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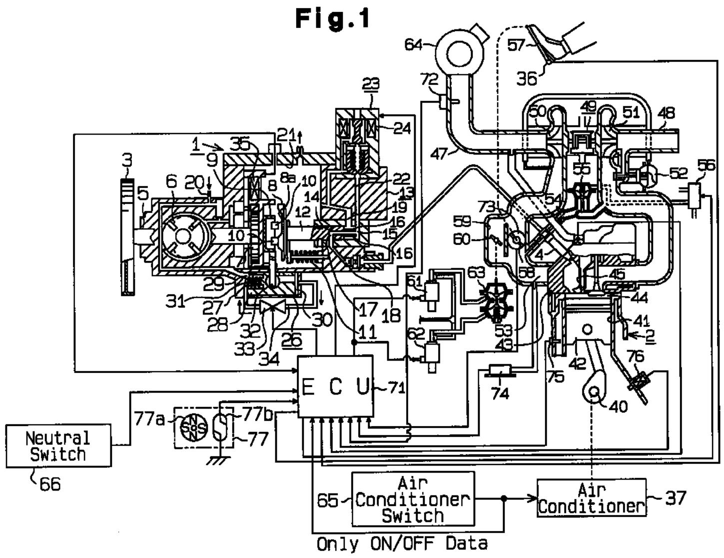
(54) Idle speed control apparatus for engine

(57) An apparatus for controlling the idle speed of an engine (2) is disclosed. The apparatus includes an electric control unit (ECU) (71) for controlling the engine speed, an air conditioner switch (65) for detecting application and removal of an external engine load, or air conditioner (37), and sensors (36, 66, 77) for detecting that the engine (2) is idling when the vehicle is stationary and when the vehicle is moving. The ECU (71) gradually increases the engine speed by a predetermined amount to shift the engine (2) to a raised idle state when the external engine load (37) is applied and gradually decreases the engine speed by the predetermined amount when the external engine load (37) is removed. The ECU (71) adjusts the engine speed at a certain rate when the vehicle is stationary and at a different rate when the vehicle is traveling.

Fig.1



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Description

TECHNICAL FIELD

[0001] The present invention relates to an apparatus for controlling idle speeds of vehicle engines, and more particularly, to an apparatus for controlling idle speeds of engines in accordance with a raised idle state of the engine.

RELATED BACKGROUND ART

[0002] Idling, as the term is used herein, occurs when the gas pedal is not depressed, regardless of whether the vehicle is traveling or not. The idle speed normally differs between when an external load (e.g., the load produced by an air conditioning system) is applied to the engine and when the engine is free from such load. When the load is not applied, the engine idles at a normal speed. However, the engine speed is increased by a predetermined amount when an external load is applied to improve the operation of the load source and to prevent the engine from stalling. The state where the idle speed is increased is referred to as a raised idle state.

[0003] The engine enters the raised idle state and returns to the normal idle state when certain conditions are satisfied. For example, if the air conditioner switch is turned on, the engine enters the raised idle state. If the air conditioner switch is turned off, the engine returns to the normal idle state. When shifting between idle states, the engine is controlled to prevent the engine speed from changing in a sudden manner due to sudden changes in the load applied to the engine. Japanese Unexamined Patent Publication No. 6-129292 describes a controller that prevents sudden changes in the idle speed.

[0004] With reference to the time charts of Figs. 12(a) to 12(c) and Figs. 12(a) to 12(c), the processing performed by the controller to control the engine's idle speed will now be described. Figs. 12(a) and 13(b) show the state of an air conditioner switch. Figs. 12(b) and 13(b) show the change of a fuel compensation amount used for correcting the amount of fuel injection. Figs. 12(c) and 13(c) show the fluctuation of the engine speed.

[0005] As shown in Fig. 12(a), the air conditioner switch is turned on at time point t1 thereby satisfying the raised idle condition. This adds a compensation amount NIP, which corresponds to the presumed fluctuation of the load applied to the engine, to a fuel compensation amount as shown in Fig. 12(b). The load fluctuation compensation amount NIP is the amount of fuel injection compensation that is necessary to maintain the same engine speed when the load of the air conditioner system is applied to the engine.

[0006] As time elapses from time point t1, the compensation amount is increased by incremental amounts ΔNIPAC in a gradual manner. The total of the incremental amounts ΔNIPAC causes the engine speed to increase by an idle compensation amount NIPACMX at time point t2. As shown in Fig. 12(c), the engine speed NE increases gradually from time point t1 in accordance with the increasing compensation amount. At time point t2, the engine speed NE reaches a target engine speed NTRG1.

[0007] The engine starts to return to the normal idle speed when the air conditioner switch is turned off at time point t3, as shown in Fig. 13(a). The stopping of the air conditioner system decreases the load applied to the engine. Thus, as shown in Fig. 13(b), the fuel injection compensation amount is decreased by the load fluctuation compensation amount NIP, which is the amount necessary to maintain the same engine speed.

[0008] As time elapses from time point t3, the compensation amount is decreased by the incremental amounts ΔNIPAC in a gradual manner until reaching the compensation amount corresponding to the normal idle state. As shown in Fig. 13(c), the engine speed NE decreases gradually in accordance with the decreasing compensation amount. At time point t4, the engine speed NE reaches a target engine speed NTRG2.

[0009] Accordingly, the idle speed changes are graded when the engine shifts between a normal idle state and a raised idle state. Thus, shocks, which are produced when the engine speed changes suddenly, are not experienced by passengers.

[0010] The incremental amount ΔNIPAC, or the grading rate for varying the engine speed when the engine shifts between the normal idle state and the raised idle state, has the same value regardless of whether the vehicle is traveling or not. Therefore, the incremental amount ΔNIPAC may be varied to optimize the grading rate. However, if the grading rate is too high, sudden acceleration or deceleration of the engine may be felt by the passengers when the vehicle is traveling. On the other hand, if the grading rate is too low, the change in engine speed may become slow if the vehicle is not moving, and the operator may experience an unusual engine response.

DISCLOSURE OF THE INVENTION

[0011] Accordingly, it is an objective of the present invention to provide an idle speed control apparatus that smoothly shifts an engine between different idle states. To achieve the above objective, the present invention provides an idle speed control apparatus for an engine including a controller for controlling the engine speed, a load detector for detecting the application and removal of an external engine load, and a vehicle state detector for detecting whether the engine is idling and whether the vehicle is moving. The controller gradually increases the engine speed from a normal idle state by a predetermined amount to shift the engine to a raised idle state when the external engine load is applied and gradually returns the engine speed to the normal idle state when the external engine load is removed. The controller changes the idle speed between the raised and normal states at a first rate when the vehicle is stationary and at a second, different rate when the vehicle is traveling.

[0012] Other aspects and advantages of the present invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The features of the present invention that are believed to be novel are set forth with particularity in the appended claims. The invention, together with objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

Fig. 1 is a schematic view showing a diesel engine idle speed controller according to the present invention;

Fig. 2 is a cross-sectional schematic view showing the fuel injection pump of Fig. 1;

Fig. 3 is a block diagram showing the circuit structure in the ECU of Fig. 1;

Fig. 4 is a flowchart showing an idle speed control routine;

Fig. 5 is a continuation of the flowchart of Fig. 4;

Fig. 6 is a flowchart showing a fuel injection control routine;

Fig. 7 is a flowchart showing an incremental amount computation routine;

Fig. 8 is a graph showing the relationship between the coolant temperature and the coolant temperature compensation coefficient;

Fig. 9 is a map showing the relationship between the engine speed and the governor injection amount;

Fig. 10(a) is a time chart showing the state of an air conditioner switch;

Fig. 10(b) is a time chart showing changes in the compensation amount;

Fig. 10(c) is a time chart showing the fluctuation of the engine speed;

Fig. 11(a) is a time chart showing the state of an air conditioner switch;

Fig. 11(b) is a time chart showing changes in the compensation amount;

Fig. 11(c) is a time chart showing the fluctuation of the engine speed;

Fig. 12(a) is a time chart showing the state of an air conditioner switch in the prior art;

Fig. 12(b) is a time chart showing changes in the compensation amount in the prior art;

Fig. 12(c) is a time chart showing the fluctuation of the engine speed in the prior art;

Fig. 13(a) is a time chart showing the state of an air conditioner switch in the prior art;

Fig. 13(b) is a time chart showing changes in the compensation amount in the prior art; and

Fig. 13(c) is a time chart showing the fluctuation of the engine speed in the prior art.

DESCRIPTION OF SPECIAL EMBODIMENT

[0014] A control apparatus according to the present invention for controlling the idle speed of a diesel engine in a vehicle will now be described with reference to the drawings. The controller controls the engine speed differently when the vehicle is traveling from when the vehicle is not traveling. More specifically, when the vehicle is traveling, the controller gradually varies the idle speed of the engine if the load applied to the engine by an external load source changes in a sudden manner. When the vehicle is not traveling, the controller rapidly varies the idle speed if the external drive source is connected to or disconnected from the engine. This smoothly varies the idle speed regardless of whether the vehicle is traveling or not.

[0015] As shown in Fig. 1, the diesel engine 2 includes a fuel injection pump 1. The fuel injection pump 1 has a drive pulley 3 and a drive shaft 5. The drive pulley 3 is connected to a crank shaft 40 of the engine 2 with, for example, a belt. The fuel injection pump 1 is driven when the drive shaft 5 is rotated with the drive pulley 3. As a result, fuel is pumped from the fuel injection pump 1 to fuel injection nozzles 4, which are provided in each cylinder of the diesel engine 2. The fuel is then discharged from the nozzles 4. An automatic transmission (not illustrated) is connected to crankshaft 40 of the diesel engine 2.

[0016] The diesel engine 2 has cylinder bores 41 and pistons 42, which are accommodated in the cylinder bores 41. The upper end of each cylinder bore 41 is closed by a cylinder head 43. A main combustion chamber 44 is defined in each cylinder bore 41 between the cylinder head 43 and the piston 42. The cylinder head 43 has a precombustion chamber 45, which is communicated with the main combustion chamber 44. The fuel injection nozzle 4 injects fuel into the precombustion chamber 45.

[0017] The diesel engine 2 further includes an intake passage 47 and an exhaust passage 48. A compressor 50 and a turbine 51 of a turbocharger 49 are respectively arranged in the intake passage 47 and the exhaust passage 48. A waste gate valve 52, which regulates boost pressure, is further arranged in the exhaust passage 48. As is known, the turbine 51 of the turbocharger 49 is rotated by the exhaust gas to rotate the compressor 50, which is coaxially arranged with the turbine 51. A large amount of air is supplied to the main combustion chamber 44 from the intake passage 47 through an intake port 53 to promote combustion of fuel for increasing power of the diesel engine 2.

[0018] The diesel engine 2 further includes an exhaust gas recirculation system (EGR). The EGR includes an EGR passage 54 and a diaphragm type EGR valve 55, which is provided in the EGR passage 54. Some of the exhaust gas in the exhaust passage 48 is returned to the intake passage 47 through the EGR passage 54. An electric vacuum regulating valve (EVRV) 56 regulates pressure that is applied to the EGR valve 55 to regulate the opening of the EGR valve 55. With this, the amount of exhaust gas, which is conducted from the exhaust passage 48 to the intake passage 47 through the EGR passage 54, is regulated.

