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(54) **VEHICLE DRIVE-FORCE TRANSMITTING APPARATUS**

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(57) **ABSTRACT**

A vehicle drive-force transmitting apparatus including: a mode switching clutch; a torque converter; a lock-up clutch included in the torque converter; a switching solenoid valve configured to output a switching pressure for switching an operating mode of the mode switching clutch between a one-way mode and a lock mode; and a lock-up clutch control valve configured to switch an operating state of the lock-up clutch between an engaged state and a released state. The mode switching clutch is to be placed in the lock mode when the switching pressure is supplied from the switching solenoid valve to the mode switching clutch. The lock-up clutch control valve is configured to receive the switching pressure supplied from the switching solenoid valve, and to switch the operating state of the lock-up clutch to the released state when the switching pressure is supplied to the lock-up clutch control valve.

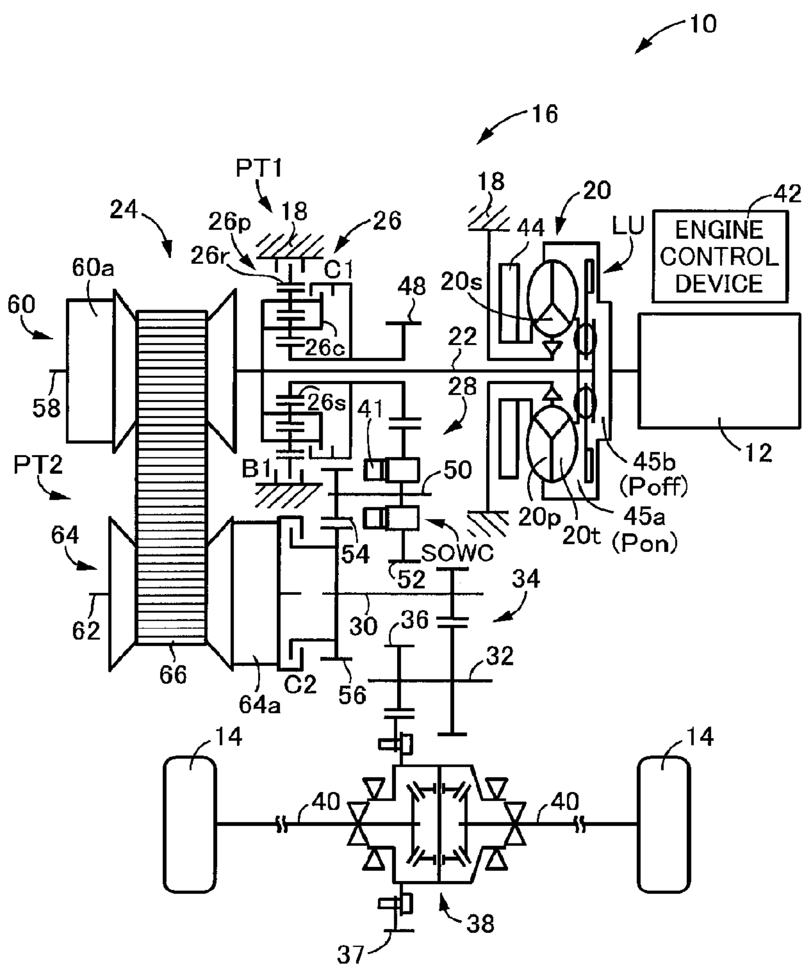


FIG.1

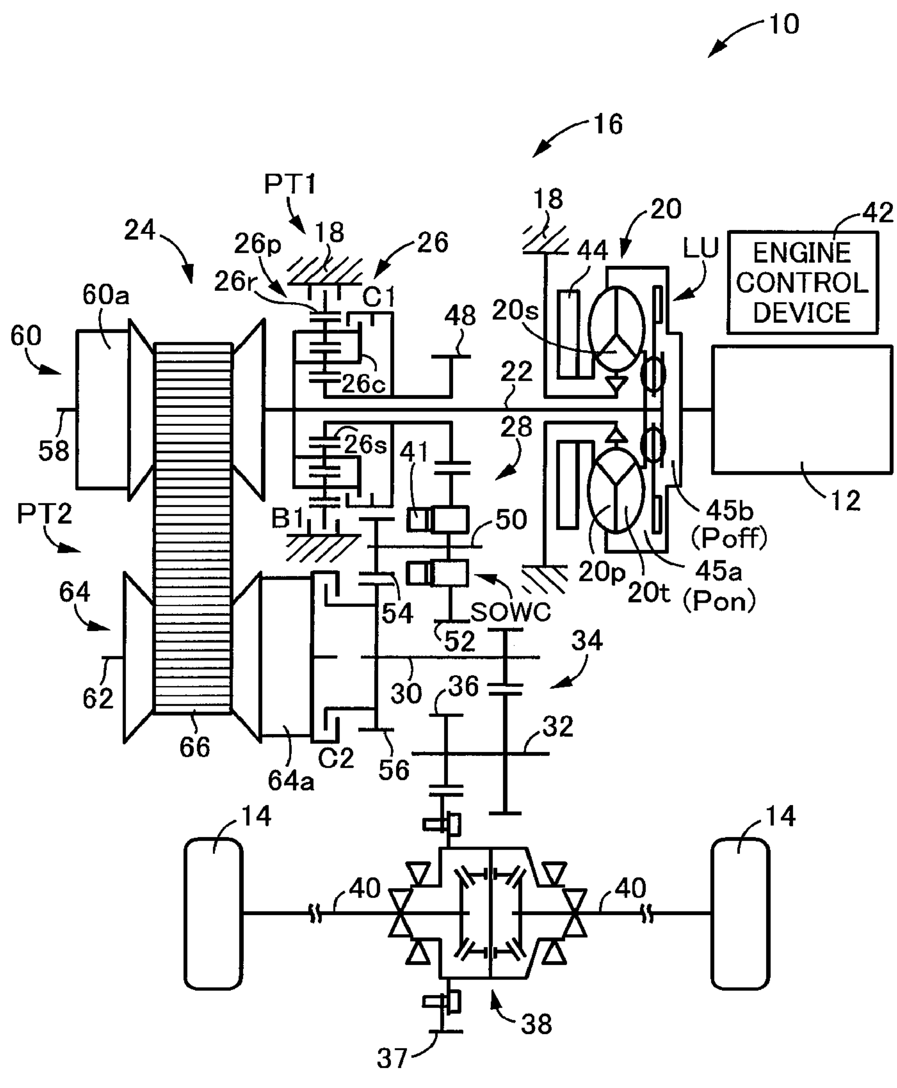

10
16
PT1
18
20
42
ENGINE CONTROL DEVICE
24
26p
26
26r
C1
44
LU
60a
48
20s
60
26c
22
28
58
26s
41
12
45b
(Poff)
PT2
B1
50
20p
45a
(Pon)
20t
64
54
SOWC
52
34
62
30
36
66
64a
C2
56
32
14
40
38
37

FIG.2

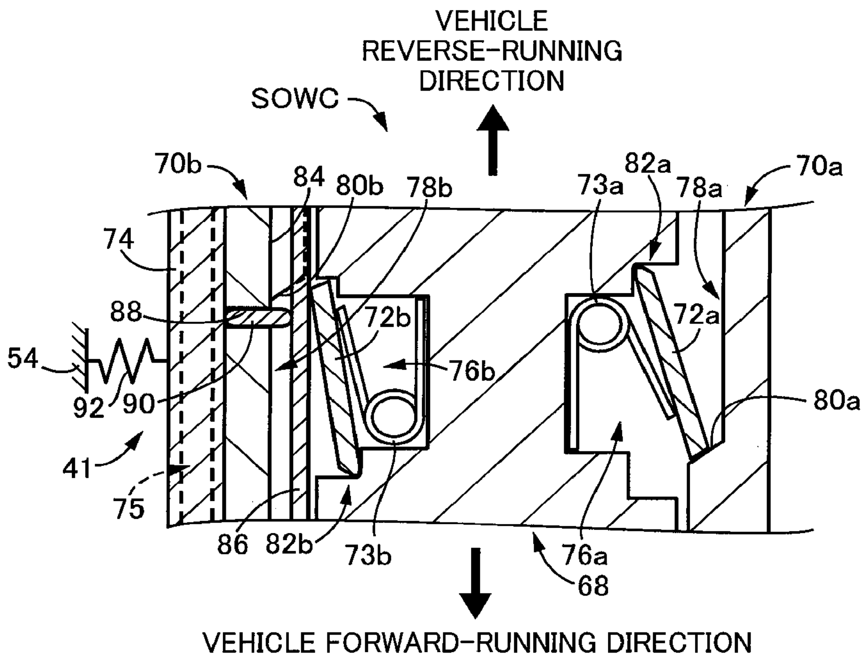

VEHICLE
REVERSE-RUNNING
DIRECTION
SOWC
70b
84
80b
78b
73a
82a
78a
70a
74
88
72b
72a
54
76b
92
90
80a
41
75
86
82b
73b
76a
68
VEHICLE FORWARD-RUNNING DIRECTION

FIG.3

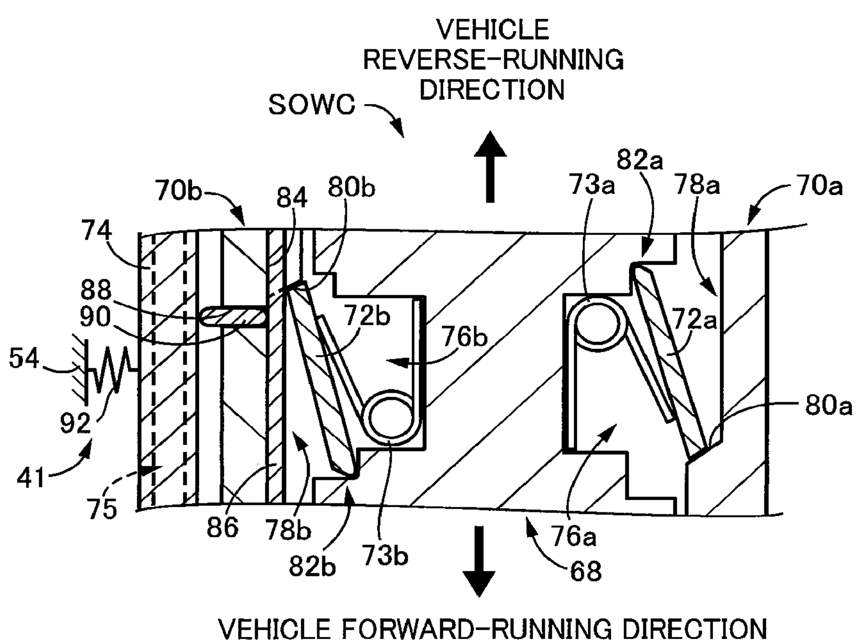

VEHICLE
REVERSE-RUNNING
DIRECTION
SOWC
70b
84
80b
73a
82a
78a
70a
74
88
90
72b
72a
76b
54
92
80a
41
75
86
78b
82b
73b
76a
68
VEHICLE FORWARD-RUNNING DIRECTION

FIG.4

		TABLE			
		C1	C2	B1	SOWC
P					
R				○	○
N					
D	(D1)	○			
	(D2)		○		
M	(M1)	○			○
	(M2)		○		

FIG.5

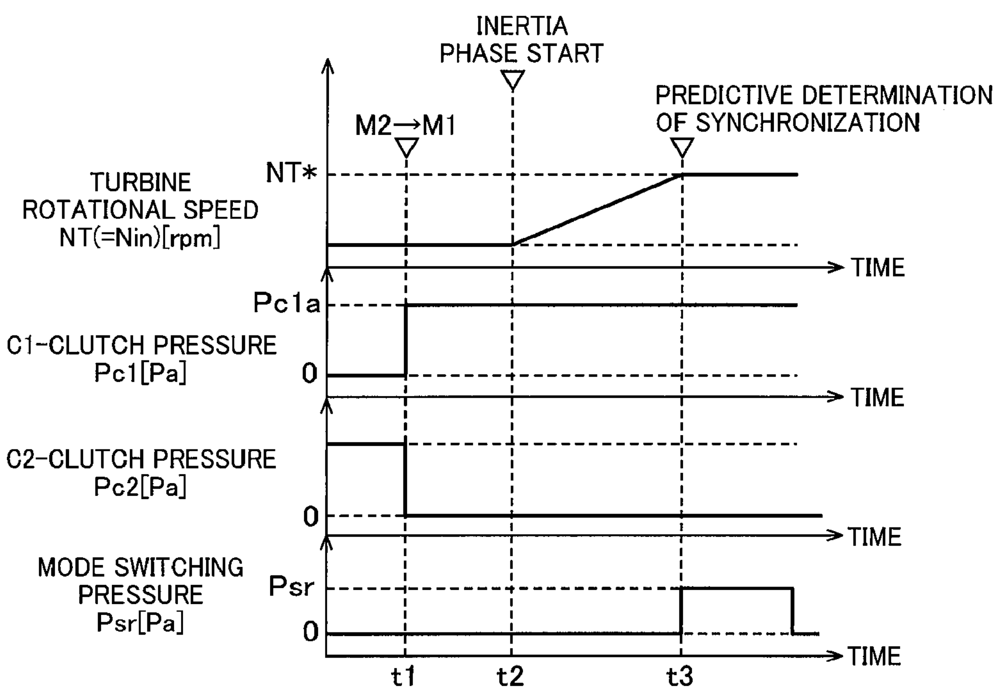

INERTIA
PHASE START
PREDICTIVE DETERMINATION
OF SYNCHRONIZATION
M2→M1
NT*
TURBINE
ROTATIONAL SPEED
NT(=Nin)[rpm]
TIME
Pc1a
C1-CLUTCH PRESSURE
Pc1[Pa]
0
TIME
C2-CLUTCH PRESSURE
Pc2[Pa]
0
TIME
MODE SWITCHING
PRESSURE
Psr[Pa]
Psr
0
TIME
t1
t2
t3

