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Takada

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[54] ON-VEHICLE CONTROL APPARATUS

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[30] Foreign Application Priority Data

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[51] Int. Cl.[6] F02D 9/02

[52] U.S. Cl. 477/107; 123/400

[58] Field of Search 477/107, 906, 477/907; 123/400

[56] References Cited

U.S. PATENT DOCUMENTS

4,873,957	10/1989	Ueyama et al.	123/400
4,962,680	10/1990	Kirstein	477/907
5,033,328	7/1991	Shimanaka	477/906
5,056,022	10/1991	Witowski et al.	477/906
5,297,521	3/1994	Sasaki et al.	123/400
5,366,424	11/1994	Wataya	477/907
5,415,605	5/1995	Yoshimura et al.	477/907
5,447,133	9/1995	Kamio et al.	123/400
5,681,240	10/1997	Sunada et al.	477/906

FOREIGN PATENT DOCUMENTS

5-71365 3/1993 Japan .

Primary Examiner—Dirk Wright
Attorney, Agent, or Firm—Oliff & Berridge, PLC

[57] ABSTRACT

An on-vehicle control apparatus having a throttle valve in an intake passage of the engine is disclosed. The system for actuating the throttle valve includes electric and mechanical components. A electrical motor incorporated in the electric component actuates the throttle valve. An electronic control unit (ECU) controls the motor such that the opening of the throttle valve matches a target opening, which corresponds to a manipulation amount of a gas pedal. When there is an abnormality in the motor, if the gas pedal is manipulated by a predetermined amount or more, the mechanical component couples the gas pedal with the throttle valve, thereby actuating the throttle valve. When there is an abnormality in the motor, the ECU cuts fuel supply to some of the injectors. This allows the actual torque of the engine to be slightly lower than a computed engine torque that corresponds to the amount of a gas pedal manipulation.