[0019] A throttle valve 58, which is operated based on the depression amount of a gas pedal 57, is arranged in the intake passage 47. A bypass passage 59, which bypasses the throttle valve 58, is connected to the intake passage 47. A flow-restricting valve 60 is arranged in the bypass passage 59. The flow-restricting valve 60 is driven by an actuator 63, which includes two diaphragm chambers. The actuator 63 is controlled by two vacuum switching valves (VSV) 61 and 62. The flow-restricting valve 60 is controlled based on the current running conditions of the engine 2. For example, the flow-restricting valve 60 is half-opened to reduce noise and vibration during idling of the engine, is fully opened during normal running of the vehicle, and is fully closed when the engine 2 is not operating.

[0020] The construction of the fuel injection pump 1 will now be described with reference to Fig. 2. The drive shaft 5, which is connected to the drive pulley 3, has a disc shaped pulser 7 at its inner end. The pulser 7 has teeth arranged in segments, which are equally spaced apart. The number of segments is equal to the number of cylinders in the engine. Each segment has a number of equally spaced teeth. A vane feed pump 6 (rotated 90 degrees to show details in Fig. 2) is arranged at the middle of the drive shaft 5. A roller ring 9, which is rotatable relative to the drive shaft 5, is supported on the inner end of the drive shaft 5. The roller ring 9 can be rotated or held stationary by a timing device 26 (rotated 90 degrees to show details in Fig. 2) while the drive shaft 5 is rotated. The details and functions of the timing device 26 will be described later. The roller ring 9 has cam rollers 10, which are arranged in the circumferential direction of the roller ring 9.

[0021] The fuel injection pump 1 includes a plunger 12, which is coaxial with the drive shaft 5. A cam plate 8 is attached to a proximal end of the plunger 12. The cam plate 8 has a cam face 8a, which is opposed to the roller ring 9. The cam face 8a has lobes. The number of lobes is equal to the number of cylinders of the engine 2. A coupling (not shown) is accommodated in the roller ring 9. The coupling couples the drive shaft 5 and the cam plate 8 to rotate the cam plate 8 integrally with the drive shaft 5. The coupling allows axial movement of the cam plate 8 and the plunger 12. The cam plate 8 is urged against the cam rollers 10 by a spring 11 to continuously engage the cam face 8a with the cam rollers 10.

[0022] When the drive shaft 5 is rotated, the cam plate 8 is integrally rotated with the drive shaft 5 via the coupling. During rotation of the cam plate 8, the cam plate 8 is also reciprocated axially by the engagement between the cam plate 8 and the cam rollers 10. The number of reciprocations of the cam plate 8 per rotation of the cam plate 8 is equal to the number of cylinders of the engine 2. As the cam plate 8 is rotated and reciprocated, the plunger 12 is integrally rotated and reciprocated with the cam plate 8. More specifically, as the lobes of the cam face 8a are rotated and are engaged with corresponding cam rollers 10, the plunger 12 is urged to move in the rightward direction of Fig. 2. Furthermore, as the lobes of the cam face 8a are further rotated to disengage from the cam rollers 10, the plunger 12 is urged to move in leftward direction of Fig. 2 by the spring 11.

[0023] The plunger 12 is received in a cylinder 14, which is defined in a pump housing 13. A pressure chamber 15 is defined between a distal end face of the plunger 12 and the inner wall of the cylinder 14. Intake grooves 16 are defined around the periphery of the distal end of the plunger 12. The number of intake grooves 16 is equal to the number of cylinders of the engine 2. Also, a distribution port 17 is formed on the periphery of the plunger 12. An intake port 19 is formed in the pump housing 13. The intake port 19 is radially aligned with each of the intake grooves 16 at various rotational positions of the plunger 12. Furthermore, distribution passages 18, which intermittently communicate with the distribution port 17, are defined in the pump housing 13.

[0024] As the feed pump 6 is driven by rotation of the drive shaft 5, fuel is supplied in the fuel chamber 21 from a fuel tank (not shown) through a supply port 20. As the plunger 12 is moved in the leftward direction of Fig. 2 (i.e., as the plunger 12 performs a suction stroke) through the rotation of the drive shaft 5, the pressure chamber 15 is depressurized. When one of the intake grooves 16 is aligned with the intake port 19, fuel is drawn into the pressure chamber 15 from the fuel chamber 21. As the plunger 12 is moved in the rightward direction of Fig. 2 (i.e., as the plunger 12 performs a compression stroke), the pressure chamber 15 is pressurized, so that fuel in the pressure chamber 15 is forced into the fuel injection nozzles 4 (Fig. 1) through the respective distribution passage 18.

[0025] The pressure chamber 15 is communicated with the fuel chamber 21 via a spill passage 22. An electromagnetic spill valve 23 is provided in the spill passage 22. The spill valve 23 is a normally opened valve, which has a solenoid 24. That is, the spill valve 23 is held open when no electric current is supplied to the solenoid 24. When the spill valve 23 is open, fuel in the pressure chamber 15 escapes into the fuel chamber 21 through the spill passage 22. When electric current is supplied to the solenoid 24, the spill valve 23 closes the spill passage 22 to prevent the escape of fuel from the pressure chamber 15 into the fuel chamber 21.

[0026] When the spill valve 23 opens the spill passage 22 during the compression stroke of the plunger 12, the pressure chamber 15 is depressurized, and fuel injection from the fuel injection nozzle 4 is terminated. Therefore, the spill valve 23 regulates the cut-off timing of fuel injection from the fuel injection nozzle 4. That is, the spill valve 23 regulates the amount of fuel injected from the fuel injection nozzle 4.

[0027] The timing device 26 (rotated 90 degrees for illustrative purposes in Fig. 2) is provided at the bottom of the pump housing 13. The timing device 26 controls the injection timing of fuel from the fuel injection nozzle 4. The timing device 26 changes the rotational position of the roller ring 9 about the axis of the drive shaft 5. In accordance with positional changes of the roller ring 9, the timing at which the lobes on the cam face 8a engage the cam rollers 10 is changed. In other words, the timing at which the compression stroke of the plunger 12 is initiated is changed.

[0028] The timing device 26 is driven by hydraulic pressure and includes a housing 27 and a piston 28, which is accommodated in the housing 27. In the housing 27, a low pressure chamber 29 is defined at one side of the piston 28, and a pressurizing chamber 30 is defined at the other side of the piston 28. A spring 31, which is positioned in the low pressure chamber 29, urges the piston 28 against the pressurizing chamber 30. The piston 28 is connected to the roller ring 9 via a slide pin 32. In accordance with movement of the piston 28, the roller ring 9 is pivoted about its axis by the slide pin 32.

[0029] Fuel, which is pressurized by the feed pump 6, is supplied to the pressurizing chamber 30. The axial position of the piston 28 is changed in accordance with the balance between fuel pressure in the pressurizing chamber 30 and the urging force of the spring 31. The rotational position of the roller ring 9 is changed in accordance with the axial position of the piston 28. In other words, the timing at which the plunger 12 initiates reciprocation is determined based on the position of the piston 28.

[0030] The pressurizing chamber 30 and the low pressure chamber 29 are connected by a communication passage 34. A timing control valve (TCV) 33, which is an electromagnetic valve, is arranged in the communication passage 34. Opening and closing of the TCV 33 are controlled by a duty signal. The TCV 33 regulates the flow rate of fuel in the communication passage 34 to regulate the fuel pressure in the pressuring chamber 30. The position of the piston 28 changes in accordance with the changes of fuel pressure in the pressurizing chamber 30, so that the injection timing of fuel from respective fuel injection nozzle 4 is changed.

[0031] An engine speed sensor 35, which includes an electromagnetic pickup coil, is arranged to face the circumferential surface of the pulser 7. The engine speed sensor 35 outputs a pulse signal as each tooth of the pulser 7 passes the engine speed sensor 35. The pulse signal is output when the crank shaft 40 of the engine 2 is rotated for a predetermined rotational angle. As a result, the engine speed NE can be measured based on the time interval between subsequent pulse signals. The engine speed sensor 35 is integrally pivoted with the roller ring 9. Therefore, the phase of the pulse signal, which is output from the sensor 35, has a constant relationship with the reciprocal phase of the plunger 12, even though the roller ring 9 is pivoted by the timing device 26.

[0032] The engine 2 has sensors other than the engine speed sensor 35 to measure running conditions of the engine 2. More specifically, as shown in Fig. 1, an intake air temperature sensor 72, which measures intake air temperature THA, is arranged near an air cleaner 64, which is positioned at an air inlet of the intake passage 47. A gas pedal sensor 73, which measures the opening amount of the throttle valve 58 as the depression amount ACCP of the gas pedal 67, is arranged near the throttle valve 58. The depression amount ACCP indicates the amount of engine load. An intake air pressure sensor 74, which measures pressure PM of the intake air after pressurization by the turbocharger 49, is arranged near the intake port 53. A coolant temperature sensor 75, which measures circulating coolant temperature THW, is arranged in a water jacket of the engine 2. A crank angle sensor 76, which measures a reference rotational position of the crank shaft 40, is arranged near the crank shaft 40. The vehicle speed sensor 77 includes a magnet 77a, which is rotated by a gear of the transmission, and a reed switch 77b, which is switched between ON and OFF states by the magnet 77a. The vehicle speed sensor 77 measures vehicle speed SPD based on the changes in the state (ON/OFF) of the reed switch 77b.

[0033] An idle switch 36 is connected to the gas pedal 57 and activated when the gas pedal 57 is not depressed at all. A neutral switch 66 is connected to the transmission and actuated when the gear position is in neutral.

[0034] An air conditioner switch 65 for actuating or deactuating an air conditioner 37, which serves as an external load source, is installed in the vehicle. The air conditioner switch 65 selectively connects and disconnects an air conditioner compressor (not shown) and a crank shaft 40. Accordingly, the actuated and de-actuated states of the air conditioner 37 are determined by the air conditioner switch 65.

[0035] The electromagnetic spill valve 23, the TCV 33, the EVRV 56, the VSV 61, 62, the sensors 35, 72-77 and the switches 36, 65, 66 are connected to an electronic control unit (ECU) 71. The ECU 71 adequately controls the electromagnetic spill valve 23, the TCV 33, EVRV 56 and VSVs 61, 62 based on signals, which are transmitted from the sensors 35,72-77 and the switches 36, 65, 66.

[0036] The construction of the ECU 71 will now be described with reference to Fig. 3. The ECU 71 includes a central processing unit (CPU) 81, a read only memory (ROM) 82, which stores various control programs and function data, a random access memory (RAM) 83, which temporarily stores data, such as, computations of the CPU 81 and the engine speed NE, and a backup RAM 84, which is a nonvolatile RAM that is backed up by a battery

[0037] The ECU 71 is constructed as a logic circuit, in which respective components 81-84 are connected to an input port 85 and an output port 86 via a bus 87.

[0038] The intake air temperature sensor 72, the gas pedal sensor 73, the intake air pressure sensor 74, and the coolant temperature sensor 75 are connected to the input port 85 via buffers 88, 89, 90, 91, a multiplexer 93 and an A/D converter 94. Furthermore, the engine speed sensor 35, the starter switch 38a, the crank angle sensor 76, and the vehicle speed sensor 77 are connected to the input port 85 via a waveform shaping circuit 95.