FIG.6

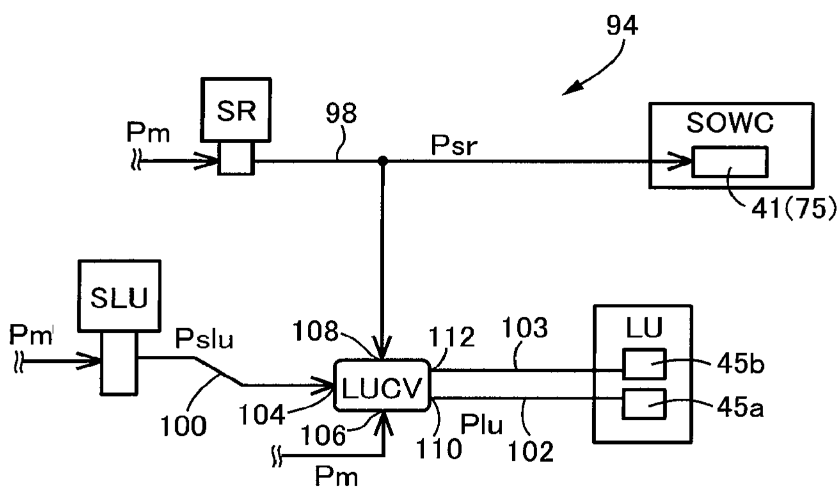
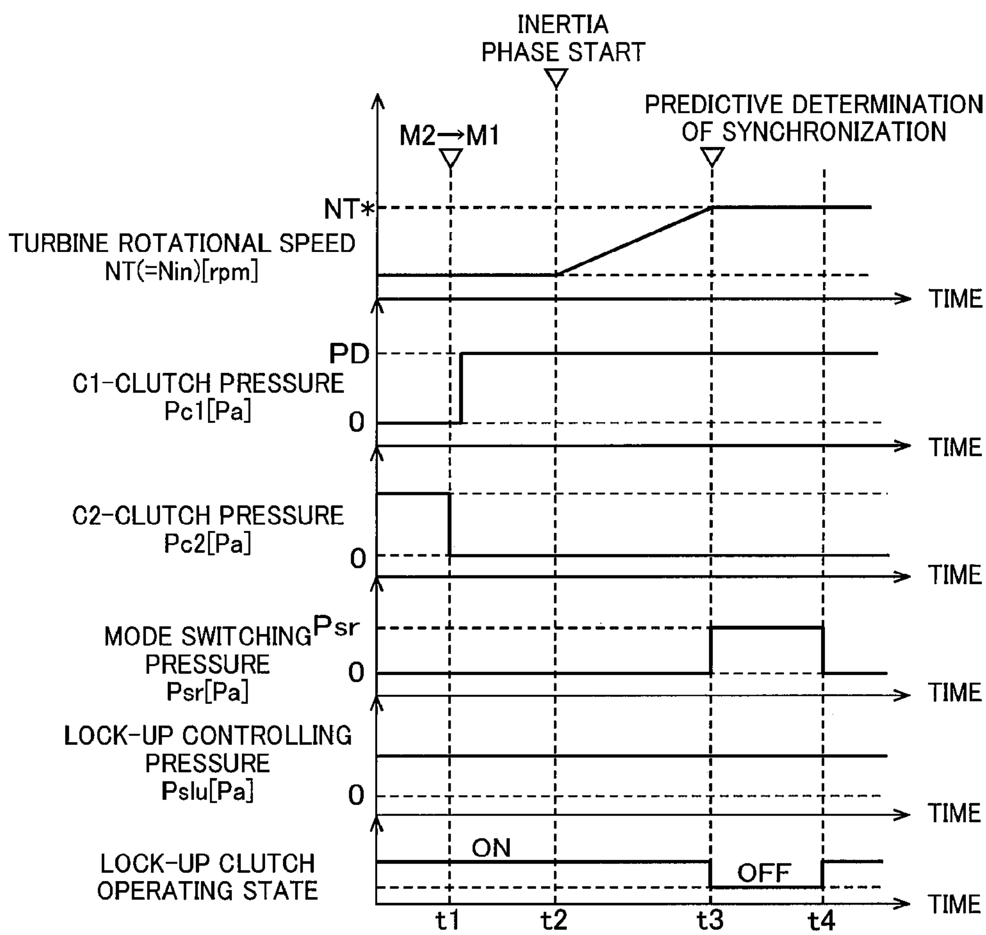

94
SR
98
Pm
Psr
SOWC
41(75)
SLU
Pm
Pslu
108
112
103
LU
45b
LUCV
45a
100
104
106
Plu
110
102
Pm

FIG.7


INERTIA PHASE START
PREDICTIVE DETERMINATION OF SYNCHRONIZATION
M2→M1
NT*
TURBINE ROTATIONAL SPEED NT(=Nin)[rpm]
TIME
PD
C1-CLUTCH PRESSURE Pc1[Pa]
0
TIME
C2-CLUTCH PRESSURE Pc2[Pa]
0
TIME
MODE SWITCHING PRESSURE Psr[Pa]
Psr
0
TIME
LOCK-UP CONTROLLING PRESSURE Pslu[Pa]
0
TIME
LOCK-UP CLUTCH OPERATING STATE
ON
OFF
TIME
t1
t2
t3
t4

VEHICLE DRIVE-FORCE TRANSMITTING APPARATUS

[0001] This application claims priority from Japanese Patent Application No. 2019-099456 filed on May 28, 2019, the disclosure of which is herein incorporated by reference in its entirety.

FIELD OF THE INVENTION

[0002] The present invention relates to a drive-force transmitting apparatus for a vehicle, wherein the drive-force transmitting apparatus defines first and second drive-force transmitting paths that are provided in parallel to each other between an engine and drive wheels of the vehicle.

BACKGROUND OF THE INVENTION

[0003] There is known a drive-force transmitting apparatus that is to be installed in a vehicle including an engine and drive wheels, wherein the drive-force transmitting apparatus includes first and second clutches, a gear mechanism, a dog clutch and a continuously variable transmission, and defines first and second drive-force transmitting paths that are provided in parallel to each other between the engine and the drive wheels, and wherein the first drive-force transmitting path is provided with the first clutch, the gear mechanism and the dog clutch, while the second drive-force transmitting path is provided with the continuously variable transmission and the second clutch. Such a drive-force transmitting apparatus is disclosed in JP-5765485-B2.

SUMMARY OF THE INVENTION

[0004] By the way, in the drive-force transmitting apparatus disclosed in JP-5765485-B2, when a manual shift-down operation is executed to switch a drive-force transmitting (along which a drive force is to be transmitted during running of the vehicle) from the second drive-force transmitting path to the first drive-force transmitting path, since the dog clutch is in its engaged state, a clutch-to-clutch control is executed to release the second clutch and engage the first clutch in a shift-down transition. For the purpose of reducing the cost, the dog clutch may be replaced by a mode switching clutch, which is to be placed in a selected one of a plurality of operating modes including at least a one-way mode and a lock mode, such that the mode switching clutch is configured to transmit the drive force during a driving state of the vehicle and to cut off transmission of the drive force during a driven state of the vehicle when the mode switching clutch is placed in the one-way mode, and such that the mode switching clutch is configured to transmit the drive force during the driving state of the vehicle and during the driven state of the vehicle when the mode switching clutch is placed in the lock mode. In this arrangement employing the mode switching clutch, when the manual shift-down operation is executed to switch the drive-force transmitting path from the second drive-force transmitting path to the first drive-force transmitting path, an operating mode of the mode switching clutch is switched from the one-way mode to the lock mode, and there is a risk of generation of a switching shock if the switching to the lock mode is made with a difference of rotational speed between rotary elements disposed on respective front-side and rear-side of the mode switching clutch.

[0005] The present invention was made in view of the background art described above. It is therefore an object of the present invention to provide an apparatus to be installed in a vehicle that includes an engine and drive wheels, wherein the apparatus includes a first clutch, a second clutch and a mode switching clutch, and defines first and second drive-force transmitting paths that are provided in parallel to each other between the engine and the drive wheels, such that the first drive-force transmitting path is provided with the first clutch and the mode switching clutch while the second drive-force transmitting path is provided with the second clutch, and wherein the apparatus is capable of reducing a switching shock generated in a switching transition from the one-way mode to the lock mode in the mode switching clutch when a drive-force transmitting is switched from the second drive-force transmitting path to the first drive-force transmitting path during running of the vehicle.

[0006] The object indicated above is achieved according to the following aspects of the present invention.

[0007] According to a first aspect of the invention, there is provided a drive-force transmitting apparatus to be installed in a vehicle that includes an engine and drive wheels. The drive-force transmitting apparatus comprises a first clutch, a second clutch, a mode switching clutch and a torque converter that includes a lock-up clutch. The drive-force transmitting apparatus defines first and second drive-force transmitting paths that are provided in parallel to each other between the engine and the drive wheels. The first drive-force transmitting path is provided with the first clutch and the mode switching clutch, such that the first clutch is disposed between the mode switching clutch and the engine in the first drive-force transmitting path. The second drive-force transmitting path is provided with the second clutch. The torque converter is provided between the engine and the first and second drive-force transmitting paths. An operating mode of the mode switching clutch is to be switched between at least a one-way mode and a lock mode, such that the mode switching clutch is configured to transmit a drive force during a driving state of the vehicle and to cut off transmission of the drive force during a driven state of the vehicle when the mode switching clutch is placed in the one-way mode, and such that the mode switching clutch is configured to transmit the drive force during the driving state of the vehicle and during the driven state of the vehicle when the mode switching clutch is placed in the lock mode. The drive-force transmitting apparatus further comprises: a switching solenoid valve configured to output a switching pressure by which the operating mode of the mode switching clutch is to be switched between at least the one-way mode and the lock mode; and a lock-up clutch control valve configured to switch an operating state of the lock-up clutch between an engaged state and a released state. The mode switching clutch is placed in the lock mode when the switching pressure is supplied from the switching solenoid valve to the mode switching clutch. The lock-up clutch control valve is configured to receive the switching pressure supplied from the switching solenoid valve, and to switch the operating state of the lock-up clutch to the released state when the switching pressure is supplied from the switching solenoid valve to the lock-up clutch control valve. For example, each of the mode switching clutch and the lock-up clutch control valve is connected to the switching solenoid valve through a fluid passage through which the switching pressure outputted by the switching solenoid valve is to be supplied to the mode switching clutch and the lock-up clutch control valve. Further, for example, the lock-up clutch is to be placed in the engaged state when a lock-up pressure is supplied through the lock-up clutch control valve to a fluid chamber defined in the torque converter, and is to be placed in the released state when the lock-up pressure is discharged through the lock-up clutch control valve from the fluid chamber, wherein the lock-up clutch control valve is to be switched between a first communicating state and a second communicating state, such that the lock-up clutch control valve allows supply of the lock-up pressure through the lock-up clutch control valve to the fluid chamber, when the lock-up clutch control valve is placed in the first communicating state, and such that the lock-up clutch control valve allows discharge of the lock-up pressure through the lock-up clutch control valve from the fluid chamber, when the lock-up clutch control valve is placed in the second communicating state, and wherein, when the switching pressure is supplied from the switching solenoid valve to the lock-up clutch control valve, the lock-up clutch control valve is placed in the second communicating state, whereby the lock-up pressure is discharged through the lock-up clutch control valve from the fluid chamber so as to place the lock-up clutch in the released state.

[0008] According to a second aspect of the invention, the drive-force transmitting apparatus according to the first aspect of the invention further comprises a gear mechanism and a continuously variable transmission, wherein the gear mechanism is provided in the first drive-force transmitting path, and is disposed between the mode switching clutch and the engine in the first drive-force transmitting path, and wherein the continuously variable transmission is provided in the second drive-force transmitting path.

[0009] According to a third aspect of the invention, the drive-force transmitting apparatus according to the second aspect of the invention further comprises a forward/reverse switching device which is provided in the first drive-force transmitting path and which is disposed between the gear mechanism and the engine in the first drive-force transmitting path, wherein the forward/reverse switching device is constituted by a planetary gear device, and wherein the first clutch is configured to connect two rotary elements of the planetary gear device to each other and to disconnect the two rotary elements from each other.