11 Claims, 6 Drawing Sheets

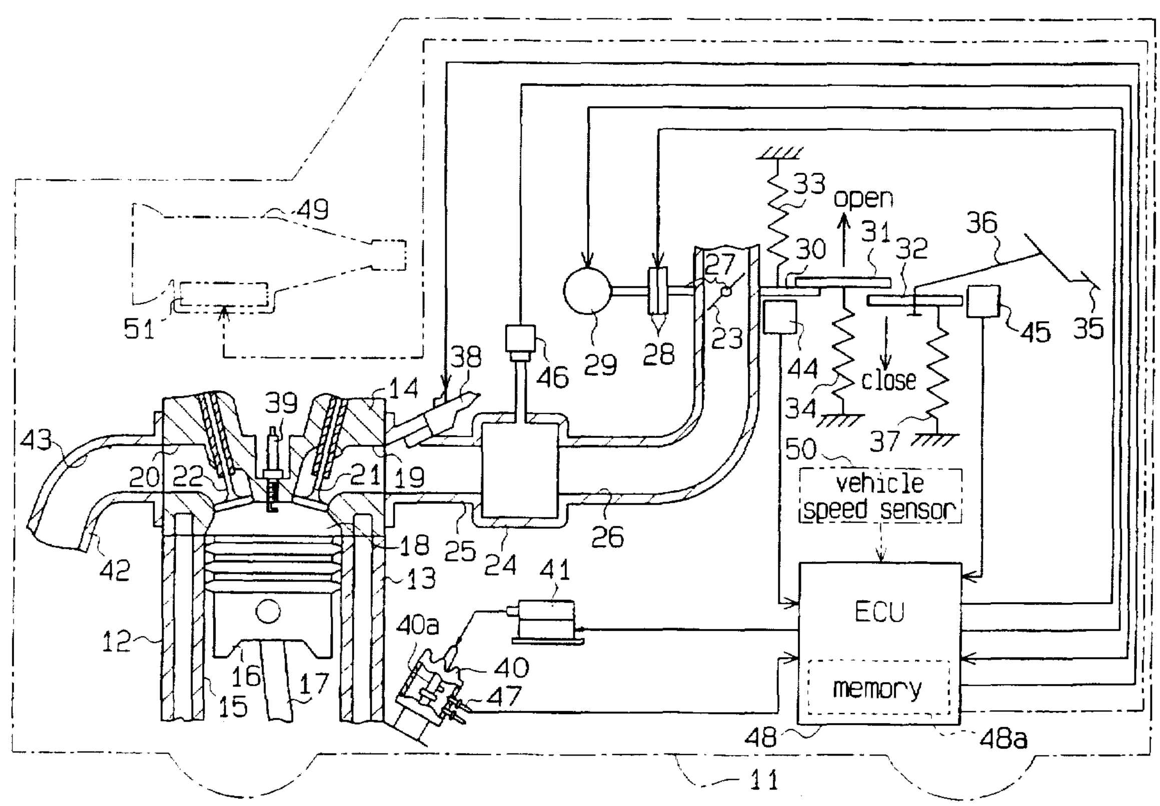


Fig.1

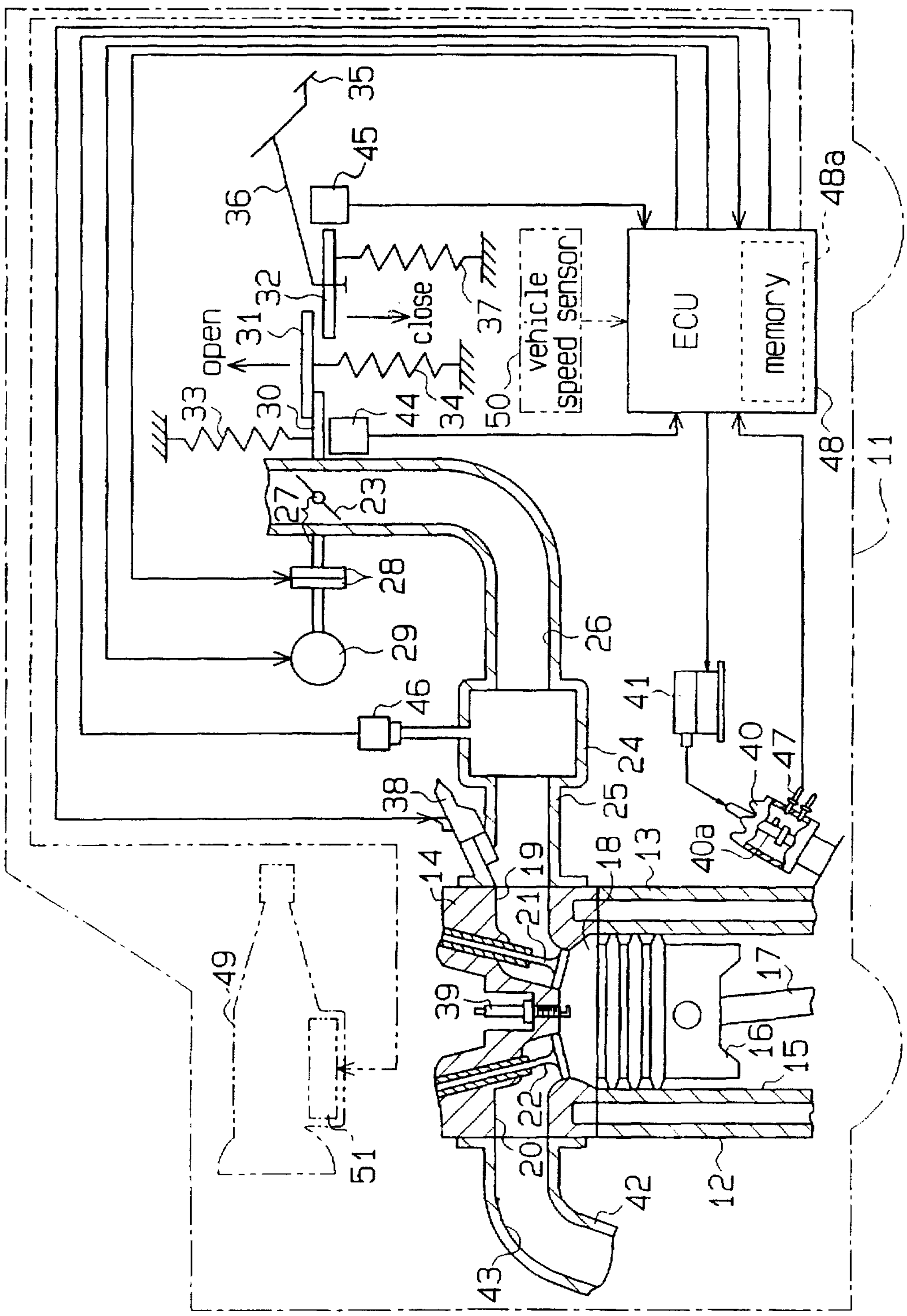


Fig.4

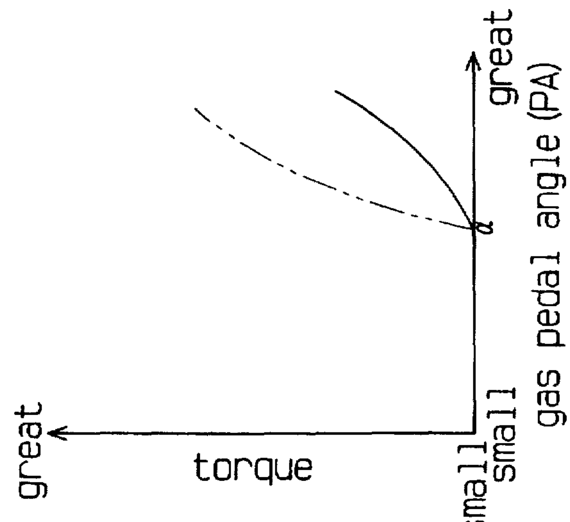


Fig.3

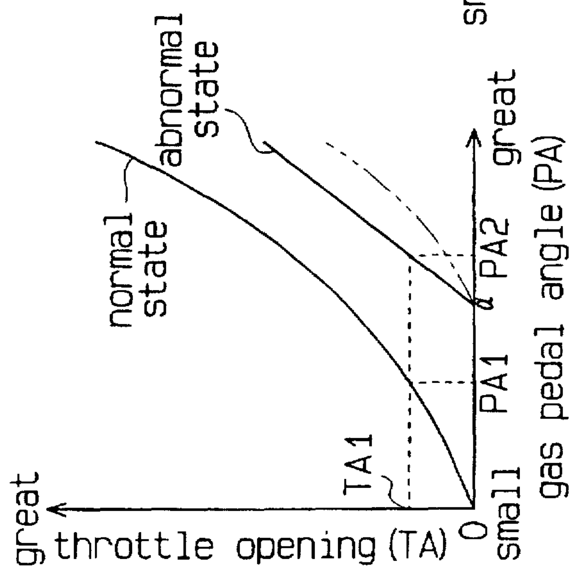


Fig.2

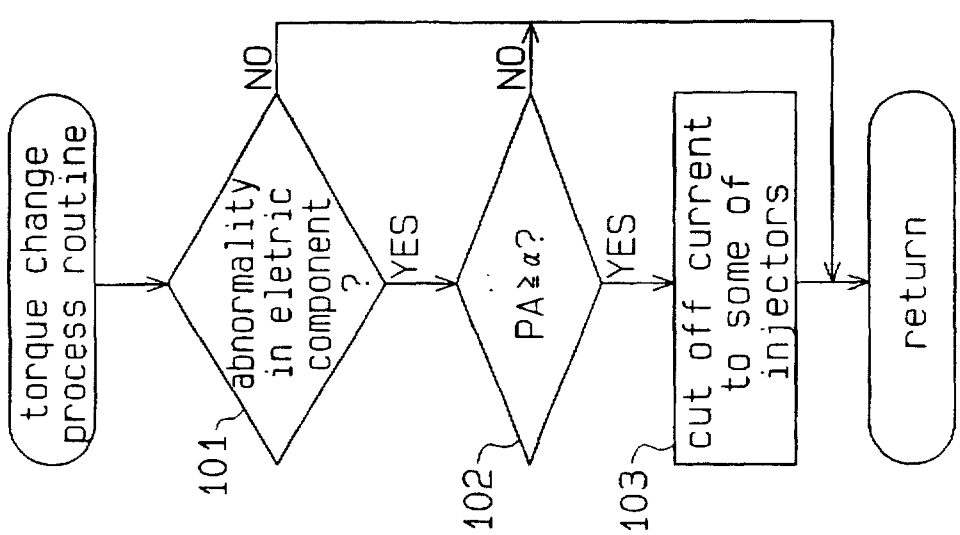


Fig.5

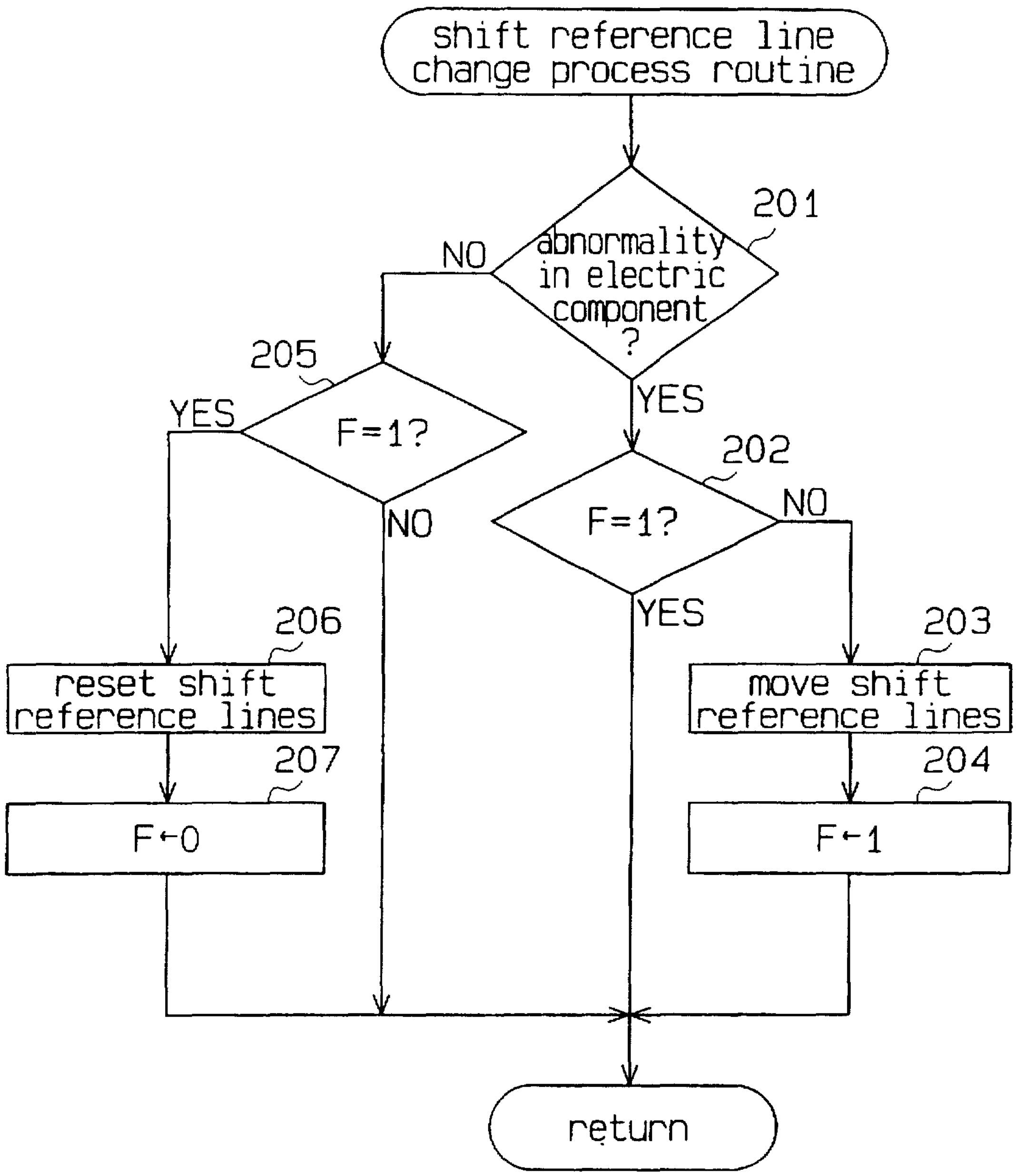

shift reference line change process routine
abnormality in electric component ?
201
NO
YES
205
F=1?
YES
NO
202
F=1?
NO
YES
206
reset shift reference lines
207
F←0
203
move shift reference lines
204
F←1
return