[0039] The idle switch 36, the air conditioner switch 65, and the neutral switch 66 are connected to the input port 85 via buffers 102, 103, 104, respectively.

[0040] The CPU 81 receives signals transmitted from the sensors 35, 72-77 and the switches 36, 65, 66 via the input port 85. The electromagnetic spill valve 23, the TCV 33, EVRV 56 and VSV 61, 62 are connected to the output port 86 via drive circuits 96, 97, 99, 100, 101.

[0041] The idle speed control (hereafter referred to as ISC) performed by the ECU 71 will now be described with reference to Figs. 4 to 9. The steps of the routine executed to perform ISC are illustrated in the flowchart of Figs. 4 and 5. The routine is executed in a cyclic and interrupting manner for every predetermined time interval (e.g., 64 milliseconds).

[0042] When the ECU 71 enters the routine, the ECU 71 performs step 101 and reads the engine speed NE. The engine speed NE is computed based on the signals sent from the engine speed sensor 35.

[0043] At step 102, the ECU 71 checks an actuation flag XAC to determine whether or not the air conditioner 37 has been actuated. The actuation flag XAC is set at one when the air conditioner switch 65 is turned on and set at zero when the switch 65 is turned off. If the value of the actuation flag XAC indicates that the air conditioner switch 65 has been turned on, the ECU 71 proceeds to step 103.

[0044] At step 103, the ECU 71 computes a target engine speed NTRG1, which is the target engine speed when the air conditioner switch 65 is turned on. The target engine speed NTRG1 may be set in accordance with the coolant temperature THW, which is detected by the coolant temperature sensor 75, and the gear range (i.e., drive range or neutral range), which is determined from the signal sent from the neutral switch 66, and computed using function data, which is stored in the ROM 80. The target engine speed NTRG1 is higher than the target value set when the air conditioner switch 65 is turned off.

[0045] At step 104, the ECU 71 judges whether or not the engine 2 is idling while the vehicle is stationary. This may be determined by confirming whether the idle switch 36 is turned on, whether the vehicle speed SPD detected by the vehicle speed sensor 77 indicates zero kilometers per hour, and whether the depression amount ACCP detected by the gas pedal sensor 73 indicates zero percent. If all three of these conditions are satisfied, the vehicle is stationary and the engine 2 is idling.

[0046] If it is determined that the engine 2 is stationary and idling in step 104, the ECU 71 proceeds to step 105. At step 105, the ECU 71 computes an engine speed difference NEDL, which is the difference between the target engine speed NTRG1 and the engine speed NE read in step 101 (NTRG1-NE).

[0047] At step 106, the ECU 71 computes an integral compensation amount ΔQII in accordance with the difference NEDL computed in step 105. Function data, which is stored in the ROM 80, is used to compute the integral compensation amount ΔQII.

[0048] At step 107, the ECU 71 adds the integral compensation amount ΔQII, which was computed in step 106, to the previous integral compensation amount QII(i-1), which was computed in the preceding cycle, and computes the current integral compensation amount QII(i). The ECU 71 stores the current integral compensation amount QII(i) as an integral compensation amount QII in the RAM 83.

[0049] If it is determined that the engine 2 is not idling while stationary in step 104, the ECU 71 proceeds directly to step 108. The current integral compensation amount QII(i) is thus not computed in this case.

[0050] At step 108, the ECU 71 computes the compensation amount QIPB, which corresponds to the presumed increase of the load applied to the engine 2. The load fluctuation compensation amount QIPB is computed in accordance with the gear range (i.e., drive range or neutral range), which is determined in accordance with the signal sent from the neutral switch 66, using function data, which is stored in the ROM 80. The load fluctuation compensation amount QIPB increases the fuel injection amount in a relatively sudden manner when the air conditioner switch 65 is turned on. The increased fuel injection amount (increased by QIPB) offsets the load added by the air conditioner 37 and prevents the engine speed NE from fluctuating. The ECU 71 stores the load fluctuation compensation amount QIPB in the RAM 83 and then proceeds to step 109, which is illustrated in Fig. 5.

[0051] At step 109, the ECU 71 computes a maximum compensation amount QIPACMX of a raised idle state when the air conditioner switch 65 is turned on. The maximum compensation amount QIPACMX is computed using compensation factors tKQPA, tKQPAC and a coolant temperature compensation coefficient MNTTW from the equation described below.

$$QIPACMX=tKQPA-tKQPAC\times MNTTW$$

Predetermined values corresponding to the current gear range (i.e., drive range or neutral range) are selected as the compensation factors tKQPA, tKQPAC. The predetermined values are each stored in the ROM 80. The coolant temperature compensation coefficient MNTTW is obtained from the graph of Fig. 8 based on the detected coolant temperature THW.

[0052] The compensation factor tKQPA represents the additional amount of fuel injection that is necessary to enter the raised idle state when the engine 2 is warm. However, the engine 2 is controlled such that the engine speed NE becomes high when the engine is cool, or when the engine temperature is relatively low. When the engine is cool, the compensation amount need not be as high as when the engine 2 is warm. Thus, a compensation amount corresponding to the coolant temperature THW (tKQPAC×MNTTW) is subtracted from the compensation amount that corresponds to a warm engine state (tKQPA) in the above equation.

[0053] After computing the maximum compensation amount QIPACMX in step 109, the ECU 71 proceeds to step 110. At step 110, the ECU 71 computes an incremental amount ΔQIPAC by executing a further routine (refer to Fig. 7), which will be described later.

[0054] At step 111, the ECU 71 adds the incremental amount ΔQIPAC, which was computed in step 110, to the previous compensation amount QIPAC(i-1), which was obtained in the preceding cycle, to compute the current compensation amount QIPAC(i). The ECU 71 then stores the current compensation amount QIPAC(i) in the RAM 83.

[0055] At step 112, the ECU 71 judges whether or not the current compensation amount QIPAC(i) is equal to or greater than the maximum compensation amount QIPACMX, which was computed in step 109. If it is determined that the current compensation amount QIPAC(i) is smaller than the maximum compensation amount QIPACMX, the ECU 71 proceeds to step 114. At step 114, the ECU 71 sets the value of the current compensation amount QIPAC(i) as the raised idle compensation amount QIPAC and then temporarily terminates subsequent processing.

[0056] If it is determined that the current compensation amount QIPAC(i) is equal to or greater than the maximum compensation amount QIPACMX in step 112, the ECU 71 proceeds to step 113. At step 113, the ECU 71 sets the value of the maximum compensation amount QIPACMX as the raised idle compensation amount QIPAC and then terminates subsequent processing.

[0057] At step 102, if it is determined that the actuation flag XAC is set at zero, which indicates that the air conditioner switch 65 is not turned on, the ECU 71 proceeds to step 115. At step 115, the ECU 71 computes a target engine speed NTRG2, which is the target engine speed when the air conditioner switch 65 is turned off. In the same manner as the target engine speed NTRG1, the target engine speed NTRG2 may be set in accordance with the coolant temperature THW, which is detected by the coolant temperature sensor 75, and the gear range (i.e., drive range or neutral range), which is determined from the signal sent from the neutral switch 66, and computed using function data, which is stored in the ROM 80. The target engine speed NTRG2 is lower than the target value set when the air conditioner switch 65 is turned on. The ECU 71 then proceeds to step 116.

[0058] At step 116, the ECU 71 judges whether or not the engine 2 is in an idle state and the vehicle is stationary. In the same manner as step 104, this may be determined by confirming whether the idle switch 36 is turned on, whether the vehicle speed SPD detected by the vehicle speed sensor 77 indicates zero kilometers per hour, and whether the depression amount ACCP detected by the gas pedal sensor 73 indicates zero percent. If all three of these conditions are satisfied, the vehicle is deemed to be stationary and idling.

[0059] If it is determined that the vehicle is stationary and the engine 2 is idling in step 116, the ECU 71 proceeds to step 117. At step 117, the ECU 71 computes the engine speed difference NEDL, which is the difference between the target engine speed NTRG2 and the engine speed NE read in step 101 (NTRG1-NE).

[0060] At step 118, the ECU 71 computes an integral compensation amount ΔQII in accordance with the difference NEDL computed in step 117. Function data, which is stored in the ROM 80, is used to compute the integral compensation amount ΔQII.

[0061] At step 119, the ECU 71 adds the integral compensation amount ΔQII, which was computed in step 118, to the previous integral compensation amount QII(i-1), which was computed in the preceding cycle, and computes the current integral compensation amount QII(i). The ECU 71 stores the current integral compensation amount QII(i) as the integral compensation amount QII in the RAM 83.

[0062] If it is determined that the engine 2 is not idling in step 116, the ECU 71 proceeds directly to step 120. The current integral compensation amount QII(i) is thus not computed in this case.

[0063] At step 120, in the same manner as step 108, the ECU 71 computes the compensation amount QIPB, which corresponds to the presumed decrease of the load applied to the engine 2. The load fluctuation compensation amount QIPB decreases the fuel injection amount in a relatively sudden manner when the air conditioner switch 65 is turned off. The decreased fuel injection amount (decreased by the load fluctuation compensation amount QIPB) offsets the decrease of the load caused by the de-actuation of the air conditioner and prevents the engine speed NE from fluctuating. The ECU 71 stores the load fluctuation compensation amount QIPB in the RAM 83 and then proceeds to step 121, which is illustrated in Fig. 5.

[0064] At step 121, the ECU 71 computes an incremental amount ΔQIPAC by executing the routine illustrated in Fig. 7. The ECU 71 then proceeds to step 122.

[0065] At step 122, the ECU 71 subtracts the incremental amount ΔQIPAC, which was computed in step 121, from the previous compensation amount QIPAC(i-1), which was obtained in the preceding cycle, and computes the current compensation amount QIPAC(i). The ECU 71 then stores the current compensation amount QIPAC(i) in the RAM 83.

[0066] At step 123, the ECU 71 judges whether or not the value of the current compensation amount QIPAC(i) is equal to or smaller than zero. If it is determined that the current compensation amount QIPAC(i) is greater than zero, the ECU 71 proceeds to step 125. At step 125, the ECU 71 sets the value of the current compensation amount QIPAC(i) as the raised idle compensation amount QIPAC and then temporarily terminates subsequent processing.

[0067] If it is determined that the current compensation amount QIPAC(i) is equal to or smaller than zero in step 123, the ECU 71 proceeds to step 124. At step 124, the ECU 71 sets zero as the value of the raised idle compensation amount QIPAC.

[0068] The fuel injection amount control that is performed in accordance with the integral compensation amount QII, the load fluctuation compensation amount QIPB, and the raised idle compensation amount QIPAC will now be described with reference to Fig. 6. The routine is executed in an interrupting manner for every predetermined crank angle.

[0069] The ECU 71 first performs step 201 when entering the routine and reads the current engine speed NE, the gas pedal depression amount ACCP, the integral compensation amount QII, the load fluctuation compensation amount QIPB, and the raised idle compensation amount QIPAC from the RAM 83. The ECU 71 then proceeds to step 202.