[0010] In the drive-force transmitting apparatus according to the first aspect of the invention, when the second drive-force transmitting path is to be switched to the first drive-force transmitting path, the operating mode of the mode switching clutch is switched from the one-way mode to the lock mode with the switching pressure being supplied from the switching solenoid valve to the mode switching clutch. The lock-up clutch control valve is configured, when the switching pressure is supplied from the switching solenoid valve to the lock-up clutch control valve, to switch the operating state of the lock-up clutch to the released state. Therefore, when the switching pressure is outputted from the switching solenoid valve, the lock-up clutch is placed into the released state. Thus, in the switching transition from the one-way mode to the lock mode in the mode switching clutch, the lock-up clutch is placed in the released state whereby a connection between the engine and the torque converter (i.e., between the engine and the first and second drive-force transmitting paths) through the lock-up clutch is cut off. As a result of the placement of the lock-up clutch in the released state, an inertia acting on an upstream side of the mode switching clutch is reduced by a magnitude corresponding to an inertia of the engine, whereby the switching shock generated in the switching transition from the one-way mode to the lock mode in the mode switching clutch can be made smaller than in a case in which the lock-up clutch is placed in the engaged state.

[0011] In the drive-force transmitting apparatus according to the second aspect of the invention, when the first drive-force transmitting path provided with the gear mechanism is established, a gear ratio of the drive-force transmitting apparatus becomes dependent of a gear ratio of the gear mechanism. Further, when the second drive-force transmitting path provided with the continuously variable transmission is established, the gear ratio of the drive-force transmitting apparatus can be continuously changed by operation of the continuously variable transmission.

[0012] In the drive-force transmitting apparatus according to the third aspect of the invention, the first clutch is provided to connect and disconnect the two rotary elements included in the planetary gear device that constitutes the forward/reverse switching device, to and from each other, such that all rotary elements of the planetary gear device are to be rotated integrally with one another with the first clutch being engaged. Therefore, the drive force of the engine is transmitted toward the gear mechanism through the forward/reverse switching device, so that it is possible to cause the vehicle to run in a forward direction with the drive force being transmitted to the drive wheels along the first drive-force transmitting path.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIG. **1** is a schematic view showing a construction of a vehicle to which the present invention is applied;

[0014] FIG. **2** is a view showing a mode switching clutch shown in FIG. **1**, in a state in which the mode switching clutch is placed in its one-way mode;

[0015] FIG. **3** is a view showing the mode switching clutch shown in FIG. **1**, in a state in which the mode switching clutch is placed in its lock mode;

[0016] FIG. **4** is a table indicating an operating state of each of engagement devices for each of operating positions which is selected by operation of a shift lever that is provided in the vehicle;

[0017] FIG. **5** is a time chart showing a control status in a conventional construction when a position **M2** is switched to a position **M1** by a shift-down operation made by an operator of the vehicle during running of the vehicle with the position **M2** being established;

[0018] FIG. **6** is a circuit diagram showing a part of a hydraulic control unit for controlling a drive-force transmitting apparatus that is to be installed in the vehicle, wherein the part of the hydraulic control unit is configured to control a working fluid supplied to each of a lock-up clutch and a hydraulic actuator of the mode switching clutch; and

[0019] FIG. **7** is a time chart showing a control status when the position **M2** is switched to the position **M1** by a shift-down operation made by the operator during running of the vehicle with the position **M2** being established.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

[0020] Hereinafter, a preferred embodiment of the invention will be described in detail with reference to the accompanying drawings. The figures of the drawings are simplified or deformed as needed, and each portion is not necessarily precisely depicted in terms of dimension ratio, shape, etc.

Embodiment

[0021] FIG. **1** is a schematic view showing a construction of a vehicle **10** to which the present invention is applied. As shown in FIG. **1**, the vehicle **10** is provided with an engine **12** functioning as a drive force source configured to generate a drive force, drive wheels **14** and a vehicle drive-force transmitting apparatus **16** that is configured to transmit the drive force of the engine **12** to the drive wheels **14**.

[0022] The drive-force transmitting apparatus **16** is disposed between the engine **12** and the drive wheels **14**. The drive-force transmitting apparatus **16** includes a non-rotary member in the form of a casing **18**, a fluid-operated type drive-force transmitting device in the form of a known torque converter **20** that is connected to the engine **12**, an input shaft **22** connected to an output side of the torque converter **20**, a belt-type continuously variable transmission **24** connected to the input shaft **22**, a forward/reverse switching device **26** connected to the input shaft **22**, a gear mechanism **28** which is provided in parallel with the continuously variable transmission **24** and which is connected to the input shaft **22** via the forward/reverse switching device **26**, an output shaft **30** serving as an output rotary member that is common to the continuously variable transmission **24** and the gear mechanism **28**, a drive-force transmitting shaft **32**, a reduction gear device **34** consisting of a pair of mutually meshing gears each of which is connected to a corresponding one of the output shaft **30** and the drive-force transmitting shaft **32** so as to unrotatable relative to the corresponding one of the shafts **30**, **32**, a gear **36** connected to the drive-force transmitting shaft **32** so as to be unrotatable relative to the drive-force transmitting shaft **32**, a differential gear device **38** having a differential ring gear **37** meshing with the gear **36**, and right and left axles **40** that are connected to the differential gear device **38**. The torque converter **20**, input shaft **22**, continuously variable transmission **24**, forward/reverse switching device **26**, gear mechanism **28**, output shaft **30**, drive-force transmitting shaft **32**, reduction gear device **34**, gear **36** and differential gear device **38** are disposed within the casing **18**.

[0023] In the drive-force transmitting apparatus **16** constructed as described above, the drive force generated by the engine **12** is transmitted to the right and left drive wheels **14**, via the torque converter **20**, forward/reverse switching device **26**, gear mechanism **28**, reduction gear device **34**, differential gear device **38**, axles **40** and other elements, or alternatively, via the torque converter **20**, continuously variable transmission **24**, reduction gear device **34**, differential gear device **38**, axles **40** and other elements. It is noted that the above-described drive force is synonymous with a drive torque or a drive power unless otherwise distinguished from them.

[0024] The engine **12** is provided with an engine control device **42** including an electronic throttle device, a fuel injection device, an ignition device and other devices that are required for controlling an output of the engine **12**. In the engine **12**, the engine control device **42** is controlled, by an electronic control apparatus (not shown), based on an operation amount of an accelerator pedal that corresponds to a required drive force of the vehicle **10** required by an operator of the vehicle **10**, whereby an engine torque Te as an output torque of the engine **12** is controlled.

[0025] The torque converter **20** is disposed between the engine **12** and the input shaft **22**, namely, between the engine **12** and the first and second drive-force transmitting paths PT**1**, PT**2**, and is a fluid-operated type drive-force transmitting device configured to covert the engine torque Te outputted from the engine **12**, though a fluid. The torque converter **20** includes a pump impeller **20***p* connected to the engine **12**, a turbine impeller **20***t* is connected to the input shaft **22**, and a stator impeller **20***s* connected to the casing **18** through a one-way clutch. The torque converter **20** is a fluid drive-force transmitting device configured to transmit the drive force of the engine **12** to the input shaft **22** through the fluid. Since the torque converter **20** is a known device, detailed description thereof will not be provided.

[0026] Further, the torque converter **20** is provided with a known lock-up clutch LU through which the pump impeller **20***p* and the turbine impeller **20***t* can be connected directly to each other. An operating state of the lock-up clutch LU, based on which the pump impeller **20***p* and the turbine impeller **20***t* (i.e., the engine **12** and the input shaft **22**) are to be connected to each other or are disconnected from each other, is controlled depending on a running state of the vehicle **10**. Specifically, the torque converter **20** defines therein an engaging-side fluid chamber **45***a* and a releasing-side fluid chamber **45***b*, and a pressure difference (=Pon−Poff) between a hydraulic pressure Pon of the engaging-side fluid chamber **45***a* and a hydraulic pressure Poff of the releasing-side fluid chamber **45***b* is adjusted whereby the operating state of the lock-up clutch LU is controlled. It is noted that the engaging-side fluid chamber **45***a* corresponds to "fluid chamber" recited in the appended claims.

[0027] The drive-force transmitting apparatus **16** defines first and second drive-force transmitting paths PT**1**, PT**2** that are provided in parallel to each other between the engine **12** and the drive wheels **14** (more precisely, between the input and output shafts **22**, **30**). The first drive-force transmitting path PT**1** is provided with the gear mechanism **28**, while the second drive-force transmitting path PT**2** is provided with the continuously variable transmission **24**.

[0028] The first drive-force transmitting path PT**1** is provided with: the forward/reverse switching device **26** including a first clutch C**1** and a first brake B**1**; the gear mechanism **28**; and a mode switching clutch SOWC, and is a drive-force transmitting path along which the drive force of the engine **12** is to be transmitted from the input shaft **22** to the drive wheels **14** through the gear mechanism **28**. In the first drive-force transmitting path PT**1**, the forward/reverse switching device **26**, gear mechanism **28** and mode switching clutch SOWC are arranged in this order of description in a direction away from the engine **12** toward the drive wheels **14**. Therefore, the first clutch C**1**, which is included in the forward/reverse switching device **26**, is disposed between the mode switching clutch SOWC and the engine **12**.

[0029] The second drive-force transmitting path PT**2** is provided with the continuously variable transmission **24** and a second clutch C**2**, and is a drive-force transmitting path along which the drive force of the engine **12** is to be transmitted from the input shaft **22** to the drive wheels **14** through the continuously variable transmission **24**. In the second drive-force transmitting path PT**2**, the continuously variable transmission **24** and second clutch C**2** are arranged in this order of description in a direction away from the engine **12** toward the drive wheels **14**.

[0030] The forward/reverse switching device **26** is disposed is disposed between the gear mechanism **28** and the engine **12** in the first drive-force transmitting path PT**1**, namely, disposed on an upstream side of the gear mechanism **28** in the first drive-force transmitting path PT**1**. The forward/reverse switching device **26** includes a planetary gear device **26***p* of double-pinion type in addition to the first clutch C**1** and the first brake B**1**. The planetary gear device **26***p* is a differential mechanism including three rotary elements consisting of an input element in the form of a carrier **26***c*, an output element in the form of a sun gear **26***s* and a reaction element in the form of a ring gear **26***r*. The carrier **26***c* is connected to the input shaft **22**. The ring gear **26***r* is operatively connected to the casing **18** through the first brake B**1**. The sun gear **26***s* is disposed radially outside the input shaft **22**, and is connected to a small-diameter gear **48** that is rotatable relative to the input shaft **22**. The first clutch C**1** is configured to connect and disconnect the carrier **26***c* and the sun gear **26***s* to each other and from each other.

[0031] Each of the first clutch C**1** and first brake B**1** is a known hydraulically-operated wet-type frictional engagement device that is to be frictionally engaged by operation of a hydraulic actuator. Each of the first clutch C**1** and first brake B**1** constitutes a part of the forward/reverse switching device **26**. For example, when the first clutch C**1** is engaged, the sun gear **26***s*, carrier **26***c* and ring gear **26***r* become rotatable integrally with one another. Therefore, with the first clutch C**1** being engaged, a rotation of the input shaft **22** is transmitted to the small-diameter gear **48**, without a speed of the rotation being increased or reduced, thereby enabling the vehicle **10** to run in a forward direction. With the first brake B**1** being engaged, the rotation of the input shaft **22** is transmitted to the small-diameter gear **48**, with a direction of the rotation being inverted, thereby enabling the vehicle **10** to run in a reverse direction.

[0032] The gear mechanism **28** is disposed is disposed between the mode switching clutch SOWC and the engine **12** in the first drive-force transmitting path PT**1**, namely, disposed on an upstream side of the mode switching clutch SOWC in the first drive-force transmitting path PT**1**. The gear mechanism **28** includes, in addition to the above-described small-diameter gear **48**, a counter shaft **50** and a large-diameter gear **52** which meshes with the small-diameter gear **48** and which is mounted on the counter shaft **50**, rotatably relative to the counter shaft **50**. The gear mechanism **28** further includes a counter gear **54** and an output gear **56**. The counter gear **54** is mounted on the counter shaft **50**, unrotatably relative to the counter shaft **50**, and meshes with the output gear **56** that is mounted on the output shaft **30**.

[0033] The continuously variable transmission **24** includes a primary shaft **58** provided to be coaxial with the input shaft **22** and connected integrally to the input shaft **22**, a primary pulley **60** connected to the primary shaft **58** and having a variable effective diameter, a secondary shaft **62** provided to be coaxial with the output shaft **30**, a secondary pulley **64** connected to the secondary shaft **62** and having a variable effective diameter, and a transfer element in the form of a transmission belt **66** looped over or mounted on the pulleys **60**, **64**. The continuously variable transmission **24** is a known belt-type continuously variable transmission in which the drive force is transmitted owing to a friction force generated between the transmission belt **66** and each of the pulleys **60**, **64**, and is configured to transmit the drive force of the engine **12** toward the drive wheels **14**. The effective diameter of the primary pulley **60** is changed by operation of the hydraulic actuator **60***a*, while the effective diameter of the secondary pulley **64** is changed by operation of the hydraulic actuator **64***a*.

