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(54) **SHIFT CONTROL APPARATUS OF A CONTINUOUSLY VARIABLE TRANSMISSION AND METHOD OF DETERMINING WHETHER SHIFT CONTROL APPARATUS IS OPERATING NORMALLY**

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(57) **ABSTRACT**

The invention provides a shift control apparatus of a continuously variable transmission, which includes a feedback control portion which executes feedback control that brings an actual speed ratio close or equal to a target speed ratio, and a normal operation determining portion which determines whether the shift control apparatus is operating normally based on a difference between the actual speed ratio and the target speed ratio, and an amount of change in the actual speed ratio and an amount of change in the target speed ratio during a predetermined interval.

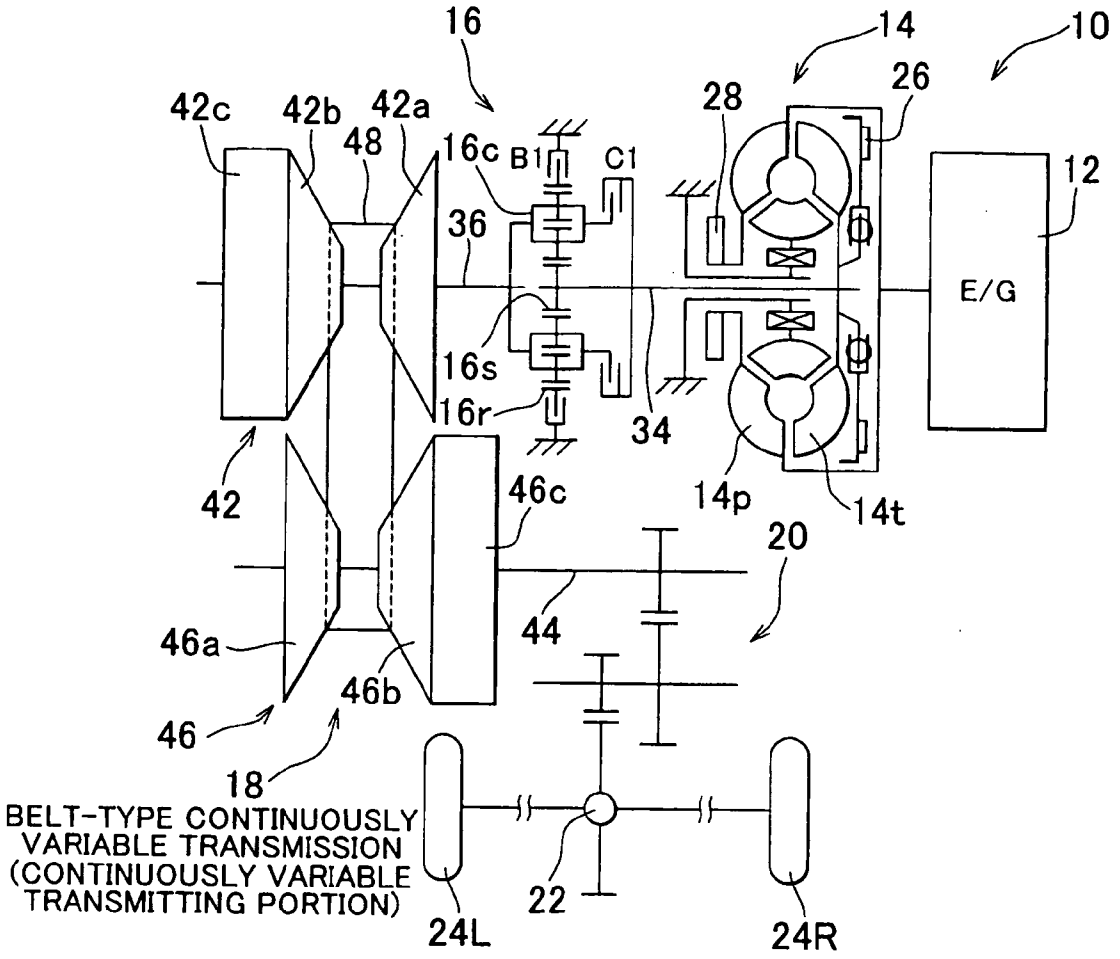


FIG. 1

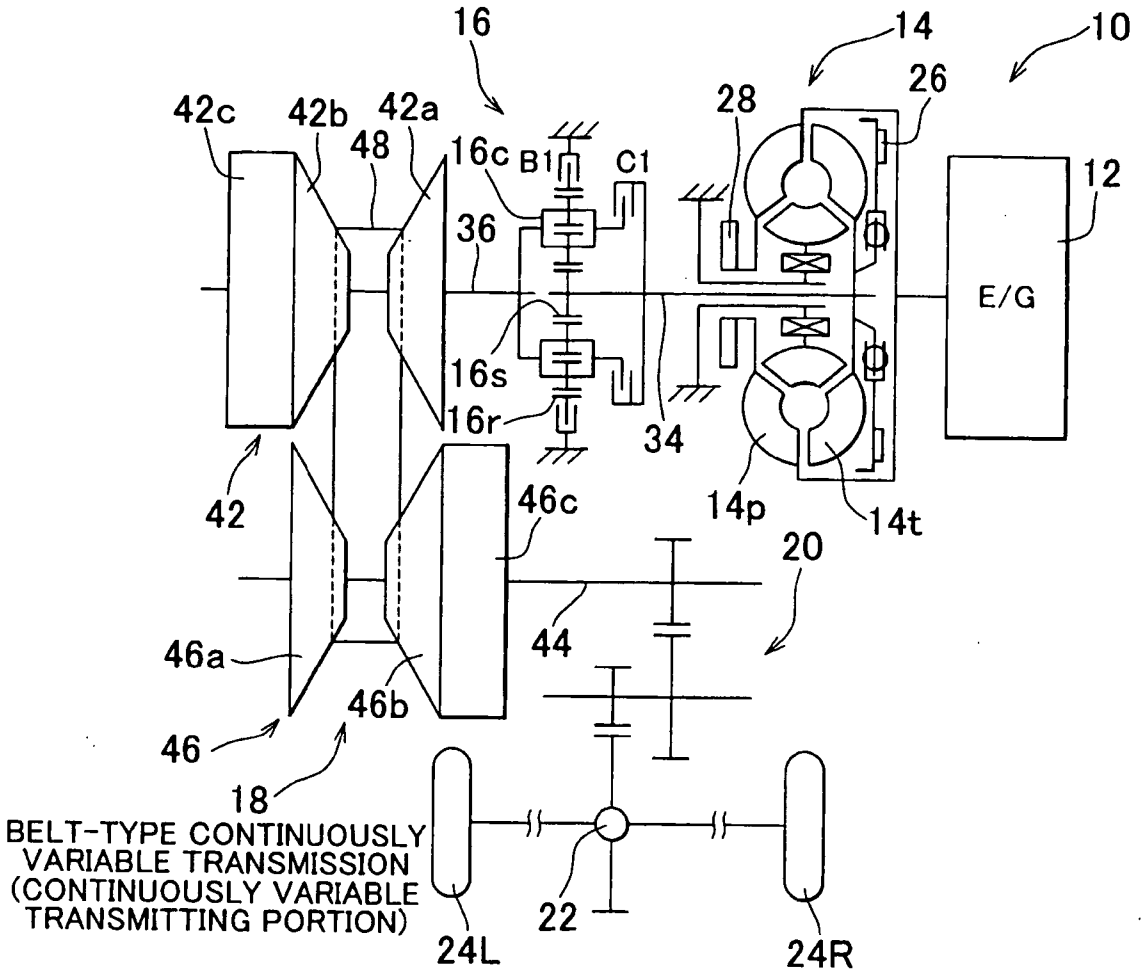