Fig.6

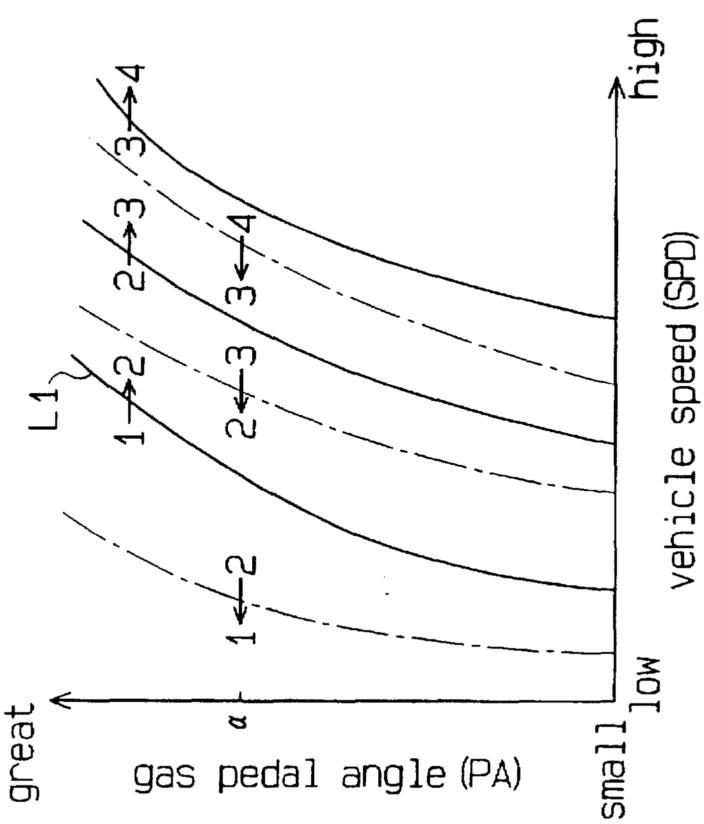

great
gas pedal angle (PA)
α
small
low
high
vehicle speed (SPD)
L1
1→2
1←2
2←3
2→3
3←4
3→4

Fig.7

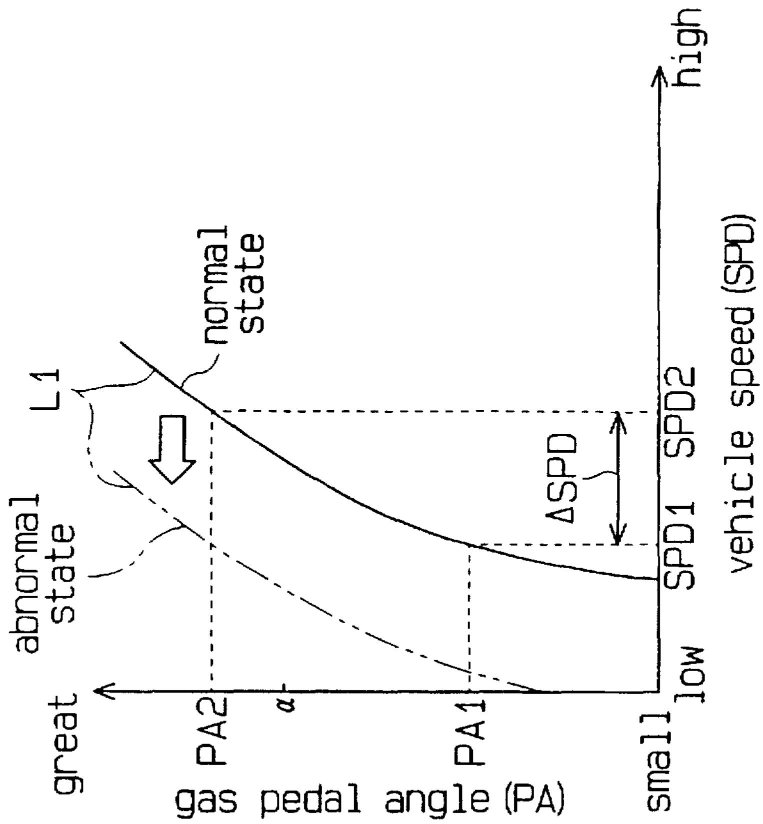

great
PA2
α
PA1
gas pedal angle (PA)
small
low
SPD1
SPD2
vehicle speed (SPD)
high
ΔSPD
L1
normal state
abnormal state

Fig.8 (Prior Art)

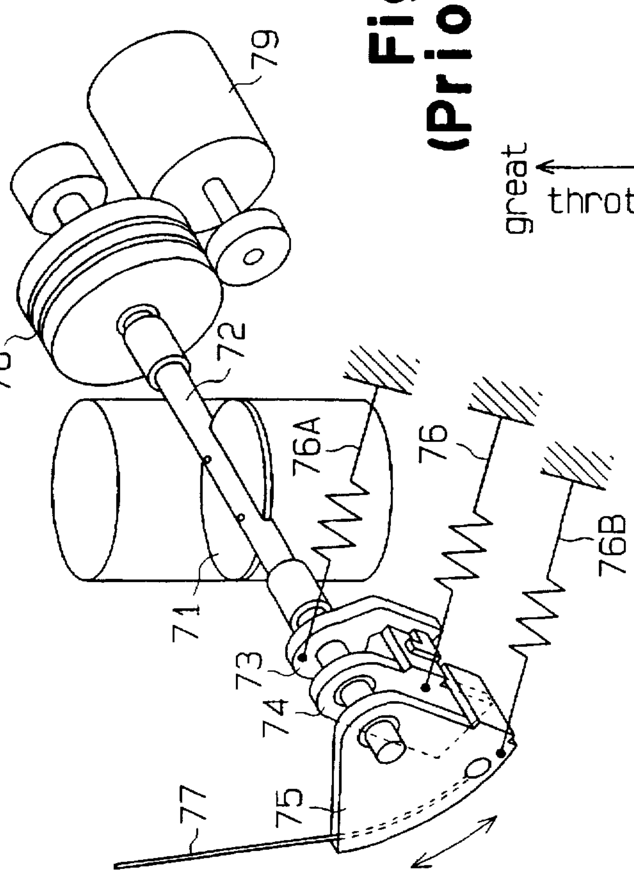


Fig.9 (Prior Art)

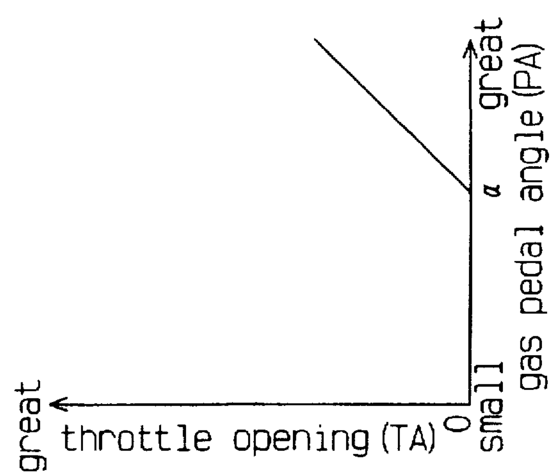


Fig.10 (Prior Art)

