine stall from occurring without unnecessarily increasing the engine rotation number.

[0023] In the vehicular control apparatus (1) with the additional feature (2) described above, as an additional feature (3), the vehicular control apparatus may further include real rotation number detecting means for detecting a real rotation number of the internal combustion engine, and in which the control means has a target value of rotation number of the internal combustion engine set higher in response to a larger operation amount of the increasing and decreasing means, and the second control amount is set in response to a difference between the target value of the rotation number and the real rotation number.

[0024] Accordingly, the fact that the control means sets the target value of the rotation number of the engine at a higher value for the start of the vehicle that has a high possibility of the real rotation number of the engine being abruptly decreased resulting from a large operation amount of the increasing and decreasing means allows the output of the internal combustion engine to be increased with the control amount including the second control amount set before the real rotation number of the internal combustion engine starts being abruptly decreased, thereby making it possible to reliably prevent an engine stall.

[0025] In the vehicular control apparatus (1) with the additional feature (3) described above, as an additional feature (4), the control means may be operative to start setting the second control amount under a condition that the real rotation number of the internal combustion engine is lower than the target value of the rotation number.

[0026] Accordingly, the control means can prevent the rotation number of the engine from being unnecessarily increased without setting the second control amount in the cruising state of the vehicle having a low possibility of an engine stall, thereby preventing a fuel efficiency of the vehicle from being deteriorated.

[0027] In the vehicular control apparatus (1) with the additional features of up to (4) described above, as an additional feature (5), the control means may be operative to finish setting the second control amount when the speed of the vehicle exceeds a predetermined value.

[0028] Accordingly, the control means can finish setting the second control amount when the possibility of an engine stall becomes low at the start of the vehicle. As a consequence, the rotation number of the engine can be prevented from being unnecessarily increased.

[0029] In the vehicular control apparatus (1) with the additional features of up to (5) described above, as an additional feature (6), the state detecting means may be operative to detect whether or not the changing means is being operated, and the control means may be operative to finish setting the second control amount when the changing means being not operated is detected by the state detecting means.

[0030] Accordingly, the control means can finish setting the second control amount when the possibility of an engine stall becomes low at the start of the vehicle. As a result, the rotation number of the engine can be prevented from being unnecessarily increased.

[0031] In the vehicular control apparatus (1) with the additional features of up to (6) described above, as an additional feature (7), the second control amount may be indicative of either one of a torque amount of the internal combustion engine and an opening degree of a throttle valve for adjusting an air amount to be introduced into the internal combustion engine.

[0032] Accordingly, the fact that the control means can control the torque amount of the internal combustion engine and the opening degree of the throttle valve as the second control amount when start moving the vehicle makes it possible to reliably prevent the engine from stalling.

Effect of Invention

[0033] According to the present invention, provided is a vehicular control apparatus capable of preventing an engine stall from occurring without unnecessarily increasing the rotation number of the engine when start moving the vehicle with the operations of the accelerator pedal and the clutch pedal.

{Brief Description of Drawings}

[0034]

{Fig. 1} FIG. 1 is a schematic diagram of a power train mounted on a vehicle according to an embodiment of the present invention;
{Fig. 2} FIG. 2 is a cross-sectional view of a clutch mechanism according to the embodiment of the present invention;
{Fig. 3} FIG. 3 is a graph illustrating the relations of clutch stroke and clutch torque of the clutch mechanism according to the embodiment of the present invention;
{Fig. 4} FIG. 4 is a schematic illustrating a target rotation number map according to the embodiment of the present invention;
{Fig. 5} FIG. 5 is a schematic illustrating a guard map according to the embodiment of the present invention;
{Fig. 6} FIG. 6 is a timing chart illustrating an assist control according to the embodiment of the present invention;
{Fig. 7} FIG. 7 is a flow chart illustrating the assist control according to the embodiment of the present invention;
{Fig. 8} FIG. 8 is a flow chart illustrating a starting condition determination control according to the embodiment of the present invention;
{Fig. 9} FIG. 9 is a flow chart illustrating a feedback control according to the embodiment of the present invention;
{Fig. 10} FIG. 10 is a flow chart illustrating a releasing condition determination control according to the embodiment of the present invention; and
{Fig. 11} FIGS. 11A and 11B are graphs illustrating examples of the assist control according to the embodiment, FIG. 11A being graphs depicting the vehicle characteristics at start off with the assist control according to the embodiment of the present invention, while FIG. 11B being graphs depicting the conventional vehicle characteristics at start off without the assist control.

{Description of Embodiment}

[0035] The control apparatus for the engine according to an embodiment of the present invention will be explained hereinafter with reference to FIGS. 1 to 11B. The construction of the control apparatus will firstly be explained.
[0036] As shown in FIG. 1, the power train mounted on the vehicle 1 comprises an engine 11 serving as an internal combustion engine, a manual transmission 12 capable of changing speeds in response to the operations performed by a driver, and a clutch mechanism 13 capable of selectively connecting and disconnecting the driving force from the engine 11 to the transmission 12.
[0037] The engine 11 has a cylinder block formed with a plurality of cylinders in the form of a cylindrical shape and mounted on a vehicle body by way of an engine mount, a plurality of pistons axially slidably received in the respective cylinders, a cylinder head mounted on the cylinder block, air inlet valves for selectively opening and closing air inlet ports 17 formed in the cylinder head, and exhaust valves for selectively opening and closing exhaust gas ports 18 formed in the cylinder head. The cylinder block and the cylinder head combined with the pistons form combustion chambers 19. The following description about the present embodiment will be directed to a gasoline engine of the type having four cylinders.
[0038] Each of the air inlet port 17 is connected to an air inlet pipe 23 through an air inlet manifold 21 and a surge tank 22. The air inlet pipe 23 has an air inlet opening having an air cleaner 24 installed therein. In the air inlet pipe 23 is installed an electronically controlled throttle apparatus 26 having a throttle valve 25 therein. Each of the exhaust port 18 is connected to an exhaust pipe 28 through an exhaust manifold 27.
[0039] In the neighborhood of each air inlet port 17 is disposed an injector 29 for injecting fuel into the corresponding combustion chamber 19. In the upper portion of each combustion chamber 19 is provided an ignition plug 16 for igniting a mixture of gasoline and air.
[0040] The engine 11 has a crank shaft serving as an output shaft 32 to output the driving force from the engine 11 and being connected through a clutch mechanism 13 with an input shaft 33 of the manual transmission 12. The clutch mechanism 13 is constructed to be changed between a transmission state in which the output shaft 32 of the engine 11 is connected with the input shaft 33 of the transmission 12 to have the driving force from the output shaft 32 of the engine 11 transmitted to the input shaft 33 of the transmission 12 and a non-transmission state in which the output shaft 32 of the engine 11 is disconnected from the input shaft 33 of the transmission 12 to have the driving force from the output

shaft 32 of the engine 11 not transmitted to the input shaft 33 of the transmission 12. The state transition in the clutch mechanism 13 between the transmission state and the non-transmission state is performed in response to the depressed position of a clutch pedal 35 to be operated by the driver, i.e., in response to a clutch stroke Cs. This means that the clutch mechanism 13 assumes the transmission state in which the clutch pedal 35 is not depressed, viz., being not operated, and the non-transmission state in which the clutch pedal 35 is fully depressed, so that the clutch mechanism 13 can transmit the driving force from the output shaft 32 of the engine 11 to the input shaft 33 of the transmission 12 when the clutch mechanism 13 assumes the transmission state, while the clutch mechanism 13 cannot transmit the driving force from the output shaft 32 of the engine 11 to the input shaft 33 of the transmission 12 when the clutch mechanism 13 assumes the non-transmission state. It will be understood that the clutch pedal 35 constitutes changing means capable of changing between the transmission state having the driving force from the output shaft 32 of the engine 11 transmitted to the input shaft 33 of the transmission 12 and the non-transmission state having the driving force from the output shaft 32 of the engine 11 not transmitted to the input shaft 33 of the transmission 12. The clutch pedal 35 constitutes part of the vehicular control apparatus according to the present invention.

[0041] The manual transmission 12 has an output shaft 36, and a plurality of gear trains capable of reducing the rotations of the input shaft 33 at predetermined transmission gear ratios to rotate the output shaft 36. The manual transmission 12 is designed to change the power transmission paths between the input shaft 33 and the output shaft 36 in response to the operation of the shift lever 37 by the driver. Further, the manual transmission 12 is set with the speed ratios corresponding to the power transmission paths.

[0042] The shift lever 37 is constructed to assume a neutral position at which the input shaft 33 and the output shaft 36 of the manual transmission 12 are disconnected from each other and thus cause no power transmission therebetween, a reverse position at which the vehicle 1 can be moved backwardly with the input shaft 33 and the output shaft 36 being rotated in rotation directions opposite to each other, and a drive range including first to fifth gear positions corresponding to the predetermined speed ratios of the manual transmission 12.

[0043] Next, the construction of the clutch mechanism 13 according to the embodiment of the present invention will be explained hereinafter with reference to FIG. 2, schematically showing the cross-sectional view of the clutch mechanism 13.

The clutch mechanism 13 is constructed by a friction clutch of a single dry plate type. The clutch mechanism 13 comprises a disc-shaped flywheel 42 integrally rotated with the crank shaft 32, a clutch disc 43 integrally rotated with the input shaft 33, an annular pressure plate 44 for pressuring the clutch disc 43 toward the flywheel 42, a disc-shaped diaphragm spring 45 for imparting a pressure force to the pressure plate 44, and a clutch cover 46 integrally rotated with the flywheel 42.

[0044] The flywheel 42 is adapted to be rotated by the rotation torque outputted by the engine 11 through the crank shaft 32. The clutch disc 43, the pressure plate 44, and the diaphragm spring 45 are accommodated in the clutch cover 46 in axial alignment with the flywheel 42 and the clutch cover 46.

[0045] The clutch disc 43 is splined to the input shaft 33 so that the clutch disc 43 can be integrally rotated with the input shaft 33 and can be axially moved with respect to the input shaft 33.

[0046] The pressure plate 44 is engaged with the annular outer peripheral portion 45a of the diaphragm spring 45 to be resiliently urged toward the flywheel 42 by the diaphragm spring 45. The pressure force toward the flywheel 42 by the diaphragm spring 45 causes the pressure plate 44 to be pressed to the clutch disc 43, thereby generating a friction force between the clutch disc 43 and the flywheel 42. The friction force thus generated causes the flywheel 42 and the clutch disc 43 to be brought into engagement with each other, viz., resulting in the transmission state in which the flywheel 42 and the clutch disc 43 are integrally rotated with each other. In this way, the power transmission between the engine 11 and the manual transmission 12 is established.