FIG. 2

	C1 CLUTCH	B1 BRAKE
FORWARD	○	
REVERSE		○

○ : APPLIED

FIG. 3

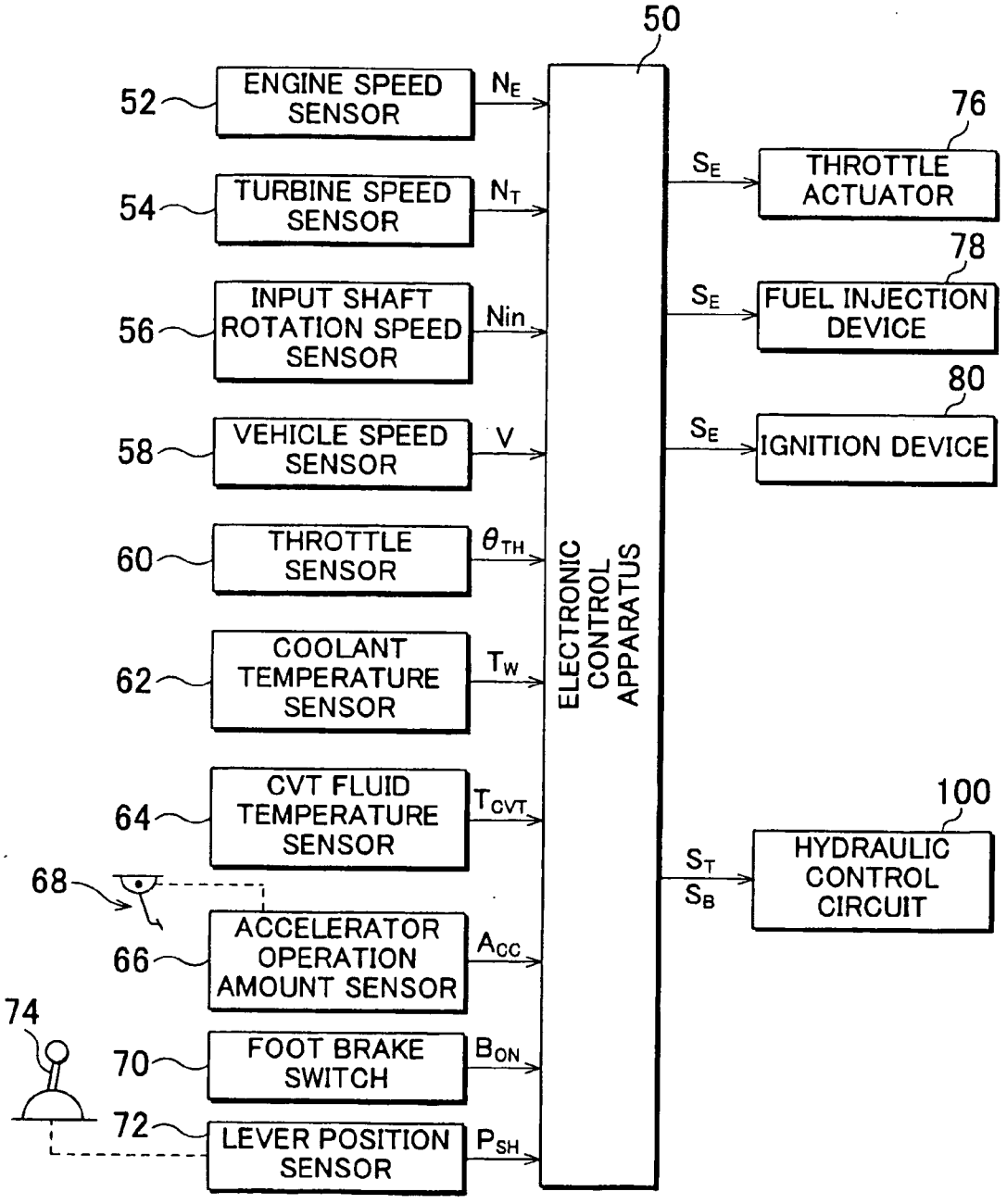

50
52
ENGINE SPEED SENSOR
N_E
54
TURBINE SPEED SENSOR
N_T
56
INPUT SHAFT ROTATION SPEED SENSOR
Nin
58
VEHICLE SPEED SENSOR
V
60
THROTTLE SENSOR
θ_{TH}
62
COOLANT TEMPERATURE SENSOR
T_W
64
CVT FLUID TEMPERATURE SENSOR
T_{CVT}
68
66
ACCELERATOR OPERATION AMOUNT SENSOR
A_{CC}
74
70
FOOT BRAKE SWITCH
B_{ON}
72
LEVER POSITION SENSOR
P_{SH}
ELECTRONIC CONTROL APPARATUS
S_E
76
THROTTLE ACTUATOR
S_E
78
FUEL INJECTION DEVICE
S_E
80
IGNITION DEVICE
S_T
S_B
100
HYDRAULIC CONTROL CIRCUIT

FIG. 4

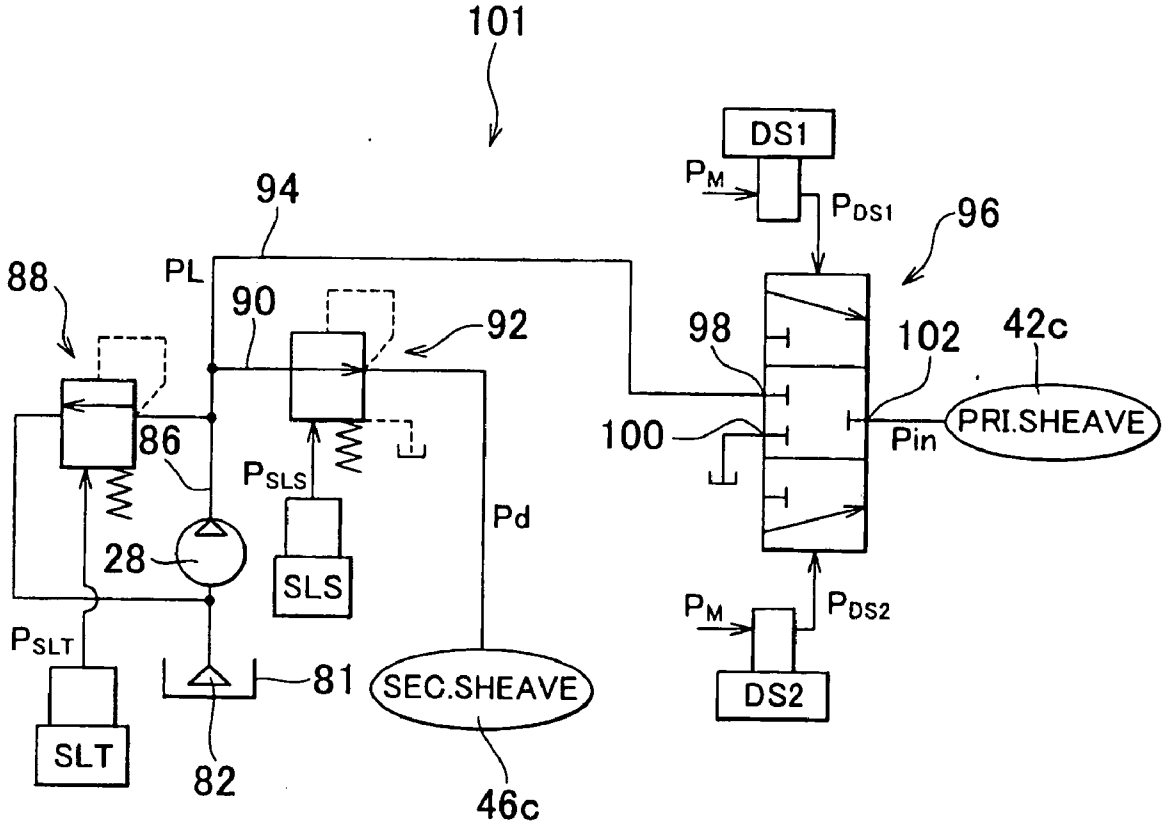

101
DS1
P_M
P_{DS1}
96
94
PL
88
90
92
98
102
42c
100
Pin
PRI.SHEAVE
86
P_{SLS}
Pd
28
SLS
P_{SLT}
81
SEC.SHEAVE
P_M
P_{DS2}
DS2
SLT
82
46c

FIG. 5

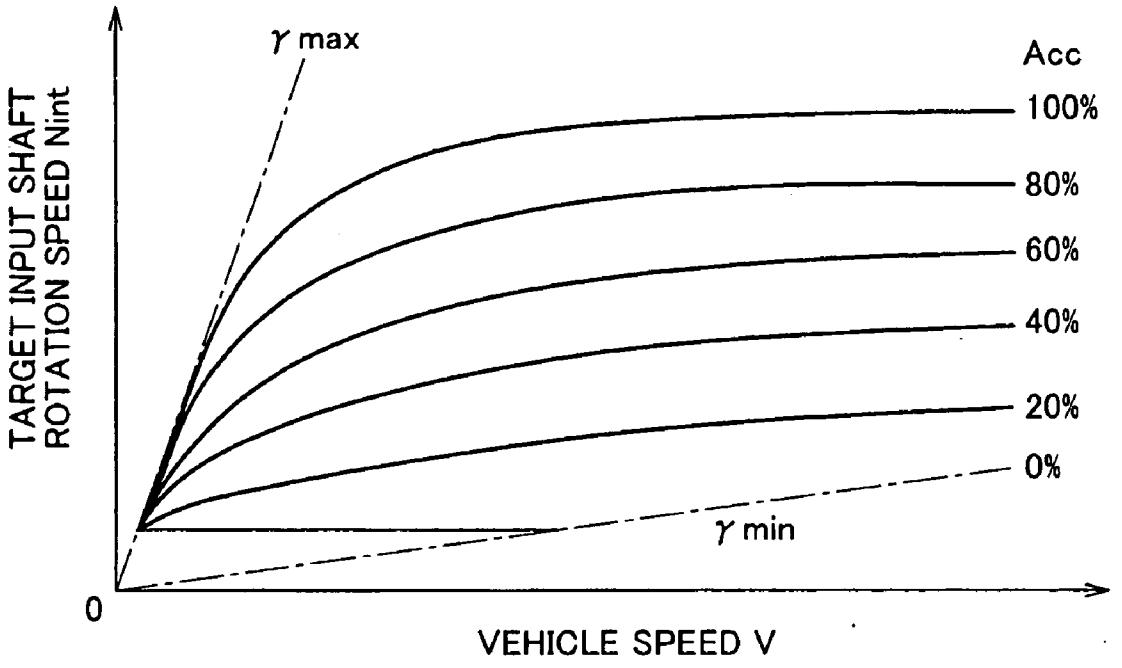

γ max
Acc
100%
80%
60%
40%
20%
0%
γ min
TARGET INPUT SHAFT ROTATION SPEED Nint
0
VEHICLE SPEED V