[0070] At step 202, the ECU 71 obtains an idle governor injection amount tQGOV1 and a drive governor injection amount tQGOV2 by referring to the two dimensional function data shown in Fig. 9. The two dimensional function data is related to the engine speed NE and the depression amount ACCP. The idle governor injection amount tGOV1 is plotted along the dashed lines in Fig. 9 and indicates the amount of fuel injection when the engine speed NE is in a low speed range, that is, when the engine is in a normal idle state. The drive governor injection amount tQGOV2 is indicated by the solid lines in Fig. 9 and indicates the amount of fuel injection when the engine speed NE is outside the low speed range, that is, mainly when the vehicle is traveling.

[0071] At step 203, the ECU 71 compares the sum of the idle governor injection amount tQGOV1, the integral compensation amount QII, the load fluctuation compensation amount QIPB, and the raised idle compensation amount QIPAC with the sum of the drive governor injection amount tGOV2 and the load fluctuation compensation amount QIPB. The larger of the two sums is set as a governor injection amount QGOV. If the engine speed NE is in the low speed range, that is, if the engine 2 is in the normal idle state, the governor injection amount QGOV tends to be the sum of the idle governor injection amount tQGOV1, the integral compensation amount QII, the load fluctuation compensation amount QIPB, and the raised idle compensation amount QIPAC. On the other hand, if the engine speed NE is outside the low speed range, that is, if the vehicle is traveling, the governor injection amount QGOV tends to be the sum of the drive governor injection amount tGOV2 and the load fluctuation compensation amount QIPB.

[0072] At step 204, the ECU 71 computes the maximum injection amount QFULL. The maximum injection amount QFULL indicates the upper limit value of the amount of fuel that is to be sent to each combustion chamber 21. The maximum injection amount QFULL also indicates the upper limit value of the amount of fuel that suppresses a sudden increase in smoke exhausted from the combustion chamber, while also suppressing the generation of excessive torque.

[0073] At step 205, the ECU 71 sets the value of the smaller of the maximum injection amount QFULL and the governor injection amount QGOV as a final fuel injection amount QFIN. The ECU 71 then proceeds to step 206.

[0074] At step 206, the ECU 71 computes an injection amount command value (value converted to time, or injection time) TSP that corresponds to the final injection amount QFIN. At step 207, the ECU 71 outputs the injection amount command value TSP and then temporarily terminates processing. The electromagnetic spill valve 23 of the fuel injection pump 1 is controlled to perform fuel injection in accordance with the injection amount command value TSP.

[0075] An incremental amount computation routine will now be described with reference to Fig. 7. This routine is executed to compute and determine the incremental amount ΔQIPAC.

[0076] When entering this routine, the ECU 71 first carries out step 301 and reads the value of an idle stability flag XISTBL. The idle stability flag XISTBL is set at one when the vehicle is stationary and set at zero when the vehicle is traveling. More specifically, the idle stability flag XISTBL is set at one when the neutral switch 66 indicates that the transmission is in the neutral range, while the idle switch 36 is in an actuated state. The idle stability flag XISTBL is also set at one when the neutral switch 36 indicates that the transmission is in the drive range with the idle switch 36 in an actuated state and the vehicle speed SPD detected by the vehicle speed sensor 77 indicating zero kilometers per hour. Under other conditions, the idle stability flag XISTBL is set at zero.

[0077] At step 302, the ECU 71 judges whether or not the idle stability flag XISTBL is set at one. If the ECU 71 determines that the idle stability flag XISTBL is set at one, the vehicle is deemed to be stationary, and step 303 follows. At step 303, the ECU 71 selects a relatively large value (in the preferred embodiment, 1.172) as the incremental amount ΔQIPAC.

[0078] If the ECU 71 determines that the idle stability flag XISTBL is set at zero in step 302, the vehicle is deemed to be traveling. In this case, the ECU 71 proceeds to step 304 and selects a relatively small value (in the preferred embodiment, 0.078) as the incremental amount ΔQIPAC.

[0079] The operation of the ISC in correspondence with each of the above routines will now be described with reference to Figs. 10(a), (b), (c) and Figs. 11(a), 11(b), 11(c) . Figs. 10(a) to 10(c) show the state of the idle switch 65, the variation of the compensation amount, and the fluctuation of the engine speed NE when the vehicle is stationary. Figs. 11(a) to 11(c) show the state of the idle switch 65, the changes in the compensation amount, and the fluctuation of the engine speed NE when the vehicle is traveling.

[0080] The operation of the ISC when the vehicle is stationary will first be described with reference to Figs. 10(a) to 10(c). As shown in Fig. 10(a), the air conditioner switch 65 is turned on at time point t11 thereby shifting the engine 2 to a raised idle state from the normal idle state. The actuation of the air conditioner switch 65 adds the load fluctuation compensation amount QIPB, which corresponds to the presumed increase of the load applied to the engine, to the fuel compensation amount as shown in Fig. 10(b). The load fluctuation compensation amount QIPB is the amount of fuel injection compensation that is necessary to maintain the same engine speed NE when the load of the air conditioner 37 is applied to the engine 2.

[0081] As time elapses from time point t11, the compensation amount is increased by the incremental amount ΔQIPAC in a gradual manner. As shown in Fig. 10(c), the engine speed NE increases gradually from time point t11 in accordance with the increasing compensation amount. In this state, the vehicle is stationary. Thus, the incremental amount ΔQIPAC is set at a value (1.172) greater than that used when the vehicle is traveling.

[0082] As shown in Fig. 10(b), the compensation amount reaches its maximum compensation amount QIPACMX at time point t12 and is maintained at this value until the air conditioner switch 65 is turned off. As shown in Fig. 10(c), the engine speed NE reaches its target engine speed NTRG1 at time point t12 and is maintained at the same speed until the air conditioner switch 65 is turned off.

[0083] Since the value used as the increment value ΔQIPAC when the vehicle is stationary is greater than that used when the vehicle is traveling, the engine speed NE reaches the target engine speed NTRG1 within a relatively short period of time. Accordingly, the integral compensation amount QII when the vehicle is stationary and the engine 2 is idling varies the engine speed NE within a relatively short period of time when the air conditioner 37 is turned on.

[0084] Furthermore, the driver of the vehicle can immediately notice the increase in the engine speed NE. Thus, the driver does not notice unusual engine speed NE behavior.

[0085] When the air conditioner switch 65 is turned off at time point t13 as shown in Fig. 10(a), the engine 2 shifts from the raised idle state to the normal idle state. As shown in Fig. 10(b), the stopping of the air conditioner 37 causes the fuel compensation amount to be decreased by the load fluctuation compensation amount QIPB, which corresponds to the presumed decrease of the load when the air conditioner 37 is turned off. The load fluctuation compensation amount QIPB is the amount of fuel injection compensation that is necessary to maintain the same engine speed NE when the load applied to the engine 2 decreases due to the de-actuation of the air conditioner 37.

[0086] As time elapses from time point t13 to time point t14, the compensation amount is decreased by the incremental amounts ΔQIPAC in a gradual manner. As shown in Fig. 10(c), the engine speed NE decreases gradually in accordance with the decreasing compensation amount. In this state, the vehicle is stationary. Thus, the incremental amount ΔQIPAC is set at a value (1.172) greater than that used when the vehicle is traveling.

[0087] The compensation amount reaches the value of zero at time point t14 and is maintained at this value afterward. Furthermore, the engine speed NE reaches its target engine speed NTRG2 at time t14 and maintains the same speed afterward.

[0088] As described above, the engine speed NE reaches the target engine speed NTRG2 within a relatively short period of time since the value of the incremental amount ΔQIPAC when the vehicle is stationary is greater than that used when the vehicle is traveling.

Accordingly, the computation of the integral compensation amount QII when the vehicle is stationary and the engine 2 is idling results in the engine speed NE changing within a short period when the air conditioner 37 is turned off.

[0089] Furthermore, the driver of the vehicle can immediately notice the decrease in the engine speed NE. Thus, the driver does not notice unusual engine speed NE behavior.

[0090] The operation of the ISC when the vehicle is traveling will now be described with reference to Figs. 11(a) to 11(c). As shown in Fig. 11(a), the air conditioner switch 65 is turned on at time point t21 thereby shifting the engine 2 to the raised idle state from the normal idle state. The actuation of the air conditioner switch 65 adds the load fluctuation compensation amount QIPB, which corresponds to the presumed increase of the load applied to the engine, to the fuel compensation amount as shown in Fig. 11(b). The load fluctuation compensation amount QIPB is the amount of fuel injection compensation that is necessary to maintain the same engine speed NE when load of the air conditioner 37 is applied to the engine 2.

[0091] As time elapses from time point t21, the compensation amount is increased by the incremental amounts ΔQIPAC in a gradual manner. As shown in Fig. 11(c), the engine speed NE increases gradually from time point t11 in accordance with the increasing compensation amount. In this state, the vehicle is traveling. Thus, the incremental amount ΔQIPAC is set at a value (0.078), which is smaller than that used when the vehicle is stationary.

[0092] As shown in Fig. 11(b), the compensation amount reaches its maximum compensation amount QIPACMX at time point t22 and is maintained at this value afterward. As shown in Fig. 11(c), the engine speed NE thus reaches its target engine speed NTRG1 at time point t22 and maintains the same speed afterward.

[0093] Since the incremental amount ΔQIPAC used when the vehicle is traveling is smaller than that used when the vehicle is stationary, the engine speed NE reaches the target engine speed NTRG1 in a relatively slow manner. Accordingly, the driver does not feel sudden acceleration when the actuation of the air conditioner 37 increases the engine speed NE.

[0094] When the air conditioner switch 65 is turned off at time point t23 as shown in Fig. 11(a), the engine 2 shifts from the raised idle state to the normal idle state. As shown in Fig. 11(b), the stopping of the air conditioner 37 causes the fuel compensation amount to be decreased by the load fluctuation compensation amount QIPB, which corresponds to the presumed decrease of the load when the air conditioner 37 is turned off. Thus, the engine speed NE is maintained at the same speed regardless of the stoppage of the air conditioner 37.

[0095] As time elapses from time point t23 to time point t24, the compensation amount is decreased by the incremental amounts ΔQIPAC in a gradual manner. As shown in Fig. 11(c), the engine speed NE decreases gradually in accordance with the decreasing compensation amount. In this state, the vehicle is traveling. Thus, the incremental amount ΔQIPAC is set at a value (0.078), which is smaller than that used when the vehicle is stationary.

[0096] The compensation amount reaches the value of zero at time point t24 and is maintained at this value afterward. Furthermore, the engine speed NE reaches the target engine speed NTRG2 at time t24 and is maintained at this value afterward.

[0097] As described above, the engine speed NE reaches the target engine speed NTRG2 in a relatively slow manner since the value of the incremental amount ΔQIPAC when the vehicle is traveling is smaller than that when the vehicle is stationary. Accordingly, the driver does not feel sudden deceleration when the deactuation of the air conditioner 37 decreases the engine speed NE.

[0098] It should be apparent to those skilled in the art that the present invention may be embodied in many other specific forms without departing from the spirit or scope of the invention. More particularly, the present invention may be embodied as described below.

[0099] In the preferred and illustrated embodiment, the incremental amount ΔQIPAC is selected from the values of 1.172 and 0.078 depending on whether the vehicle is stationary or traveling. However, the incremental amount ΔQIPAC is not limited to these values and may take other arbitrary values as long as the value selected when the vehicle is stationary is greater than that selected when the vehicle is traveling.