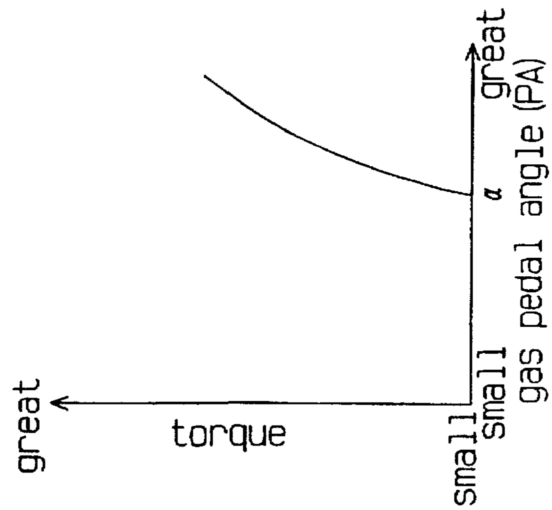


Fig.12 (Prior Art)

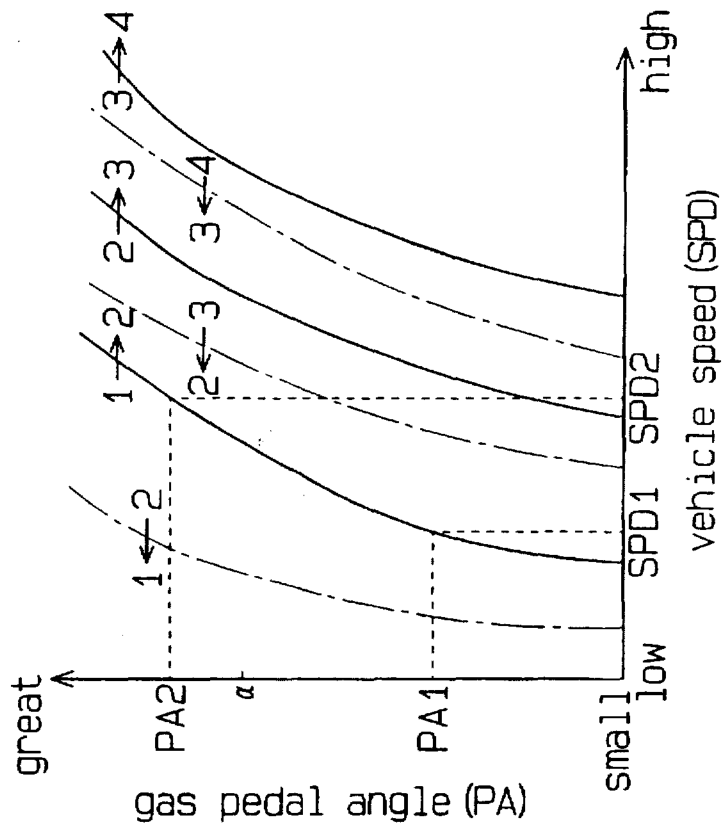
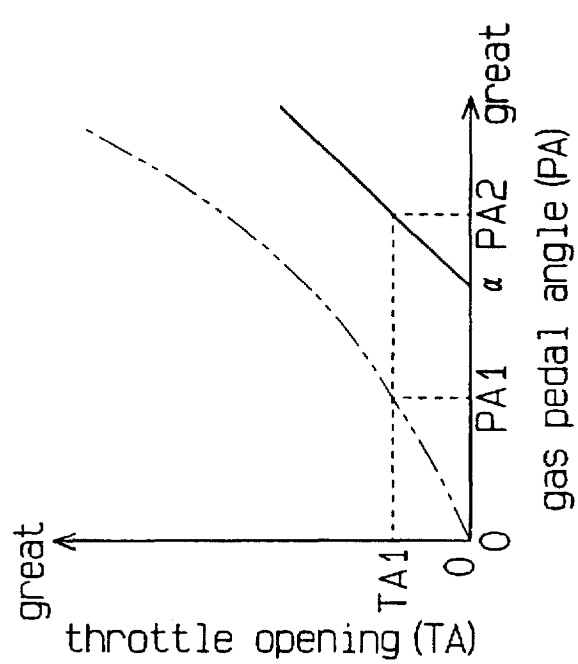


Fig.11 (Prior Art)



ON-VEHICLE CONTROL APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to a control apparatus for vehicles. More particularly, the present invention relates to a control apparatus that has an electronic controlled throttle valve in an intake passage. The apparatus controls the opening of the throttle valve by electrical and mechanical components.

2. Description of the Related Art

Vehicle engines burn air-fuel mixture in a combustion chamber to gain power. The amount of fuel supplied is controlled in accordance with the amount of air drawn into the combustion chamber. Accordingly, the torque of the engine is controlled.

A throttle valve located in an intake passage controls the amount of air drawn into a combustion chamber. One of the systems for actuating the throttle valve is a mechanical system, in which an gas pedal is coupled to the throttle valve by a wire or the like. In this system, there is a one-to-one correspondence between the amount of the manipulation of a gas pedal (pedal angle) PA and the inclination of a throttle valve (throttle opening) TA. In a so-called electronic controlled throttle system, the throttle opening TA is controlled by an electric component such as an electrically powered actuator. This type of throttle apparatus incorporates a computer for controlling the throttle opening TA. The computer computes a target throttle opening in accordance with the manipulation amount of a gas pedal (gas pedal angle) PA. The computer controls the actuator such that the actual throttle opening TA detected by sensors matches the target throttle opening. In this type of throttle apparatus, the correspondence between the throttle opening TA and the gas pedal angle PA is arbitrarily determined.

Electronic controlled throttle apparatuses must allow the driver to control the throttle valve when a malfunction occurs in an electric component such as the actuator. Japanese Unexamined Patent Publication No. 5-71365, which is incorporated herein by reference, discloses such a throttle apparatus.

As shown in FIG. 8, the throttle apparatus includes an interlocking lever **73** fixed to the axle **72** of a throttle valve **71**, an intermediate lever **74** and a throttle lever **75**. The interlocking lever **73** rotates with the axle **72**. A spring **76** is coupled to the lever **73** to urge the lever in a direction to close the throttle valve **71**. A weaker spring **76A** acts to open the throttle valve **71**. Levers **74** and **75** pivot with respect to the axle **72**. A cable **77**, an end of which is coupled to the throttle lever **75**, is connected to a gas pedal (not shown). The throttle lever **75** is normally separated from the intermediate lever **74**. Pressing the gas pedal against the force of spring **76B** over a predetermined amount causes the throttle lever **75** to contact the intermediate lever **74**. The resulting pivoting motion of the intermediate lever **74** permits the lever **73** to open the throttle valve **71** under the force of spring **76A**. The driver's manipulation of the gas pedal is thus mechanically transmitted to the throttle valve **71**.

An electromagnetic clutch **78** is attached to the axle **72**. An electrical motor **79** is located next to the clutch**78**. When actuated, the clutch **78** couples the motor **79** with the throttle valve **71**. De-actuating the clutch **78** disconnects the motor **79** from the throttle valve **71**.

When a malfunction occurs in the motor **79**, the electromagnetic clutch **78** is de-actuated to disconnect the motor **79** from the throttle valve **71**. In this case, the throttle lever **75** does not contact the intermediate lever **74** until the gas pedal is manipulated over a predetermined amount. Before the throttle lever **75** contacts the intermediate lever **74**, the manipulation of the gas pedal does not affect the movement of the throttle valve **71**. The throttle valve **71**, which is urged by the spring **76**, is fully closed regardless of the gas pedal manipulation. When the gas pedal is manipulated over the predetermined amount, on the other hand, the throttle lever **75** contacts the intermediate lever **74**. This mechanically connects the gas pedal and the throttle valve **71**. The manipulation of the gas pedal is thus reflected on the movement of the throttle valve **71**.

The graph of FIG. **9** shows the relationship between the throttle opening TA and the gas pedal angle PA when the motor **79** does not function normally. In this graph, a gas pedal angle PA, at which the throttle lever **75** contacts the intermediate lever **74**, is used as a predetermined angle α. When a gas pedal angle PA is smaller than the angle α, the throttle opening TA is zero. When the gas pedal angle PA is over the angle α, the throttle opening TA increases in proportion with the gas pedal angle PA.