[0047] The diaphragm spring 45 is in the form of a conical shape tapered away from the engine 11 and has an annular peripheral portion 45a formed with a plurality of tongue-like levers radially inwardly extending toward the center axis of the input shaft 33. The diaphragm spring 45 has a center portion 45b to which the radially inner ends of the tongue-like levers extend, and a support portion 45c between the annular peripheral portion 45a and the tongue-like levers. The diaphragm spring 45 in the form of a conical shape tapered away from the engine 11 functions as a disc spring.

[0048] The diaphragm spring 45 is positioned in axial alignment with the input shaft 33 with the support portion 45c being retained by the radially inner ends 46a of the clutch cover 46, with the outer peripheral portion 45a being held in engagement with the pressure plate 44, and with the center portion 45b held in engagement with a release sleeve 55. The release sleeve 55 is formed with a center through bore 55a allowing the input shaft 33 to pass therethrough. The release sleeve 55 has an annular projection 55b projecting from the outer peripheral surface thereof.

[0049] In the vicinity of the clutch pedal 35 (see FIG. 1) is provided a master cylinder not shown in the drawings. The master cylinder has a piston reciprocally received therein and formed with a pair of hydraulic chambers separated by the piston drivably connected with the clutch pedal 35. The master cylinder is operative to reciprocate the piston in response to the operation of the clutch pedal 35.

[0050] The clutch mechanism 13 further comprises a release fork 54 having one end portion to be held in engagement with the annular projection 55b of the release sleeve 55, and a release cylinder 52 for operating the release fork 54. The release cylinder 52 has a piston reciprocally received therein and formed with a pair of hydraulic chambers separated by the piston drivably connected with the other end portion of the release fork 54. The release fork 54 can be swung around the center pin 54a when the release cylinder 52 is operated.

[0051] The cylinder portions of the master cylinder and the release cylinder 52 are held in communication with each other by a clutch pipe 53. The cylinder portions of the master cylinder and the release cylinder 52, and the passageway of the clutch pipe 53 are filled with clutch fluid.

[0052] The operation of the clutch mechanism 13 will then be explained hereinafter.

The clutch pedal 35 is firstly depressed to operate the master cylinder and the release cylinder 52. At this time, the release fork 54 is swung around the center pin_54a to have the release sleeve 55 axially moved toward the flywheel 42. The axial movement of the release sleeve 55 causes inner ends of the diaphragm spring 45 to be resiliently deformed toward the flywheel 42. As a consequence, the pressure force of the diaphragm spring 45 to the pressure plate 44 is decreased so that the friction force between the clutch disc 43 and the flywheel 42 can be lowered. It will be understood from the foregoing description that the friction force between the clutch disc 43 and the flywheel 42 can be varied in response to the depressing operation of the clutch pedal 35 (see FIG.1) in the clutch mechanism 13 according to the present embodiment of the present invention.

[0053] When the clutch mechanism 13 is held in the transmission state, the friction force between the clutch disc 43 and the flywheel 42 becomes large so that the flywheel 42, the clutch disc 43, and the pressure plate 44 are integrally rotated, thereby transmitting the driving force from the engine 11 to the manual transmission 12. At this time, the transmitted torque becomes a maximum.

[0054] When the clutch mechanism 13 is held in a half transmission state, viz., between the transmission state and the non-transmission state, the friction force between the clutch disc 43 and the flywheel 42 becomes smaller than the friction force between the clutch disc 43 and the flywheel 42 in the transmission state, viz., the friction forces between the clutch disc 43 and the flywheel 42 being intermediate between in the transmission state and the non-transmission state so that the flywheel 42, the clutch disc 43, and the pressure plate 44 rotate while slipping with respect to one another. At this time, the transmitted torque in the half transmission state becomes smaller than that of the transmission state.

[0055] The clutch mechanism 13 thus constructed has a torque capacity Tc in response to a depressed amount of the clutch pedal 35 operated by the driver, viz., a torque capacity Tc in response to a clutch stroke Cs as shown in FIG. 3. Generally, the amount of changes in clutch torque capacity in response to the amount of changes in clutch stroke Cs becomes largest when the clutch stroke Cs is at near the center of its stroke range. For example, in FIG. 3, the amount of changes in the clutch torque capacity Tc at the clutch stroke Cs2 position is larger than the amount of changes in the clutch torque capacity Tc at the clutch stroke Cs1 position when the clutch stroke Cs is minutely changed. In the following explanation, the amount of changes in the clutch torque capacity Tc in response to the amount of changes in clutch stroke Cs becomes a maximum when the clutch stroke Cs is in the vicinity of 50% position.

[0056] Returning to FIG. 1, the output shaft 36 of the manual transmission 12 is drivably connected with right and left drive wheels 59 through a propeller shaft 56, differential gears 57, and drive shafts 58.

[0057] The vehicle 1 has mounted thereon an engine control apparatus 100 constituting the vehicular control apparatus according to the embodiment of the present invention. The engine control apparatus 100 is constituted by a known electronic control unit (hereinafter simply referred to as "ECU"), and is operative to control the torque outputted from the engine 11.

[0058] The engine control apparatus 100 is constituted by a microcomputer having a CPU (Central Processing Unit), a RAM (Random Access Memory), a ROM (Read Only Memory), an input port, and an output port, which are all connected with one another through an interactive bus. The CPU is operative to process signals in compliance with a program and a map stored in the ROM in advance while utilizing a memory function of the RAM to execute the output control of the engine 11. The signal outputted from the output port is to be transmitted to an actuator and the like through a D/A converter.

[0059] The engine control apparatus 100 is operative to control the opening degree of the throttle valve 25 of the electronically operated throttle apparatus 26, the fuel injection amount and the timing of the injector 29, and the ignition timing of the ignition plug 16 in accordance with the signals inputted into the CPU from various sensors which become apparent as the description proceeds.

[0060] The vehicle 1 is provided with an engine rotation number sensor 40, an input shaft rotation number sensor 64, a speed sensor 65, and a speed meter 68 indicative of cruising speed of the vehicle 1.

[0061] The engine rotation number sensor 40 is constructed to detect the real rotation number Nereal of the engine 11 in accordance with the rotation of the crank shaft 32. The engine rotation number sensor 40 thus constructed constitutes detection means for detecting the real rotation number of the engine 11, and constitutes part of the vehicular control apparatus according to the present invention.

[0062] The speed sensor 65 is adapted to output to the engine control apparatus 100 the signal indicative of the rotation number of the output shaft 36 of the manual transmission 12, so that the engine control apparatus 100 can calculate the speed V of the vehicle in accordance with the signal inputted therein. The speed sensor 65 thus constructed constitutes speed detection means for detecting the speed of the vehicle 1, and constitutes part of the vehicular control apparatus according to the present invention.

[0063] The input shaft rotation number sensor 64 is adapted to output to the engine control apparatus 100 the signal indicative of the rotation number of the input shaft 33 of the manual transmission 12.

[0064] The vehicle 1 is provided with an accelerator pedal 61, and an accelerator sensor 62 for detecting the operation amount, i.e., the opening degree of the accelerator pedal 61. The accelerator sensor 62 is constituted, for example, by an electronically operated position sensor using a hall element and adapted to output to the engine control apparatus 100 the signal indicative of an accelerator opening degree Acc, viz., indicative of the position as well as the operation of the accelerator pedal 61 when the accelerator pedal 61 is operated by the driver. The engine control apparatus 100 is operative to control the opening degree of the throttle valve 25 of the electronically operated throttle apparatus 26, the fuel injection amount and the timing of the injector 29, and the ignition timing of the ignition plug 16, so that the engine 11 can produce a required torque amount Te in response to the accelerator opening degree Acc. The accelerator pedal 61 and the accelerator sensor 62 collectively constitute part of the vehicular control apparatus according to the present invention.

[0065] The vehicle 1 is provided with a clutch pedal switch 63. The clutch pedal switch 63 has a first sensor for detecting whether or not the clutch stroke Cs of the clutch pedal 35 assumes a minimum position, i.e., a 0% position, and a second sensor for detecting whether or not the clutch stroke Cs of the clutch pedal 35 assumes a maximum position, i.e., a 100% position. The clutch pedal switch 63 is designed to transmit a signal indicative of CsMAX=ON to the engine control apparatus 100 when the clutch pedal 35 is depressed to a maximum level by the driver, while to transmit a signal indicative of Cs0=ON to the engine control apparatus 100 when the clutch pedal 35 is not depressed, viz., being not operated, by the driver. The clutch pedal switch 63 is designed to transmit a signal indicative of CsMAX=OFF and a signal indicative of Cs0=OFF to the engine control apparatus 100 when the clutch stroke Cs of the clutch pedal 35 assumes neither the minimum position nor the maximum position. It will therefore be understood that the engine control apparatus 100 and the clutch pedal switch 63 collectively constitute detecting means for detecting whether or not the changing means starts moving from the non-transmission state to the transmission state and whether or not the changing means is being operated, and constitute part of the vehicular control apparatus according to the present invention.

[0066] The specific construction of the engine control apparatus 100 according to the embodiment of the present invention will further be explained hereinafter.

The engine control apparatus 100 is adapted to execute an assist control of having the torque of the engine 11 increased in order to prevent an engine stall from occurring resulting from the operation of the clutch pedal 35 by the driver to start moving the vehicle 1.

[0067] At the start of the vehicle 1, the depressed amount of the accelerator pedal 61, i.e., the accelerator opening degree Acc becomes larger in response to the higher expectation by the driver to the acceleration of the vehicle 1. Further, the releasing amount of the clutch pedal 35 returning towards its original position from the maximum depressed position of the clutch pedal 35 becomes larger in response to the higher expectation by the driver to the acceleration of the vehicle 1. In other words, the higher the driver expects to the acceleration of the vehicle 1, the larger the requirement arises to increase the clutch torque capacity Tc. This leads to the clutch engagement being performed at the small clutch stroke Cs.

[0068] Here, the clutch torque variation dTc in response to the minute variation dCs of the clutch stroke Cs becomes larger as the clutch stroke Cs becomes smaller as the clutch pedal 35 is released and the clutch torque variation dTc in response to the minute variation dCs of the clutch stroke Cs becomes largest in the vicinity of the clutch stroke Cs of 50%, viz., in the vicinity of the clutch stroke Cs2 shown in FIG. 3.