[0100] In the preferred embodiment, the gas pedal sensor 73 may be employed in lieu of the idle switch 36 to determine whether the vehicle is in a still state.

[0101] The engine 2 is connected to an automatic transmission in the preferred embodiment. Furthermore, the target engine speeds NTRG1, NTRG2, the load fluctuation compensation amount QIPB, and the compensation factors tKQPA, tKQPAC are obtained in accordance with the gear range (drive range or neutral range) detected by the neutral switch 66. However, the engine 2 may be connected to a manual transmission instead of an automatic transmission. In such case, the target engine speeds NTRG1, NTRG2, the load fluctuation compensation amount QIPB, and the compensation factors tKQPA, tKQPAC are set at values that are inherent to the vehicle. Furthermore, it can be determined that the vehicle is not moving when the vehicle speed SPD detected by the speed sensor 77 indicates zero km/h with the idle switch 36 in an actuated state.

[0102] In the preferred embodiment, the engine 2 is shifted between a normal idle state and a raised idle state in accordance with the operation of the air conditioner switch 65, that is, in accordance with whether the air conditioner 37 and engine 2 are connected to or disconnected from each other. However, the idle state of the engine 2 may also be shifted when other external load sources are connected to or disconnected from the engine 2. Such external load sources include a power steering system, which produces loads when turning the steering wheel.

[0103] In the preferred embodiment, the fuel injection amount undergoes compensation to adjust the idle speed. However, the idle speed may be changed by compensating other parameters, which are capable of changing the engine speed NE.

[0104] The present invention may be applied to a gasoline engine. In such case, the engine speed can be adjusted by controlling the amount of air sent to the engine.

[0105] Therefore, the present examples and embodiments are to be considered as illustrative and not restrictive, and the invention is not to be limited to the details given herein, but may be modified within the scope and equivalence of the appended claims.

[0106] An apparatus for controlling the idle speed of an engine (2) is disclosed. The apparatus includes an electric control unit (ECU) (71) for controlling the engine speed, an air conditioner switch (65) for detecting application and removal of an external engine load, or air conditioner (37), and sensors (36, 66, 77) for detecting that the engine (2) is idling when the vehicle is stationary and when the vehicle is moving. The ECU (71) gradually increases the engine speed by a predetermined amount to shift the engine (2) to a raised idle state when the external engine load (37) is applied and gradually decreases the engine speed by the predetermined amount when the external engine load (37) is removed. The ECU (71) adjusts the engine speed at a certain rate when the vehicle is stationary and at a different rate when the vehicle is traveling.

Claims

1. An idle speed control apparatus for an engine (2) including a controller (71) for controlling the engine speed, a load detector (65) for detecting the application and removal of an external engine load (37), a vehicle state detector (36, 66, 77) for detecting whether the engine (2) is idling and whether the vehicle is moving, wherein the controller (71) gradually increases the engine speed from a normal idle state by a predetermined amount to shift the engine (2) to a raised idle state when the external engine load (37) is applied and gradually returns the engine speed to the normal idle state when the external engine load (37) is removed, the apparatus being **characterized in that:**

the controller (71) changes the idle speed between the raised and normal states at a first rate when the vehicle is stationary and at a second, different rate when the vehicle is traveling.

2. The apparatus according to claim 1 **characterized in that** the rate of the engine speed change between the raised and normal states when the vehicle is stationary is greater than that when the vehicle is traveling.

3. The apparatus according to claim 2 **characterized by** an injection nozzle (4) for injecting fuel into the engine (2), wherein the controller (71) gradually changes the amount of fuel injection to gradually adjust the engine speed.

4. The apparatus according to claim 3 **characterized in that** the controller (71) varies the amount of fuel injection in a sudden manner in response to removal or application of the load to offset the effect of the application or removal of the external engine load (37) on the engine speed, and in that the controller (71) gradually varies the amount of fuel injection after the sudden variation to change the engine speed.

5. The apparatus according to claim 2 **characterized by** an air amount adjustor for adjusting the amount of air supplied to the engine (2), wherein the controller controls the air amount adjustor such that the amount of air supplied to the engine is varied gradually to adjust the engine speed gradually.

6. The apparatus according to any one of the preceding claims **characterized in that** the external load is applied by an air conditioner (37).

7. The apparatus according to claim 6 **characterized in that** the load detector includes a switch (65) operated by a driver to actuate the air conditioner.

8. The apparatus according to any one of the preceding claims **characterized in that** the vehicle state detector includes an idle state detector (36) for detecting when a gas pedal (57) is not depressed at all.

9. The apparatus according to claim 8 **characterized in that** the vehicle state detector includes a vehicle speed sensor for detecting the vehicle speed.

10. The apparatus according to claim 8 **characterized in that** the engine is operably connected to an automatic transmission, and that the vehicle state detector includes a sensor for detecting the gear position of the automatic transmission.

Fig.1

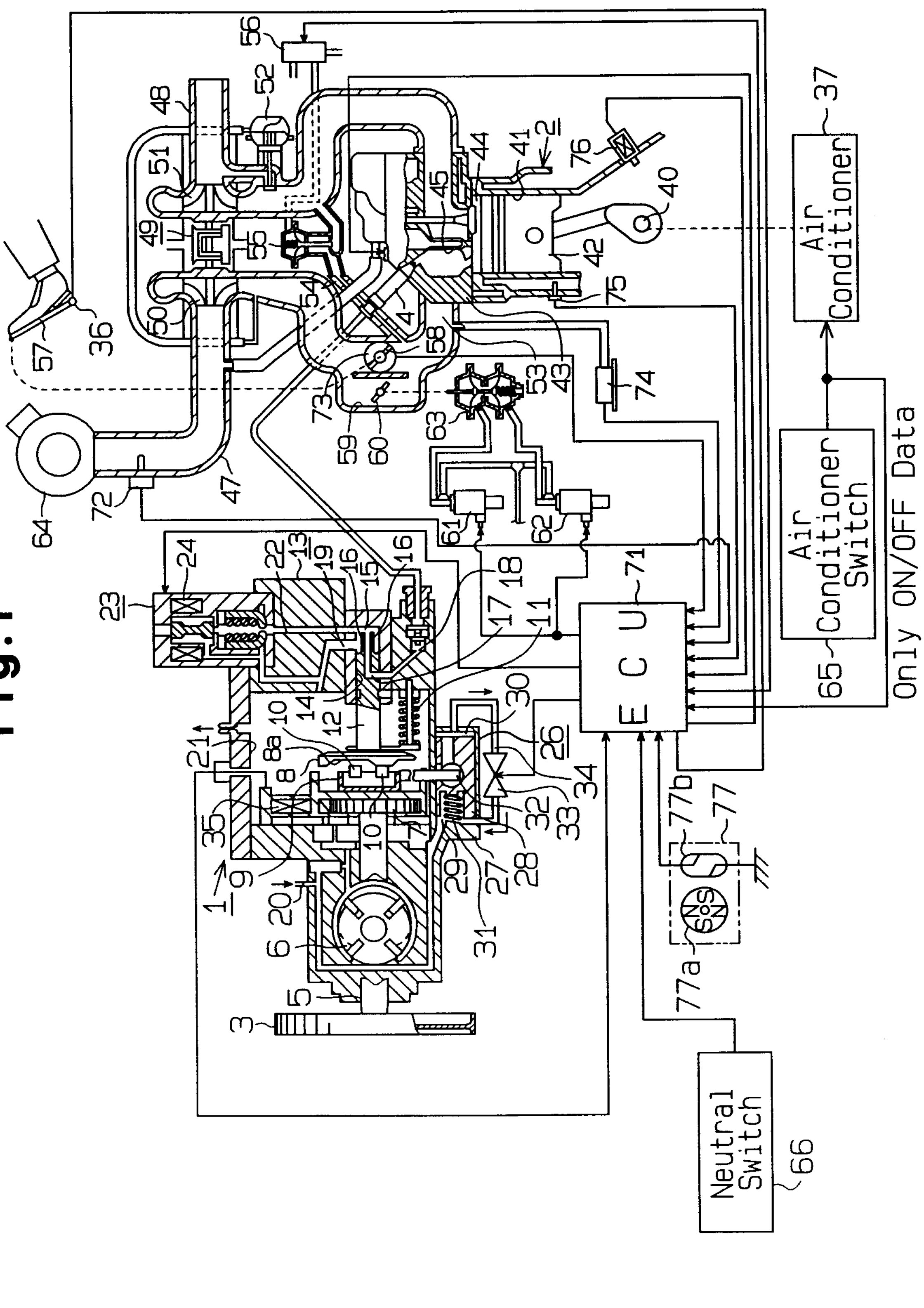
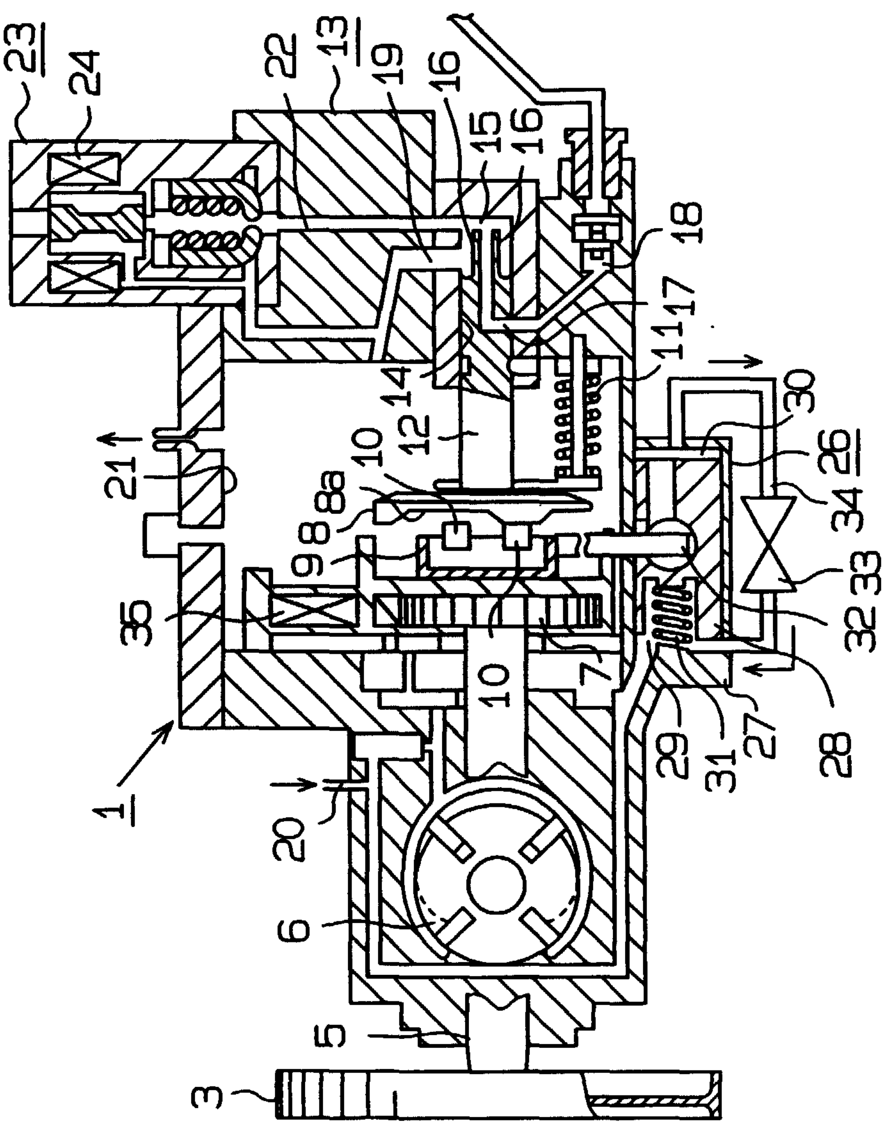