In other words, manipulation of the gas pedal does not increase the power of the engine before it reaches the angle α. This may encourage the driver to abruptly step on the gas pedal to increase the engine power. An abrupt manipulation of the gas pedal causes the throttle lever **75** to contact the intermediate lever **74** and suddenly increases the throttle opening TA. As shown in FIG. **10**, the engine torque abruptly increases, accordingly. This affects the drivability of the vehicle.

The throttle apparatus of the above publication is intended for a vehicle having an automatic transmission. In this case, the gears are shifted at a higher vehicle speed SPD when a malfunction occurs. This also affects the drivability of the vehicle.

The graph of FIG. **11** shows the relationship between the gas pedal angle PA and the throttle opening TA in a vehicle having an automatic transmission. The two-dot chain line indicates normal functioning while the solid line shows the relationship when the electric component is malfunctioning. In the normal state, a throttle opening TA1 is obtained when the pedal angle PA is PA1 ($<\alpha$). Contrarily, when there is a malfunction, TA1 is obtained only when the pedal angle PA reaches PA2 ($>\alpha$).

The graph of FIG. **12** shows function data applied to control of an automatic transmission. Solid and one-dot chain lines show shift reference lines. These lines are referred to when the gears are shifted. The gear shift reference lines are defined by the relationship between the vehicle's speed SPD and the gas pedal angle PA. As shown in FIG. **11**, when there is no electric component malfunction, the throttle opening TA1 is obtained when the gas pedal angle PA is PA1. At this time, as shown in FIG. **12**, if the vehicles speed SPD is SPD1, the automatic transmission shifts gears from first to second. On the other hand, when there is a malfunction in the electric component, the gas pedal angle PA needs to be PA2 to obtain the throttle opening TA1 as shown in FIG. **11**. At this time, the vehicle's speed SPD needs to be SPD2, as shown in FIG. **12**, to cause the automatic transmission to shift from first to second. That is, when there is a malfunction in the electric component, the vehicle's speed SPD needs to be higher to shift gears as compared to a normal state.

SUMMARY OF THE INVENTION

The present invention relates to an on-vehicle control apparatus. The engine of the vehicle includes an electronically controlled throttle valve, the opening of which is controlled by electrical and mechanical components. Accordingly, it is a primary objective of the present invention to provide an on-vehicle control apparatus that prevents a sudden increase in the torque of the engine. The engine torque is abruptly increased by a manipulation of the gas pedal when the throttle valve stops functioning due to a malfunction in an electric component of the control apparatus. The apparatus thereby improves the drivability of the vehicle.

Another objective of the present invention is to provide an on-vehicle apparatus that controls an automatic transmission. When the throttle valve stops functioning due to a malfunction in electric component in the valve, the transmission shifts the gear only at a higher vehicle's speed than in a normal state. The apparatus resolves this drawback, thereby improving the drivability of the vehicle.

To achieve the foregoing and other objects and in accordance with the purpose of the present invention, a throttle valve control apparatus for a vehicle having an internal combustion engine is provided. The engine has a throttle valve for controlling the amount of intake air, and the vehicle has an accelerator that is manipulated by the driver for actuating the throttle valve. The apparatus includes an urging member, an electric control system and a mechanical control system. The urging member urges the throttle valve towards a closed position. The electric control system electrically controls the opening of the throttle valve against the force of the urging member in accordance with the position of the accelerator. The electric control system is disabled when an abnormality is detected therein. The mechanical control system mechanically connects the accelerator with the throttle valve and opens the throttle valve against the force of the urging member if the accelerator is manipulated by more than a predetermined amount when there is an abnormality in the electrical control system. The apparatus also includes means for reducing the output torque of the engine for lowering the actual output torque of the engine to a level that is lower than normal for a given position of the throttle valve when an abnormality is detected in the electric control system.

BRIEF DESCRIPTION OF THE DRAWINGS

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 diagram illustrating an on-vehicle control apparatus according to a first embodiment of the present invention;

FIG. **2** is a flowchart of a torque change process routine;

FIG. **3** is a graph showing the relationship between the gas pedal angle and the throttle opening;

FIG. **4** is a graph showing the relationship between the gas pedal angle and the torque of an engine;

FIG. **5** is a flowchart of a routine for moving shift reference lines according to a second embodiment of the present invention;

FIG. **6** is a graph showing function data of the automatic transmission control when there is no malfunction in an electric component;

FIG. **7** is a graph showing the difference between sets of function data used for an automatic transmission in normal and abnormal states of electric component in a throttle valve;

FIG. **8** is a diagrammatic perspective view illustrating a prior art throttle apparatus;

FIG. **9** is a graph showing the relationship between the gas pedal angle and the throttle opening in the prior art throttle apparatus;

FIG. **10** is a graph showing the relationship between the gas pedal angle and the torque of the engine in the prior art throttle apparatus;

FIG. **11** is a graph showing the relationship between the gas pedal angle and the throttle opening in the prior art throttle apparatus; and

FIG. **12** is a graph showing function data relating to automatic transmission control in the prior art throttle apparatus.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A first embodiment of an on-vehicle control apparatus according to the present invention will now be described with reference to FIGS. **1** to **4**.

As shown in FIG. **1**, a multi-cylinder gasoline engine **12** mounted on a vehicle **11** includes a cylinder block **13** and a cylinder head **14**. A plurality of cylinder bores **15** (only one is shown) are defined in the cylinder block **13**. A piston **16** is reciprocatively accommodated in each cylinder bore **15**. A connecting rod **17** couples each piston **16** to a crankshaft (not shown). Reciprocation of each piston **16** is converted into rotation of crankshaft by the rod **17**.

Each cylinder bore **15**, cylinder head **14** and each cylinder **16** define a combustion chamber **18**. A plurality of intake ports **19** (only one is shown) and a plurality of exhaust port **20** (only one is shown) are defined in the cylinder head **14**. Each suction port **19** and each exhaust port **20** are communicated with the associated combustion chamber **18**. A plurality of suction valves **21** (only one is shown) selectively open and close each intake port **19**. Likewise, a plurality of exhaust valve **22** (only one is shown) selectively open and close each exhaust port **20**.

An intake passage **26** connected to each intake port **19** includes a throttle valve **23**, a surge tank **24** and an intake manifold **25**. When the engine **12** is running, the air in the intake passage **26** is drawn into each combustion chamber **18**.

A throttle valve **23** is supported by a throttle shaft **27** in the intake passage **26**. A system for operating the throttle valve **23** includes an electric component and a mechanical component. The amount of airflow in the intake passage **26** (intake amount) is controlled by the inclination of the throttle valve **23**, or the throttle opening TA. The electric component for operating the valve **23** includes an electromagnetic clutch **28** and an electric motor **29**. The electromagnetic clutch **28** is located at an end (the left end in FIG. **1**) of the shaft **27**. The motor **29** is coupled to the shaft **27** by the clutch **28**. Actuating the clutch **28** couples the motor **29** to the valve **23**. De-actuating the clutch **28** disconnects the motor **29** from the valve **23**. An interlocking lever **30**, an intermediate lever **31** and a throttle lever **32** are located at the other end of the shaft **27** in a manner similar to the mechanism of FIG. **8**.

The interlocking lever **30** is fixed to the throttle shaft **27** in a manner similar to the interlocking liver **73** of FIG. **8**. A first weak spring **33** is coupled to the interlocking lever **30** and urges the lever **30** in a direction to open the throttle valve **23**. The intermediate lever **31** pivots with respect to the shaft **27** like the intermediate lever **74** of FIG. **8**. A second stronger spring **34** is coupled to the intermediate lever **31** and urges the lever **31** in a direction to close the throttle valve **23**. The levers **30** and **31** contact and separate at their overlapping portions. The force of the second spring **34** is greater than that of the first spring **33**. Therefore, when the electromagnetic clutch **28** is de-actuated to disconnect the motor **29** from the throttle valve **23**, the throttle valve **23** is closed by the force of the second spring **34**.