[0034] The gear mechanism **28**, which is provided in the first drive-force transmitting path PT**1**, provides a gear ratio EL (=input-shaft rotational speed Nin/output-shaft rotational speed Nout) that is higher than a highest gear ratio in the second drive-force transmitting path PT**2** which corresponds to a highest gear ratio γmax of the continuously variable transmission **24**. That is, the gear ratio EL of the gear mechanism **28**, which may be interpreted also as a gear ratio in the first drive-force transmitting path PT**1**, is set to be a gear ratio that provides a lower speed than the highest gear ratio γmax, so that a gear ratio established in the second drive-force transmitting path PT**2** provides a higher speed than the gear ratio EL established in the first drive-force transmitting path PT**1**. It is noted that the input-shaft rotational speed Nin is a rotational speed of the input shaft **22** and that the output-shaft rotational speed Nout is a rotational speed of the output shaft **30**.

[0035] In the drive-force transmitting apparatus **16**, one of the first and second drive-force transmitting paths PT**1**, PT**2**, which is selected depending on the running state of the vehicle **10**, is established, and the drive force of the engine **12** is transmitted to the drive wheels **14** along the established one of the first and second drive-force transmitting paths PT**1**, PT**2**. Therefore, the drive-force transmitting apparatus **16** includes a plurality of engagement devices for selectively establishing the first and second drive-force transmitting paths PT**1**, PT**2**. The plurality of engagement devices include the above-described first clutch C**1**, first brake B**1**, second clutch C**2** and mode switching clutch SOWC.

[0036] The first clutch C**1**, which is provided in the first drive-force transmitting path PT**1**, is an engagement device which is configured to selectively connect and disconnect the first drive-force transmitting path PT**1**, and which is configured, when the vehicle **10** is to run in the forward direction, to enable the drive force to be transmitted along the first drive-force transmitting path PT**1**, by being engaged. The first brake B**1**, which is also provided in the first drive-force transmitting path PT**1**, is an engagement device which is configured to selectively connect and disconnect the first drive-force transmitting path PT**1**, and which is configured, when the vehicle **10** is to run in the reverse direction, to enable the drive force to be transmitted along the first drive-force transmitting path PT**1** by being engaged. Thus, the first drive-force transmitting path PT**1** is established by engagement of either the first clutch C**1** or the first brake B**1**.

[0037] The mode switching clutch SOWC, which is also provided in the first drive-force transmitting path PT**1**, is to be placed in a selected one of a one-way mode and a lock mode, such that the mode switching clutch SOWC is configured to transmit the drive force during a driving state of the vehicle **10** in the forward running and to cut off transmission of the drive force during a driven state of the vehicle **10** in the forward running when the mode switching clutch SOWC is placed in the one-way mode, and such that the mode switching clutch SOWC is configured to transmit the drive force during the driving state of the vehicle **10** and during the driven state of the vehicle **10** when the mode switching clutch SOWC is placed in the lock mode.

[0038] For example, with the first clutch C**1** being placed in the engaged state and with the mode switching clutch SOWC being placed in the one-way mode, the drive force is transmittable along the first drive-force transmitting path PT**1** during the driving state of the vehicle **10** during which the vehicle **10** runs in the forward direction by the drive force of the engine **12**. That is, during the forward running of the vehicle **10**, the drive force of the engine **12** is transmitted to the drive wheels **14** along the first drive-force transmitting path PT**1**. On the other hand, during the driven state of the vehicle **10**, for example, during an inertia running of the vehicle **10** in the forward direction, rotation transmitted from the drive wheels **14** is blocked by the mode switching clutch SOWC even when the first clutch C**1** is in the engaged state. It is noted that the driving state of the vehicle **10** is a state in which a torque applied to the input shaft **22** takes a positive value so as to act on the input shaft **22** in a direction corresponding to a direction of the running of the vehicle **10**, namely, practically, a state in which the vehicle **10** is driven by the drive force of the engine **12**. It is further noted that the driven state of the vehicle **10** is a state in which a torque applied to the input shaft **22** takes a negative value so as to act on the input shaft **22** in a direction opposite to the above-described direction corresponding to the direction of the running of the vehicle **10**, namely, practically, a state in which the vehicle **10** is caused to run by an inertia with the input shaft **22** and the engine **12** being dragged by rotation transmitted from the drive wheels **14**.

[0039] Further, in a state in which the mode switching clutch SOWC is in the lock mode with the first clutch C**1** being in the engaged state, the drive force is enabled to be transmitted through the mode switching clutch SOWC during the driven state of the vehicle **10** as well as during the driving state of the vehicle **10**. In this state, the drive force of the engine **12** is transmitted to the drive wheels **14** along the first drive-force transmitting path PT**1**, and, during the driven state of the vehicle **10** such as the inertia running, the rotation transmitted from the drive wheels **14** is transmitted to the engine **12** along the first drive-force transmitting path PT**1** whereby the engine **12** is dragged to generate an engine brake. Further, in a state in which the mode switching clutch SOWC is in the lock mode with the first brake B**1** being in the engaged state, the drive force of the engine **12** is transmitted to the drive wheels **14** through the mode switching clutch SOWC along the first drive-force transmitting path PT**1** and acts on the drive wheels **14** so as to force the drive wheels **14** to be rotated in a direction that causes the vehicle **10** to run in the reverse direction. Thus, in this state, the vehicle **10** is enabled to run in the reverse direction with the drive force transmitted along the transmitting path PT**1** to the drive wheels **14**. The mode switching clutch SOWC has a construction that will be described later.

[0040] The second clutch C**2**, which is provided in the second drive-force transmitting path PT**2**, is an engagement device which is configured to selectively connect and disconnect the second drive-force transmitting path PT**2**, and which is configured, when the vehicle **10** is to run in the forward direction, to enable the drive force to be transmitted along the second drive-force transmitting path PT**2**, by being engaged. The second clutch C**2** is a known hydraulically-operated wet-type frictional engagement device that is to be frictionally engaged by operation of a hydraulic actuator.

[0041] The drive-force transmitting apparatus **16** is provided with a mechanical oil pump **44** connected to the pump impeller **20***p*. The oil pump **44** is to be driven by the engine **12**, to supply a working fluid pressure as its original pressure to a hydraulic control unit (hydraulic control circuit) **94** (see FIG. **6**) that is provided in the vehicle **10**, for performing a shifting control operation in the continuously variable transmission **24**, generating a belt clamping force in the continuously variable transmission **24**, switching the operating state of the lock-up clutch LU and switching the operating state of each of the above-described engagement devices between its engaged state and released state, or between its one-way mode and lock mode.

[0042] The construction of the mode switching clutch SOWC will be described. The mode switching clutch SOWC is provided between the large-diameter gear **52** and the counter gear **54** in an axial direction of the counter shaft **50**, such that the mode switching clutch SOWC is located to be closer, than the first clutch C**1** and the gear mechanism **28**, to the drive wheels **14** in the first drive-force transmitting path PT**1**. That is, the mode switching clutch SOWC is disposed between the first clutch C**1** (and the gear mechanism **28**) and the output shaft **30** in the first drive-force transmitting path PT**1**. The mode switching clutch SOWC is switchable between the one-way mode and the lock mode by operation of a hydraulic actuator **41** that is disposed to be adjacent to the mode switching clutch SOWC in the axial direction of the counter shaft **50**, so as to be placed in a selected one of the one-way mode and the lock mode.

[0043] Each of FIGS. **2** and **3** is a view schematically showing the construction of the mode switching clutch SOWC, which enables switching between the one-way mode and the lock mode, wherein the view is a cross sectional view of a circumferential portion of the mode switching clutch SOWC, and the cross sectional view is a development of a cylindrical plane whose center lies on an axis of the counter shaft **50**. FIG. **2** shows a state in which the mode switching clutch SOWC is placed in the one-way mode. FIG. **3** shows a state in which the mode switching clutch SOWC is placed in the lock mode. In each of FIGS. **2** and **3**, a vertical direction on the drawing sheet corresponds to a circumferential direction of the mode switching clutch SOWC, an upward direction on the drawing sheet corresponds to a vehicle reverse-running direction (i.e., direction of rotation for reverse running of the vehicle **10**) and a downward direction on the drawing sheet corresponds to a vehicle forward-running direction (i.e., direction of rotation for forward running of the vehicle **10**). Further, in each of FIGS. **2** and **3**, a horizontal direction on the drawing sheet corresponds to the axial direction of the counter shaft **50** (hereinafter, the term "axial direction" means the axial direction of the counter shaft **50** unless otherwise specified), a rightward direction on the drawing sheet corresponds to a direction toward the large-diameter gear **52** shown in FIG. **1**, and a leftward direction on the drawing sheet corresponds to a direction toward the counter gear **54** shown in FIG. **1**.

[0044] The mode switching clutch SOWC has generally a disk shape, and is disposed radially outside the counter shaft **50**. The mode switching clutch SOWC includes an input-side rotary member **68**, first and second output-side rotary members **70***a*, **70***b* that are disposed to be adjacent to the input-side rotary member **68** so as to be disposed on respective opposite sides of the input-side rotary member **68** in the axial direction, a plurality of first struts **72***a* and a plurality of torsion coil springs **73***a* that are interposed between the input-side rotary member **68** and the first output-side rotary member **70***a* in the axial direction, and a plurality of second struts **72***b* and a plurality of torsion coil springs **73***b* that are interposed between the input-side rotary member **68** and the second output-side rotary member **70***b* in the axial direction.

[0045] The input-side rotary member **68** has generally a disk shape, and is rotatable relative to the counter shaft **50** about the axis of the counter shaft **50**. The input-side rotary member **68** is disposed between the first and second output-side rotary members **70***a*, **70***b* (hereinafter referred to as output-side rotary members **70** when they are not to be particularly distinguished from each other) in the axial direction. The input-side rotary member **68** is formed integrally with the large-diameter gear **52**, such that teeth of the large-diameter gear **52** are disposed radially outside the input-side rotary member **68**. The input-side rotary member **68** is connected to the engine **12**, in a drive-force transmittable manner, through the gear mechanism **28** and the forward/reverse switching device **26**, for example.

[0046] The input-side rotary member **68** has, in its axial end surface that is opposed to the first output-side rotary member **70***a* in the axial direction, a plurality of first receiving portions **76***a* in which the first struts **72***a* and the torsion coil springs **73***a* are received. The first receiving portions **76***a* are equi-angularly spaced apart from each other in a circumferential direction of the input-side rotary member **68**. Further, the input-side rotary member **68** has, in another axial end surface thereof that is opposed to the second output-side rotary member **70***b* in the axial direction, a plurality of second receiving portions **76***b* in which the second struts **72***b* and the torsion coil springs **73***b* are received. The second receiving portions **76***b* are equi-angularly spaced apart from each other in the circumferential direction of the input-side rotary member **68**. The first and second receiving portions **76***a*, **76***b* are substantially aligned in a radial direction of the input-side rotary member **68**.

[0047] The first output-side rotary member **70***a* has generally a disk-shaped, and is rotatable about the axis of the counter shaft **50**. The first output-side rotary member **70***a* is fixed to the counter shaft **50** unrotatably relative to the counter shaft **50**, so as to be rotated integrally with the counter shaft **50**.

[0048] The first output-side rotary member **70***a* has, in its surface that is opposed to the input-side rotary member **68** in the axial direction, a plurality of first recessed portions **78***a* each of which is recessed in a direction away from the input-side rotary member **68**. The first recessed portions **78***a*, whose number is the same as the first receiving portions **76***a*, are equi-angularly spaced apart from each other in the circumferential direction. The first recessed portions **78***a* are substantially aligned with the first receiving portions **76***a* provided in the input-side rotary member **68**, in a radial direction of the first output-side rotary member **70***a*.

[0049] Therefore, when each of the first receiving portions **76***a* is aligned with one of the first recessed portions **78***a* in the circumferential direction, namely, when a rotational position of each of the first receiving portions **76***a* coincides with that of one of the first recessed portions **78***a*, the first receiving portion **76***a* and the first recessed portion **78***a* are opposed to and adjacent with each other in the axial direction. Each of the first recessed portions **78***a* has a shape by which a longitudinal end portion of any one of the first struts **72***a* can be received in the first recessed portion **78***a*. Further, each of the first recessed portions **78***a* has, in its circumferential end, a first wall surface **80***a* with which the longitudinal end portion of one of the first struts **72***a* is to be in contact, when the input-side rotary member **68** is rotated in the above-described vehicle forward-running direction (corresponding to the downward direction on the drawing sheet of each of FIGS. **2** and **3**) relative to the output-side rotary members **70**, by the drive force of the engine **12**.