Air Conditioner
Air Conditioner Switch
Only ON/OFF Data
E C U
Neutral Switch

Fig.2


1
3
5
6
7
8
8a
9
10
11
12
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21
22
23
24
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28
29
30
31
32
33
34
35

Fig.3

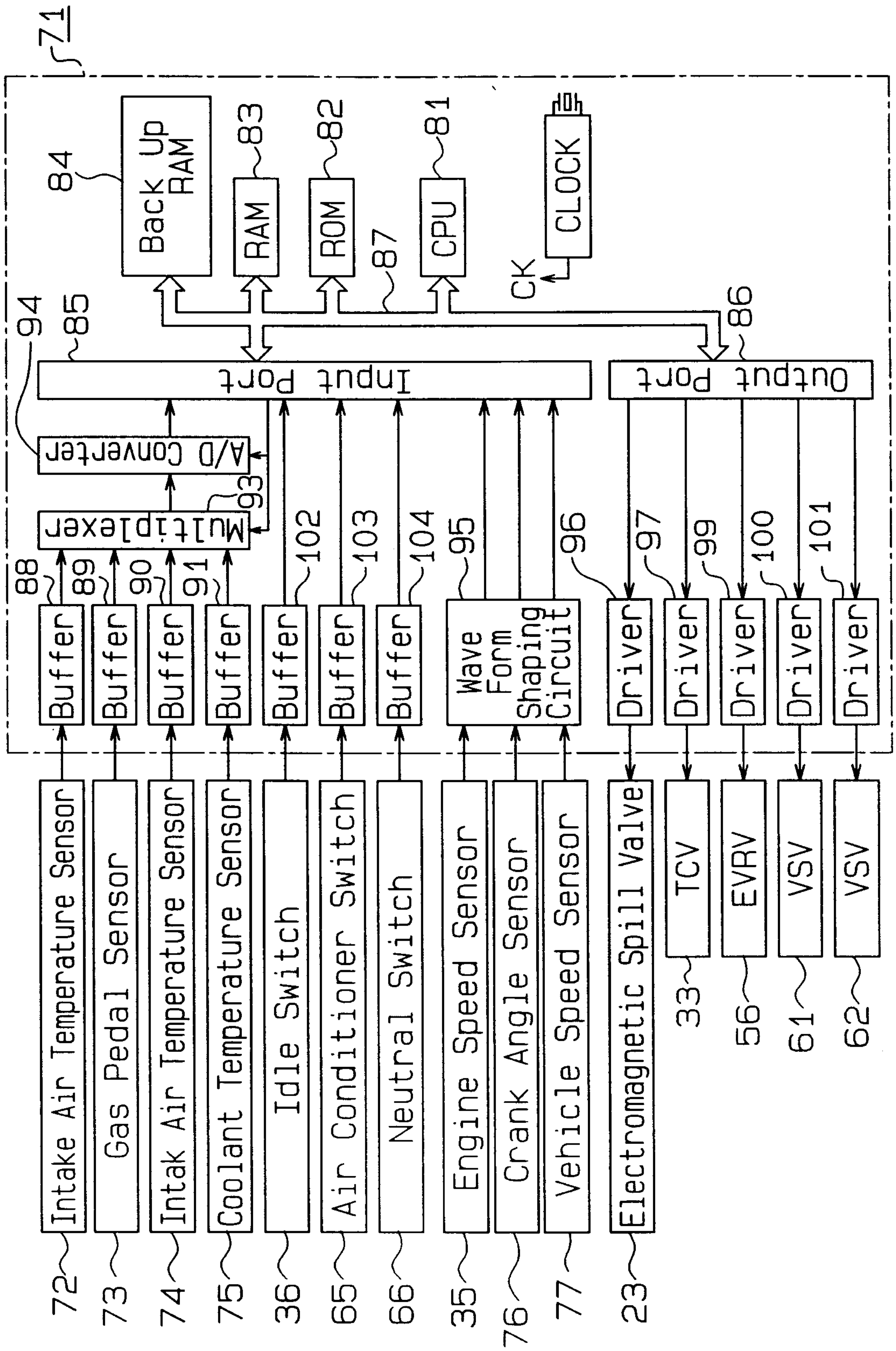

71
Back Up RAM
84
RAM
83
ROM
82
CPU
81
CLOCK
CK
87
86
85
94
Input Port
Output Port
A/D Converter
93
Multiplexer
88
89
90
91
Buffer
Buffer
Buffer
Buffer
Buffer
Buffer
Buffer
102
103
104
95
Wave Form Shaping Circuit
96
97
99
100
101
Driver
Driver
Driver
Driver
Driver
Intake Air Temperature Sensor
72
Gas Pedal Sensor
73
Intak Air Temperature Sensor
74
Coolant Temperature Sensor
75
Idle Switch
36
Air Conditioner Switch
65
Neutral Switch
66
Engine Speed Sensor
35
Crank Angle Sensor
76
Vehicle Speed Sensor
77
Electromagnetic Spill Valve
23
TCV
33
EVRV
56
VSV
61
VSV
62

Fig.4

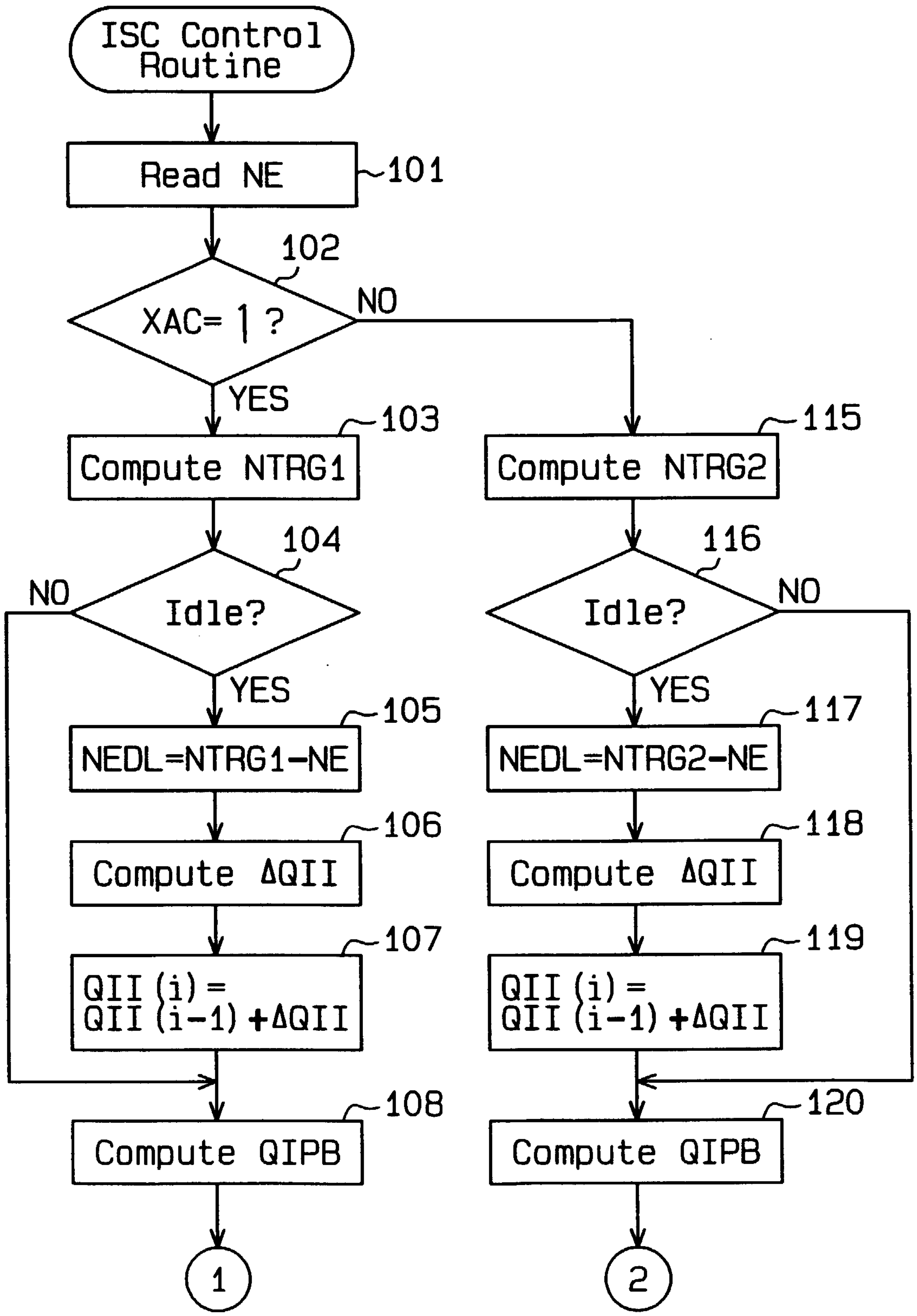

ISC Control Routine
Read NE
101
102
XAC= 1 ?
NO
YES
103
Compute NTRG1
115
Compute NTRG2
104
Idle?
NO
YES
116
Idle?
NO
YES
105
NEDL=NTRG1−NE
117
NEDL=NTRG2−NE
106
Compute ΔQII
118
Compute ΔQII
107
QII (i) =
QII (i−1) +ΔQII
119
QII (i) =
QII (i−1) +ΔQII
108
Compute QIPB
120
Compute QIPB
1
2