The throttle lever **32** is rotatably supported by the shaft **27** just like lever **75** of FIG. **8**. A gas pedal **35** is located in the passenger compartment of the vehicle **11** and is mechanically coupled to the throttle lever **32** by a wire **36**. A third spring **37** is coupled to the throttle lever **32** and urges the lever **32** in the direction to close the throttle valve **23**. A protrusion formed on the lever **32** is normally separated from the intermediate lever **31**. The protrusion of the throttle lever **32** contacts the intermediate lever **31** only when the motor **29** is disconnected from the throttle valve **23** by de-actuating the electromagnetic clutch **28** and the gas pedal **35** is manipulated over a predetermined distance. The mechanical component to actuate the throttle valve **23** includes the interlocking lever **30**, the intermediate lever **31**, the throttle lever **32**, the wire **36** and the springs **33**, **34** and **37**.

The intake manifold **25** has a plurality of injectors **38**, each of which corresponds to one of the combustion chambers **18**. Each injector **38** injects fuel toward the corresponding intake port **19**. The fuel injected by the injectors **38** and the airflow form an air-fuel mixture. The mixture is drawn into each combustion chambers **18**. The cylinder head **14** has a plurality of spark plugs **39**, each of which corresponds to one of the combustion chamber **18**. Each spark plug **39** is activated by spark signals distributed by a distributor **40**. The distributor **40** distributes high voltage from an igniter **41** to the spark plugs **39** in synchronization with an angle of the crankshaft's rotation. Activating the spark plug **39** burns the air-fuel mixture in the combustion chambers **18**. The high pressure gas in each chamber **18** causes the piston **16** to reciprocate. The reciprocation of the pistons **16** rotates the crankshaft. The vehicle **11** has driving wheels (not shown) driven by the engine **12**. The force of the engine **12** is transmitted to the driving wheels as the torque of the crankshaft and moves the vehicle **12**.

An exhaust manifold **42** and a catalytic converter (not shown) are connected to each exhaust port **20** and constitute an exhaust passage **43**. The burned gas in each combustion chamber **18** is discharged from the engine **12** via the exhaust passages **43**.

The engine **12** is provided with various kinds of sensors **44**, **45**, **46**, **47** that detect the running condition of the engine **12**. The throttle sensor **44** detects the rotation angle of the shaft **27** of the throttle valve **23**, thereby detecting the opening of the throttle valve **23**, or throttle opening TA. The gas pedal sensor **45** detects the amount of manipulation of the gas pedal **35** by the driver, or the gas pedal angle PA. The intake pressure sensor **46** detects the intake pressure in the intake passage **26**. The rotation speed sensor **47** detects the crankshaft's rotational speed, or the engine speed NE by referring to the rotation of a rotor **40***a* incorporated in the distributor **40**.

The ECU **48** has a memory **48***a*, a central processing unit (CPU) and I/O ports. The memory **48***a* stores predetermined control programs and data. The CPU performs various computations based on control programs. The I/O ports allow the ECU **48** to transmit data to and to receive data from the sensors **44** to **47**, the electromagnetic clutch **28**, motor **29**, the injectors **38** and the igniter **41**. The ECU **48** controls the electromagnetic clutch **28**, the motor **29**, the injectors **38** and the igniter **41** based on the data detected by the sensors **44** to **47**, thereby performing the fuel injection control, the spark timing control, throttle control and torque change control.

The ECU **48** computes an intake amount based on the detected intake pressure PM and the engine speed NE for performing the fuel injection control. The ECU **48** computes the amount of fuel in accordance with the computed intake air amount as the fuel injection amount TAU injected from each injector **38**. The ECU **48** determines the fuel injection amount TAU as the length of current passage time to the solenoid coil (not shown) in the injectors **38**. The ECU **48** controls the amount of fuel injected from the injectors **38** by controlling the injectors **38** based on the computed fuel injection amount TAU.

For performing a spark timing control, the ECU **48** refers to function data previously stored in the memory **48***a*. The function data has an optimal relationship between spark timings and parameters of an engine's running condition. The ECU **48** computes the running condition of the engine **12** such as load status and warm-up status based on the data detected by the sensors **44** to **47**. The ECU **48** computes the optimal spark timing for the running condition by referring to the function data. The ECU **48** issues current cut-off signals to the igniter **41** based on the computed spark timings, thereby controlling the actuation timing of spark plugs **39**.

For performing a throttle control, the ECU **48** computes the optimal throttle opening (a target opening) based on the gas pedal angle PA detected by the gas pedal sensor **45**. The ECU **48** controls the motor **29** such that the actual throttle opening TA detected by the throttle sensor **44** matches the computed optimal opening. The ECU **48** diagnoses whether the electric component of the throttle valve **23** such as the motor **29** is functioning normally. If the actual throttle opening TA does not match or approaches the target opening when a predetermined period of time has passed after the ECU **48** transmits a command signal to the motor **29**, the ECU **48** determines that there is a malfunction in the motor **29**. If the ECU **48** determines that the electric component is functioning normally, the ECU **48** actuates the electromagnetic clutch **28**. When the ECU **48** determines that there is a malfunction in the electric component, the ECU **48** de-actuates the electromagnetic clutch **28**.

The torque change routine will now be described with reference to the flowchart of FIG. **2**. The ECU **48** executes the routine with predetermined intervals.

In step **101**, the ECU **48** judges whether there is an abnormality in the electric component in the throttle valve **23**. If the result of the judgment is negative, the ECU **48** does not execute the subsequent steps and temporarily suspends the routine. If the judgment result is positive, on the other hand, the ECU **48** moves on to step **102**.

In step **102**, the ECU **48** judges whether the gas pedal angle PA is smaller than a predetermined angle α. The angle a of the gas pedal **35** is a pedal angle at which the protrusion of the throttle lever **32** contacts the intermediate lever **31**. In other words, the angle α is a gas pedal angle PA at which manipulation of the gas pedal **35** starts to affect the movement of the throttle valve **23** when the electric component does not function normally.

If the judgment result in step **102** is negative, the ECU **48** does not execute the subsequent steps and temporarily suspends the routine. If the judgment result is positive, on the other hand, the ECU **48** moves on to step **103**.

In step **103**, the ECU **48** cuts off current to some of the injectors **38** and stops supplying fuel to the corresponding combustion chambers **18**, thereby temporarily suspending the routine. In this manner, the ECU **48** reduces the torque of the engine **12**.

When the electric component of the throttle valve **23** functions normally, the judgment result of step **101** in FIG. **2** is negative. Therefore, if the driver manipulates the gas pedal **35**, steps **102** and **103** are not executed. The throttle valve **23** thus operates as follows. The protrusion of the throttle lever **32** separates from the intermediate lever **31**, thereby disconnecting the throttle valve **23** from the gas pedal **35**. Therefore, manipulation of the gas pedal **35** is not reflected on the movement of the throttle valve **23** by the mechanical component. The throttle valve **23** is controlled by the electric component including the motor **29** against the force of the spring **34**. This allows the throttle opening TA to match the target opening, which corresponds to the manipulation amount of the gas pedal **35**.

If the throttle valve **23** fails to function because of an abnormality in its electric component, the abnormality is detected by the ECU **48**. In this case, the motor **29** is disconnected from the shaft **27** by de-actuating the electromagnetic clutch **28** and the spring **34** moves the throttle valve **23** to the fully closed position.

FIG. **3** shows the relationship between the throttle opening TA and the gas pedal angle PA. The predetermined pedal angle α in this chart, is a gas pedal angle PA at which the throttle lever **32** contacts the intermediate ever **31**. When the gas pedal angle PA is smaller than α, the throttle opening TA is zero. When the gas pedal angle PA is α or more, the throttle opening TA increases in proportion to the gas pedal angle PA. The graph of FIG. **4** shows the relationship between the torque of the engine **12** and the gas pedal angle PA.

When there is an abnormality in the electric component, if the gas pedal angle PA is smaller than the angle α as shown in FIG. **3**, the protrusion on the throttle lever **32** does not contact the intermediate lever **31**. The throttle opening TA thus stays zero. Accordingly, the judgment result of step **102** in the routine of FIG. **2** is negative. Steps **101** and **102** are thus repeated and the engine's torque stays low as shown in FIG. **4**.