FIG. 6

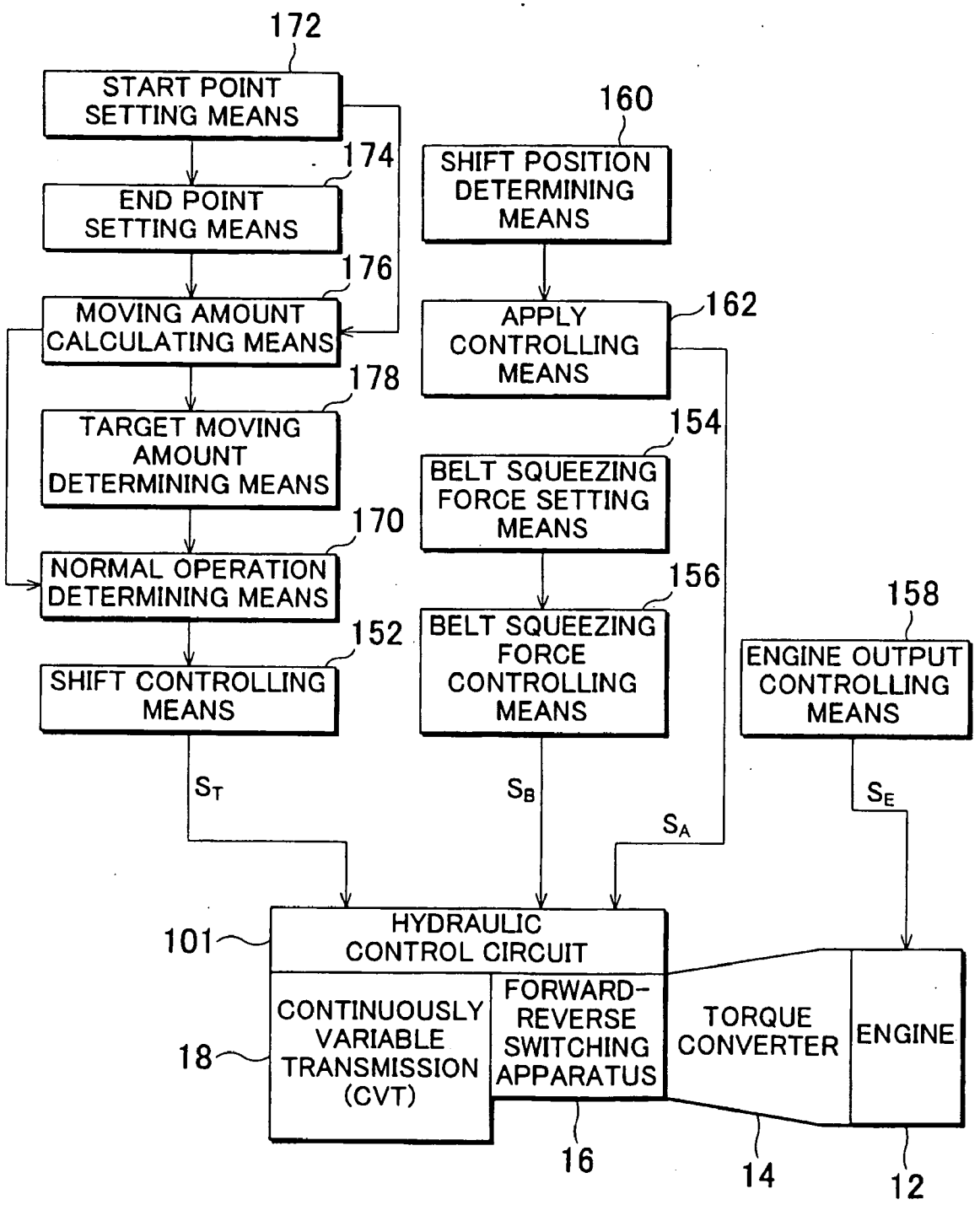

172
START POINT SETTING MEANS
174
END POINT SETTING MEANS
176
MOVING AMOUNT CALCULATING MEANS
178
TARGET MOVING AMOUNT DETERMINING MEANS
170
NORMAL OPERATION DETERMINING MEANS
152
SHIFT CONTROLLING MEANS
160
SHIFT POSITION DETERMINING MEANS
162
APPLY CONTROLLING MEANS
154
BELT SQUEEZING FORCE SETTING MEANS
156
BELT SQUEEZING FORCE CONTROLLING MEANS
158
ENGINE OUTPUT CONTROLLING MEANS
S_T
S_B
S_A
S_E
101
HYDRAULIC CONTROL CIRCUIT
18
CONTINUOUSLY VARIABLE TRANSMISSION (CVT)
FORWARD-REVERSE SWITCHING APPARATUS
TORQUE CONVERTER
ENGINE
16
14
12

FIG. 7

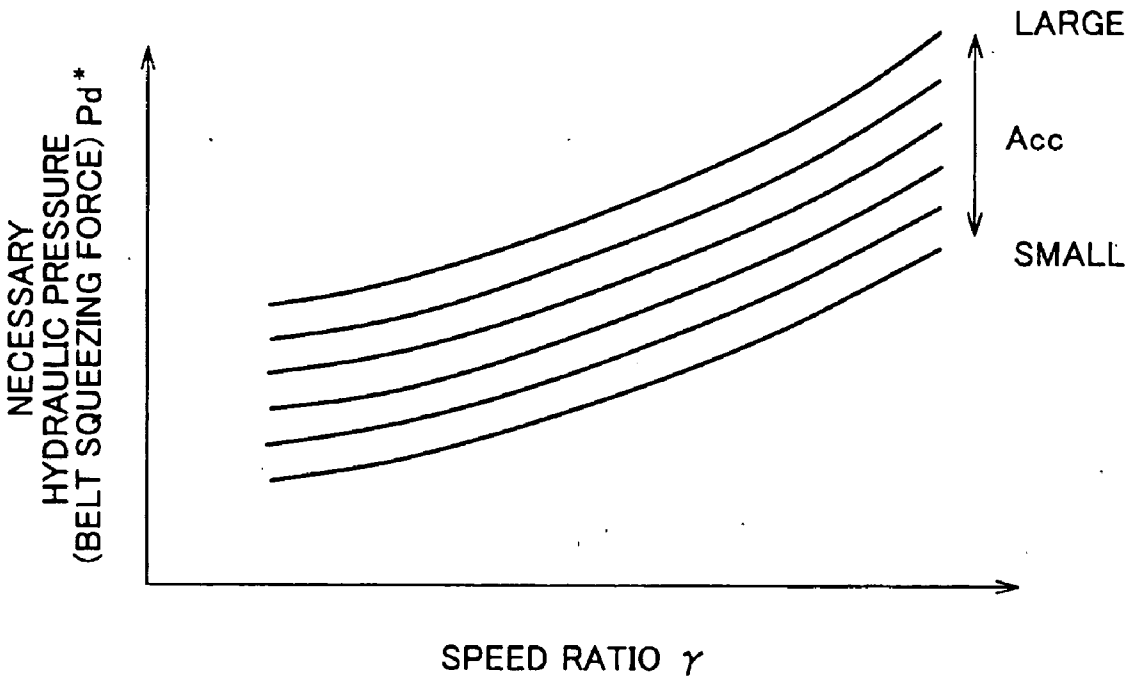

LARGE
Acc
SMALL
NECESSARY HYDRAULIC PRESSURE (BELT SQUEEZING FORCE) Pd*
SPEED RATIO γ

FIG. 8

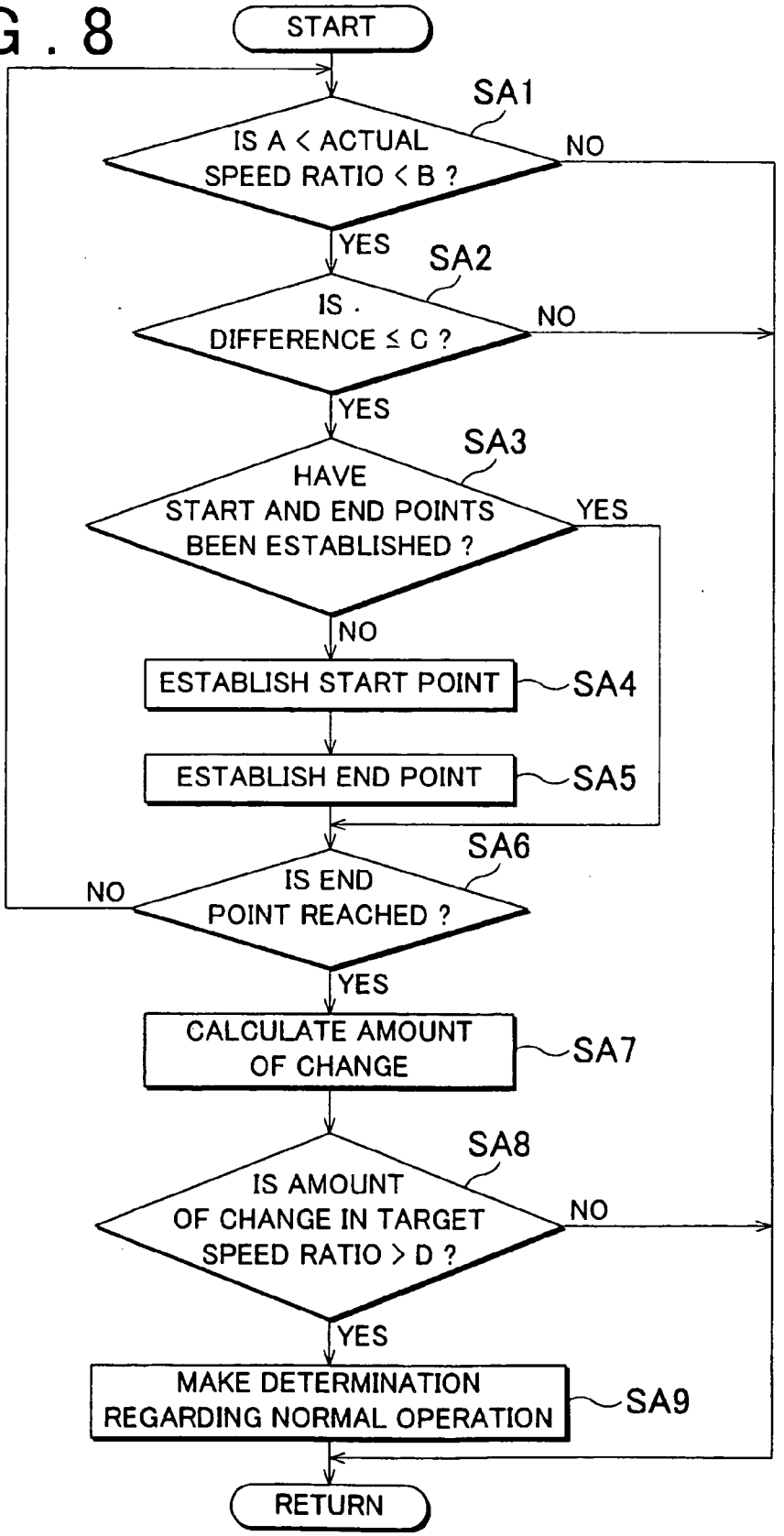
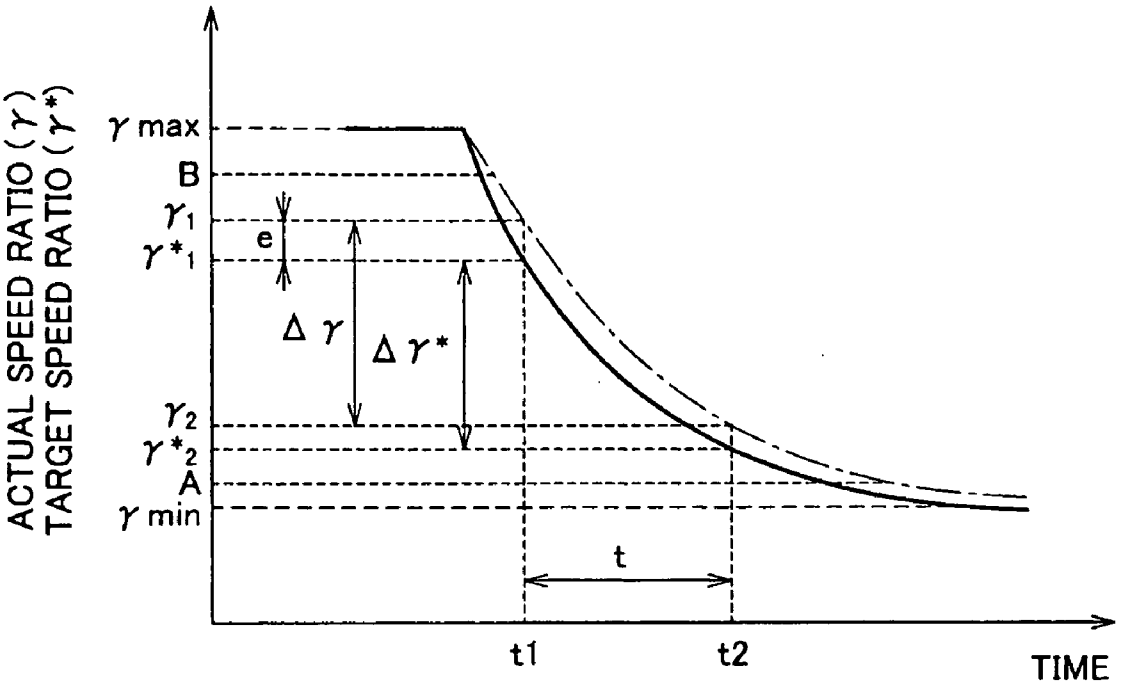