Fig.5

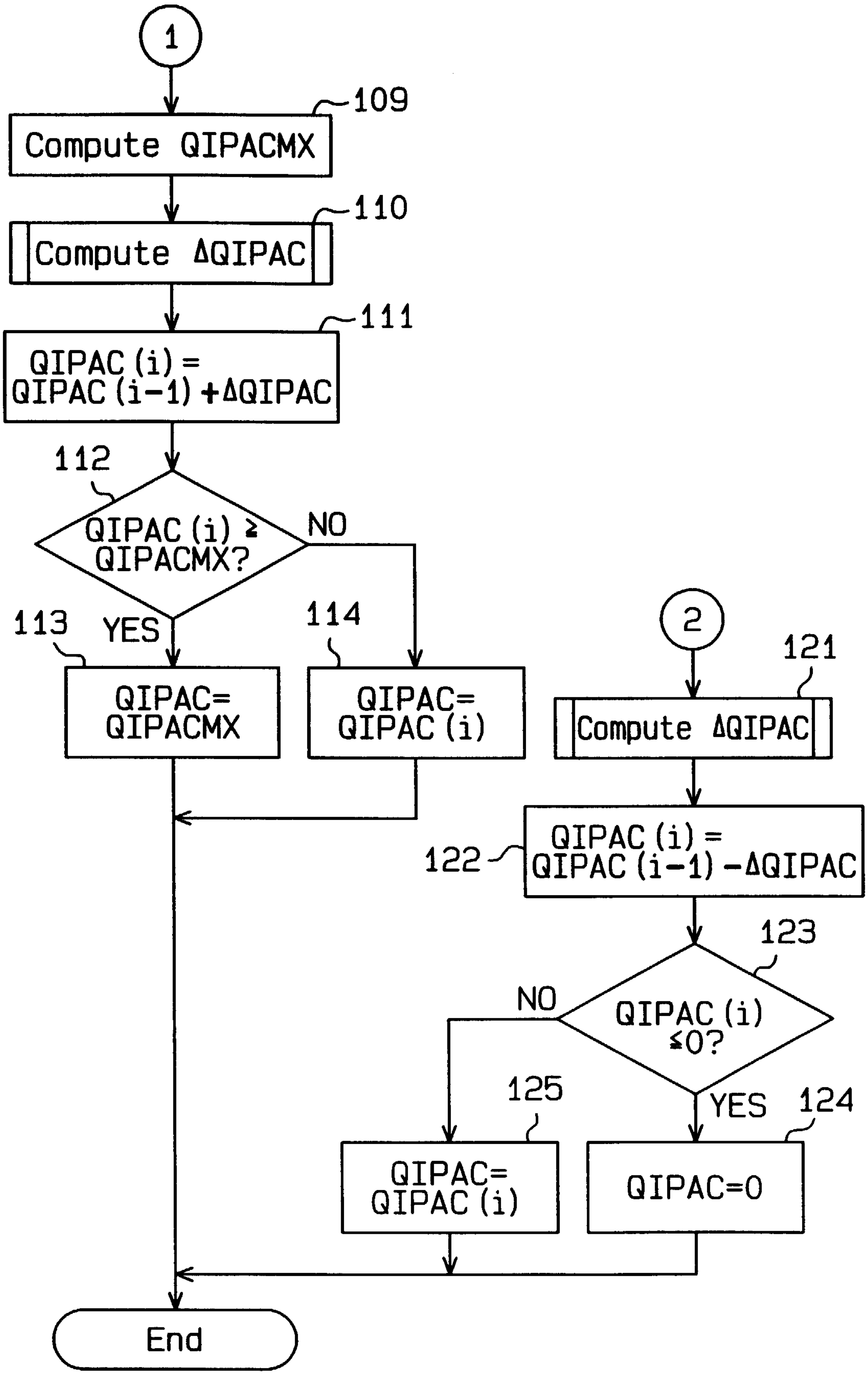

1
109
Compute QIPACMX
110
Compute ΔQIPAC
111
QIPAC (i) =
QIPAC (i−1) +ΔQIPAC
112
QIPAC (i) ≥
QIPACMX?
NO
YES
113
QIPAC=
QIPACMX
114
QIPAC=
QIPAC (i)
2
121
Compute ΔQIPAC
122
QIPAC (i) =
QIPAC (i−1) −ΔQIPAC
123
QIPAC (i)
≤0?
NO
YES
125
QIPAC=
QIPAC (i)
124
QIPAC=0
End

Fig.6

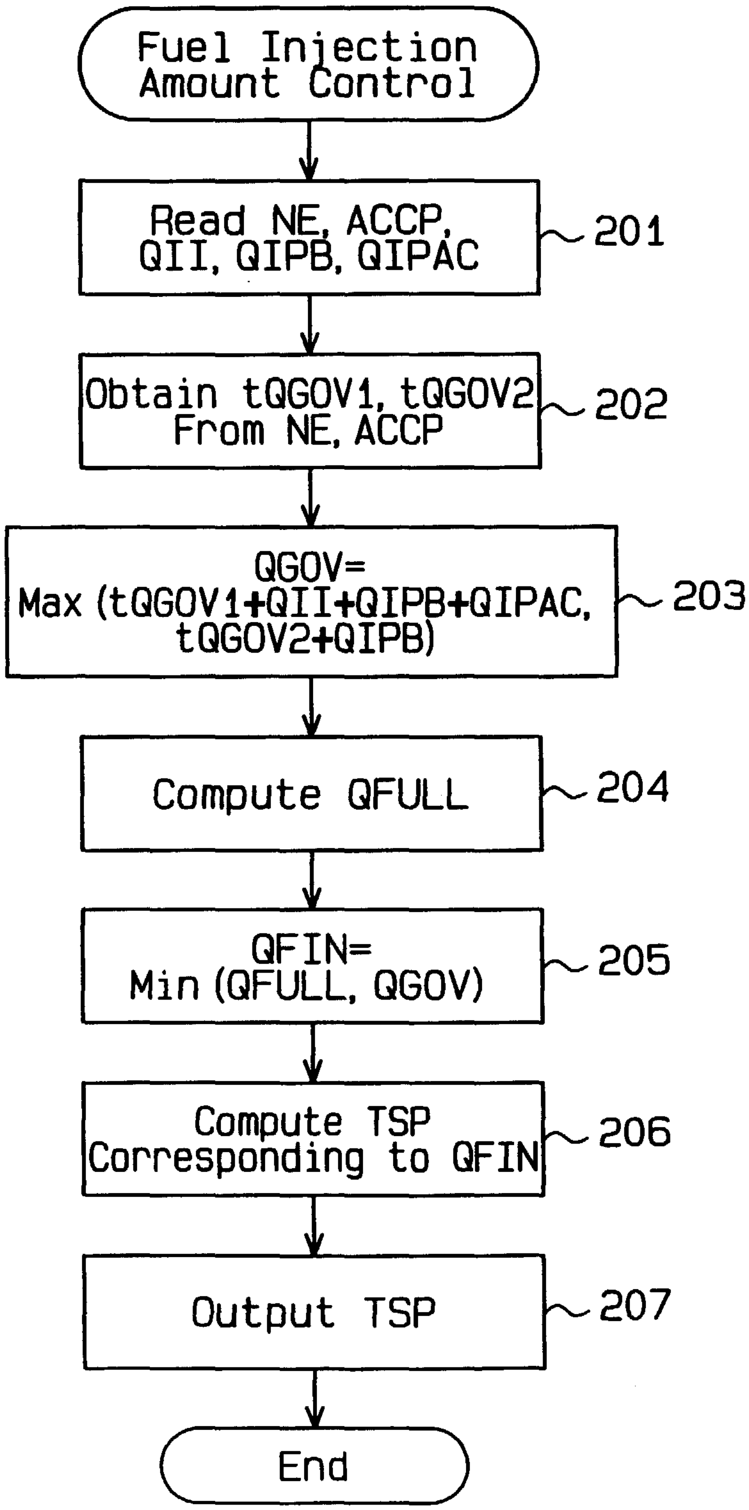

Fuel Injection Amount Control
Read NE, ACCP, QII, QIPB, QIPAC
201
Obtain tQGOV1, tQGOV2 From NE, ACCP
202
QGOV= Max (tQGOV1+QII+QIPB+QIPAC, tQGOV2+QIPB)
203
Compute QFULL
204
QFIN= Min (QFULL, QGOV)
205
Compute TSP Corresponding to QFIN
206
Output TSP
207
End

Fig.7

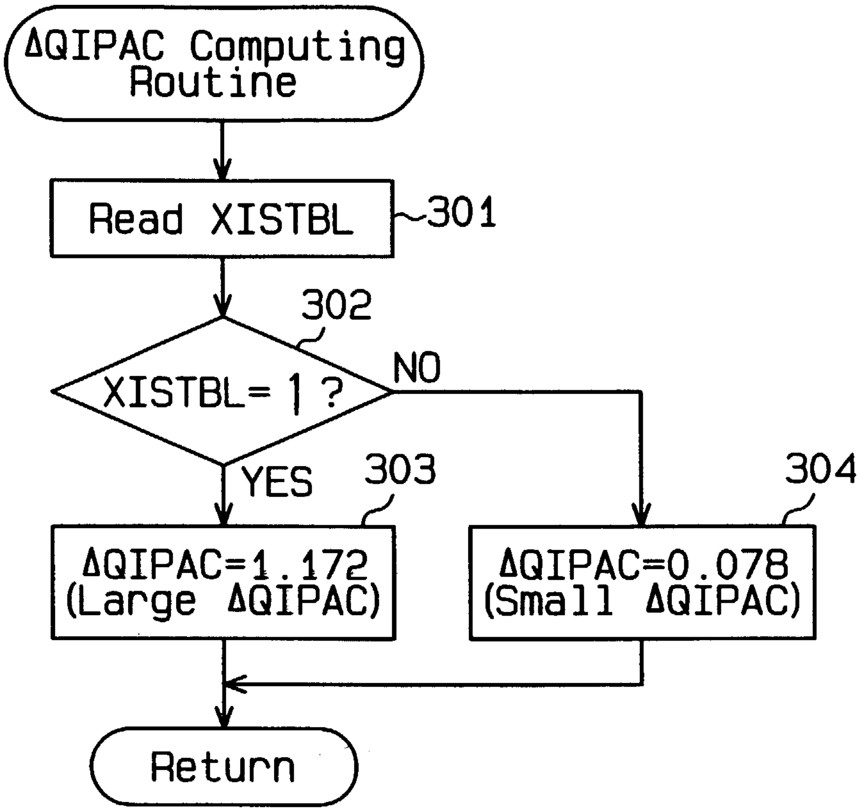

ΔQIPAC Computing Routine
Read XISTBL
301
302
XISTBL= 1 ?
NO
YES
303
304
ΔQIPAC=1.172 (Large ΔQIPAC)
ΔQIPAC=0.078 (Small ΔQIPAC)
Return