When there is an abnormality in the electric component, if the gas pedal angle PA is the predetermined value a or more, the protrusion on the throttle lever **32** contacts the intermediate lever **31**. This mechanically connects the gas pedal **35** with the throttle valve **23**, thereby allowing the manipulation of the gas pedal **23** to be transmitted to the throttle valve **23**. The throttle valve **23** rotates against the force of the spring **34** in accordance with the manipulation amount of the gas pedal **35**. Therefore, when the gas pedal angle PA is the angle α or more, the throttle opening TA increases in proportion to the increase in the gas pedal angle PA.

If the ECU **48** computes the fuel injection amount TAU in accordance with the intake air amount, which corresponds to the throttle opening TA, and allows all the injectors **38** to inject fuel equivalent to the amount TAU, the engine's torque shows the characteristics illustrated by a two-dot chain line in FIG. **4**. Thus, the engine's torque abruptly increases when the gas pedal angle PA exceeds the angle α. In this embodiment however, the process in steps **101** to **103** prevents some of the injectors **38** from supplying fuel to the corresponding cylinders. Accordingly, the amount of fuel supplied to the combustion chambers **18** is less than that supplied in a normal condition. As a result, as illustrated with a solid line in FIG. **4**, the engine's torque increases less dramatically than the rate illustrated by the two-dot chain line. In other words, when the gas pedal angle PA exceeds the angle α, an abrupt increase in the engine's torque is prevented. Accordingly, fast starts of the vehicle **11** are prevented and the drivability is improved.

A special cam may be located between the throttle lever **32** and the intermediate lever **31** to prevent an abrupt increase in the torque of the engine **12**. The characteristics of the cam are illustrated with a two-dot chain line in FIG. **3**. As shown in FIG. **3**, the cam causes the increase in the throttle opening TA with respect to the gas pedal angle PA to be more moderate than that of the abnormal state illustrated by a solid line. This structure however increases the number of the parts in the valve's mechanical component. This increases the manufacturing cost, the size and the weight of the throttle apparatus. The previously described embodiment, on the other hand, requires no special cams.

In this embodiment, the number of the injectors **38** to which current is stopped in step **103** is readily changed. The amount of reduced torque of the engine **12** is thus controlled when a malfunction occurs in the electric component of the valve **23**.

A second embodiment of an on-vehicle control apparatus will now be described with reference to FIGS. **1** and **5** to **7**. To avoid a redundant description, like or same reference numerals are given to those components which are like or the same as the corresponding components of the first embodiment.

In addition to the components illustrated by solid lines in Fig. **1**, the second embodiment has an automatic transmission **49** and a vehicle speed sensor **50** illustrated by two-dot chain lines. The vehicle speed sensor **50** detects the speed of the vehicle **11** SPD. In addition to stopping the fuel supply to some of the cylinders as described in the first embodiment, the shift control of the automatic transmission **49** differs between normal conditions and abnormal conditions of the valve's electric component.

The automatic transmission **49** functions as a power transmission apparatus for transmitting the rotation of the crankshaft to the driving wheels. The automatic transmission **49** is coupled to the engine **12** with a clutch (not shown). Combinations of the gear wheels in the transmission **49** convert the rotation speed of the crankshaft (engine speed NE) and the engine's torque at various ratios. The transmission **49** has four gear ratios including a first gear for low speed and a fourth gear for high speed. The automatic transmission **49** has a hydraulic circuit (not shown) and a solenoid valve **51**. The hydraulic circuit changes the combination of the gear wheels and thus the gear ratio. The solenoid valve **51** controls oil pressure to the hydraulic circuit for switching the gears.

The ECU **48** refers to a function data shown in FIG. **6** stored in the memory **48***a* when switching the gears. The solid lines and one-dot chain lines in FIG. **6** are reference lines for shifting the gears. These shift reference lines are defined by the relationship between the vehicle speed SPD and the gas pedal angle PA. Each one-dot chain line is referred to when the gear is shifted down to a lower gear and each solid line is referred to when the gear is shifted up to a higher gear.

The ECU **48** selects a gear corresponding to the relationship between the vehicle speed SPD and the gas pedal angle PA by referring to the function data shown in FIG. **6**. Then the ECU **48** controls the solenoid valve **51** such that the actual gear matches the selected one. When the point corresponding to the vehicle speed SPD and the gas pedal angle PA on the graph in FIG. **6** crosses a solid line or a one-dot chain line, the ECU **48** issues a command signal to the solenoid valve **51**. The command signal causes the solenoid valve **51** to change oil flow to the hydraulic circuit. This either shifts the gears up or down. If the point corresponding to SPD and PA does not cross a line on the graph, the ECU **48** issues a command signal to the solenoid valve **51** for maintaining the current gear.

Fig. **5** shows a routine for moving shift reference lines. While the engine **12** is running, the ECU **48** executes the routine at predetermined intervals. The ECU **48** refers to an abnormality flag F in this routine. The abnormality flag F indicates the condition of the electric component of the throttle valve **23**. That is, when the throttle valve's electric component functions normally, the flag F has a value "0" and when the component has an abnormality, the flag F has a value "1".

In step **201**, the ECU **48** judges whether there is an abnormality in the electric component of the throttle valve **23**. If the judgment result is positive, the ECU **48** moves on to step **202**.

In step **202**, the ECU **48** judges if the abnormality flag F has a value "1". If the judgment result is positive (F=1), the ECU **48** temporarily suspends the routine without executing the subsequent steps. If the judgment result is negative (F=0), the ECU **48** moves on to step **203**.

In step **203**, the ECU **48** moves the shift reference lines on the function data stored in the memory **48a** toward the low vehicle speed SPD side. In step **204**, the ECU **48** gives a value "1" to the flag F and temporarily suspends this routine.

Taking a line L1 in FIG. **6** as an example, the movement of the shift reference lines on the graph will be explained. The line L1 is referred to when the gear is shifted up from first gear to second gear. It is assumed that the throttle opening TA is TA1 as shown in FIG. **3**. When the electric component functions normally, the ECU **48** computes a gas pedal angle PA1 so that TA1 corresponds to the PA on the graph. When there is an abnormality in the electric component, the ECU **48** computes a gas pedal angle PA2 so that TA1 matches the PA on the graph.

As shown in FIG. **7**, when the gas pedal angle PA is PA1, the ECU **48** refers to the line L1 to compute the vehicle's speed SPD1 at which the gear is shifted from first gear to second gear. Similarly, when the gas pedal angle PA is PA2, the ECU **48** refers to the line L1 to compute the vehicle's speed SPD2 at which the gear is shifted from first to second. Further, the ECU **48** computes the difference between the vehicle's speeds SPD2 and SPD1 as a value ΔSPD. The ECU **48** moves the shift reference line L1 toward the low speed side (that is, to the left in FIG. **7**) by the amount of ΔSPD. The shift reference line L1, which is illustrated by an solid line in FIG. **7** when the electric component functions normally, is moved to the position illustrated by a two-dot chain line in FIG. **7**. The movement of the shift reference line L1 causes the gear to be shifted substantially at the same vehicle's speed SPD when there is an abnormality in the electric component as when there is no abnormality. The other shift reference lines are moved in the same manner.

Back to FIG. **5**, when the judgment result in step **201** is negative, the ECU **48** goes to step **205**. In step **205** the ECU **48** judges whether the abnormality flag F is "1". If the judgment result is negative (F=0), the ECU **48** temporarily suspends the routine without executing the subsequent steps. If the judgment result is positive (F=1), the ECU **48** moves on to step **206**.

In step **206**, the ECU **48** resets the position of the shift reference lines, which have been moved in step **203**. That is, as shown in FIG. **7**, the line L1, which has been moved to the position illustrated by a two-dot chain line, is moved back to the position illustrated by a solid line. In step **207**, the ECU **48** gives a value "0" to the abnormality flag F and temporarily suspends the routine.

When the electrical component in the throttle valve **23** functions normally, steps **201** and **205** in FIG. **5** are repeated. The ECU **48** shifts the gear of the automatic transmission **49** by referring to the relationship between the vehicle's speed SPD and the gas pedal angle PA in the function data shown in FIG. **6**.