[0069] The motion equation at the starting time of the vehicle 1 is given as follows.

$$Ie \times d\omega e/dt = Te - Tc \qquad (1)$$

Here, "Ie" represents a rotational inertia moment of the engine 11, "ωe" represents an angular velocity of the crank shaft 32, "Te" represents an engine side torque amount to be transmitted to the crank shaft 32, and "Tc" represents the clutch side torque amount, i.e., clutch torque capacity. Generally, the clutch side torque amount Tc has a value two to three times larger than the engine side torque amount Te for preventing the slipping of the clutch. The clutch pedal 35 abruptly released to its original position by the driver leads to the abruptly increased clutch side torque amount Tc. As a consequence, the angular velocity ωe is abruptly decreased if the engine side torque amount Te is constant. As compared with the idle starting time of the vehicle 1 without depressing the accelerator pedal 61, the starting time of the vehicle 1 with the accelerator pedal 61 and the clutch pedal 35 concurrently depressed requires two pedals to be concurrently operated. Therefore, the operation of the clutch pedal 35 tends to be lowered in accuracy, thereby raising a possibility that the clutch side torque amount Tc is abruptly increased.

[0070] At the normal start of the vehicle 1, the larger the depressed amount of the accelerator pedal 61 is, the smaller the clutch stroke Cs of the clutch pedal 35 being engaged becomes, so that the real engine rotation number Nereal has a high possibility to abruptly drop. It is, nevertheless, assumed that the real engine rotation number Nereal for starting the torque assist control is set at the idle rotation number similar to the conventional assist control at the start of the vehicle 1. In this case, there is a high possibility that the assist control is not performed in time, viz., delayed and thereby causes the engine 11 to stall when the real engine rotation number Nereal abruptly drops.

[0071] In view of this problem, the vehicular control apparatus according to the present embodiment is constructed to set a target engine rotation number Neref in response to the depressed amount of the accelerator pedal 61 so that the assist control can be executed when the real engine rotation number Nereal is below the target engine rotation number Neref as will be understood from the description appearing hereinafter.

[0072] The target engine rotation number Neref can be set from the equation (2) as follows.

$$\mathrm{Neref} = k \times d\mathrm{Tc}/d\mathrm{Cs} \qquad (2)$$

Here, "dTc" represents a minute variation of the torque capacity, and "dCs" represents a minute variation of the clutch stroke. Further, "k" is a coefficient which can be obtained from various values of the engine 11 and the clutch mechanism 13. The coefficient is predetermined from the various experimentally measured values.

[0073] The target engine rotation number Neref is stored in the ROM as a target rotation number map as shown in FIG. 4. The engine control apparatus 100 is adapted to obtain the signal indicative of the accelerator opening degree Acc from the accelerator sensor 62 when the starting conditions of assist control are established and to set the target engine rotation number Neref in response to the accelerator opening degree Acc in accordance with the signal thus obtained. It will therefore be understood that the engine control apparatus 100 constitutes setting means for setting the target engine rotation number Neref of the internal combustion engine at a larger value in response to the detected operation amount of the accelerator pedal 61 with respect to the initial condition of the accelerator pedal 61. Further, the engine control apparatus 100 is adapted to control the engine 11 such that the real engine rotation number Nereal follows the target engine rotation number Neref by the feedback control which will become apparent as the description proceeds. The initial condition here means the condition that the acceleration pedal 61 is not being operated by the driver.

[0074] Here, the accelerator opening degree Acc by the operation of the accelerator pedal 61 and the clutch stroke Cs of the clutch pedal 35 are in compliance with the driver’s expectation with respect to the vehicle 1 as explained in the foregoing description. In the target rotation number map according to the present embodiment, the maximum position of the opening degree Acc of the accelerator pedal 61 and the clutch stroke Cs=50% position of the clutch pedal 35 are set to match with each other.

[0075] The engine control apparatus 100 is designed to perform the assist control to increase the output torque of the engine 11 without the real engine rotation number Nereal being below the target engine rotation number Neref at the time of calculating the target engine rotation number Neref.

[0076] In the assist control, the engine control apparatus 100 is designed to perform a feedback control of having the real engine rotation number Nereal follow the target engine rotation number Neref to give rise to the assist torque of the engine 11.

[0077] In the feedback control, the engine control apparatus 100 is designed to use the real engine rotation number Nereal and the target engine rotation number Neref to calculate a feedback value FB1 with the following equation (3).

[0078]

$$\begin{aligned}&\mathrm{FB1}(\mathrm{Neref}-\mathrm{Nereal})\\&=\mathrm{Kp}\times(\mathrm{Neref}-\mathrm{Nereal})+\mathrm{Ki}\times\int(\mathrm{Neref}-\mathrm{Nereal})dt+\mathrm{Kd}\times d(\mathrm{Neref}-\mathrm{Nereal})/dt \qquad (3)\end{aligned}$$

"Kp", "Ki", and "Kd" respectively represent a proportional gain, an integral gain, and a differential gain which are determined beforehand in accordance with the properties of the engine 11. Here, in order to shorten the time for calculating the feedback value FB1, the derivative term can be calculated using the following equations (4) to (6).

[0079]

$$d(\mathrm{Neref}-\mathrm{Nereal})/dt \leftarrow \mathrm{Te}-\mathrm{Tc} \qquad (4)$$

$$Te=Fe(Acc, Ne) \quad (5)$$

$$Tc=Fc(Cs) \quad (6)$$

Here, "Fe" in the equation (5) is a function to relate the accelerator opening degree Acc and the real engine rotation number Nereal to the torque Te outputted from the engine 11. This function is experimentally determined beforehand in accordance with the output characteristics of the engine 11, and its data is stored as one of the maps in the ROM. "Fc" in the equation (6) is a function to relate the clutch stroke Cs to the clutch side torque amount Tc. This function is also experimentally determined beforehand in accordance with the characteristics shown in FIG. 3, and its data is stored as one of the maps in the ROM. In this case, it is preferable that, in lieu of the clutch pedal switch 63, a clutch pedal switch capable of continuously detecting the clutch stroke Cs from 0% to 100% be used according to the present invention.

[0080] The engine control apparatus 100 is designed to execute a guard process to the feedback value FB1 calculated thereby. The guard process is performed in accordance with a guard map shown in FIG. 5. The data of the guard map is stored beforehand in the ROM. If the feedback value FB1 calculated in accordance with the above equation (3) is above a predetermined value "a", the feedback value FB2 used for calculating an assist torque amount ATe of the engine 11 is given "a" without exception. If the feedback value FB2 calculated in accordance with the above equation (3) is below a predetermined value "-b", the feedback value FB2 used for calculating the assist torque amount ATe is given "-b" without exception. The predetermined values "a" and "b" are determined for the purpose of preventing the acceleration of the vehicle 1 from being abruptly fluctuated in such a way that the assist torque ATe is abruptly increased or decreased by the large absolute value of the feedback value FB1 due to the abrupt fluctuation of the depressed amount of the accelerator pedal 61 while the assist control being executed. The predetermined values "a" and "b" are obtained in accordance with the results of experimental measurement performed in advance.

[0081] The predetermined values "a" and "b" may be the same values. The engine control apparatus 100 may have the ROM stored the information of a plurality of guard maps indicative of the predetermined values "a" and "b" varied in response to the accelerator opening degree Acc. In this case, each of the guard maps in the ROM corresponds to the respective predetermined range of the accelerator opening degree Acc. The guard map is prepared in such a manner that the predetermined values "a" and "b" in the guard map corresponding to a small range of the accelerator opening degree Acc is smaller than the predetermined values "a" and "b" in the guard map corresponding to a large range of the accelerator opening degree Acc.

[0082] The engine control apparatus 100 is designed to increase the amount of torque outputted by the engine 11 in accordance with the feedback value FB2. More specifically, the engine control apparatus 100 is operative in accordance with a throttle opening degree map indicative of the relation between the opening degree of the throttle and the required torque amount Te, i.e., the engine side torque amount, corresponding to the depressed amount of the accelerator pedal 61. The engine control apparatus 100 is also operative in accordance with an assist map indicative of the relation between the feedback value FB2 and the assist torque amount ATe. The engine control apparatus 100 is constructed to allow the ROM to store in advance the information of an opening degree correction map indicative of the relation between the assist torque amount ATe and the increased amount of the throttle opening degree to correct the throttle opening degree in response to the assist torque amount ATe. The engine control apparatus 100 is designed to obtain the assist torque amount ATe with reference to the assist map when calculated the feedback value FB2. The throttle valve 25 is adapted to be controlled by correcting the throttle opening degree obtained from the throttle opening degree map in accordance with the increased amount of the throttle opening degree obtained from the opening degree correction map.

[0083] Here, the required torque amount Te of the engine 11 in the present embodiment constitutes a first control amount defined in the present invention, while the assist torque amount ATe of the engine 11 constitutes a second control amount defined in the present invention. The engine control apparatus 100 according to the present invention constitutes control means for controlling the internal combustion engine in accordance with the first and the second control amounts, the first control amount being in response to the depressed amount of the accelerator pedal 61 detected while the second control amount being at least larger when the depressed amount is large than when the depressed amount is small. In other words, the engine control apparatus 100 is operative with the maximum value of the second control amount being larger when the depressed amount is large than when the depressed amount is small. The engine control apparatus 100 is operative with the second control amount being set in response to the difference between the target engine rotation number Neref and the real engine rotation number Nereal.

[0084] The above present embodiment has been explained about the engine control apparatus 100 for controlling the engine 11 in accordance with the addition of the required torque amount Te and the assist torque ATe, viz., the addition of the first and the second control amounts. According to the present invention, the engine control apparatus 100 may be operative with the correction ratio to the required torque Te calculated as the second control amount in place of the assist torque amount ATe. In this case, the engine control apparatus 100 is to be operative to control the engine 11 in accordance with the control amount obtained by multiplying the first and the second control amounts defined in the present invention.

[0085] According to the present invention, the required torque amount Te and the assist torque amount ATe may be replaced with a throttle valve opening degree obtained from the throttle opening degree map and a correction amount obtained from the opening degree correction map. In this case, the throttle valve opening degree and the correction amount respectively constitute the first and the second control amounts defined in the present invention. The engine control apparatus 100 may be constructed to store a correction map defined to correct the control amount with respect to the control for the fuel injection amount, for example, for increasing the torque generated by the engine in place of the opening degree correction map according to the present invention. Further, the engine control apparatus 100 may be constructed to store the correction map defined to correct both the throttle valve opening degree and the fuel injection amount according to the present invention.