START
SA1
IS A < ACTUAL SPEED RATIO < B ?
NO
YES
SA2
IS DIFFERENCE ≤ C ?
NO
YES
SA3
HAVE START AND END POINTS BEEN ESTABLISHED ?
YES
NO
ESTABLISH START POINT
SA4
ESTABLISH END POINT
SA5
SA6
IS END POINT REACHED ?
NO
YES
CALCULATE AMOUNT OF CHANGE
SA7
SA8
IS AMOUNT OF CHANGE IN TARGET SPEED RATIO > D ?
NO
YES
MAKE DETERMINATION REGARDING NORMAL OPERATION
SA9
RETURN

FIG. 9



e : DIFFERENCE (= $\gamma^* - \gamma$)

$\Delta\gamma$: AMOUNT OF CHANGE IN ACTUAL SPEED RATIO (= $\gamma_1 - \gamma_2$)

$\Delta\gamma^*$: AMOUNT OF CHANGE IN TARGET SPEED RATIO (= $\gamma^*_1 - \gamma^*_2$)

γ max : MAXIMUM SPEED RATIO

γ min : MINIMUM SPEED RATIO

SHIFT CONTROL APPARATUS OF A CONTINUOUSLY VARIABLE TRANSMISSION AND METHOD OF DETERMINING WHETHER SHIFT CONTROL APPARATUS IS OPERATING NORMALLY

INCORPORATION BY REFERENCE

[0001] The disclosure of Japanese Patent Application No. 2008-161276 filed on Jun. 20, 2008, including the specification, drawings and abstract is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The invention relates to a shift control apparatus of a continuously variable transmission (CVT) that continuously (i.e., steplessly) changes speed ratios. More particularly, the invention relates to a shift control apparatus that determines whether that shift control apparatus is operating normally, as well as to a method of determining whether a shift control apparatus is operating normally.

[0004] 2. Description of the Related Art

[0005] A vehicle is known which has a continuously variable transmission that continuously changes speed ratios provided in a power transmitting path between an engine and driving wheels. In this continuously variable transmission, the actual speed ratio calculated based on the input shaft rotational speed and the output shaft rotational speed of the continuously variable transmission is normally shift-controlled to a target speed ratio determined based on the vehicle speed and accelerator operation amount, for example. Shifting in the continuously variable transmission is normally performed by a hydraulic control circuit in the continuously variable transmission. However, if a solenoid valve or the like arranged in the hydraulic control circuit fails, shift control is unable to be performed normally. Therefore, it is desirable to determine whether shift control will be performed normally.

[0006] Thus, Japanese Patent Application Publication No. 8-233083 (JP-A-8-233083) describes technology which calculates an absolute value of the difference between a target speed ratio of a continuously variable transmission (a toroidal-type continuously variable transmission) and the actual speed ratio of the continuously variable transmission, and determines that the continuously variable transmission is operating normally if the change in the absolute value of that difference is small. Also, Japanese Patent Application Publication No. 8-127261 (JP-A-8-127261) describes technology that determines whether shift control is normal based on whether a difference between a target speed ratio and an actual speed ratio continues to exceed a set value for a predetermined period of time.

[0007] In addition to a shift control solenoid valve, a plurality of other valves, such as linear solenoid valves which control the line pressure, i.e., the base pressure, are also provided in the hydraulic control circuit in JP-A-8-233038 and JP-A-8-127261 and the like. For example, if a linear solenoid valve that controls the line pressure fails, sufficient line pressure will no longer be able to be supplied to the various valves in the hydraulic control circuit. As a result, the difference between the actual speed ratio and the target speed ratio will increase so it will be determined that shift control will not be able to be performed normally. That is, even if the shift control solenoid valve is operating normally, it will be determined that an abnormally has occurred in the shift control apparatus. In this way, because it will be determined that shift control is abnormal due to the failure of another part, even if the shift control solenoid valve is operating normally, it is not possible to accurately determine whether the shift control solenoid valve is operating normally by only the determination based on that difference.

SUMMARY OF THE INVENTION

[0008] This invention thus provides a shift control apparatus of a continuously variable transmission that changes gear ratios continuously (i.e., steplessly), which can accurately determine whether the shift control apparatus is operating normally, as well as a method for determining whether a shift control apparatus of a continuously variable transmission that changes gear ratios continuously (i.e., steplessly) is operating normally.

[0009] A first aspect of the invention relates to a shift control apparatus of a continuously variable transmission. The shift control apparatus includes a feedback control portion which executes feedback control that brings an actual speed ratio close or equal to a target speed ratio, and a normal operation determining portion which determines whether the shift control apparatus is operating normally based on a difference between the actual speed ratio and the target speed ratio, and an amount of change in the actual speed ratio and an amount of change in the target speed ratio during a predetermined interval.

[0010] Providing the normal operation determining means that determines whether the shift control apparatus is operating normally based on the difference between the actual speed ratio and the target speed ratio, as well as the amounts of change in those speed ratios during a predetermined interval, makes it possible to accurately determine whether shift control solenoid valves are operating normally. That is, the reliability of that determination is improved because the determination is made based on the amounts of change as well as the difference.

[0011] A second aspect of the invention relates to a method of determining whether a shift control apparatus of a continuously variable transmission is operating normally. This method includes executing feedback control that brings an actual speed ratio close or equal to a target speed ratio, and determining whether the shift control apparatus is operating normally based on a difference between the actual speed ratio and the target speed ratio, and an amount of change in the actual speed ratio and an amount of change in the target speed ratio during a predetermined interval.

[0012] A third aspect of the invention relates to a method of determining whether a shift control apparatus of a continuously variable transmission is operating normally. This method includes executing feedback control that brings an actual speed ratio close or equal to a target speed ratio, calculating a difference between the actual speed ratio and the target speed ratio, calculating an amount of change in the actual speed ratio and an amount of change in the target speed ratio during a predetermined interval, and determining that the shift control apparatus is operating normally when i) the difference is equal to or less than a predetermined-value, and ii) the difference between the amount of change in the actual speed ratio and the amount of change in the target speed ratio is equal to or less than a first predetermined value, or the ratio of the amount of change in the actual speed ratio to the amount of change in the target speed ratio is within a second predetermined value.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The foregoing and further objects, features and advantages of the invention will become apparent from the following description of preferred embodiments with reference to the accompanying drawings, wherein like numerals are used to represent like elements and wherein:

[0014] FIG. **1** is a skeleton view of a vehicular power transmitting device according to an example embodiment of the invention;

[0015] FIG. **2** is a clutch and brake application chart showing the operating states of the vehicular power transmitting device in FIG. **1**;

[0016] FIG. **3** is a block line diagram showing the main portions of a control system provided in a vehicle for controlling the vehicular power transmitting device and the like in FIG. **1**;

[0017] FIG. **4** is a simplified diagram of part of a hydraulic control circuit that supplies hydraulic fluid to an input side hydraulic cylinder and an output side hydraulic cylinder;

[0018] FIG. **5** is a graph showing one example of a shift map used when obtaining a target input rotational speed in shift control of a continuously variable transmission in FIG. **1**;

[0019] FIG. **6** is a functional block line diagram showing the main control functions of an electronic control apparatus shown in FIG. **3**;

[0020] FIG. **7** is a graph showing one example of a necessary hydraulic pressure map for obtaining the necessary hydraulic pressure for a speed ratio and the like in squeezing force control of the continuously variable transmission in FIG. **1**;

[0021] FIG. **8** is a flowchart illustrating the main portion of a control operation of the electronic control apparatus, i.e., a control operation that makes it possible to accurately determine whether shift control in a belt-type continuously variable transmission is normal; and

[0022] FIG. **9** is a graph showing the relationship between i) a target speed ratio and the actual speed ratio and ii) time, when the belt-type continuously variable transmission is upshifted.

DETAILED DESCRIPTION OF AN EMBODIMENT

[0023] In the following description and the accompanying drawings, the present invention will be described in more detail in terms of an example embodiment.

[0024] FIG. **1** is a skeleton view of a vehicular power transmitting device **10** according to one example embodiment of the invention. This vehicular power transmitting device **10** is a transverse mounted automatic transmission which is preferably employed in a FF (front engine-front drive) vehicle, and includes an engine **12** that serves as the power source for running. Output from the engine **12**, which is an internal combustion engine in this example embodiment, is transmitted from a crankshaft of the engine **12** to a final reduction gear **22** via a torque converter **14** that serves as a fluid power transmitting device, a forward-reverse switching apparatus **16**, an input shaft **36**, a belt-type continuously variable transmission (hereinafter simply referred to as "belt-type CVT") **18**, an output shaft **44**, and reduction gears **20**. From the final reduction gear **22**, the output it is distributed to left and right driving wheels **24**L and **24**R. Incidentally, the belt-type CVT **18** in this example embodiment may correspond to a continuously variable transmission of the invention.