[0050] The second output-side rotary member **70***b* has generally a disk-shaped, and is rotatable about the axis of the counter shaft **50**. The second output-side rotary member **70***b* is fixed to the counter shaft **50** unrotatably relative to the counter shaft **50**, so as to be rotated integrally with the counter shaft **50**.

[0051] The second output-side rotary member **70***b* has, in its surface that is opposed to the input-side rotary member **68** in the axial direction, a plurality of second recessed portions **78***b* each of which is recessed in a direction away from the input-side rotary member **68**. The second recessed portions **78***b*, whose number is the same as the second receiving portions **76***b*, are equi-angularly spaced apart from each other in the circumferential direction. The second recessed portions **78***b* are substantially aligned with the second receiving portions **76***b* provided in the input-side rotary member **68**, in a radial direction of the second output-side rotary member **70***b*.

[0052] Therefore, when each of the second receiving portions **76***b* is aligned with one of the second recessed portions **78***b* in the circumferential direction, namely, when a rotational position of each of the second receiving portions **76***b* coincides with that of one of the second recessed portions **78***b*, the second receiving portion **76***b* and the second recessed portion **78***b* are opposed to and adjacent with each other in the axial direction. Each of the second recessed portions **78***b* has a shape by which a longitudinal end portion of any one of the second struts **72***b* can be received in the second recessed portion **78***b*. Further, each of the second recessed portions **78***b* has, in its circumferential end, a second wall surface **80***b* with which the longitudinal end portion of one of the second struts **72***b* is to be in contact, when the input-side rotary member **68** is rotated in the above-described vehicle reverse-running direction (corresponding to the upward direction on the drawing sheet of each of FIGS. **2** and **3**) relative to the output-side rotary members **70**, by the drive force of the engine **12** with the mode switching clutch SOWC being placed in the lock mode, and when the vehicle **10** is in an inertia running state during the forward running with the mode switching clutch SOWC being placed in the lock mode.

[0053] Each of the first struts **72***a* is constituted by a plate-like member having a predetermined thickness, and is elongated in the circumferential direction (corresponding to the vertical direction on the drawing sheet of FIGS. **2** and **3**), as shown in the cross sectional views of FIGS. **2** and **3**. Further, each of the first struts **72***a* has a predetermined dimension as measured in a direction perpendicular to the drawing sheet of FIGS. **2** and **3**.

[0054] The longitudinal end portion of each of the first struts **72***a* is constantly forced or biased, by a corresponding one of the torsion coil springs **73***a*, toward the first output-side rotary member **70***a*. Further, each of the first struts **72***a* is in contact at another longitudinal end portion thereof with a first stepped portion **82***a* provided in a corresponding one of the first receiving portions **76***a*, such that the first strut **72***a* is pivotable about the other longitudinal end portion thereof that is in contact with the first stepped portion **82***a*. Each of the torsion coil springs **73***a* is interposed between a corresponding one of the first struts **72***a* and the input-side rotary member **68**, and constantly forces or biases the longitudinal end portion of the corresponding one of the first struts **72***a* toward the first output-side rotary member **70***a*.

[0055] Owing to the above-described construction, in a state in which the mode switching clutch SOWC is placed in either the one-way mode or the lock mode, when the input-side rotary member **68** receives the drive force which is transmitted from the engine **12** and which acts in the vehicle forward-running direction, each of the first struts **72***a* is in contact at the longitudinal end portion with the first wall surface **80***a* of the first output-side rotary member **70***a* and is in contact at the other longitudinal end portion with the first stepped portion **82***a* of the input-side rotary member **68**, so that the input-side rotary member **68** and the first output-side rotary member **70***a* are inhibited from being rotated relative to each other whereby the drive force acting in the vehicle forward-running direction is transmitted to the drive wheels **14** through the mode switching clutch SOWC. The above-described first struts **72***a*, torsion coil springs **73***a*, first receiving portions **76***a* and first recessed portions **78***a* (each defining the first wall surface **80***a*) cooperate to constitute a one-way clutch that is configured to transmit the drive force acting in the vehicle forward-running direction, to the drive wheels **14**, and to cut off transmission of the drive force acting in the vehicle reverse-running direction.

[0056] Each of the second struts **72***b* is constituted by a plate-like member having a predetermined thickness, and is elongated in the circumferential direction (corresponding to the vertical direction on the drawing sheet of FIGS. **2** and **3**), as shown in the cross sectional views of FIGS. **2** and **3**. Further, each of the second struts **72***b* has a predetermined dimension as measured in a direction perpendicular to the drawing sheet of FIGS. **2** and **3**.

[0057] The longitudinal end portion of each of the second struts **72***b* is constantly forced or biased, by a corresponding one of the torsion coil springs **73***b*, toward the second output-side rotary member **70***b*. Further, each of the second struts **72***b* is in contact at another longitudinal end portion thereof with a second stepped portion **82***b* provided in one of the second receiving portions **76***b*, such that the second strut **72***b* is pivotable about the other longitudinal end portion thereof that is in contact with the second stepped portion **82***b*. Each of the torsion coil springs **73***b* is interposed between a corresponding one of the second struts **72***b* and the input-side rotary member **68**, and constantly forces or biases the longitudinal end portion of the corresponding one of the second struts **72***b* toward the second output-side rotary member **70***b*.

[0058] Owing to the above-described construction, in a state in which the mode switching clutch SOWC is placed in the lock mode, when the input-side rotary member **68** receives the drive force which is transmitted from the engine **12** and which acts in the vehicle reverse-running direction, each of the second struts **72***b* is in contact at the longitudinal end portion with the second wall surface **80***b* of the second output-side rotary member **70***b* and is in contact at the other longitudinal end portion with the second stepped portion **82***b* of the input-side rotary member **68**, so that the input-side rotary member **68** and the second output-side rotary member **70***b* are inhibited from being rotated relative to each other whereby the drive force acting in the vehicle reverse-running direction is transmitted to the drive wheels **14** through the mode switching clutch SOWC. Further, in the state in which the mode switching clutch SOWC is placed in the lock mode, when the inertia running is made during running of the vehicle **10** in the forward direction, too, each of the second struts **72***b* is in contact at the longitudinal end portion with the second wall surface **80***b* of the second output-side rotary member **70***b* and is in contact at the other longitudinal end portion with the second stepped portion **82***b* of the input-side rotary member **68**, so that the input-side rotary member **68** and the second output-side rotary member **70***b* are inhibited from being rotated relative to each other whereby the rotation transmitted from the drive wheels **14** is transmitted toward the engine **12** through the mode switching clutch SOWC. The above-described second struts **72***b*, torsion coil springs **73***b*, second receiving portions **76***b* and second recessed portions **78***b* (each defining the second wall surface **80***b*) cooperate to constitute a one-way clutch that is configured to transmit the drive force acting in the vehicle reverse-running direction, toward the drive wheels **14**, and to cut off transmission of the drive force acting in the vehicle forward-running direction, toward the drive wheels **14**.

[0059] Further, the second output-side rotary member **70***b* has a plurality of through-holes **88** that pass through the second output-side rotary member **70***b* in the axial direction. Each of the through-holes **88** is disposed in a position that overlaps with a corresponding one of the second recessed portions **78***b* in the axial direction of the counter shaft **50**, so that each of the through-holes **88** is in communication at its end with a corresponding one of the second recessed portions **78***b*. A cylindrical-shaped pin **90** is received in each of the through-holes **88**, and is slidable in the through-hole **88**. The pin **90** is in contact at one of its axially opposite ends with a pressing plate **74** that constitutes a part of the hydraulic actuator **41**, and is in contact at the other of its axially opposite ends with an annular ring **86** that includes a plurality of portions that are disposed in the respective second recessed portions **78***b* in the circumferential direction.

[0060] The ring **86** is fitted in a plurality of arcuate-shaped grooves **84**, each of which is provided in the second output-side rotary member **70***b* and interconnects between a corresponding adjacent pair of the second recessed portions **78***b* that are adjacent to each other in the circumferential direction. The ring **86** is movable relative to the second output-side rotary member **70***b* in the axial direction.

[0061] Like the mode switching clutch SOWC, the hydraulic actuator **41** is disposed on the counter shaft **50**, and is disposed in a position adjacent to the second output-side rotary member **70***b* in the axial direction of the counter shaft **50**.

[0062] The hydraulic actuator **41** includes the above-described pressing plate **74**, and defines a hydraulic chamber **75** to which a working fluid is to be supplied whereby a thrust is generated to move the pressing plate **74** toward the counter gear **54** away from the second output-side rotary member **70***b* in the axial direction. It is noted that the hydraulic chamber **75** is represented by broken lines in FIGS. **2** and **3** since the hydraulic chamber **75** is disposed in a position that is disposed radially inwardly of positions in which the pin **90** and other members are disposed.

[0063] The pressing plate **74** has generally a disk shape, and is disposed to be movable relative to the counter shaft

50 in the axial direction. The pressing plate **74** is constantly forced or biased by a spring **92** toward the second output-side rotary member **70***b* in the axial direction. Therefore, in a state in which the working fluid is not supplied to the hydraulic chamber **75** of the hydraulic actuator **41**, the pressing plate **74** is moved, by biasing force of the spring **92**, toward the second output-side rotary member **70***b* in the axial direction, whereby the pressing plate **74** is in contact with the second output-side rotary member **70***b*, as shown in FIG. **2**. In this state, the pins **90**, the ring **86** and the longitudinal end portion of each of the second struts **72***b* are moved toward the input-side rotary member **68** in the axial direction, as shown in FIG. **2**, whereby the mode switching clutch SOWC is placed in the one-way mode.

[0064] On the other hand, in a state in which the working fluid is supplied to the above-described hydraulic chamber **75** of the hydraulic actuator **41**, the pressing plate **74** is moved, against the biasing force of the spring **92**, toward the counter gear **54** in the axial direction, so as to be separated from the second output-side rotary member **70***b*. In this state, the pins **90**, the ring **86** and the longitudinal end portion of each of the second struts **72***b* are moved, by the biasing force of the torsion coil springs **73***b*, toward the counter gear **54** in the axial direction, as shown in FIG. **3**, whereby the mode switching clutch SOWC is placed in the lock mode.

[0065] In the state in which the mode switching clutch SOWC is placed in the one-way mode, as shown in FIG. **2**, the pressing plate **74** is in contact with the second output-side rotary member **70***b* by the biasing force of the spring **92**. In this state, the pins **90** are forced, by the pressing plate **74**, to be moved toward the input-side rotary member **68** in the axial direction, and the ring **86** is forced, by the pins **90**, to be moved toward the input-side rotary member **68** in the axial direction. Consequently, the longitudinal end portion of each of the second struts **72***b* is forced, by the ring **86**, to be moved toward the input-side rotary member **68**, so as to be blocked from being in contact with the second wall surface **80***b*, whereby the input-side rotary member **68** and the second output-side rotary member **70***b* are allowed to be rotated relative to each other so that the second struts **72***b* do not serve as a one-way clutch. Meanwhile, the longitudinal end portion of each of the first struts **72***a* is biased, by the corresponding torsion coil spring **73***a*, toward the first output-side rotary member **70***a*, whereby the longitudinal end portion of each of the first struts **72***a* can be bought into contact with the first wall surface **80***a* of any one of the first recessed portions **78***a* so that the first struts **72***a* serve as a one-way clutch configured to transmit the drive force acting in the vehicle forward-running direction. That is, the first struts **72***a* serve as the one-way clutch that is configured to transmit the drive force during the driving state in the forward running of the vehicle **10**, and to cut off transmission of the drive force during the driven state in the forward running of the vehicle **10**.

[0066] In the state in which the mode switching clutch SOWC is placed in the one-way mode, as shown in FIG. **2**, the longitudinal end portion of each of the first struts **72***a* can be brought into contact with the first wall surface **80***a* of the first output-side rotary member **70***a*. Therefore, in a state of the one-way mode of the mode switching clutch SOWC, when the vehicle **10** is placed in the driving state in which the drive force acting in the vehicle forward-running direction is transmitted from the engine **12** to the mode switching clutch SOWC, the longitudinal end portion of each of the first struts **72***a* is in contact with the first wall surface **80***a* and the other longitudinal end portion of each of the first struts **72***a* is in contact with the first stepped portion **82***a*, so that the input-side rotary member **68** is inhibited from being rotated relative to the first output-side rotary member **70***a* in the vehicle forward-running direction whereby the drive force of the engine **12** is transmitted to the drive wheels **14** through the mode switching clutch SOWC. On the other hand, in the state of the one-way mode of the mode switching clutch SOWC, when the vehicle **10** is placed in the driven state by inertia running during the forward running, the input-side rotary member **68** is allowed to be rotated relative to the first output-side rotary member **70***a* in the vehicle reverse-running direction, without the longitudinal end portion of each of the first struts **72***a* being in contact with the first wall surface **80***a*, whereby the transmission of the drive force through the mode switching clutch SOWC is blocked. Thus, in the state in which the mode switching clutch SOWC is placed in the one-way mode, the first struts **72***a* serve as the one-way clutch which is configured to transmit the drive force in the driving state of the vehicle **10** in which the drive force acting in the vehicle forward-running direction is transmitted from the engine **12**, and which is configured to block the transmission of the drive force in the driven state of the vehicle **10** in which the vehicle **10** is in the inertia running state during the forward running. In other words, the input-side rotary member **68** is inhibited from being rotated in the vehicle forward-running direction relative to the output-side rotary members **70**, and is allowed to be rotated in the vehicle reverse-running direction relative to the output-side rotary members **70**, when the mode switching clutch SOWC is placed in the one-way mode.