[0086] The engine control apparatus 100 is adapted to finish the assist control when the possibility of an engine stall is lowered. More specifically, the engine control apparatus 100 is adapted to finish the assist control by determining that the possibility of the engine stall is lowered when the clutch mechanism 13 is completely shifted into the non-transmission state or the speed V of the vehicle 1 becomes above a predetermined value Vtho. At this time, the engine control apparatus 100 is operative to control the assist torque to gradually be close to zero so that the cruising state of the vehicle 1 can be prevented from being abruptly changed. The predetermined value Vtho is defined as a vehicle speed the vehicle 1 usually reaches when the clutch mechanism 13 is brought into the transmission state at the start of the vehicle 1. In other words, the engine control apparatus 100 is operative to finish setting the second control amount when the vehicle speed of the vehicle 1 becomes above the predetermined value. Further, the engine control apparatus 100 is operative to finish setting the second control amount when the changing means is detected to be not operated.

[0087] The assist control of the engine control apparatus 100 will then be described hereinafter with reference to FIG. 6 showing a timing chart for the assist control.

[0088] When the driver operates an ignition switch at the time t0, the engine 11 is started and the real engine rotation number Nereal begins to rise (see a solid line 87).

[0089] When the clutch pedal 35 is depressed by the driver at the time t1, the clutch stroke Cs reaches CsMAX (see a solid line 82).

[0090] When the shift lever 37 is operated by the driver at the time t2, the shift position is moved to the first gear position from the neutral position (a solid line 81).

[0091] When the accelerator pedal 61 is depressed by the driver at the time t3 to increase the accelerator opening degree Acc (see a solid line 83) concurrently with the throttle valve opening being increased (see a solid line 84). When the clutch pedal 35 is then started to be released by the driver at the time t4, the clutch stroke Cs is being reduced (see a solid line 82). At this time, the starting condition of the assist control is established to start calculating the target engine rotation number Neref in response to the accelerator opening degree Acc (see a solid line 86).

[0092] Here, in the case that the real engine rotation number Nereal is below the target engine rotation number Neref, the engine control apparatus 100 starts calculating the assist torque amount ATe. More specifically, the engine control apparatus 100 is operated to add the required torque amount Te defined in response to the accelerator opening degree Acc and the assist torque ATe (see a solid line 88) calculated from the feedback value FB2 to have an added torque, with which the engine 11 is controlled by the engine control apparatus 100 to generate a torque amount equal to the added torque. At this time, the engine control apparatus 100 is operated to allow the throttle opening degree to be increased so that the torque amount outputted from the engine 11 can be increased by the assist torque amount ATe with respect to the accelerator opening degree Acc (see a dotted line 85) corresponding to the required torque amount Te (see a solid line 84). Therefore, the engine control apparatus 100 starts setting the second control amount in the case that the real engine rotation number of the internal combustion engine is lowered below the target engine rotation number of the internal combustion engine. According to the present invention, the engine control apparatus 100 may be constructed to start calculating the assist torque ATe at the time t4 regardless whether or not the real engine rotation number Nereal is below the target engine rotation number Neref in place of calculating the assist torque ATe in the case that the real engine rotation number Nereal is below the target engine rotation number Neref. In this case, the engine control apparatus 100 is constructed to have the assist torque amount ATe set at zero until the real engine rotation number Nereal is below the target engine rotation number Neref.

[0093] When the driver then finishes depressing the clutch pedal 35, viz., fully released and not operated, at the time t5 (see the solid line 82), the engine control apparatus 100 judges that the releasing condition of the assist control is established to finish calculating the target engine rotation number Neref (see a solid line 86). At this time, the engine control apparatus 100 is operated to gradually reduce the throttle valve opening degree to have the torque amount from the engine 11 equal to the required torque amount Te (see the solid line 84).

[0094] The operation will then be explained with reference to FIGS. 7 to 10. The following process is executed at a predetermined interval by the CPU in accordance with a program stored in the ROM in advance.

[0095] As shown in FIG. 7, the engine control apparatus 100 is operated to execute a starting condition determination control for determining whether or not the starting condition of the feedback control with respect to the torque assist is established (Step 1). The starting condition determination control will become apparent as the description proceeds.

[0096] The engine control apparatus 100 is operated to move to Step 3 in the case that the starting condition of the feedback control is determined to be established as a result of the starting condition determination control (YES in Step 2). On the other hand, the engine control apparatus 100 is operated to move to RETURN in the case that the starting condition of the feedback control is determined to be not established as a result of the starting condition determination control (NO in Step 2).

[0097] The engine control apparatus 100 is then operated to execute the feedback control with respect to the torque assist to prevent an engine stall from occurring at the start of the vehicle 1 (Step S3). The feedback control will also become apparent as the description proceeds.

[0098] The engine control apparatus 100 is then operated to execute the releasing condition determination control for determining whether or not the releasing condition for releasing the feedback control is established (Step S4). The releasing condition determination control will also become apparent as the description proceeds.

[0099] The engine control apparatus 100 is then operated to move to Step 6 in the case that the releasing condition for releasing the feedback control is determined to be established as a result of the releasing condition determination control (YES in Step S5). At this time, the calculation of the target engine rotation number Neref is finished and the assist torque amount ATe is set at zero. On the other hand, the engine control apparatus 100 is operated to move to RETURN in the case that the releasing condition for releasing the feedback control is determined to be not established as a result of the releasing condition determination control (NO in Step S5).

[0100] The starting condition determination control of the engine control apparatus 100 will then be explained with reference to FIG. 8.

[0101] The engine control apparatus 100 is operated to obtain signals respectively detected by the accelerator opening degree sensor 62, the clutch pedal switch 63, and the speed sensor 65 (Step S11).

[0102] The engine control apparatus 100 is then operated to determine whether or not the clutch pedal 35 is started to be released. More specifically, the engine control apparatus 100 is operated to move to Step 13 in the case that the signal inputted from the clutch pedal switch 63 in Step 11 is a signal indicative of the clutch pedal 35 being started to be released, viz., indicative of Cs0=OFF and CsMAX=OFF (YES in Step S12). On the contrary, the engine control apparatus 100 is operated to move to RETURN after determining that the starting condition is not established (Step S16) in the case that the signal inputted from the clutch pedal switch 63 is determined to be indicative of Cs0=ON or CsMAX=ON (NO in Step S12).

[0103] The engine control apparatus 100 is then operated to determine whether or not the signal inputted from the accelerator opening degree sensor 62 in Step S11 is an ON signal indicative of the accelerator pedal 61 being depressed (Step S13). More specifically, the engine control apparatus 100 is operated to move to Step 14 in the case that the signal inputted from the accelerator opening degree sensor 62 in Step S11 is determined to be an ON signal indicative of the accelerator pedal 61 being depressed (YES in Step S13). On the other hand, the engine control apparatus 100 is operated to move to RETURN after determining that the starting condition is not established (Step S16) in the case that the signal inputted from the accelerator opening degree sensor 62 in Step S11 is determined to be an OFF signal indicative of the accelerator opening degree Acc being 0% (NO in Step S 13).

[0104] The engine control apparatus 100 is then operated to determine (Step S 14) whether the vehicle speed V is below or above the predetermined value Vtho in accordance with the signal inputted from the vehicle speed sensor 65 in Step S11. The engine control apparatus 100 is then operated to move to RETURN after determining (Step S15) that the starting condition is established in case that the vehicle speed V is determined to be below the predetermined value Vtho (YES in Step S14). On the other hand, the engine control apparatus 100 is then operated to move to RETURN after determining (Step S16) that the starting condition is not established in case that the vehicle speed V is determined to be above the predetermined value Vtho (NO in Step S 14).

[0105] In the case that the vehicle 1 is provided with a neutral position sensor for detecting the neutral position of the shift lever 37, the above starting condition determination control may include an additional starting condition under which the shift lever 37 is not detected by the neutral position sensor according to the present invention. In the case that the vehicle 1 is provided with a position sensor for detecting the first gear position of the shift lever 37, the above starting condition determination control may include an additional starting condition under which the shift lever 37 is detected by the position sensor according to the present invention.

[0106] The feedback control to be executed by the engine control apparatus 100 will then be described hereinafter with reference to FIG. 9.

[0107] The engine control apparatus 100 is firstly operated to calculate the target engine rotation number Neref (Step S31). More specifically, the engine control apparatus 100 is operated to obtain the target engine rotation number Neref in response to the accelerator opening degree Acc while referring to the target rotation number map with the accelerator opening degree Acc obtained from the accelerator opening degree sensor 62. Further, the engine control apparatus 100 is repeatedly operated to calculate the target engine rotation number Neref (Step S31) until the real engine rotation number Nereal is below the target engine rotation number Neref.

[0108] The engine control apparatus 100 is then operated to calculate the feedback value FB2 (Step S32). More specifically, the engine control apparatus 100 is operated to obtain the signal indicative of the real engine rotation number Nereal from the engine rotation number sensor 40. The engine control apparatus 100 is operated to calculate the feedback value FB1 by using the above equation (1), with the target engine rotation number Neref obtained in Step 31 and the real engine rotation number Nereal. The engine control apparatus 100 calculates the feedback value FB2 by using the guard map shown in FIG. 5.

[0109] The engine control apparatus 100 is then operated to calculate the assist torque amount ATe (Step S33). More specifically, the engine control apparatus 100 is operated to calculate the assist torque amount ATe in response to the feedback value FB2 while referring to the assist map stored in the ROM.

[0110] The engine control apparatus 100 is then operated to control the engine 11 to output the torque amount equivalent to the addition of the required torque amount Te and the assist torque amount ATe. More specifically, the engine control apparatus 100 is operated to obtain the information about the throttle valve opening degree corresponding to the required torque Te in response to the depressed amount of the accelerator pedal 61 while referring to the throttle opening degree map stored in the ROM. The engine control apparatus 100 is operated to obtain an opening degree correction value for correcting the throttle valve opening degree to be increased corresponding to the assist torque amount ATe while referring to the throttle opening degree correction map stored in the ROM. The engine control apparatus 100 is then operated to control the throttle valve 25, when the feedback value FB2 is calculated, by correcting the throttle valve opening degree obtained from the throttle opening degree map with the opening degree correction value obtained from the opening degree correction map.

[0111] The releasing condition determination control to be executed by the engine control apparatus 100 will then be described hereinafter with reference to FIG. 10.

[0112] The engine control apparatus 100 is operated to obtain the signals from the clutch pedal switch 63 and the speed sensor 65 (Step S41).