[0025] The torque converter **14** includes a pump impeller **14***p* that is connected to the crankshaft of the engine **12**, and a turbine runner **14***t* that is connected to the forward-reverse switching apparatus **16** via a turbine shaft **34**. The torque converter **14** transmits power through fluid. Also, a lock-up clutch **26** is provided between the pump impeller **14***p* and the turbine runner **14***t*. This lock-up clutch **26** is switched between being applied and released by switching the supply of hydraulic pressure to an apply side fluid chamber and a release side fluid chamber using a switching valve or the like in a hydraulic control apparatus, not shown. When the lock-up clutch **26** is completely applied, the pump impeller **14***p* and the turbine runner **14***t* rotate together as a single unit. A mechanical oil pump **28** that generates hydraulic pressure for controlling a shift in the belt-type CVT **18**, generating belt squeezing force, and supplying lubrication oil to various parts is provided with the pump impeller **14***p*.

[0026] The forward-reverse switching apparatus **16** mainly includes a double-pinion type planetary gear set in which the turbine shaft **34** of the torque converter **14** is integrally connected to a sun gear **16***s* and the input shaft **36** of the belt-type CVT **18** is integrally connected to a carrier **16***c*. Meanwhile, the carrier **16***c* and the sun gear **16***s* may be selectively connected via a forward clutch C**1**, and a ring gear **16***r* may be selectively fixed to a housing by a reverse brake B**1**. The forward clutch C**1** and the reverse brake B**1** are both hydraulic friction apply devices that are frictionally applied by hydraulic cylinders. As shown in FIG. **2**, when the forward clutch C**1** is applied and the reverse brake B**1** is released, the forward-reverse switching apparatus **16** rotates as a single unit, thereby establishing a forward power transmitting path such that forward rotation is transmitted to the belt-type CVT **18** without a reduction in rotational speed. On the other hand, when the reverse brake B**1** is applied and the forward clutch C**1** is released, the forward-reverse switching apparatus **16** establishes a reverse power transmitting path in which the input shaft **36** rotates in the direction opposite that of the turbine shaft **34** such that reverse rotation is transmitted to the belt-type CVT **18**. Also, when both the forward clutch C**1** and the reverse brake B**1** are released, the forward-reverse switching apparatus **16** is in a neutral state (i.e., in a disconnected state) in which the transmission of power is interrupted.

[0027] The belt-type CVT **18** includes an input side variable pulley **42** with a variable effective radius that is provided on the input shaft **36** and functions as an input side member, an output side variable pulley **46** with a variable effective radius that is provided on the output shaft **44** and functions as an output side member, and a drive belt **48** that is wound around the variable pulleys **42** and **46** and functions as a power transmitting member that is in frictional contact with the variable pulleys **42** and **46**. Power is transmitted via the frictional force between the drive belt **48** and the variable pulleys **42** and **46**. The input side variable pulley **42** includes a fixed sheave **42***a*, a movable sheave **42***b*, and an input side hydraulic cylinder **42***c*. The fixed sheave **42***a* is fixed to the input shaft **36**. The movable sheave **42***b* is provided on the input shaft **36** in such a manner that it is able to move in the axial direction of the input shaft **36** but unable to rotate relative to the input shaft **36**. The input side hydraulic cylinder **42***c* applies thrust to the movable sheave **42***b*, thereby changing a V groove width between the fixed sheave **42***a* and the movable sheave **42***b*. Similarly, the output side variable pulley

46 includes a fixed sheave **46***a*, a movable sheave **46***b*, and an output side hydraulic cylinder **46***c*. The fixed sheave **46***a* is fixed to the output shaft **44**. The movable sheave **46***b* is provided on the output shaft **44** in such a manner that it is able to move in the axial direction of the output shaft **44** but unable to rotate relative to the output shaft **44**. The output side hydraulic cylinder **46***c* applies thrust to the movable sheave **46***b*, thereby changing a V groove width between the fixed sheave **46***a* and the movable sheave **46***b*. The winding radius (i.e., the effective radius) of the drive belt **48** can be changed by changing the V groove widths of the variable pulleys **42** and **46**, which is done by controlling the hydraulic pressure in the input side hydraulic cylinder **42***c* of the input side variably pulley **42**. As a result, the speed ratio γ (=input shaft rotational speed Nin/output shaft rotational speed Nout) can be changed continuously (i.e., in a non-stepped manner). Meanwhile, the squeezing force that squeezes the drive belt **48** is changed by controlling the hydraulic pressure in the output side hydraulic cylinder **46***c* of the output side variable pulley **46**. Also, the drive belt **48** is made of many metal pieces that are sandwiched between two (left and right) steel bands each of which is composed of several layers of thin steel bands.

[0028] FIG. **3** is a block line diagram showing the main portions of a control system provided in a vehicle for controlling the vehicular power transmitting device **10** and the like in FIG. **1**. An electronic control apparatus **50** which may correspond to a shift control apparatus of the invention includes a so-called microcomputer that has a CPU, RAM, ROM, and an input/output interface and the like, for example. The CPU executes various controls, such as output control of the engine **12**, shift control of the belt-type CVT **18**, belt squeezing force control, and torque capacity control of the lock-up clutch **26** and the like, by signal processing according to programs stored in the ROM beforehand while using the temporary storage function of the RAM. The. CPU may also be divided for engine control and hydraulic pressure control of the continuously variable transmission **18** and the lock-up clutch **26** and the like when necessary.

[0029] Various signals are supplied to the electronic control apparatus **50**. Some of these signals include a signal indicative of the crankshaft rotational angle (position) ACR (°) and the crankshaft rotational speed that corresponds to the speed of the engine **12** (i.e., the engine speed) N_E detected by an engine speed sensor **52**, a signal indicative of the rotational speed (i.e., turbine speed) N_T of the turbine shaft **34** detected by a turbine speed sensor **54**, a signal indicative of the rotational speed (i.e., input shaft rotational speed) Nin of the input shaft **36**, which is the input speed of the continuously variable transmission **18**, detected by an input shaft rotational speed sensor **56**, a signal indicative of the rotational speed (i.e., output shaft rotational speed) Nout of the output shaft **44**, which is the output speed of the continuously variable transmission **18**, i.e., the vehicle speed V that corresponds to the output shaft rotational speed Nout, detected by a vehicle speed sensor (i.e., an output shaft rotational speed sensor) **58**, and a signal indicative of the opening amount θ_{TH} of an electronic throttle valve provided in an intake conduit of the engine **12**, which is detected by a throttle sensor **60**. Other signals supplied to the electronic control apparatus **50** include, for example, a signal indicative of the coolant temperature T_W of the engine **12** detected by a coolant temperature sensor **62**, a signal indicative of the fluid temperature T_{CVT} in a hydraulic circuit of the continuously variable transmission **18** and the like detected by a CVT fluid temperature sensor **64**, a signal indicative of the accelerator operation amount Acc, which is the operation amount of an accelerator pedal **68**, detected by an accelerator operation amount sensor **66**, a signal indicative of whether a foot brake which is a service brake is being operated, which is detected by a foot brake switch **70**, and a signal indicative of the lever position (operating position) P_{SH} of a shift lever **77** detected by a lever position sensor **72**.

[0030] The electronic control apparatus **50** also outputs various signals, including engine output control command signals S_E for controlling the output of the engine **12**, such as a throttle signal that controls a throttle actuator **76** for controlling the opening and closing of the electronic throttle valve, an injection signal for controlling the quantity of fuel to be injected from a fuel injection device **78**, and an ignition timing signal for controlling the ignition timing of the engine **12** by an ignition device **80**, for example. The electronic control apparatus **50** also outputs various signals to a hydraulic control circuit **101**, including i) shift control command signals S_T for changing the speed ratio γ of the belt-type CVT **18**, such as a command signal for driving a shift control solenoid valve DS**1** and a shift control solenoid valve DS**2** that control the flowrate of hydraulic fluid to the driving side hydraulic cylinder **42***c*, and ii) squeezing force control command signals S_B for adjusting the squeezing force applied to the drive belt **48**, such as a command signal for driving a linear solenoid valve SLS that regulates the belt squeezing force control pressure Pd and a command signal for driving a linear solenoid valve SLT and a linear solenoid valve SLS that control the line pressure PL.

[0031] The shift lever **74** is arranged near the driver's seat, for example, and is manually operated into one of five sequential lever positions, i.e., P, R, N, D, and L.

[0032] The P (Parking) position (range) is a park position for interrupting the power transmitting path of the vehicular power transmitting device **10**, i.e., placing the vehicular power transmitting device **10** in a neutral state in which the transmission of power is interrupted and the output shaft **44** is mechanically prevented from rotating (i.e., locked) by a mechanical parking lock mechanism. The R (Reverse) position is a reverse running position for making the output shaft **44** rotate in the reverse direction. The N (Neutral) position is a neutral position for placing the vehicular power transmitting device **10** in a neutral state in which the transmission of power is interrupted. The D (Drive) position is a forward running position that executes shift control by establishing an automatic shift mode in a shift range within which shifting is possible by the belt-type CVT **18**. The L (Low) position is an engine brake position in which a strong engine brake is applied. In this way, the P and N positions are non-driving positions which place the power transmitting path in a neutral state and are selected when the driver does not wish to drive the vehicle forward or backward, while the R, D, and L positions are driving positions which place the power transmitting path in a power transmittable state in which power is able to be transmitted along the power transmitting path and are selected when the driver wishes to drive the vehicle forward or backward.

[0033] FIG. **4** is a simplified diagram of part of the hydraulic control circuit **101** that supplies hydraulic fluid to the input side hydraulic cylinder **42***c* and the output side hydraulic cylinder **46***c*. As shown in FIG. **4**, hydraulic fluid is drawn up through a strainer **82** from an oil pan **81** by an oil pump **28** which increases the hydraulic pressure before supplying the

hydraulic fluid to a fluid passage **86**. The hydraulic pressure in the fluid passage **86**, i.e., the discharge pressure of the oil pump **28**, is regulated to line pressure PL by a pressure regulating valve **88** that is controlled based on a signal pressure P_{SLT} output from the solenoid valve SLT. The hydraulic fluid at this line pressure PL is supplied to a fluid passage **90** that branches off from the fluid passage **86**. The pressure of the hydraulic fluid supplied to the fluid passage **90** is regulated by a pressure regulating valve **92** provided in the fluid passage **90**. The pressure regulating valve **92** is controlled based on a signal pressure P_{SLS} output from a belt squeezing control solenoid valve SLS with the line pressure PL as the base pressure, and the pressure-regulated hydraulic fluid is supplied to the output side hydraulic cylinder **46***c*. In this way, the belt squeezing force applied to the drive belt **48** that is wound around the input side variable pulley **42** and the output side variable pulley **46** is adjusted by adjusting the hydraulic pressure Pd (i.e., the belt squeezing force control pressure Pd) applied to the output side hydraulic cylinder **46***c* (see FIG. **1**).