[0067] In the state in which the mode switching clutch SOWC is placed in the lock mode, as shown in FIG. **3**, the working fluid is supplied to the hydraulic chamber **75** of the hydraulic actuator **41** whereby the pressing plate **74** is moved, against the spring **92**, in a direction away from the second output-side rotary member **70***b*, and the longitudinal end portion of each second strut **72***b* is moved, by biasing force of the corresponding torsion coil spring **73***b*, toward the corresponding second recessed portion **78***b* of the second output-side rotary member **70***b*, whereby the longitudinal end portion of each second strut **72***b* can be brought into contact with the second wall surface **80***b* of the second output-side rotary member **70***b*. Meanwhile, each first strut **72***a* can be brought into contact at the longitudinal end portion with the first wall surface **80***a* of the first output-side rotary member **70***a*, as in the state of the one-way mode shown in FIG. **2**.

[0068] In the state in which the mode switching clutch SOWC is placed in the lock mode, as shown in FIG. **3**, when the drive force acting in the vehicle forward-running direction is transmitted to the input-side rotary member **68**, the longitudinal end portion of each first strut **72***a* is brought into contact with the first wall surface **80***a* of the first output-side rotary member **70***a*, and the other longitudinal end portion of each first strut **72***a* is brought into contact with the first stepped portion **82***a* of the input-side rotary member **68**, whereby the input-side rotary member **68** is inhibited from being rotated relative to the first output-side rotary member **70***a* in the vehicle forward-running direction. In the state of the lock mode of the mode switching clutch SOWC, when the drive force acting in the vehicle reverse-running direction is transmitted to the input-side rotary member **68**, the longitudinal end portion of each second strut **72***b* is brought into contact with the second wall surface **80***b* of the second output-side rotary member **70***b*, and the other longitudinal end portion of each second strut **72***b* is brought into contact with the second stepped portion **82***b* of the input-side rotary member **68**, whereby the input-side rotary member **68** is inhibited from being rotated relative to the second output-side rotary member **70***b* in the vehicle reverse-running direction.

[0069] Thus, in the state of the lock mode of the mode switching clutch SOWC, the first struts **72***a* serve as a one-way clutch and the second struts **72***b* serve as a one-way clutch, so that the mode switching clutch SOWC is configured to transmit the drive force acting in the vehicle forward-running direction and the drive force acting in the vehicle reverse-running direction. In other words, the input-side rotary member **68** is inhibited from being rotated in both of opposite directions relative to the output-side rotary members **70**, when the mode switching clutch SOWC is placed in the lock mode. When the vehicle **10** is to run in the reverse direction, the vehicle **10** is enabled to run in the reverse direction with the mode switching clutch SOWC being placed in the lock mode. Further, when the vehicle **10** is placed in the driven state by inertia running during the forward running, an engine brake can be generated with the mode switching clutch SOWC being placed in the lock mode by which the engine **12** is dragged by rotation transmitted from the drive wheels **14** to the engine **12** through the mode switching clutch SOWC. Thus, in the state of the lock mode of the mode switching clutch SOWC, the first struts **72***a* serve as a one-way clutch and the second struts **72***b* serve as a one-way clutch, so that the mode switching clutch SOWC is configured to transmit the drive force during the driving state and the driven state of the vehicle **10**.

[0070] FIG. **4** is a table indicating an operating state of each of the engagement devices for each of a plurality of operating positions POSsh which is selected by operation of a manually-operated shifting device in the form of a shift lever (not shown). In FIG. **4**, "C**1**" represents the first clutch C**1**, "CT" represents the second clutch C**2**, "B**1**" represents the first brake B**1**, and "SOWC" represents the mode switching clutch SOWC. Further, "P", "R", "N", "D" and "M" represent a parking position P, a reverse position R, a neutral position N, a drive position D and a manual position M, respectively, as the plurality of operating positions POSsh, each of which is to be selected by operation of the shift lever. In the table of FIG. **4**, "0" in the first clutch C**1**, second clutch C**2** or first brake B**1** indicates its engaged state, and blank in the first clutch C**1**, second clutch C**2** or first brake B**1** indicates its released state. Further, in the table of FIG. **4**, "0" in the mode switching clutch SOWC indicates its lock mode, and blank in the mode switching clutch SOWC indicates its one-way mode.

[0071] For example, when the shift lever is placed in the parking position P as one of the operating positions POSsh that is a vehicle stop position or in the neutral position N as one of the operating positions POSsh that is a drive-force transmission block position, the first clutch C**1**, second clutch C**2** and first brake B**1** are placed in released positions, as indicated in FIG. **4**, so that the drive-force transmitting apparatus **16** is placed in its neutral state in which the drive force is not transmitted along either the first drive-force transmitting path PT**1** or the second drive-force transmitting path PT**2**.

[0072] When the shift lever is placed in the reverse position R as one of the operating positions POSsh that is a reverse running position, the first brake B**1** is placed in the engaged state and the mode switching clutch SOWC is placed in the lock mode, as indicated in FIG. **4**. With the first brake B**1** being placed in the engaged state, the drive force acting in the vehicle reverse-running direction is transmitted from the engine **12** to the gear mechanism **28**. In this instance, if the mode switching clutch SOWC is in the one-way mode, the drive force is blocked by the mode switching clutch SOWC so that reverse running cannot be made. Thus, with the mode switching clutch SOWC being placed in the lock mode, the drive force acting in the vehicle reverse-running direction is transmitted to the output shaft **30** through the mode switching clutch SOWC so that reverse running can be made. When the shift lever is placed in the reverse position R, the first brake B**1** is placed in the engaged state and the mode switching clutch SOWC is placed in the lock mode, whereby a reverse gear position is established to transmit the drive force acting in the vehicle reverse-running direction, through the gear mechanism **28** along the first drive-force transmitting path PT**1**, to the drive wheels **14**.

[0073] When the shift lever is placed in the drive position D as one of the operating positions POSsh that is a forward running position, the first clutch C**1** is placed in the engaged state or the second clutch C**2** is placed in the engaged state, as indicated in FIG. **4**. In FIG. **4**, "D**1**" and "D**2**" represent a drive position D**1** and a drive position D**2**, respectively, which are operating positions virtually set in control. When the shift lever is placed in the drive position D, one of the drive position D**1** and the drive position D**2** is selected depending the running state of the vehicle **10**, and the selected one is automatically established. The drive position D**1** is established when vehicle running speed is within a relatively low speed range including zero speed (vehicle stop). The drive position D**2** is established when the vehicle running speed is within a relatively high speed range including a middle speed range. For example, during running of the vehicle **10** with the shift lever being placed in the drive position D, when the running state of the vehicle **10** is changed from the low speed range to the high speed range, the drive position D**1** is automatically switched to the drive position D**2**.

[0074] For example, when the running state of the vehicle **10** is in a speed range corresponding to the drive position D**1** upon placement of the shift lever into the drive position D, the first clutch C**1** is engaged and the second clutch C**2** is released. In this case, a gear running mode is established whereby the drive force acting in the vehicle forward-running direction is transmitted from the engine **12** to the drive wheels **14** along the first drive-force transmitting path PT**1** through the gear mechanism **28**. The mode switching clutch SOWC, which is placed in the one-way mode, transmits the drive force acting in the vehicle forward-running direction, toward the drive wheels **14**.

[0075] Further, when the running state of the vehicle **10** is in a speed range corresponding to the drive position D**2** upon placement of the shift lever into the drive position D, the first clutch C**1** is released and the second clutch C**2** is engaged. In this case, a belt running mode is established whereby the drive force acting in the vehicle forward-running direction is transmitted from the engine **12** to the drive wheels **14** along the second drive-force transmitting path PT**2** through the continuously variable transmission **24**. Thus, when the shift lever is placed into the drive position D as one of the operating positions POSsh, the drive force of the engine **12** is transmitted to the drive wheels **14** along a selected one of the first drive-force transmitting path PT**1** (gear mechanism **28**) and the second drive-force transmitting path PT**2** (continuously variable transmission **24**), which is selected depending on the running state of the vehicle **10**.

[0076] When the shift lever is placed in the manual position M as one of the operating positions POSsh, a shift-up operation or a shift-down operation can be executed by a manual operation made by the operator of the vehicle **10**. That is, the manual position M is a manual shift position in which a shifting operation can be made by the manual operation made by the operator. For example, when a shift-down operation is manually made by the operator with the shift lever being placed in the manual position M, during running of the vehicle **10** with position M**2** (see FIG. **4**) being established, the position M**2** is switched to position M**1** (see FIG. **4**), whereby the first and second clutches C**1**, C**2** are engaged and released, respectively, and the mode switching clutch SOWC is placed into the lock mode, so that a forward-running gear position is established.

[0077] With the mode switching clutch SOWC being placed in the lock mode, the drive force can be transmitted through the mode switching clutch SOWC during the driven state of the vehicle **10** as well as during the driving state of the vehicle **10**. During the inertia running, for example, the vehicle **10** is placed in the driven state in which the rotation is transmitted from the drive wheels **14** toward the engine **12**. In the driven state, when the shift-down operation is manually executed with the shift lever being placed in the manual position M, the rotation transmitted from the drive wheels **14** is transmitted toward the engine **12** through the mode switching clutch SOWC that is placed in the lock mode, whereby the engine **12** is dragged to generate the engine brake. Thus, when the shift-down operation is executed with the shift lever being placed in the manual position M, the forward-running gear position is established so that the drive force is transmitted to the drive wheels **14** along the first drive-force transmitting path PT**1** through the gear mechanism **28**, and so that the rotation transmitted from the drive wheels **14** is transmitted toward the engine **12** along the first drive-force transmitting path PT**1** so as to generate the engine brake during the inertia running.

[0078] When the shift-up operation is manually made by the operator with the shift lever being placed in the manual position M as one of the operating positions POSsh, during running of the vehicle **10** with the position M**1** (see FIG. **4**) being established, the position M**1** is switched to the position M**2** (see FIG. **4**), whereby the second clutch C**2** is engaged. In this instance, a forward-running continuously-variable shifting position is established so that the drive force is transmitted to the drive wheels **14** along the second drive-force transmitting path PT**2** through the continuously variable transmission **24**.

[0079] Thus, with the shift lever being placed in the manual position M, a manual shifting can be executed by a manual operation made by the operator, to select one of the forward-running gear position (i.e., the gear running mode) and the forward-running continuously-variable shifting position (i.e., the belt running mode). When the forward-running gear position is selected, the drive force can be transmitted along the first drive-force transmitting path PT**1**. When the forward-running continuously-variable shifting position is selected, the drive force can be transmitted along the second drive-force transmitting path PT**2**.

[0080] As described above, when the shift-down operation is manually made by the operator with the shift lever being placed in the manual position M, during running of the vehicle **10** with the position M**2** (see FIG. **4**) being established, the position M**2** is switched to the position M**1** (see FIG. **4**), whereby the first clutch C**1** is engaged and the mode switching clutch SOWC is switched from the one-way mode to the lock mode. In a switching transition from the one-way mode to the lock mode in the mode switching clutch SOWC, if there is a rotational speed difference between input rotational speed Nsoin of the input-side rotary member **68** and output rotational speed Nsoout of the output-side rotary members **70**, there is a risk of generation of a shock (switching shock) that could be caused by collision between the longitudinal end portion of each of the second struts **72*b*** and the second output-side rotary member **70*b***.

[0081] FIG. **5** is a time chart showing a control status in a conventional construction when the position M**2** is switched to the position M**1** by a manual operation made by the operator during running of the vehicle **10** with the position M**2** being established. In FIG. **5**, ordinate axes represent, as seen from top to bottom, a turbine rotational speed NT corresponding to the input-shaft rotational speed Nin of the input shaft **22**, a C**1**-clutch pressure Pc' that is applied to the hydraulic actuator of the first clutch C**1**, a C**2**-clutch pressure Pc**2** that is applied to the hydraulic actuator of the second clutch C**2**, and a mode switching pressure Psr (switching pressure) for switching an operating mode of the mode switching clutch SOWC. The mode switching pressure Psr corresponds to a hydraulic pressure of the working fluid supplied to the hydraulic chamber **75** of the hydraulic actuator **41** of the mode switching clutch SOWC, and the mode switching clutch SOWC is configured, when the mode switching pressure Psr is supplied to the hydraulic chamber **75**, to be placed into the lock mode. It is noted that each of the pressures shown in FIG. **5** indicates a command pressure value and that an actual pressure value follows the command pressure value with a certain delay with respect to the command pressure value.