[0113] The engine control apparatus 100 is then operated to determine whether or not the clutch pedal 35 is being depressed (Step S42). More specifically, the engine control apparatus 100 is operated to move to RETURN in the case that the releasing condition is determined to be established (Step S44) if the signal inputted from the clutch pedal switch 63 in Step S41 is a signal indicative of the clutch pedal 35 not being depressed, viz., indicative of Cs0=ON and Cs-MAX=OFF (YES in Step S42).

[0114] In contrast, the engine control apparatus 100 is then operated to move to Step S43 in the case of determining that a signal indicative of the clutch pedal 35 being depressed, viz., indicative of Cs0=OFF is obtained (NO in Step S42).

[0115] The engine control apparatus 100 is then operated to determine whether or not the vehicle speed V is above the predetermined value Vtho (Step S43) in accordance with the signal inputted from the speed sensor 65 in step 41. The engine control apparatus 100 is then operated to move to RETURN after determining that the releasing condition is established (Step S44) in the case that the vehicle speed V is determined to be above the predetermined value Vtho (YES in Step S43). On the other hand, the engine control apparatus 100 is then operated to move to RETURN after determining that the releasing condition is not established (Step S45) in the case that the vehicle speed V is determined to be below the predetermined value Vtho (NO in Step S43).

[0116] An example of the assist control according to the present embodiment will then be explained with reference to FIGS. 11A and 11B.

[0117] FIG. 11A is graphs showing the characteristics at the start of the vehicle 1 in case of carrying out the assist control according to the present embodiment.

[0118] The graph (a) shows the fluctuation of the real engine rotation number Nereal and the rotation number Ni of the input shaft 33. The graph (b) shows the fluctuation of the assist torque amount ATe. The graph (c) shows the fluctuation of the accelerator opening degree Acc. The graph (d) shows the fluctuation of the clutch stroke Cs, and the amount released from the maximum position, i.e., CsMAX.

[0119] The engine control apparatus 100 is then operated to start calculating the target engine rotation number Neref (see graph (a)) when the clutch pedal 35 is started to be released after the accelerator pedal 61 is depressed (see graphs (c) and (d)). At this time, when the real engine rotation number Nereal becomes below the target engine rotation number Neref due to the fact that the returning amount of the clutch pedal 35 becomes larger than the appropriate value, the engine control apparatus 100 is operated to calculate the assist torque amount ATe (see graph (b)) to perform the feedback control to have the real engine rotation number Nereal follow the target engine rotation number Neref. This makes it possible to prevent the real engine rotation number Nereal from being abruptly decreased from the target engine rotation number Neref (see graph (a)) so that the vehicle 1 can start with no engine stall.

[0120] In contrast, the engine control apparatus in the conventional vehicle with the assist control not performed is operated to not correct the torque amount outputted from the engine in the case that the clutch pedal is started to be released after the accelerator pedal is depressed (see graphs (c) and (d)) as shown in FIG. 11B. For this reason, the real engine rotation number Nereal is abruptly decreased (see graph (a)) due to the fact that the releasing amount of the clutch pedal becomes larger than the appropriate value, thereby making it impossible to maintain the real engine rotation number Nereal above the stall limit value of the engine. As a consequence, an engine stall occurs.

[0121] As previously mentioned, the engine control apparatus 100 can set the maximum value of the assist torque ATe at a high value in response to the possibility of an engine stall even if the operation of the clutch pedal 35 being rough due to the concurrent operations of the accelerator pedal 61 and the clutch pedal 35, so that the engine stall can reliably be prevented without unnecessarily increasing the engine rotation number.

[0122] Further, the engine control apparatus 100 can set the target engine rotation number Neref at a high value for the start of the vehicle 1 having a high possibility of the real engine rotation number Nereal being abruptly decreased resulting from the large operation amount of the accelerator pedal 61, so that the engine output torque can be increased with the assist torque amount ATe set before the real rotation number of the engine 11 starts being abruptly decreased, thereby making it possible to reliably prevent an engine stall.

[0123] The engine control apparatus 100 can prevent the real engine rotation number Nereal from unnecessarily being increased without setting the assist toque amount ATe in the cruising state having a low possibility of an engine stall, thereby preventing the fuel efficiency of the engine from being deteriorated, viz., improving the fuel efficiency of the engine.

[0124] The above description has been directed to the explanation about the engine control apparatus 100 which can perform the feedback control of having the real engine rotation number Nereal follow the target engine rotation number Neref. The engine control apparatus 100 may perform the assist control without performing the feedback control according to the present invention. In this case, the engine control apparatus 100 is required to have the ROM stored in advance the information about a map showing the relations of the accelerator opening degree Acc with the correction value of the throttle valve opening degree, or the assist torque amount ATe. When the above-described start condition is established, the engine control apparatus 100 is operated to keep increasing the torque outputted from the engine 11 based on this map until the release condition is established. The correction value of the throttle valve opening degree or the assist torque amount ATe is required to be at large values, respectively for the large accelerator opening degree Acc as compared with the small accelerator opening degree Acc. The correction value of the throttle valve opening degree or the assist torque amount ATe set in the above case are preferably be set at large values, respectively as compared with the correction value of the throttle valve opening degree or the assist torque amount ATe set in the idle assist control, so that the engine control apparatus 100 can prevent the real engine rotation number of the engine 11 from being abruptly decreased with a certainty.

[0125] The above description has been directed to the explanation about the assist control in the case that the accelerator pedal 61 is operated and the accelerator opening degree Acc is larger than zero. However, the engine control apparatus 100 may be operated, in addition to the assist control according to the present embodiment, to perform the idle assist control of the torque outputted from the engine 11 being increased in the case that the accelerator pedal 61 is not operated and the accelerator opening degree is being zero according to the present invention.

[0126] In this case, the engine control apparatus 100 performs the idle assist control after determining that the vehicle 1 is at the idle start if the signal inputted from the speed sensor 65 is indicative of the vehicle speed V=0, the accelerator opening degree Acc is zero, and the signal inputted from the clutch pedal switch 63 is a signal indicative of the clutch stroke Cs being not 0% and not a maximum value, viz., indicative of Cs0=OFF and CsMAX=OFF.

[0127] The engine control apparatus 100 is operated to switch to the assist control according to the present embodiment if obtained from the accelerator opening sensor 62 the signal indicative of the accelerator opening degree Acc having a value larger than zero.

[0128] From the foregoing description, the vehicular control apparatus according to the present invention can prevent an engine stall from occurring without unnecessarily increasing the engine rotation number when the vehicle is started with the operations of the accelerator pedal and the clutch pedal. The vehicular control apparatus according to the present invention is useful for controlling the manually operated transmission.

Claims

1. A vehicular control apparatus, comprising:

increasing and decreasing means for increasing and decreasing an output of an internal combustion engine;
changing means for changing one of a transmission state and a non-transmission state into the other of the transmission state and the non-transmission state, the transmission state allowing a driving force outputted from the internal combustion engine to be transmitted while the non-transmission state allowing the driving force from the internal combustion engine to be not transmitted;
speed detecting means for detecting a speed of a vehicle;

operation detecting means for detecting an operation of the increasing and decreasing means and an operation amount thereof;
state detecting means for detecting whether or not the changing means starts changing the non-transmission state into the transmission state; and
control means for controlling the internal combustion engine in accordance with a control amount in a case that the speed of the vehicle detected by the speed detecting means is less than a predetermined value, the operation of the increasing and decreasing means is detected by the operation detecting means, and a start of changing the non-transmission state into the transmission state by the changing means is detected by the state detecting means,
the control amount including a first control amount defined in response to the operation amount of the increasing and decreasing means and a second control amount having a value larger when the operation detecting means detects a large operation amount than when the operation detecting means detects a small operation amount.

2. The vehicular control apparatus as defined in claim 1 in which the second control amount has a maximum value larger when the operation detecting means detects a large operation amount than when the operation detecting means detects a small operation amount.

3. The vehicular control apparatus as defined in claim 2 which further comprises real rotation number detecting means for detecting a real rotation number of the internal combustion engine, and in which the control means has a target value of rotation number of the internal combustion engine set higher in response to a larger operation amount of the increasing and decreasing means, and the second control amount is set in response to a difference between the target value of the rotation number and the real rotation number.

4. The vehicular control apparatus as defined in claim 3 in which the control means is operative to start setting the second control amount under a condition that the real rotation number of the internal combustion engine is below the target value of the rotation number.

5. The vehicular control apparatus as defined in any one of claims 1 to 4 in which the control means is operative to finish setting the second control amount when the speed of the vehicle exceeds a predetermined value.

6. The vehicular control apparatus as defined in any one of claims 1 to 5 in which the state detecting means is operative to detect whether or not the changing means is being operated, and in which the control means is operative to finish setting the second control amount when the changing means being not operated is detected by the state detecting means.

7. The vehicular control apparatus as defined in any one of claims 1 to 6 in which the second control amount is indicative of either one of a torque amount of the internal combustion engine and an opening degree of a throttle valve for adjusting an air amount to be introduced into the internal combustion engine.