[0034] Meanwhile, hydraulic fluid supplied from the fluid passage **86** to a fluid passage **94** is supplied to a speed ratio control valve **96**. This speed ratio control valve **96** selectively allows and interrupts communication between an output port **102** of the input side hydraulic cylinder **42***c* of the input side variable pulley **42** and a line pressure supply port **98** and a drain port **100** using the shift control side solenoid valves DS**1** and DS**2**. For example, when the shift control solenoid valve DS**1** is on, the line pressure supply port **98** is communicated with the output port **102** such that line pressure PL is supplied to the input side hydraulic cylinder **42***c*. On the other hand, when the shift control solenoid valve DS**2** is on, the output port **102** is communicated with the drain port **100** such that hydraulic fluid is discharged from the input side hydraulic cylinder **42***c*. In this way, the winding radius of the drive belt **48** that is wound around the input side variable pulley **42** can be appropriately changed by controlling the supply and discharge of hydraulic fluid to and from the input side hydraulic cylinder **42***c*, such that the speed ratio of the belt-type CVT **18** changes continuously (i.e., is a non-stepped manner). Also, the line pressure PL in this example embodiment is controlled by the pressure regulating valve **88** via the solenoid valve SLT, and the belt squeezing force control pressure Pd [MPa] supplied to the pressure chamber of the output side hydraulic cylinder **46***c* is controlled by the pressure regulating valve **92** via the belt squeezing pressure control solenoid valve SLS, so the line pressure PL and the belt squeezing force control pressure Pd are able to be controlled independently of one another. Modulator pressure P_M is the base pressure of both control pressure P_{DS1} which is the output pressure of the solenoid valve DS**1** that is duty controlled by the electronic control apparatus **50**, and control pressure P_{DS2} which is the output pressure of the solenoid valve DS**2** that is duty controlled by the electronic control apparatus **50**. This modulator pressure P_M is regulated to a constant pressure by a modulator valve, not shown. Incidentally, various solenoid valves provided in the hydraulic control circuit **101** are appropriately controlled by the electronic control apparatus **50** based on various data supplied by the vehicle speed sensor and the accelerator operation amount sensor and the like, not shown.

[0035] A shift map which shows the relationship between the vehicle speed V and a target input shaft rotational speed Nint which is a target input rotational speed of the continuously variable transmission **18**, with the accelerator operation amount Acc as the parameter, as shown in FIG. **5**, for example, is obtained through testing in order achieve both drivability and fuel efficiency in the vehicle, and stored in advance. The target input shaft rotational speed Nint of the input shaft **36**, which is a predetermined rotating member, is set based on the state of the vehicle which is indicated by the actual vehicle speed V and the accelerator operation amount Acc from that relationship (i.e., the shift map). The belt-type CVT **18** is shifted using feedback control, i.e., the speed ratio γ is changed in a continuous (i.e., non-stepped) manner using feedback control by changing the V groove widths of the variable pulleys **42** and **46**, which is done by supplying or discharging hydraulic fluid to or from the driving side hydraulic cylinder **42***c*, according to the difference ΔNin (=Nint−Nin) between the set target input shaft rotational speed Nint and the actual input shaft rotational speed Nin (hereinafter referred to as the "actual input shaft rotational speed Nin" when there may be confusion between it and the target input shaft rotational speed Nint), so that the actual input shaft rotational speed Nin comes to match the set target input shaft rotational speed Nint.

[0036] The map shown in FIG. **5** corresponds to shift conditions, and may alternatively be, for example, an operational expression or the like obtained through testing with the accelerator operation amount Acc and the vehicle speed V or the like as parameters. In this map, the target input shaft rotational speed Nint is set such that the speed ratio γ increases as the vehicle speed V decreases and the accelerator operation amount Acc increases (i.e., such that the sped ratio γ is larger at a lower vehicle speed and with a greater accelerator operation amount Acc). Also, the vehicle speed V corresponds to the output shaft rotational speed Nout so the target input shaft rotational speed Nint, which is the target value for the input shaft rotational speed Nin, corresponds to a target speed ratio γ*(=Nint/Nout) and is set within a range between a minimum speed ratio γmin and a maximum speed ratio γmax of the continuously variable transmission **18**.

[0037] However, the target input shaft rotational speed Nint may be set as it is as the target value of the input shaft rotational speed Nin, but preferably, a basic target input shaft rotational speed Nint_bc, which is a value obtained after processing the target input shaft rotational speed Nint according to the running state, e.g., while accelerating, decelerating (i.e., coasting), in the middle of shifting or the like, is set, and a transitional target input shaft rotational speed Nint_trs, which is a final target value of the input shaft rotational speed Nin, is set based on that basic target input shaft rotational speed Nint_bc. Accordingly, in this case, the continuously variable transmission **18** is shifted using feedback control according to the difference ΔNint_trs (=Nint_trs−Nin) between that transitional target input shaft rotational speed Nint_trs and the actual input shaft rotational speed Nin, so that the actual input shaft rotational speed Nin comes to match the transitional target input shaft rotational speed Nint_trs.

[0038] FIG. **6** is a functional block line diagram showing the main control functions of the electronic control apparatus **50**. Shift controlling means **152** in FIG. **6** sequentially sets the target input shaft rotational speed Nint corresponding to the target speed ratio γ*(=Nint/Nout) based on the state of the vehicle as indicated by the actual vehicle speed V and the accelerator operation amount Acc, according to a shift map (shift conditions) stored in advance, such as that shown in FIG. **5**, for example.

[0039] Then, the shift controlling means **152** shifts the continuously variable transmission **18** by executing feedback

control that controls the winding radius (i.e., the effective radius) of the drive belt **48** on the driving side pulley **42** so that the actual speed ratio γ (=Nin/Nout) of the continuously variable transmission **18** approaches the target speed ratio γ*. When described focusing on the actual input shaft rotational speed Nin, the shift controlling means **152** shifts the continuously variable transmission **18** using feedback control according to the difference ΔNin (=Nint−Nin) between the actual input shaft rotational speed Nin and the set target input shaft rotational speed Nint, so that the actual input shaft rotational speed Nin comes to match the set target input shaft rotational speed Nint, i.e., to eliminate the difference ΔNin. That is, the shift controlling means **152** shifts the continuously variable transmission **18** by controlling the supply and discharge of hydraulic fluid to and from the driving side hydraulic cylinder (i.e., the driving side hydraulic actuator) **42***c*. More specifically, the shift controlling means **152** outputs a shift control command signal (hydraulic pressure command) S_T to the hydraulic control circuit **101**. This shift control command signal S_T changes the V groove widths of the variable pulleys **42** and **46** by executing feedback control that controls the flowrate Q_{CVT} of hydraulic fluid to the driving side hydraulic cylinder **42***c*, so as to continuously (i.e., steplessly) change the speed ratio γ. Here, in this feedback control, the flowrate Q_{CVT} of the hydraulic fluid to the driving side hydraulic cylinder **42***c* corresponds to the change rate in the speed ratio γ during a shift (i.e., the shift speed), and is determined by the control method which is set in advance.

[0040] Belt squeezing force setting means **154** sets a belt squeezing force Pd* from a belt squeezing force map such as that shown in FIG. **7**, for example, which is obtained in advance through testing and stored. The belt squeezing force Pd* is set based on the vehicle state as indicated by the actual accelerator operation amount Acc and the actual speed ratio γ (=Nin/Nout) calculated by the electronic control apparatus **50** based on the actual input shaft rotational speed Nin and the actual output shaft rotational speed Nout. That is, the belt squeezing force setting means **154** sets the belt squeezing pressure Pd of the output side hydraulic cylinder **46***c* in order to obtain the belt squeezing force Pd*. Incidentally, when the vehicle speed V is equal to or less than a minimum vehicle speed at which the speed ratio can be detected, the actual speed ratio γ is unable to be calculated. Therefore, in this case, for example, the belt squeezing force setting means **154** sets the belt squeezing force Pd* and the belt squeezing pressure Pd presuming that that actual speed ratio γ is the maximum speed ratio γmax.

[0041] Belt squeezing force controlling means **156** adjusts the belt squeezing pressure Pd so that the drive belt **48** does not slip. More specifically, the belt squeezing force controlling means **156** increases or decreases the belt squeezing force Pd* by outputting a squeezing force control command signal S_B that adjusts the belt squeezing pressure Pd of the driven side hydraulic cylinder **46***c* to the hydraulic control circuit **101** to obtain the belt squeezing force Pd* set by the belt squeezing force setting means **154**.

[0042] The hydraulic control circuit **101** controls the amount of hydraulic fluid supplied to and discharged from the driving side hydraulic cylinder **42***c* by operating the shift control solenoid valves DS**1** and DS**2** so that the belt-type CVT **18** shifts according to the shift control command signal S_T. The hydraulic control circuit **101** also adjusts the belt squeezing pressure Pd by operating the linear solenoid valve SLS so that the belt squeezing force Pd increases or decreases according to the squeezing force control command signal S_B.

[0043] Engine output controlling means **158** outputs engine output control command signals S_E, such as a throttle signal, an injection signal, or an ignition timing signal, to the throttle actuator **76**, the fuel injection device **78**, or the ignition device **80**, respectively, in order to control the output of the engine **12**. For example, the engine output controlling means **158** controls the engine torque TE by outputting a throttle signal that opens or closes the electronic throttle valve to the throttle actuator **76** in order to realize a throttle opening amount θ_{TH} according to the accelerator operation amount Acc.