When there is an abnormality in the electric component in the throttle valve **23**, the throttle valve **23** is actuated by the mechanical component. In this case, right after the switch from the electric component to the mechanical component, the process from step **201** to **204** in FIG. **5** is executed. This moves the shift reference lines toward the low vehicle's speed side by the amount of ΔSPD. Thereafter, so long as the abnormal condition continues, steps **201** and **202** are repeated and the automatic transmission is controlled based on the moved shift reference lines. In the prior art apparatus, the shift reference lines are fixed. Therefore, with an abnormality in the electric component of the throttle valve, the gear is shifted at a higher vehicle speed SPD than in a normal state. Unlike the prior art apparatus, this embodiment causes the gear to be shifted at the same speed as the normal state even if there is an abnormality in the electric component. Therefore, the abnormality in the electric component in the throttle valve does not deteriorate the drivability of the vehicle **11** and the automatic transmission **49** changes gears without making the driver uncomfortable.

Although only two embodiments of the present invention have been described herein, 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. Particularly, the invention may be embodied in the following forms:

In the above described first embodiment, the process in step **103** in FIG. **2** may be modified as follows. Instead of cutting current to some of the injectors **38**, the current passage time to all the injectors **38** may be equally shortened by a certain amount, or the timing of the plugs **39** may be slightly delayed. Further, both current cutting to a some of the injectors **38** and spark timing delay may be performed. In these cases, when there is an abnormality in the electric component of the throttle valve **23**, the torque of the engine **12** is reduced and the vehicle's drivability is not deteriorated.

In the above described second embodiment, the shift reference lines in the function data are moved by the amount of ΔSPD. However, the amount of the lines' movement may be altered. In this case, the lines must be moved toward the low speed side as in the second embodiment. The amount of the movement is preferably close to ΔSPD. This causes the automatic transmission **49** to shift gears in an abnormal state substantially at the same vehicle's speed SPD as in the normal state.

In the second embodiment, the process in steps **205** to **207** in FIG. **5** may be omitted. If the judgment result in step **201** is positive, that is, when the electric component functions normally, the ECU **48** may suspend the routine without executing the subsequent steps.

In the first and second embodiments, the prior art apparatus (Japanese Unexamined Patent Publication No.

5-71365) may be employed for detecting an abnormality in the electric component. In this case, the intermediate lever **31** is provided with a contact switch. The switch is turned on when the intermediate lever **31** is separated from the interlocking lever **30** and turned off when the levers **31** and **30** contact. The ECU **48** detects an abnormality when the motor **29** rotates the throttle valve **23** to open the valve **23** to an amount such that the contact switch is turned off.

In the second embodiment, a set of shift reference lines may be previously prepared for an abnormal state in addition to the set of shift reference lines for a normal state. In this case, different sets of the shift reference lines are used in a normal state and an abnormal state.

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 of the appended claims.

What is claimed is:

1. An apparatus of controlling vehicle speed, said vehicle having an engine with a throttle valve being arranged to vary the opening thereof to control the amount of intake air supplied to the engine so as to change the vehicle speed, the vehicle having an accelerator for controlling the opening of the throttle valve, wherein the throttle valve is urged toward a closed position by an urging member, and wherein the throttle valve is opened by the accelerator manipulated to a predetermined effective position, the apparatus comprising:

means for electrically adjusting the opening of the throttle valve against the force of the urging member in accordance with the position of the accelerator;

means for mechanically coupling the accelerator to the throttle valve against the force of the urging member to control the opening of the throttle valve;

means for detecting an occurrence of a malfunction in the adjusting means;

means for deactivating the adjusting means based on the malfunction therein;

means for shifting the predetermined effective position of the accelerator to an increased manipulated position based on the malfunction in the adjusting means; and

means for decreasing the vehicle speed with respect the vehicle speed based on the position of the accelerator whose effective position is shifted to the increased manipulated position.

2. The apparatus as set forth in claim **1**, wherein said adjusting means includes:

an electric motor for adjusting the opening of the throttle valve;

an electromagnetic clutch for providing a the throttle valve with a connection with or disconnection from the electric motor; and

means for instructing the electromagnetic clutch to disconnect the electric motor from the throttle valve.

3. The apparatus as set forth in claim **2**, wherein said decreasing means has means for lowering output torque of the engine.

4. The apparatus as set forth in claim **3** further comprising:

a plurality of injectors electrically actuated to inject fuel so as to drive the engine; and

means for deactivating a part of the injectors based the malfunction in the adjusting means.

5. The apparatus as set forth in claim **3** further comprising an electric control unit forming the deactivating means, the, shifting means, the decreasing means and the instructing means.

6. The apparatus as set forth in claim **2** further comprising said decreasing means including:

an automatic gear transmission for converting engine speed and engine torque to the vehicle speed at transmitting ratios respectively predetermined for a plurality of stages of the vehicle speed from a minimum stage to a maximum stage;

means for computing a corrected value of each predetermined transmitting ratio, wherein said corrected value is shifted toward the minimum stage from each of the predetermined transmitting ratio by a variation computed based on the shift of the vehicle speed; and

means for actuating the automatic gear transmission based on the computed corrected value.

7. The apparatus as set forth in claim **6** further comprising an electric control unit forming the deactivating means, the shifting means, the decreasing means, the instructing means, the computing means and actuating means.

8. An apparatus of controlling vehicle speed, said vehicle having an engine with a throttle valve being arranged to vary the opening thereof to control the amount of intake air supplied to the engine so as to change vehicle speed, the vehicle having an accelerator for controlling the opening of the throttle valve, wherein the throttle valve is urged toward a closed position by an urging member and, wherein the throttle valve is opened by the accelerator manipulated to a predetermined effective position, the apparatus comprising:

means for electrically adjusting the opening of the throttle valve against the force of the urging member in accordance with the position of the accelerator;

means for mechanically coupling the accelerator to the throttle valve against the force of the urging member to control the opening of the throttle valve;

means for detecting an occurrence of a malfunction in the adjusting means;

means for selectively driving the adjusting means and the coupling means, said driving means including means for deactivating the adjusting means based on the malfunction therein, said driving means including means for shifting the predetermined effective position of the accelerator to an increased manipulated position based on the malfunction in the adjusting means;

a plurality of injectors electrically actuated to inject fuel so as to drive the engine; and

means for deactivating a part of the injectors based the malfunction in the adjusting means.

9. The apparatus as set forth in claim **8**, wherein said adjusting means includes:

an electric motor for adjusting the opening of the throttle valve;

an electromagnetic clutch for providing a the throttle valve with a connection with or disconnection from the electric motor; and

means for instructing the electromagnetic clutch to disconnect the electric motor from the throttle valve.

10. The apparatus as set forth in claim **9** further comprising an electric control unit forming the deactivating means, the, shifting means, the decreasing means and the instructing means.

11. An apparatus of controlling vehicle speed, said vehicle having an engine with a throttle valve being arranged to vary the opening thereof to control the amount of intake air supplied to the engine so as to change vehicle speed, the vehicle having an accelerator for controlling the opening of the throttle valve, wherein the throttle valve is urged toward a closed position by an urging member and, wherein the throttle valve is opened by the accelerator manipulated to a predetermined effective position, the apparatus comprising:

means for electrically adjusting the opening of the throttle valve against the force of the urging member in accordance with the position of the accelerator;

means for mechanically coupling the accelerator to the throttle valve against the force of the urging member to control the opening of the throttle valve;

means for detecting an occurrence of a malfunction in the adjusting means;

means for selectively driving the adjusting means and the coupling means, said driving means including means for deactivating the adjusting means based on the malfunction therein, said driving means including means for shifting the predetermined effective position of the accelerator to an increased manipulated position based on the malfunction in the adjusting means;

an automatic gear transmission for converting engine speed and engine torque to the vehicle speed at transmitting ratios respectively predetermined for a plurality of stages of the vehicle speed from a minimum stage to a maximum stage;

means for computing a corrected value of each predetermined transmitting ratio, wherein said corrected value is shifted toward the minimum stage from each of the predetermined transmitting ratio by a variation computed based on the shift of the vehicle speed; and

means for actuating the automatic gear transmission based on the computed corrected value.

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