FIG.1

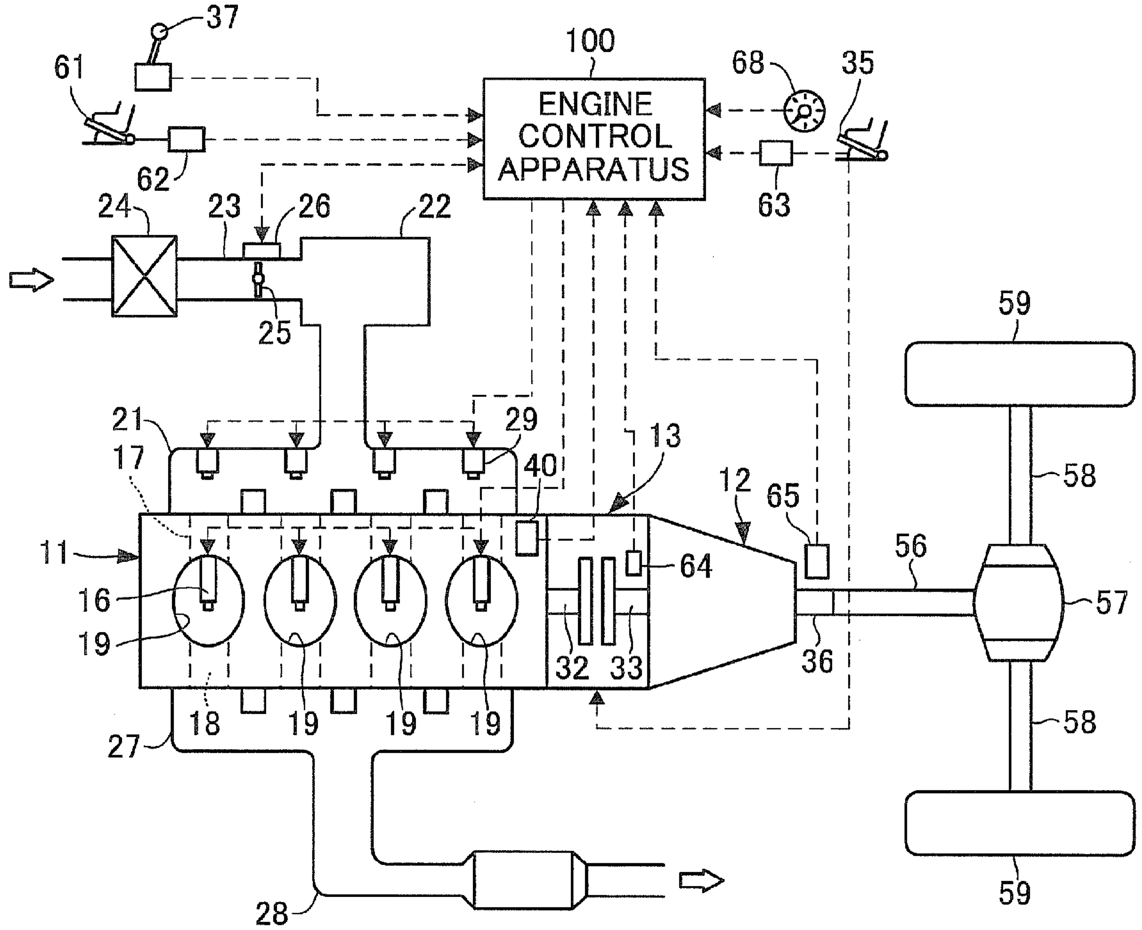

37
61
62
100
ENGINE
CONTROL
APPARATUS
68
35
63
24
23
26
22
25
59
21
29
13
17
40
12
65
58
11
64
56
16
57
19
32
33
36
18
19
19
19
58
27
28
59