[0044] Shift position determining means **160** determines the current lever position P_{SH} as well as the operating history of the shift lever **74** based on the lever position P_{SH}, i.e., based on an ON signal for each lever position P_{SH}. For example, the shift position shifting means **160** makes a N→D shift determination, a N→R shift determination, a D position determination, a N position determination, or a R position determination or the like based on the lever position P_{SH}.

[0045] When the shift position determining means **160** determines that a N→D shift or a N→R shift has been performed, apply controlling means **162** outputs a shift command signal S_A to the hydraulic control circuit **101**. This shift command signal S_A causes control pressure P_{SLT} for gradually increasing the apply pressure in order to control the forward clutch C**1** or the reverse brake B**1** throughout the transition to the applied state so as to suppress shift shock to be output, as well as causes signal pressure P_{SLS} to be output in order to regulate the line pressure PL. For example, the apply controlling means **162** outputs an apply transitional pressure command pressure to the hydraulic control circuit **101** as a command signal for duty controlling the linear solenoid valve SLT.

[0046] Normal operation determining means **170** determines whether shift control of the belt-type CVT **18** will be performed normally. More specifically, the normal operation determining means **170** determines whether the shift control solenoid valves DS**1** and DS**2** used in shift control are operating normally. Normally this determination can easily be made based on how close the speed ratio γ comes to the minimum speed ratio γmin and the like, for example. However, if the linear solenoid valve SLS or the linear solenoid valve SLT or the like fails, the speed ratio γ will be unable to reach the minimum speed ratio γmin. Therefore, with the method described above, it is not possible to determine whether the shift control solenoid valves DS**1** and DS**2** are operating normally. There is also a method by which the determination can be made based on the difference between the target speed ratio and the actual speed ratio, but the determination may be erroneous using only this difference if there is an electrical failure or the like. Therefore, the normal operation determining means **170** makes the determination based on how closely the actual speed ratio γ follows the target speed ratio γ* during a shift in the belt-type CVT **18**. More specifically, the normal operation determining means **170** determines whether the shift control solenoid valves DS**1** and DS**2** are operating normally based on the difference e between the target speed ratio γ* and the actual speed ratio γ during a shift, and the amounts of change Δγ* and Δγ in the target speed ratio γ* and the actual speed ratio γ during a shift.

[0047] This normal operation determining means **170** is appropriately applied to a continuously variable transmission

such as a belt-type continuously variable transmission that changes speed ratios continuously (i.e., steplessly) by changing the belt winding radius, or a toroidal-type continuously variable transmission that changes speed ratios continuously (i.e., steplessly) by changing the points of contact between input and output discs and power rollers.

[0048] The normal operation determining means **170** first sets a predetermined interval for measuring the amounts of change in the target speed ratio γ* and the actual speed ratio γ during a shift. Start point setting means **172** then sets the start point of that interval. The start point setting means first determines whether the actual speed ratio γ is within a predetermined speed ratio range (between A and B). Here, this predetermined speed ratio range (between A and B) is set so that it does not include the maximum speed ratio γmax or the minimum speed ratio γmin. This enables the determination regarding normal operation to be made unaffected by other parts such as the linear solenoid valve SLS and the linear solenoid valve SLT. Next, if it is determined that the actual speed ratio γ is within the predetermined speed ratio range, the start point setting means **172** calculates a difference e (=γ*−γ) between the target speed ratio γ* and the actual speed ratio y, and determines whether the calculated difference e is equal to or less than a predetermined value C. If it is determined that the actual speed ratio γ is within the predetermined speed ratio range and the difference e is equal to or less than the predetermined value C, the start point setting means **172** sets the actual speed ratio γ at that time as the start point. Incidentally, the predetermined value C is a value that is obtained in advance either empirically or theoretically, and is set to a low value such that the start point is set while the target speed ratio γ* and the actual speed ratio γ are substantially equal.

[0049] Once the actual speed ratio γ_1, which is the start point, has been set by the start point setting means **172**, an end point of the interval for measuring the amounts of change is set by end point setting means **174**. As the end point, for example, the end point setting means **174** sets i) a constant value γ_2 set as the end point in advance, ii) an actual speed ratio γ_2 that is set according to the actual speed ratio γ_1 which is the start point set by the start point setting means **172**, or iii) an actual speed ratio γ_2 after a predetermined period of time (t) has passed after the start point is set. Also, the end point starting means **174** determines whether the actual speed ratio γ has reached the speed ratio γ_2 set as the end point.

[0050] Moving amount calculating means **176** calculates the amounts of change in the target speed ratio γ* and the actual speed ratio γ. The amount of change Δγ* in the target speed ratio γ* is defined by the difference Δγ* (=γ^*_1−γ^*_2) between the target speed ratio γ^*_1 when the start point is set and the target speed ratio γ^*_2 when the end point is set. Also, the amount of change Δγ in the actual speed ratio γ is defined by the difference Δγ* (=γ_1−γ_2) between the actual speed ratio γ_1 when the start point is set and the actual speed ratio γ_2 when the end point is set.

[0051] Target moving amount determining means **178** determines whether the amount of change Δγ* in the target speed ratio γ* calculated by the moving amount calculating means **176** is greater than a predetermined value D. Here, the predetermined value D is set in advance either empirically or theoretically, and is set such that that the determination regarding normal operation that is based on the amount of change will be sufficiently reliable. For example, if the determination regarding normal operation is made when the amount of change Δγ* in the target speed ratio γ* is small, the reliability of that determination will be low. Therefore, control is performed so that a determination regarding normal operation will not be made when the amount of change Δγ* is less than the predetermined value D.

[0052] The normal operation determining means **170** compares the amount of change Δγ* in the target speed ratio γ* with the amount of change Δγ of the actual speed ratio γ calculated by the moving amount calculating means **176**. If the amounts of change are almost the same, the normal operation determining means **170** determines that the shift control solenoid valves DS**1** and DS**2** are operating normally. More specifically, for example, the normal operation determining means **170** calculates the difference f (=Δγ*−Δγ) between the amounts of change and determines that the shift control solenoid valves DS**1** and DS**2** are operating normally when that difference f is a value equal to or less than a predetermined value close to zero. Alternatively, the normal operation determining means **170** calculates the ratio g (=Δγ*/Δγ) of the amounts of change and determines that the shift control solenoid valves DS**1** and DS**2** are operating normally when that ratio g is a value equal to or less than a predetermined value close to 1.0. That is, the normal operation determining means **170** determines that the shift control solenoid valves DS**1** and DS**2** are operating normally when the difference e (=γ*−γ) is equal to or less than a predetermined value and the amounts of change (Δγ* and Δγ) in a predetermined interval are substantially equal.

[0053] FIG. **8** is a flowchart illustrating the main portion of a control operation of the electronic control apparatus **50**, i.e., a control operation for determining whether shift control in the belt-type CVT **18** is normal. The routine in the flowchart is repeatedly executed in extremely short cycle times on the order to several milliseconds or several tens of milliseconds, for example.

[0054] First in step SA**1** which corresponds to the start point setting means **172**, the electronic control apparatus **50** determines whether the actual speed ratio γ is within a predetermined speed ratio range (between A and B) that has been set in advance. If the determination in step SA**1** is no, it is determined that it is not possible to determine whether shift control is normal so this cycle of the routine ends. If, on the other hand, the determination in step SA**1** is yes, then in SA**2** which corresponds to the start point setting means **172**, the electronic control apparatus **50** calculates the difference e (=γ*−γ) between the target speed ratio γ* and the actual speed ratio γ, and determines whether that difference e is equal to or less than a predetermined value C. If the determination in Step SA**2** is no, i.e., if it is determined that the difference e is greater than the predetermined value C, then it is determined that it is not possible to determine whether shift control is normal so this cycle of the routine ends.

[0055] If, on the other hand, the determination in step SA**2** is yes, then in step SA**3** which corresponds to the start point setting means **172** and the end point setting means **174**, the electronic control apparatus **50** determines whether the start point and end point have already been set. If, the determination in step SA**3** is no, then the electronic control apparatus **50** sets the start point in step SA**4** which corresponds to the start point setting means **172**. FIG. **9** is a graph showing the relationship between i) the target speed ratio γ* and the actual speed ratio γ and ii) time, when the belt-type CVT **18** is upshifted, for example. Here, the parabola shown by the solid line represents the target speed ratio γ* and the parabola

shown by the alternate long and short dash line represents the actual speed ratio γ. In FIG. **9**, the start point is the actual speed ratio γ_1 at time t**1**, for example. Therefore, the actual speed ratio γ_1 at time t**1** is within the predetermined speed ratio range (between A and B) and the difference e at time t**1** is equal to or less than the predetermined value C.

[0056] Then in step SA**5** which corresponds to the end point setting means **174**, the electronic control apparatus **50** sets the end point. As described above, the end point is i) an actual speed ratio γ_2 set in advance, ii) an actual speed ratio γ_2 set according to the actual speed ratio γ_1 at the start point, or iii) an actual speed ratio γ_2 after a predetermined period of time (t) has passed after the start point is set. Once the start point and the end point have been set in steps SA**4** and SA**5**, respectively, or the determination in step SA**3** is yes, the electronic control apparatus **50** determines in step SA**6**, which corresponds to the end point setting means **174**, whether the actual speed ratio γ has reached the actual speed ratio γ_2 which is the end point. If the determination in step SA**6** is no, the process returns to step SA**1** and the steps are repeated. Incidentally, the start point and the end point set in steps SA**4** and SA**5**, respectively, are stored and used in the next cycle of the routine. That is, the determination in step SA**3** the next time the routine is executed will be yes.