[0082] As shown in FIG. **5**, at a point t**1** of time, when the position M**2** is switched to the position M**1** in response to a manual operation made by the operator, the C**1**-clutch pressure Pc**1** applied to the first clutch C**1** is increased to a pressure value Pcla that causes the first clutch C**1** to be placed in its engaged state. Meanwhile, the C**2**-clutch pressure Pc**2** applied to the second clutch C**2** is reduced to zero. At a point t**2** of time, when an inertia phase starts, the engine **12** is controlled to execute a blipping control by which the turbine rotational speed NT is increased toward a target rotational speed value NT*, which corresponds to a speed value of the turbine rotational speed NT after the switching to the position M**1** from the position M**2**. Then, at a point t**3** of time, when a rotational speed difference between an actual speed value of the turbine rotational speed NT and the target rotational speed value NT* becomes smaller than a predetermined value, it is predictively determined that the actual speed value of the turbine rotational speed NT will be synchronized with the target rotational speed value NT*, and the mode switching pressure Psr is outputted to enable the mode switching clutch SOWC to be switched from the one-way mode to the lock mode. In this instance, in the switching transition from the one-way mode to the lock mode in the mode switching clutch SOWC, if there is the above-described rotational speed difference (=Nsoout−Nsoin) between the input rotational speed Nsoin of the input-side rotary member **68** and the output rotational speed Nsoout of the output-side rotary members **70**, the shock (switching shock) is generated by collision between the longitudinal end portion of each of the second struts **72***b* and the second output-side rotary member **70***b*.

[0083] On the other hand, in the present embodiment, the hydraulic control unit **94** (see FIG. **6**) is constructed such that the lock-up clutch LU is placed into its lock-up-off state (i.e., released state), in the switching transition from the one-way mode to the lock mode in the mode switching clutch SOWC, for reducing the shock generated in the switching transition.

[0084] FIG. **6** is a circuit diagram showing a part of the hydraulic control unit **94** for controlling the drive-force transmitting apparatus **16**, wherein the shown part of the hydraulic control unit **94** is configured to control the hydraulic pressure of the working fluid supplied to each of the lock-up clutch LU and the hydraulic actuator **41** of the mode switching clutch SOWC.

[0085] The hydraulic control unit **94** includes: a switching solenoid valve SR configured to output the mode switching pressure Psr; a lock-up control solenoid valve SLU configured to output a lock-up controlling pressure Pslu; a lock-up clutch control valve LUCV (hereinafter referred to as "control valve LUCV") configured to switch or control the operating state of the lock-up clutch LU; a first fluid passage **98** connecting between the switching solenoid valve SR and the mode switching clutch SOWC; a second fluid passage **100** connecting between the lock-up control solenoid valve SLU and the control valve LUCV; a third fluid passage **102** connecting between the control valve LUCV and the engaging-side fluid chamber **45***a* of the lock-up clutch LU; and a fourth fluid passage **103** connecting between the control valve LUCV and the releasing-side fluid chamber **45***b* of the lock-up clutch LU.

[0086] The switching solenoid valve SR is configured to receive an original pressure in the form of a modulator pressure Pm to which a hydraulic pressure is regulated by a modulator valve (not shown), and to output the mode switching pressure Psr by which the operating mode of the mode switching clutch SOWC is to be switched. It is noted that the mode switching clutch SOWC is placed in its lock mode when the switching pressure Psr is outputted from the switching solenoid valve SR. The switching solenoid valve SR is controlled by the electronic control apparatus (not shown), and is configured, when receiving a command (command electric current) requesting the mode switching clutch SOWC to be switched to the lock mode, to output the mode switching pressure Psr whose magnitude enables the mode switching clutch SOWC to be switched to the lock mode. The mode switching pressure Psr is supplied through the first fluid passage **98** to the hydraulic actuator **41** of the mode switching clutch SOWC. The first fluid passage **98**, through which the mode switching pressure Psr is to be supplied, is diverged into two branch passages, such that one of the two branch passages is connected to the mode switching clutch SOWC while the other of the two branch passages is connected to the control valve LUCV. It is noted that the first fluid passage **98** corresponds to "fluid passage" recited in the appended claims.

[0087] The lock-up control solenoid valve SLU is configured to receive the original pressure in the form of the modulator pressure Pm, and to output the lock-up controlling pressure Pslu that is to be supplied to the control valve LUCV. The lock-up control solenoid valve SLU is controlled by the electronic control apparatus, and is configured to output the lock-up controlling pressure Pslu that is dependent on the running state of the vehicle **10**. The lock-up controlling pressure Pslu outputted from the lock-up control solenoid valve SLU is supplied through the second fluid passage **100** to the control valve LUCV.

[0088] The control valve LUCV has: a first input port **104** configured to receive the lock-up controlling pressure Pslu supplied from the lock-up control solenoid valve SLU; a second input port **106** configured to receive the modulator pressure Pm; a third input port **108** configured to receive the mode switching pressure Psr supplied from the switching solenoid valve SR; a first output port **110** connected to the engaging-side fluid chamber **45***a* of the lock-up clutch LU through the third fluid passage **102**; a second output port **112** connected to the releasing-side fluid chamber **45***b* of the lock-up clutch LU through the fourth fluid passage **103**; and a drain port (not shown).

[0089] The control valve LUCV is configured to cause the operating state of the lock-up clutch LU to be switched to a selected one of the lock-up-off state (i.e., released state) and the lock-up-on state (i.e., engaged state), which is selected depending on the mode switching pressure Psr supplied through the third input port **108**. Specifically, the control valve LUCV is configured to place the lock-up clutch LU in the lock-up-off state when the mode switching pressure Psr is supplied to the control valve LUCV through the third input port **108** to the control valve LUCV.

[0090] When the mode switching pressure Psr is not supplied to the control valve LUCV through the third input port **108** to the control valve LUCV, the control valve LUCV is placed in its lock-up-on establishing state that causes the lock-up clutch LU to be placed in its lock-up-on state (i.e., engaged state) when the mode switching pressure Psr is not supplied to the control valve LUCV through the third input port **108** to the control valve LUCV. In this case, the control valve LUCV serves as a pressure regulating valve configured to regulate a hydraulic pressure to a lock-up pressure Plu, based on the lock-up controlling pressure Pslu, wherein the lock-up pressure Plu is a hydraulic pressure that is to be supplied to the engaging-side fluid chamber **45***a* of the lock-up clutch LU. Further, when the control valve LUCV is placed in the lock-up-on establishing state, the lock-up pressure Plu, which is a regulated output of the control valve LUCV, is supplied to the engaging-side fluid chamber **45***a* of the lock-up clutch LU through the first output port **110** and the third fluid passage **102**. Further, with the control valve LUCV being placed in the lock-up-on establishing state, the releasing-side fluid chamber **45***b* of the lock-up clutch LU is brought into communication with the drain port through the fourth fluid passage **103** and the control valve LUCV. Thus, with the lock-up pressure Plu (that is the regulated output of the control valve LUCV) being supplied to the engaging-side fluid chamber **45***a* of the lock-up clutch LU, it is possible to control a torque capacity of the lock-up clutch LU. That is, the engaged state of the lock-up clutch LU can be finely controlled between its fully-engaged state and its slipping state. It is noted that the lock-up-on establishing state of the control valve LUCV corresponds to "first communicating state" recited in the appended claims.

[0091] On the other hand, when the mode switching pressure Psr is supplied to the control valve LUCV through the third input port **108** to the control valve LUCV, the control valve LUCV is placed in its lock-up-off establishing state that causes the lock-up clutch LU to be placed in the lock-up-off state. In this case, with the control valve LUCV being placed in the lock-up-off establishing state, the engaging-side fluid chamber **45***a* of the lock-up clutch LU is brought into communication with the drain port through the third fluid passage **102** and the control valve LUCV, and the releasing-side fluid chamber **45***b* is brought into communication with the second input port **106** through the fourth fluid passage **103** and the control valve LUCV. Thus, the modulator pressure Pm supplied through the second input port **106** to the control valve LUCV is supplied to the releasing-side fluid chamber **45***b*, so that the hydraulic pressure Poff of the releasing-side fluid chamber **45***b* becomes higher than the hydraulic pressure Pon of the engaging-side fluid chamber **45***a* whereby the lock-up clutch LU is released. It is noted that the lock-up-off establishing state of the control valve LUCV corresponds to "second communicating state" recited in the appended claims.

[0092] In the hydraulic control unit **94** constructed as described above, when the mode switching clutch SOWC is to be switched to the lock mode, the mode switching pressure Psr is outputted from the switching solenoid valve SR, and is supplied to the mode switching clutch SOWC and also to the control valve LUCV through the first fluid passage **98**. With the mode switching pressure Psr being supplied to the control valve LUCV, the control valve LUCV being placed in the lock-up-off establishing state whereby the lock-up clutch LU is placed in the lock-up-off state in which a connection between the engine **12** and the input shaft **22** (i.e., connection between the engine **12** and the torque converter **20**) through the lock-up clutch LU is cancelled, thereby resulting in reduction of an inertia acting on the upstream side (i.e., a side of the engine **12**) of the mode switching clutch SOWC by a magnitude corresponding to an inertia of the engine **12**. Thus, the mode switching clutch SOWC is switched to the lock mode with the lock-up clutch LU being released, so that a shock generated in the switching transition to the lock mode can be reduced as compared with an arranged in which the mode switching clutch SOWC is switched to the lock mode with the lock-up clutch LU being in the engaged state.

[0093] FIG. **7** is a time chart showing a control status when the position M2 is switched to the position M**1**, namely, a shift-down operation is made by the operator, during running of the vehicle **10** with the position M2 being established. In FIG. **7**, ordinate axes represent, as seen from top to bottom, the turbine rotational speed NT corresponding to the input-shaft rotational speed Nin of the input shaft **22**, the C**1**-clutch pressure Pc**1** that is applied to the hydraulic actuator of the first clutch C**1**, the C**2**-clutch pressure Pc**2** that is applied to the hydraulic actuator of the second clutch C**2**, the mode switching pressure Psr that is applied to the hydraulic actuator **41** of the mode switching clutch SOWC, the lock-up controlling pressure Pslu outputted from the lock-up control solenoid valve SLU, and the operating state of the lock-up clutch LU. It is noted that, in "LOCK-UP CLUTCH OPERATING STATE" in FIG. **7**, "ON" indicates the lock-up-on state, i.e., the engaged state of the lock-up clutch LU, while "OFF" indicates the lock-up-off state, i.e., the released state of the lock-up clutch LU. Further, each of the pressures shown in FIG. **7** indicates a command pressure value.

[0094] As shown in FIG. **7**, until a point t**1** of time, the second clutch C**2** is engaged so that the vehicle **10** runs in the belt running mode in which the drive force is transmitted along the second drive-force transmitting path PT**2**. Further, until the point t**1** of time, the mode switching pressure Psr is not outputted so that the lock-up clutch LU is placed in the lock-up-on state, and the engaged state of the lock-up clutch LU is controlled based on the lock-up controlling pressure Pslu.

[0095] At the point t**1** of time, when the position M**2** is switched to the position M**1** by the operator, the C**1**-clutch pressure Pc**1** is increased to a pressure value PD by which the first clutch C**1** is engaged, while the C**2**-clutch pressure Pc**2** is reduced to zero. It is noted that an actual pressure value of each of the C**1**-clutch pressure Pc**1** and the C**2**-clutch pressure Pc**2** is changed with a certain delay with respect to the command pressure value of a corresponding one of the C**1**-clutch pressure Pc**1** and the C**2**-clutch pressure Pc**2**, which is indicated in FIG. **7**.

[0096] At a point t**2** of time, when an inertia phase starts, the engine **12** is controlled to execute the blipping control by which the turbine rotational speed NT is increased toward the target rotational speed value NT*, which corresponds to a speed value of the turbine rotational speed NT after the switching to the position M**1**. The target rotational speed value NT* is calculated based on the output-shaft rotational speed Nout corresponding to a running speed V of the vehicle **10** and the gear ratio EL established in the first drive-force transmitting path PT**1**. The blipping control is performed by, for example, a feedback control that is executed to minimize a deviation in the form of the rotational speed difference ΔNT (=NT*−NT) between the target rotational speed value NT* and the turbine rotational speed NT. In this instance, since the first clutch C**1** has a torque capacity, the input shaft **22** is connected through the first clutch C**1** to the input-side rotary member **68** of the mode switching clutch SOWC. Therefore, in a period between the point t**2** of time and a point t**3** of time, when the turbine rotational speed NT is increased with execution of the blipping control, the input rotational speed Nsoin of the input-side rotary member **68** of the mode switching clutch SOWC is increased whereby the rotational speed difference of the input rotational speed Nsoin of the input-side rotary member **68** and the output rotational speed Nsoout of the output-side rotary members **70** is reduced.