Fig.8

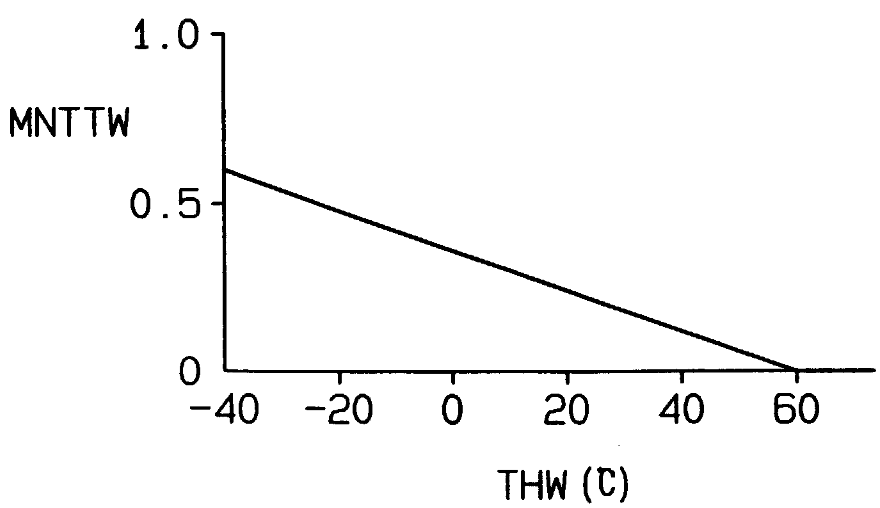
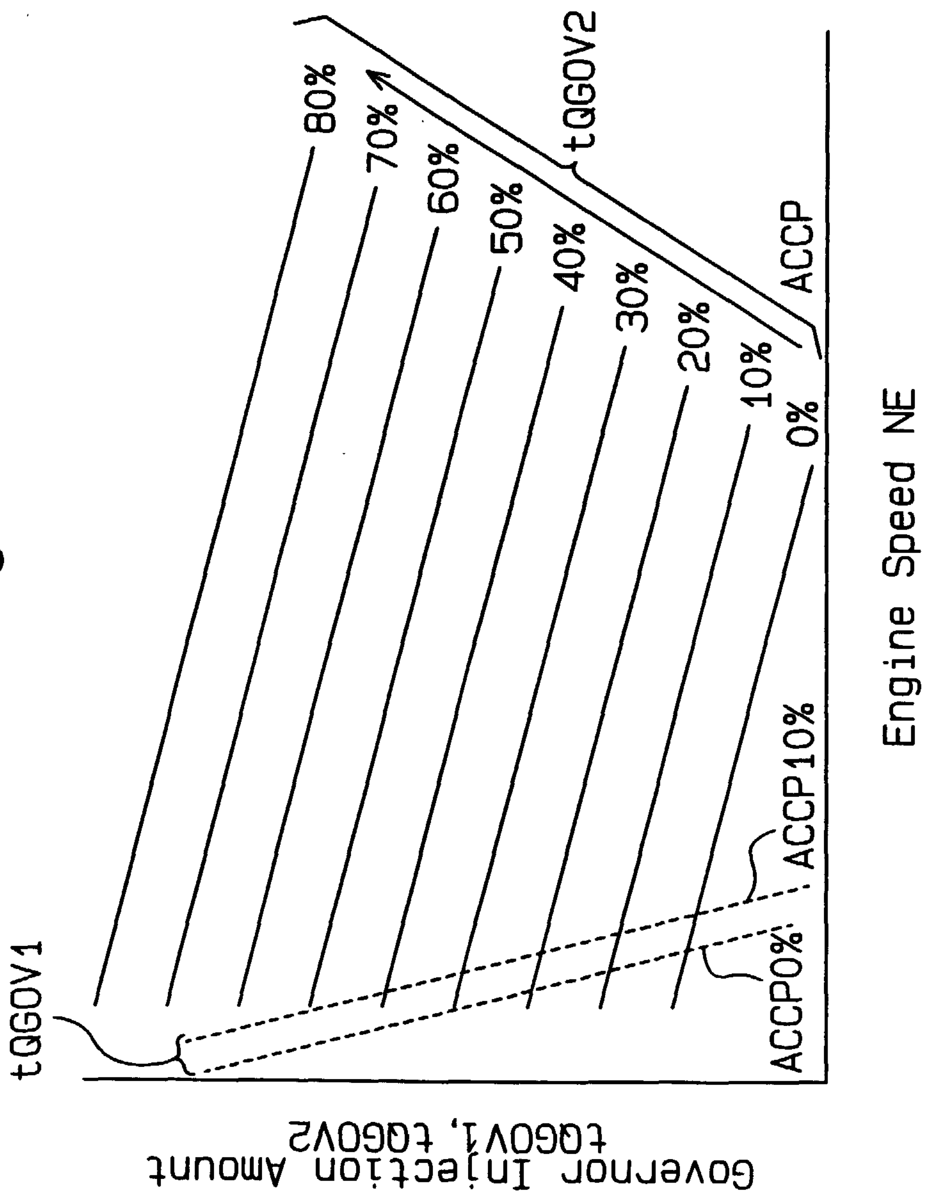

1.0
MNTTW
0.5
0
-40
-20
0
20
40
60
THW (℃)

Fig.9


tQGOV1
tQGOV2
80%
70%
60%
50%
40%
30%
20%
10%
0%
ACCP
ACCP10%
ACCP0%
Engine Speed NE
Governor Injection Amount
tQGOV1, tQGOV2

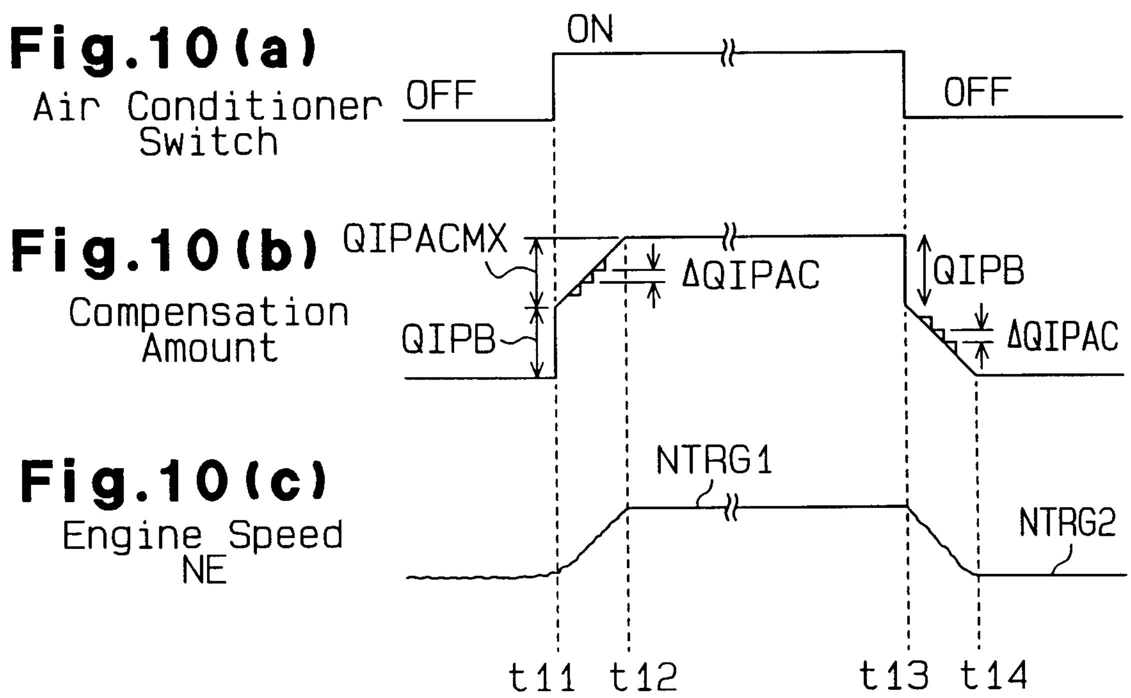


Fig.10(a)
Air Conditioner Switch
ON
OFF
OFF
Fig.10(b)
Compensation Amount
QIPACMX
QIPB
ΔQIPAC
QIPB
ΔQIPAC
Fig.10(c)
Engine Speed NE
NTRG1
NTRG2
t11
t12
t13
t14

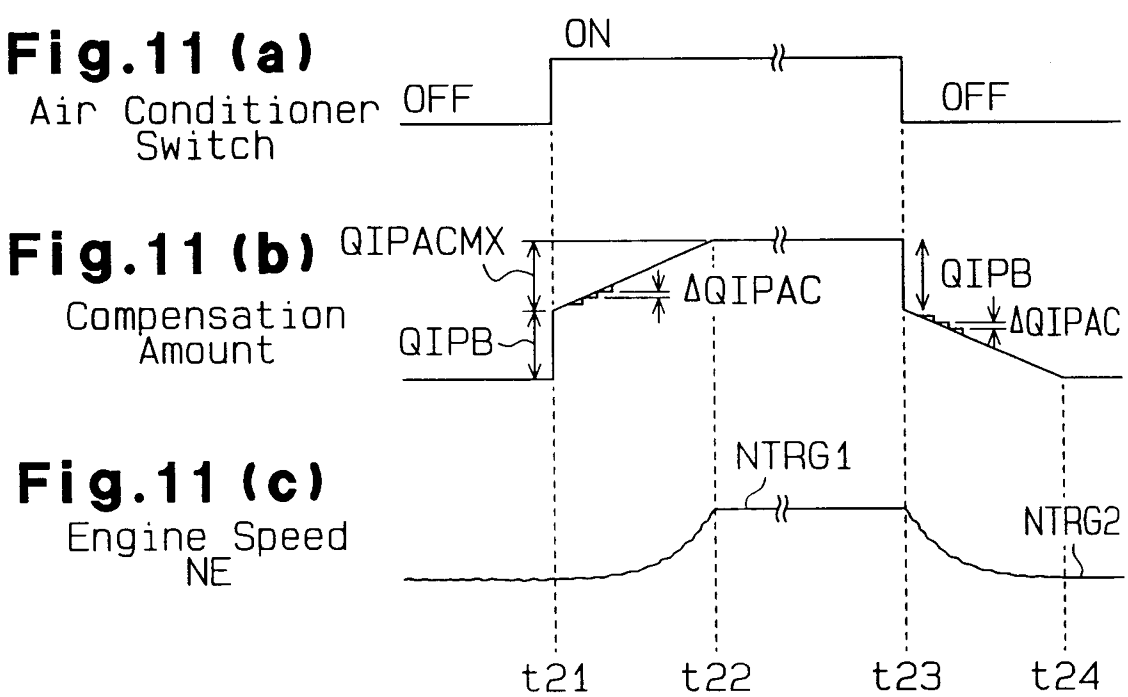


Fig.11(a)
Air Conditioner Switch
ON
OFF
OFF
Fig.11(b)
Compensation Amount
QIPACMX
QIPB
ΔQIPAC
QIPB
ΔQIPAC
Fig.11(c)
Engine Speed NE
NTRG1
NTRG2
t21
t22
t23
t24

Fig.12(a) Air Conditioner Switch

Fig.12(b) Compensation Amount

Fig.12(c) Engine Speed NE

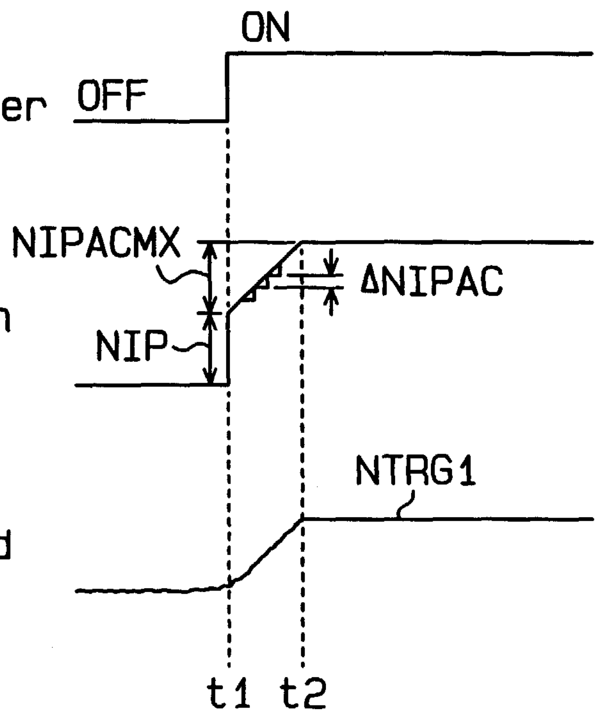


Fig.13(a) Air Conditioner Switch

Fig.13(b) Compensation Amount

Fig.13(c) Engine Speed NE