FIG.2

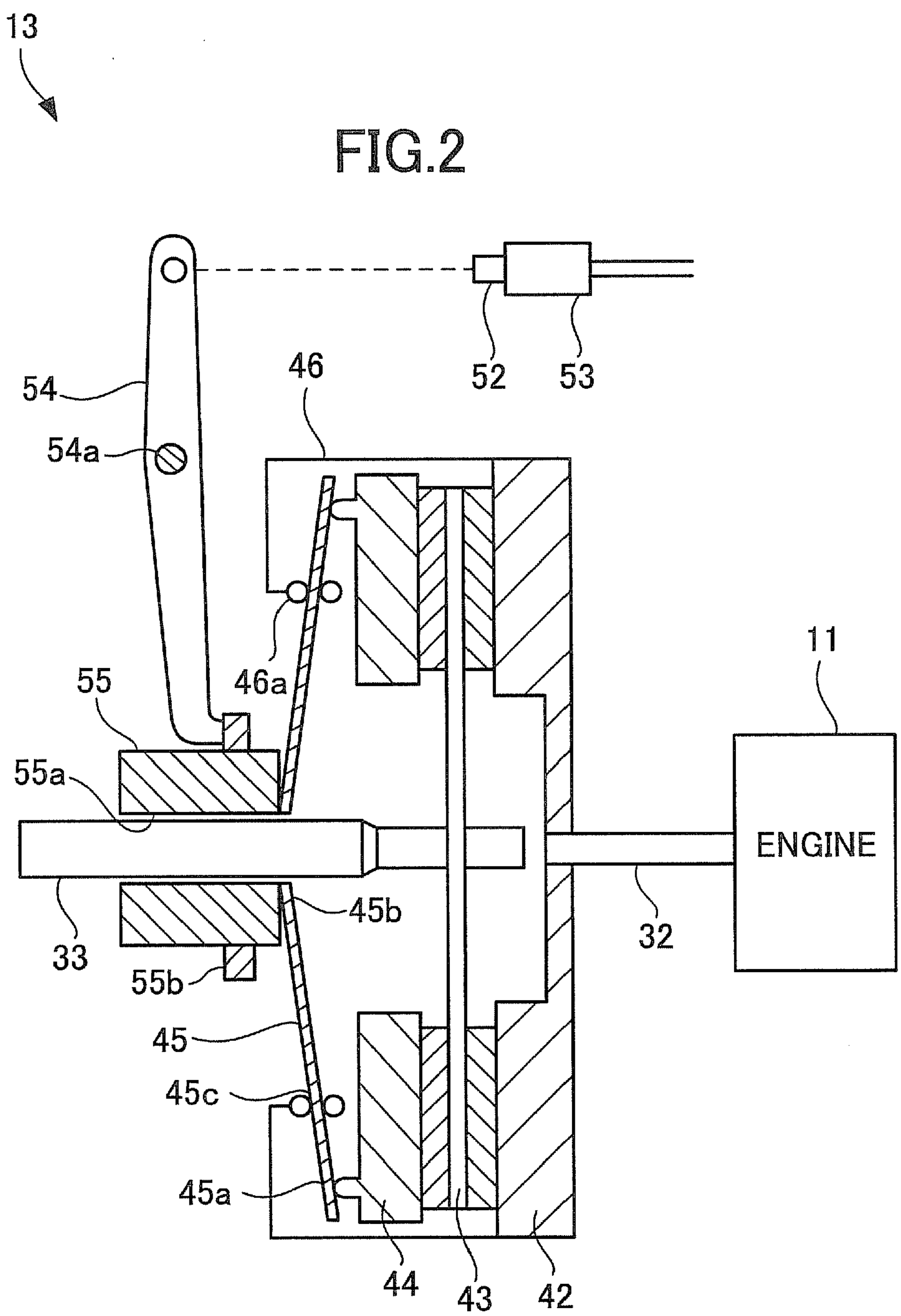

13
54
54a
46
52
53
46a
55
55a
11
ENGINE
45b
33
32
55b
45
45c
45a
44
43
42

FIG.3

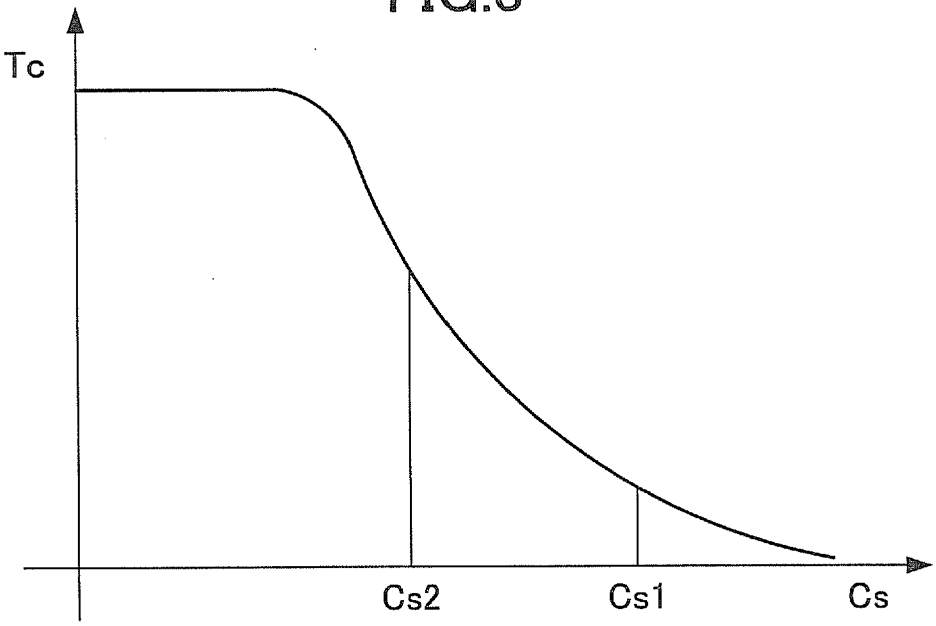


FIG.4

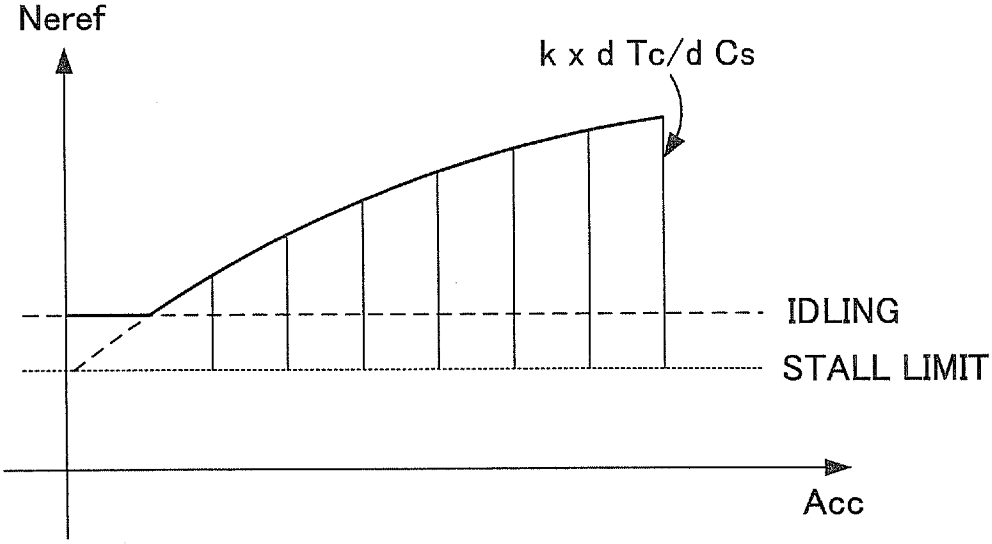


FIG.5

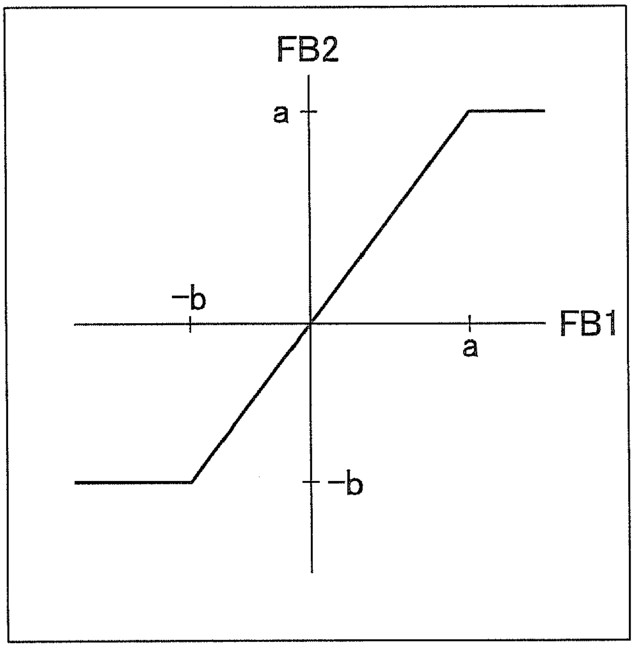


FIG.6

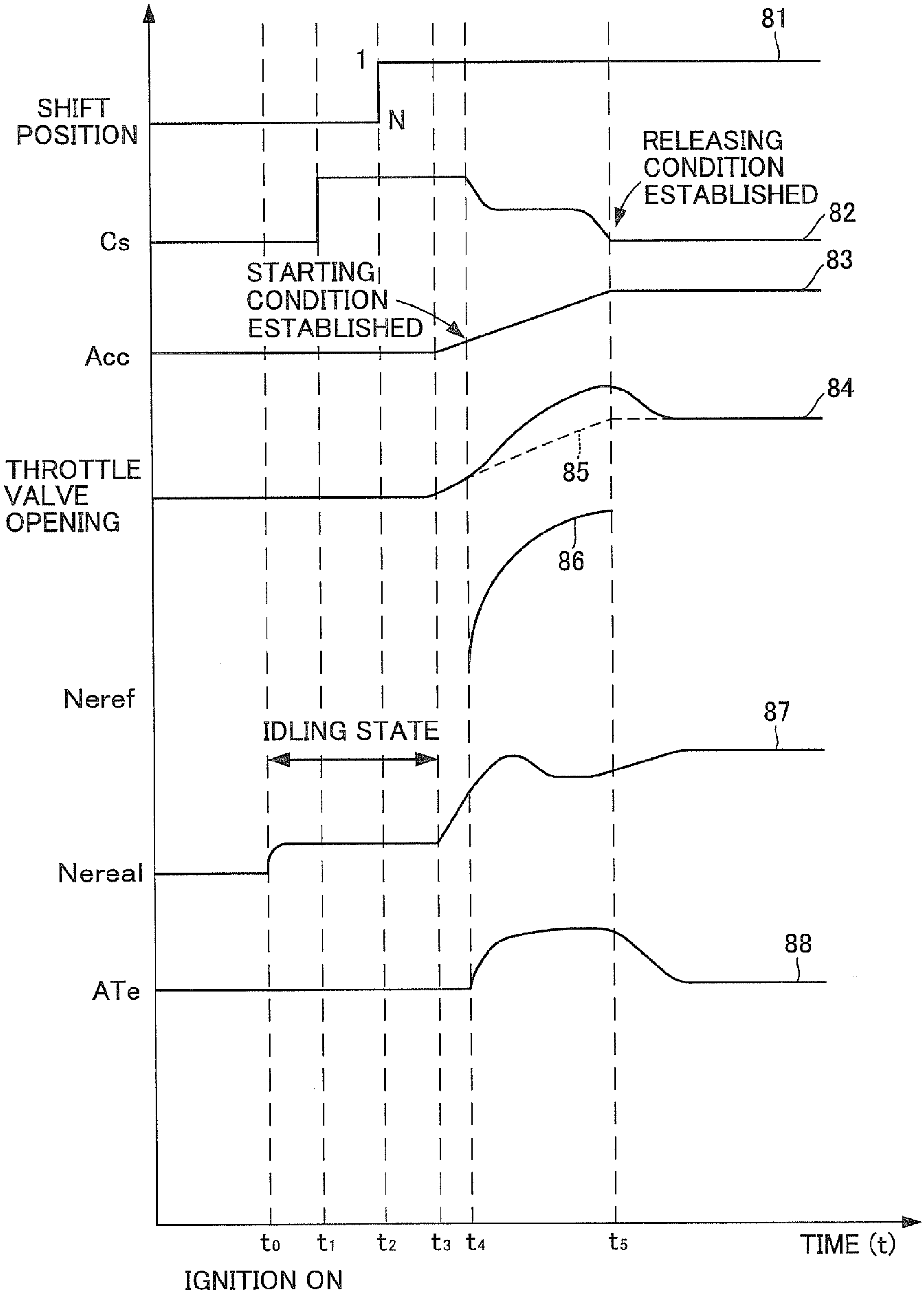

81
1
SHIFT POSITION
N
RELEASING CONDITION ESTABLISHED
82
Cs
83
STARTING CONDITION ESTABLISHED
Acc
84
THROTTLE VALVE OPENING
85
86
Neref
87
IDLING STATE
Nereal
88
ATe
t0 t1 t2 t3 t4 t5
TIME (t)
IGNITION ON

FIG.7

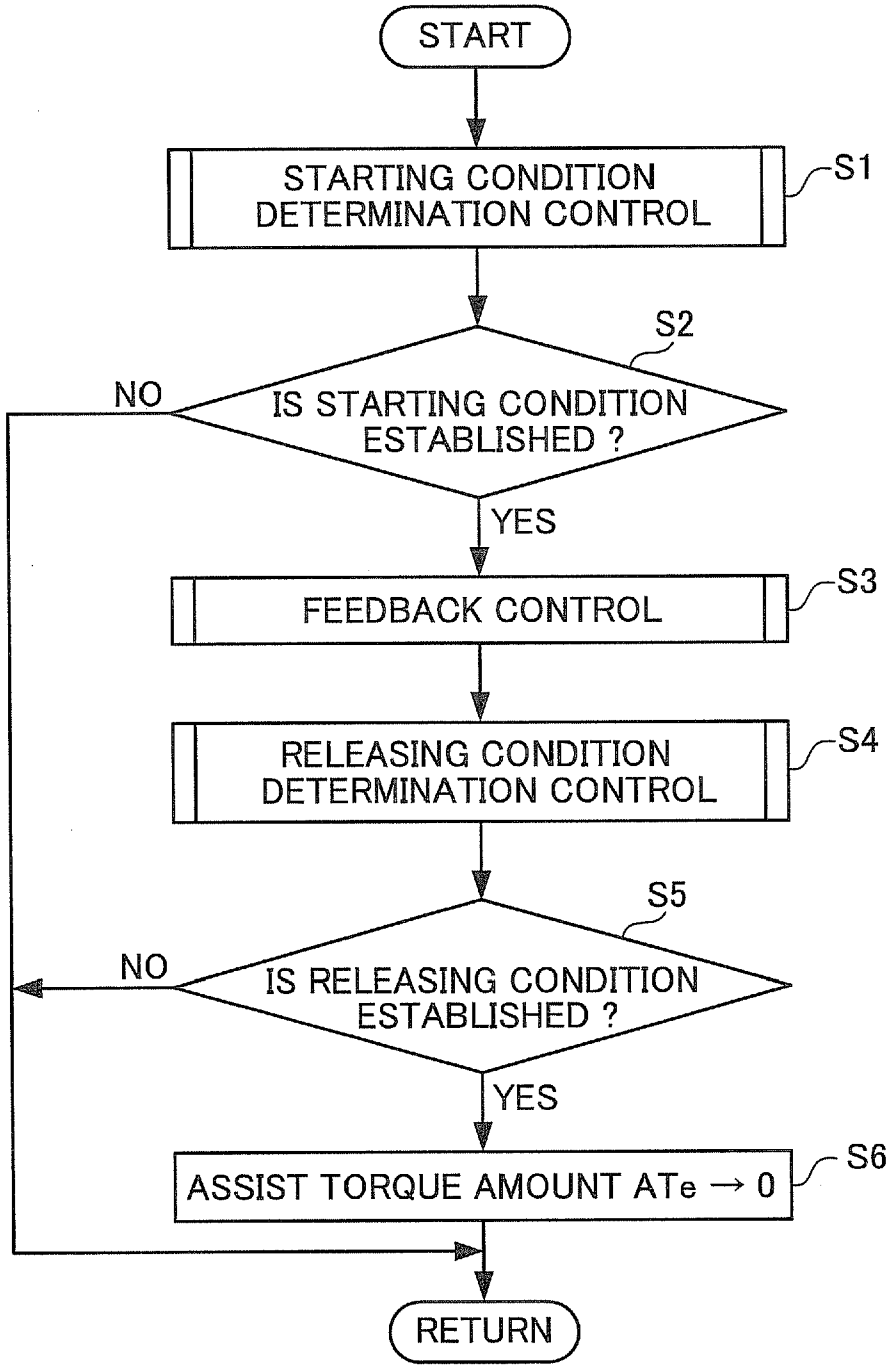

START
STARTING CONDITION DETERMINATION CONTROL
S1
S2
IS STARTING CONDITION ESTABLISHED ?
NO
YES
FEEDBACK CONTROL
S3
RELEASING CONDITION DETERMINATION CONTROL
S4
S5
IS RELEASING CONDITION ESTABLISHED ?
NO
YES
ASSIST TORQUE AMOUNT ATe → 0
S6
RETURN