[0057] If the determination in step SA**6** is yes, then in step SA**7** which corresponds to the moving amount calculating means **176**, the electronic control apparatus **50** calculates the amount of change Δγ* in the target speed ratio γ* and the amount of change Δγ in the speed ratio γ. Then in step SA**8** which corresponds to the target moving amount determining means **178**, the electronic control apparatus **50** determines whether the amount of change Δγ* in the target speed ratio γ* is greater than the predetermined value D. If the determination in step SA**8** is no, it is determined that even if a determination regarding normal operation was made, it would not be sufficiently reliable so this cycle of the routine ends. If, on the other hand, the determination in step SA**8** is yes, then the electronic control apparatus **50** determines in step SA**9**, which corresponds to the normal operation determining means **170**, whether the shift control solenoid valves DS**1** and DS**2** are operating normally, based on the amount of change Δγ* in the target speed ratio γ* and the amount of change Δγ in the actual speed ratio γ. Incidentally, the amount of change Δγ* in the target speed ratio γ* is the difference Δγ* between the target speed ratio γ^*_1 at the start point (at time t**1**) and the target speed ratio γ^*_2 at the end point (at time t**2**) in FIG. **9**. Also, the amount of change Δγ in the target speed ratio γ is the difference Δγ between the target speed ratio γ_1 at the start point and the target speed ratio γ_2 at the end point in FIG. **9**. The determination regarding normal operation is made by calculating the difference f between these amounts of change or the ratio g of these amounts of change, for example. If the difference f is equal to or less than a predetermined value, or if the ratio g is near 1.0, for example, it is determined that the shift control solenoid valves DS**1** and DS**2** are operating normally. If, on the other hand, the difference f is greater than the predetermined value or if the ratio g is not close to 1.0, it is determined that the shift control solenoid valves DS**1** and DS**2** are not operating normally.

[0058] As described above, according to this example embodiment, the normal operation determining means **170** is provided which determines whether the shift control solenoid valves are operating normally based on the difference e between the actual speed ratio γ and the target speed ratio γ*, and the amounts of change (Δγ* and Δγ) in the target speed ratio γ* and the actual speed ratio γ during the predetermined interval (i.e., between the start point and the end point). Therefore, it is possible to accurately determine whether the shift control solenoid valves are operating normally. That is, in this example embodiment, the reliability of that determination is improved because the determination is made based on the amounts of change (Δγ* and Δγ) as well as the difference e.

[0059] Also, according to the example embodiment, the normal operation determining means **170** determines that the shift control solenoid valves DS**1** and DS**2** are operating normally when the difference e between the actual speed ratio γ and the target speed ratio γ* is equal to or less than the predetermined value C and the amount of change Δγ in the actual speed ratio γ and the amount of change Δγ* in the target speed ratio γ* in the predetermined interval are substantially equal. As a result, it is possible to accurately determine whether the shift control solenoid valves DS**1** and DS**2** are operating normally.

[0060] Also, according to this example embodiment, the normal operation determining means **170** is operated within a speed ratio range that does not include the minimum speed ratio γmin and the maximum speed ratio γmax of the belt-type CVT **18**. As a result, the determination can be made generally unaffected by devices other than the shift control solenoid valves.

[0061] Also, according to this example embodiment, the amount of change Δγ in the actual speed ratio γ and the amount of change Δγ* in the target speed ratio γ* are measured when the difference e between the actual speed ratio γ and the target speed ratio γ* is equal to or less than the predetermined value C, so the reliability of the determination regarding normal operation based on the amounts of change (Δγ and Δγ*) improves.

[0062] While an example embodiment of the invention has been described in detail with reference to the drawings, it is to be understood that the invention may also be carried out in other modes.

[0063] For example, in the example embodiment described above, differences e are sequentially determined when the actual speed ratio γ changes from the start point to the end point, but differences e do not necessarily have to be sequentially determined. For example, only the difference e at the start point may be determined.

[0064] Also, in the example embodiment described above, the current cycle of the routine ends when the difference e exceeds the predetermined value. However, it is conceivable that the difference e may temporarily increase due to some sort of change in the vehicle so the control may be such that the current cycle of the routine ends when the difference has remained above a predetermined value for a predetermined period of time which has been set in advance.

[0065] Also, in the example embodiment described above, the continuously variable transmission **18** is a continuously variable transmission that continuously changes speed ratios by controlling the winding radius of the belt. However, the invention may also be applied to another kind of continuously variable transmission such as a toroidal-type continuously variable transmission, for example.

[0066] Also, in the example embodiment described above, an internal combustion engine such as a gasoline engine (petrol) or a diesel engine or the like is widely used as the engine **12** which serves as the power source for running. In

addition, an electric motor or the like may also be used together with the engine **12**, as a secondary or auxiliary power source for running. Alternatively, it is also possible to use only an electric motor as the power source for running.

[0067] In the present invention, the normal operation determining means may determine that the shift control apparatus is operating normally when the difference between the actual speed ratio and the target speed ratio is equal to or less than a predetermined value, and the amount of change in the actual speed ratio and the amount of change in the target speed ratio during the predetermined interval are substantially equal.

[0068] According to the present invention, the normal operation determining means determines that the shift control apparatus is operating normally when the difference between the actual speed ratio and the target speed ratio is equal to or less than a predetermined value, and the amount of change in the actual speed ratio and the amount of change in the target speed ratio during the predetermined interval are substantially equal. Therefore, it is possible to accurately determine whether shift control solenoid valves are operating normally.

[0069] In the present invention, the normal operation determining means may make the determination when the actual speed ratio is within a speed ratio range that does not include a maximum speed ratio and a minimum speed ratio of a continuously variable transmitting portion of the continuously variable transmission.

[0070] According to the present invention, the normal operation determining means makes the determination within a speed ratio range that does not include the maximum speed ratio and the minimum speed ratio of the continuously variable transmitting portion of the continuously variable transmission. Therefore, the determination can be made generally unaffected by devices other than shift control solenoid valves.

[0071] In the present invention, the amount of change in the actual speed ratio and the amount of change in the target speed ratio may be measured when the difference between the actual speed ratio and the target speed ratio is equal to or less than a predetermined value.

[0072] According to the present invention, the amount of change in the actual speed ratio and the amount of change in the target speed ratio are measured when the difference between the actual speed ratio and the target speed ratio is equal to or less than a predetermined value. As a result, the reliability of the determination based on the amounts of change improves.

[0073] While the invention has been described with reference to example embodiments thereof, it is to be understood that the invention is not limited to the described embodiments or constructions. To the contrary, the invention is intended to cover various modifications and equivalent arrangements. In addition, while the various elements of the example embodiments are shown in various combinations and configurations, other combinations and configurations, including more, less or only a single element, are also within the scope of the invention.

What is claimed is:

1. A shift control apparatus of a continuously variable transmission, comprising:

a feedback control portion which executes feedback control that brings an actual speed ratio close or equal to a target speed ratio; and

a normal operation determining portion which determines whether the shift control apparatus is operating normally based on a difference between the actual speed ratio and the target speed ratio, and an amount of change in the actual speed ratio and an amount of change in the target speed ratio during a predetermined interval.

2. The shift control apparatus according to claim **1**, wherein the normal operation determining portion determines that the shift control apparatus is operating normally when the difference between the actual speed ratio and the target speed ratio is equal to or less than a predetermined value, and the amount of change in the actual speed ratio and the amount of change in the target speed ratio during the predetermined interval are substantially equal.

3. The shift control apparatus according to claim **2**, wherein the normal operation determining portion makes the determination when the amount of change in the target speed ratio is greater than a predetermined amount of change.

4. The shift control apparatus according to claim **1**, wherein the normal operation determining portion determines that the shift control apparatus is operating normally when i) a difference between the amount of change in the actual speed ratio and the amount of change in the target speed ratio during the predetermined interval is equal to or less than a first predetermined value, or ii) the ratio of the amount of change in the actual speed ratio to the amount of change in the target speed ratio during the predetermined interval is within a second predetermined value.

5. The shift control apparatus according to claim **4**, wherein the normal operation determining portion makes the determination when the amount of change in the target speed ratio is greater than a predetermined amount of change.

6. The shift control apparatus according to claim **2**, wherein the normal operation determining portion makes the determination when the actual speed ratio is within a speed ratio range that does not include a maximum speed ratio and a minimum speed ratio of a continuously variable transmitting portion of the continuously variable transmission.

7. The shift control apparatus according to claim **6**, wherein the normal operation determining portion does not make the determination when the actual speed ratio is outside of the speed ratio range.

8. The shift control apparatus according to claim **4**, wherein the normal operation determining portion makes the determination when the actual speed ratio is within a speed ratio range that does not include a maximum speed ratio and a minimum speed ratio of a continuously variable transmitting portion of the continuously variable transmission.

9. The shift control apparatus according to claim **8**, wherein the normal operation determining portion does not make the determination when the actual speed ratio is outside of the speed ratio range.

10. The shift control apparatus according to claim **6**, wherein the amount of change in the actual speed ratio and the amount of change in the target speed ratio are measured when the difference between the actual speed ratio and the target speed ratio is equal to or less than a predetermined value.

11. The shift control apparatus according to claim **8**, wherein the amount of change in the actual speed ratio and the amount of change in the target speed ratio are measured when the difference between the actual speed ratio and the target speed ratio is equal to or less than a predetermined value.

12. The shift control apparatus according to claim **6**, wherein the amount of change in the actual speed ratio and the amount of change in the target speed ratio are measured when the period of time during which the difference between the

actual speed ratio and the target speed ratio is greater than a predetermined value is within a predetermined period of time.

13. The shift control apparatus according to claim **8**, wherein the amount of change in the actual speed ratio and the amount of change in the target speed ratio are measured when the period of time during which the difference between the actual speed ratio and the target speed ratio is greater than a predetermined value is within a predetermined period of time.

14. The shift control apparatus according to claim **1**, wherein the difference between the actual speed ratio and the target speed ratio is determined when the actual speed ratio is at a predetermined start point or when the actual speed ratio changes from a predetermined start point to a predetermined end point.

15. A method of determining whether a shift control apparatus of a continuously variable transmission is operating normally, comprising:

executing feedback control that brings an actual speed ratio close or equal to a target speed ratio; and

determining whether the shift control apparatus is operating normally based on a difference between the actual speed ratio and the target speed ratio, and an amount of change in the actual speed ratio and an amount of change in the target speed ratio during a predetermined interval.

16. A method of determining whether a shift control apparatus of a continuously variable transmission is operating normally, comprising:

executing feedback control that brings an actual speed ratio close or equal to a target speed ratio;

calculating a difference between the actual speed ratio and the target speed ratio;

calculating an amount of change in the actual speed ratio and an amount of change in the target speed ratio during a predetermined interval; and

determining that the shift control apparatus is operating normally when i) the difference is equal to or less than a predetermined value, and ii) the difference between the amount of change in the actual speed ratio and the amount of change in the target speed ratio is equal to or less than a first predetermined value, or the ratio of the amount of change in the actual speed ratio to the amount of change in the target speed ratio is within a second predetermined value.

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