FIG.8

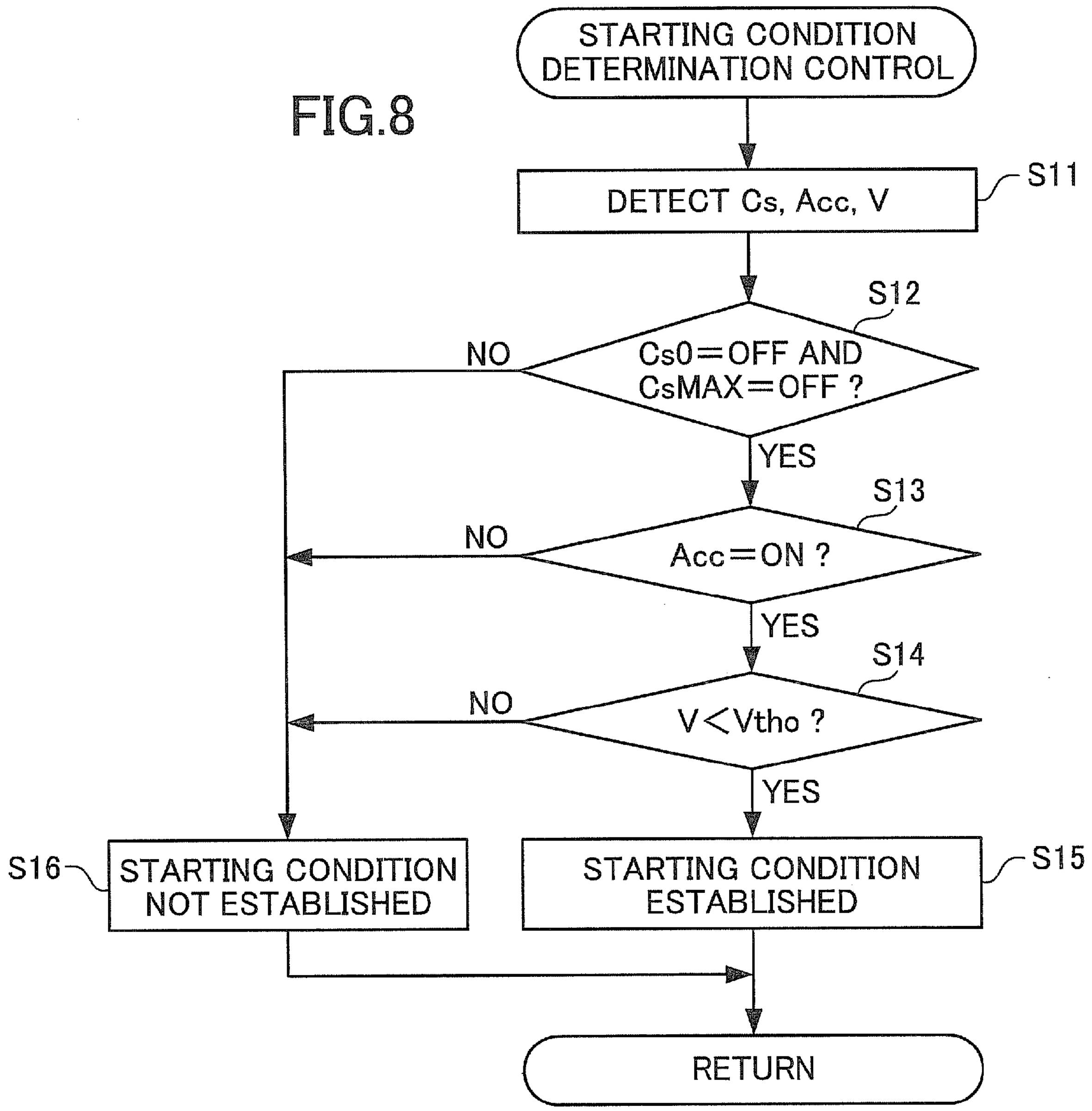

STARTING CONDITION DETERMINATION CONTROL
DETECT Cs, Acc, V
S11
S12
Cs0=OFF AND CsMAX=OFF ?
NO
YES
S13
Acc=ON ?
NO
YES
S14
V<Vtho ?
NO
YES
S16
STARTING CONDITION NOT ESTABLISHED
STARTING CONDITION ESTABLISHED
S15
RETURN

FIG.9

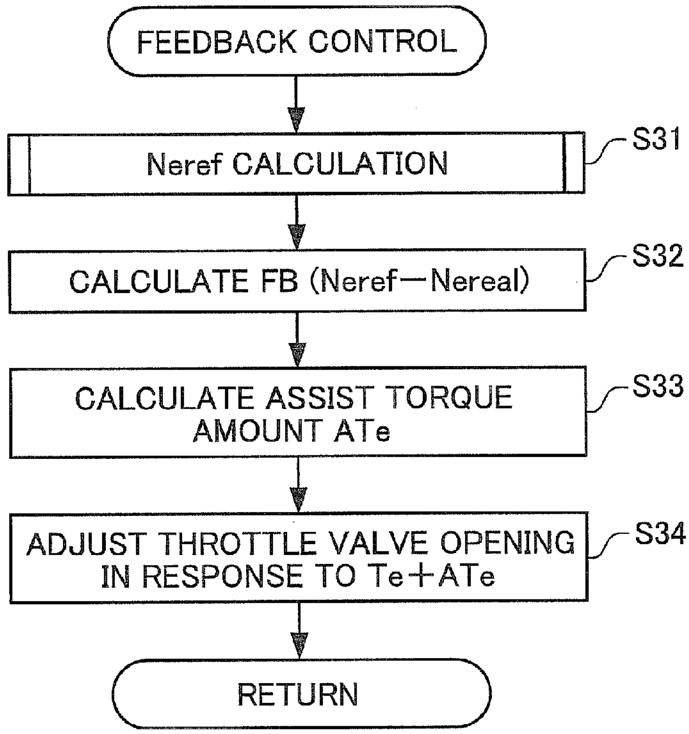
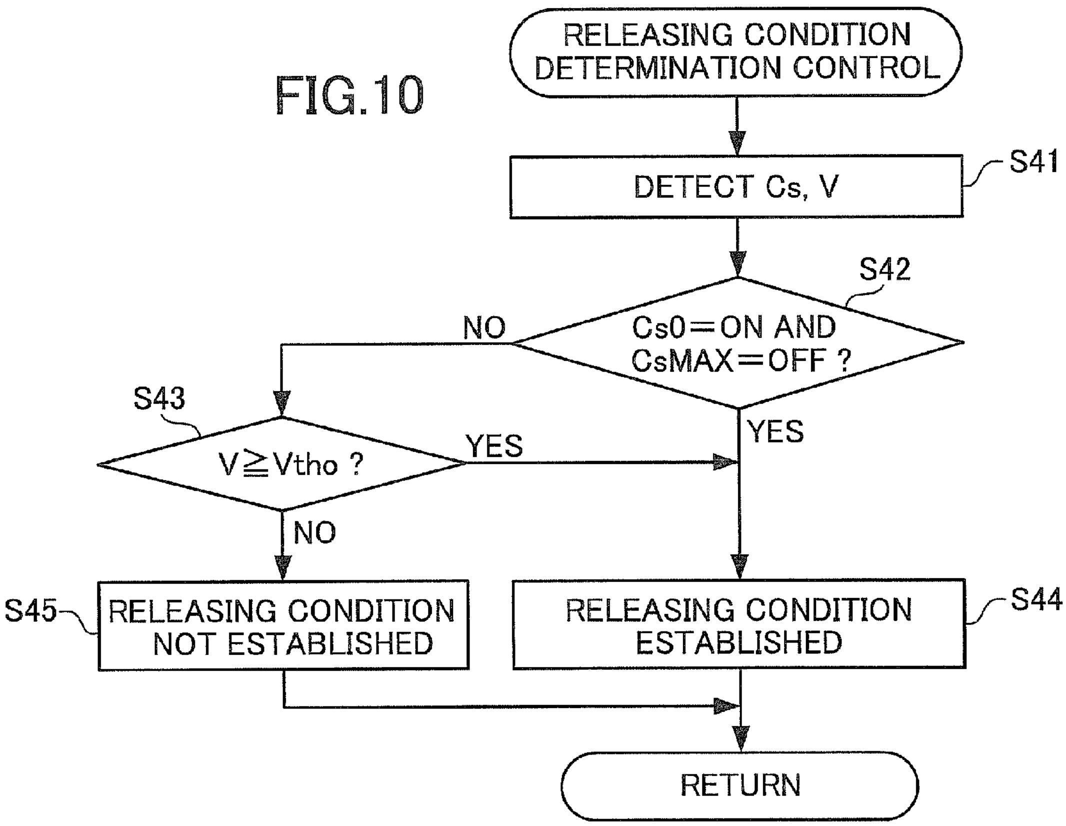
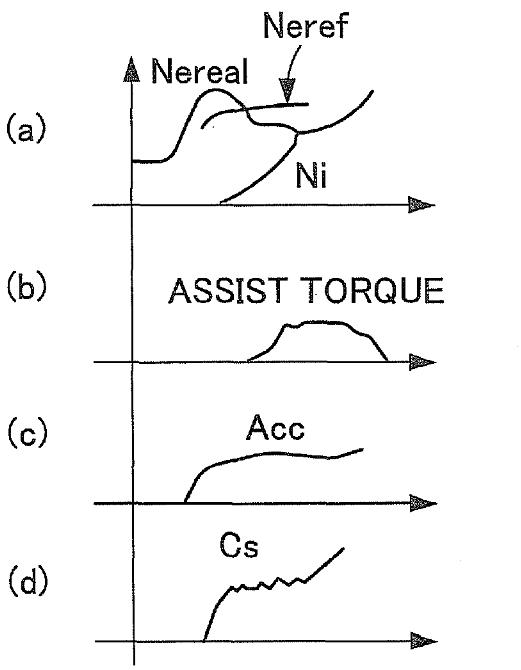

FEEDBACK CONTROL
Neref CALCULATION
S31
CALCULATE FB (Neref−Nereal)
S32
CALCULATE ASSIST TORQUE AMOUNT ATe
S33
ADJUST THROTTLE VALVE OPENING IN RESPONSE TO Te+ATe
S34
RETURN

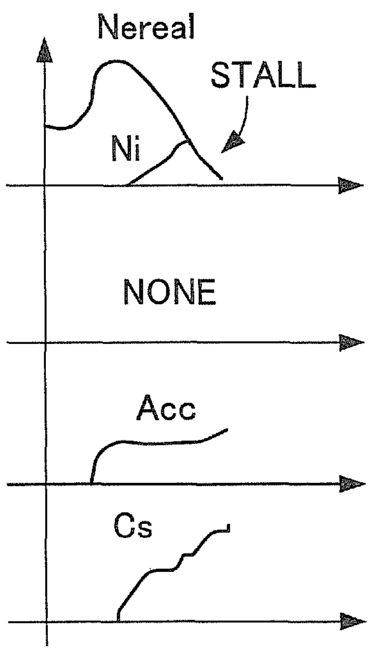
FIG.10


RELEASING CONDITION DETERMINATION CONTROL
DETECT Cs, V
S41
S42
Cs0=ON AND CsMAX=OFF ?
NO
YES
S43
V≧Vtho ?
YES
NO
S45
RELEASING CONDITION NOT ESTABLISHED
RELEASING CONDITION ESTABLISHED
S44
RETURN



NORMAL START
WITH ASSIST CONTROL

FIG.11A



NORMAL START
WITHOUT ASSIST CONTROL

FIG.11B

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2001263138 A **[0009] [0010]**
- JP H06146945 B **[0013]**