[0097] At the point t**3** of time, when the rotational speed difference ΔNT between the turbine rotational speed NT and the target rotational speed value NT* becomes not larger than a predetermined synchronization determination value, it is determined that the turbine rotational speed NT will be synchronized with the target rotational speed value NT*. When it is determined at the point t**3** of time that turbine rotational speed NT will be synchronized with the target rotational speed value NT*, the switching solenoid valve SR is configured to output the mode switching pressure Psr whose magnitude enables the mode switching clutch SOWC to be switched to the lock mode. It is noted that the magnitude of the mode switching pressure Psr is set to a magnitude value which enables the control valve LUCV to be switched to the lock-up-off establishing state.

[0098] In this instance, the mode switching pressure Psr is supplied to the control valve LUCV through the first fluid passage **98** whereby the lock-up clutch LU is switched to the lock-up-off state, namely, the lock-up clutch LU is placed in the released state. Therefore, the mode switching clutch SOWC is switched from the one-way mode to the lock mode in a state in which the lock-up clutch LU is released, so that it is possible to reduce the shock generated in the switching transition switching transition to the lock mode in the mode switching clutch SOWC, as compared with an arrangement in which the mode switching clutch SOWC is switched to the lock mode with the lock-up clutch LU being kept engaged, even in presence of the rotational speed difference between the input-side rotary member **68** of the input rotational speed Nsoin and the output rotational speed Nsoout of the output-side rotary members **70** upon the switching to the lock mode in the mode switching clutch SOWC. That is, with the lock-up clutch LU being released, an inertia acting on the upstream side of the mode switching clutch SOWC is reduced by a magnitude corresponding to an inertia of the engine **12**, so that an impact upon collision between the longitudinal end portion of each of the second struts **72*b*** and the second output-side rotary member **70*b*** is reduced whereby the shock generated in the switching transition the lock mode in the mode switching clutch SOWC is reduced.

[0099] Further, at a point t**4** of time, when the output of the mode switching pressure Psr is cancelled, the control valve LUCV is switched to the lock-up-on establishing state whereby the lock-up clutch LU is placed back into the engaged state.

[0100] As described above, when the mode switching clutch SOWC is placed in the lock mode, the control valve LUCV is placed in the lock-up-off establishing state whereby the lock-up clutch LU is released. Therefore, owing to the reduction of the inertia acting on the upstream side of the input-side rotary member **68** of the mode switching clutch SOWC, it is possible to reduce the shock generated in the switching transition to the lock mode in the mode switching clutch SOWC.

[0101] It might be possible to place the lock-up clutch LU, practically, into the released state by controlling the lock-up controlling pressure Pslu outputted from the lock-up control solenoid valve SLU when the mode switching clutch SOWC is to be switched to the lock mode. However, this arrangement requires a complicated control that is to be executed in the switching transition to the lock mode in the mode switching clutch SOWC, for assuring a high degree of accuracy of hydraulic pressure control such as accurate synchronization of timing of outputs of the switching solenoid valve SR and the lock-up control solenoid valve SLU. On the other hand, in the present embodiment in which, when the mode switching pressure Psr is outputted from the switching solenoid valve SR so as to switch the mode switching clutch SOWC to the lock mode, the lock-up clutch LU is forcibly or necessarily switched to the lock-up-off state by the control valve LUCV that receives, as well as the mode switching clutch SOWC, the mode switching pressure Psr outputted from the switching solenoid valve SR. This arrangement does not require a high degree of accuracy of hydraulic pressure control such as accurate synchronization of timing of hydraulic pressure outputs, namely, does not require a complicated control. Thus, this arrangement does not require each of the switching solenoid valve SR and the lock-up control solenoid valve SLU to be constituted by a solenoid valve having a high accuracy, so that it is possible to restrain increase of manufacturing cost. Further, the mode switching clutch SOWC can be switched to the lock mode without a complicated control process, so that it is possible to improve a controllability in the switching transition to the lock mode in the mode switching clutch SOWC.

[0102] As described above, in the present embodiment, when the second drive-force transmitting path PT**2** is to be switched to the first drive-force transmitting path PT**1**, the operating mode of the mode switching clutch SOWC is switched from the one-way mode to the lock mode with the switching pressure Psr being supplied from the switching solenoid valve SR to the mode switching clutch SOWC. The control valve LUCV is configured, when the switching pressure Psr is supplied from the switching solenoid valve SR to the control valve LUCV as well as to the mode switching clutch SOWC, to switch the operating state of the lock-up clutch LU to the lock-up-off state (i.e., released state). Therefore, when the switching pressure Psr is outputted from the switching solenoid valve SR, the lock-up clutch LU is placed into the lock-up-off state. Thus, in the switching transition from the one-way mode to the lock mode in the mode switching clutch SOWC, the lock-up clutch LU is placed in the lock-up-off state whereby a connection between the engine **12** and the torque converter **20** (i.e., a connection between the engine **12** and the first and second drive-force transmitting paths PT**1**, PT**2**) through the lock-up clutch LU is cut off. As a result of the placement of the lock-up clutch LU in the lock-up-off state, an inertia acting on the upstream side of the mode switching clutch SOWC is reduced by a magnitude corresponding to an inertia of the engine **12**, whereby the switching shock generated in the switching transition from the one-way mode to the lock mode in the mode switching clutch SOWC can be made smaller than in a case in which the lock-up clutch LU is placed in the engaged state.

[0103] Further, in the present embodiment, when the first drive-force transmitting path PT**1** provided with the gear mechanism **28** is established, a gear ratio of the drive-force transmitting apparatus **16** becomes dependent of the gear ratio EL of the gear mechanism **28**. Further, when the second drive-force transmitting path PT**2** provided with the continuously variable transmission **24** is established, the gear ratio of the drive-force transmitting apparatus **16** can be continuously changed by operation of the continuously variable transmission **24**. Further, the first clutch C**1** is provided to connect and disconnect the carrier **26*c*** and the sun gear **26*s*** of the planetary gear device **26*p*** that constitutes the forward/reverse switching device **26**, to and from each other, such that all rotary elements of the planetary gear device **26*p*** are to be rotated integrally with one another with the first clutch C**1** being engaged. Therefore, the drive force of the engine **12** is transmitted toward the gear mechanism **28** through the forward/reverse switching device **26**, so that it is possible to cause the vehicle **10** to run in the forward direction with the drive force being transmitted to the drive wheels **14** along the first drive-force transmitting path PT**1**.

[0104] While the preferred embodiment of this invention has been described in detail by reference to the drawings, it is to be understood that the invention may be otherwise embodied.

[0105] For example, in the above-describe embodiment, the lock-up clutch LU is constructed such that the operating state of the lock-up clutch LU is adjusted by adjusting a hydraulic pressure supplied to the engaging-side fluid chamber **45***a* and a hydraulic pressure supplied to the releasing-side fluid chamber **45***b*. However, in the present invention, the construction of the lock-up clutch LU is not necessarily limited to these details. For example, the lock-up clutch LU may be constituted by a multi-plate friction engagement device. In this case, too, as well as in the above-described embodiment, a hydraulic pressure, which is to be supplied to a hydraulic chamber of the friction engagement device, is supplied to the hydraulic chamber through the control valve LUCV. For example, the control valve LUCV may be constructed such that the hydraulic chamber of the friction engagement device is connected to the drain port through the control valve LUCV when the control valve LUCV is placed in the lock-up-off establishing state (i.e., second communicating state), and such that a hydraulic pressure regulated by the lock-up control solenoid valve SLU is supplied to the hydraulic chamber of the friction engagement device through the control valve LUCV when the control valve LUCV is placed in the lock-up-on establishing state (i.e., first communicating state).

[0106] In the above-described embodiment, when the control valve LUCV is placed in the lock-up-on establishing state, the lock-up pressure Plu to which a hydraulic pressure is regulated in the control valve LUCV is supplied to the engaging-side fluid chamber **45***a*. However, the lock-up controlling pressure Pslu outputted from the lock-up control solenoid valve SLU may be supplied to the engaging-side fluid chamber **45***a* through the control valve LUCV, without the lock-up controlling pressure Pslu being regulated in the control valve LUCV, when the control valve LUCV is placed in the lock-up-on establishing state.

[0107] In the above-described embodiment, the mode switching clutch SOWC is constructed such that the first struts **72***a* and the torsion coil springs **73***a* are interposed between the input-side rotary member **68** and the first output-side rotary member **70***a* and such that the second struts **72***b* and the torsion coil springs **73***b* are interposed between the input-side rotary member **68** and the second output-side rotary member **70***b*. However, in the present invention, the construction of the mode switching clutch SOWC is not necessarily limited to these details. That is, the invention is applicable to any mode switching clutch whose operating mode is to be switched between at least the one-way mode and the lock mode, such that the mode switching clutch is configured to transmit the drive force during the driving state of the vehicle and to cut off transmission of the drive force during the driven state of the vehicle when the mode switching clutch is placed in the one-way mode, and such that the mode switching clutch is configured to transmit the drive force during the driving state of the vehicle and during the driven state of the vehicle when the mode switching clutch is placed in the lock mode.

[0108] In the above-described embodiment, the operating mode of the mode switching clutch SOWC is to be switched between two modes consisting of the one-way mode and the lock mode. However, the mode switching clutch SOWC may be constructed such that the operating mode of the mode switching clutch SOWC is to be switched among three or more modes including, in addition to the one-way mode and the lock mode, for example, a free mode in which transmission of the drive force is cut off irrespective of whether the vehicle is in the driving state or in the driven state.

[0109] In the above-described embodiment, the second drive-force transmitting path PT**2** is provided with the continuously variable transmission **24** that is a belt-type continuously variable transmission. However, the continuously variable transmission mechanism provided in the second drive-force transmitting path PT**2** may be a toroidal-type continuously variable transmission, for example. Further, the second drive-force transmitting path PT**2** may be provided with a step-variable transmission in place of the continuously variable transmission.

[0110] In the above-described embodiment, the modulator pressure Pm to which a hydraulic pressure is regulated by the modulator valve (not shown in the drawings) is supplied to the second input port **106** of the control valve LUCV. However, in place of the modulator pressure Pm, another hydraulic pressure such as (i) a line pressure PL to which a hydraulic pressure is regulated by a regular valve and (ii) a secondary pressure PL**2** to which the line pressure PL is regulated by a second regulator valve, may be supplied to the second input port **106**.

[0111] It is to be understood that the embodiment described above is given for illustrative purpose only, and that the present invention may be embodied with various modifications and improvements which may occur to those skilled in the art.

NOMENCLATURE OF ELEMENTS

[0112] **12**: engine
[0113] **14**: drive wheels
[0114] **16**: vehicle drive-force transmitting apparatus
[0115] **20**: torque converter
[0116] **24**: continuously variable transmission
[0117] **28**: gear mechanism
[0118] **98**: first fluid passage (fluid passage)
[0119] C**1**: first clutch
[0120] C**2**: second clutch
[0121] SOWC: mode switching clutch
[0122] LU: lock-up clutch
[0123] LUCV: lock-up clutch control valve
[0124] SR: switching solenoid valve
[0125] PT**1**: first drive-force transmitting path
[0126] PT**2**: second drive-force transmitting path

What is claimed is:

1. A drive-force transmitting apparatus to be installed in a vehicle that includes an engine and drive wheels,

the drive-force transmitting apparatus comprising a first clutch, a second clutch, a mode switching clutch and a torque converter that includes a lock-up clutch, the drive-force transmitting apparatus defining first and second drive-force transmitting paths that are provided in parallel to each other between the engine and the drive wheels,

wherein the first drive-force transmitting path is provided with the first clutch and the mode switching clutch, such that the first clutch is disposed between the mode switching clutch and the engine in the first drive-force transmitting path,

wherein the second drive-force transmitting path is provided with the second clutch, wherein the torque converter is provided between the engine and the first and second drive-force transmitting paths, and

wherein an operating mode of the mode switching clutch is to be switched between at least a one-way mode and a lock mode, such that the mode switching clutch is configured to transmit a drive force during a driving state of the vehicle and to cut off transmission of the drive force during a driven state of the vehicle when the mode switching clutch is placed in the one-way mode, and such that the mode switching clutch is configured to transmit the drive force during the driving state of the vehicle and during the driven state of the vehicle when the mode switching clutch is placed in the lock mode,

the drive-force transmitting apparatus further comprising:

a switching solenoid valve configured to output a switching pressure by which the operating mode of the mode switching clutch is to be switched between at least the one-way mode and the lock mode; and

a lock-up clutch control valve configured to switch an operating state of the lock-up clutch between an engaged state and a released state;

wherein the mode switching clutch is placed in the lock mode when the switching pressure is supplied from the switching solenoid valve to the mode switching clutch, and

wherein the lock-up clutch control valve is configured to receive the switching pressure supplied from the switching solenoid valve, and to switch the operating state of the lock-up clutch to the released state when the switching pressure is supplied from the switching solenoid valve to the lock-up clutch control valve.

2. The drive-force transmitting apparatus according to claim **1**, further comprising a gear mechanism and a continuously variable transmission,

wherein the gear mechanism is provided in the first drive-force transmitting path, and is disposed between the mode switching clutch and the engine in the first drive-force transmitting path, and

wherein the continuously variable transmission is provided in the second drive-force transmitting path.

3. The drive-force transmitting apparatus according to claim **2**, further comprising a forward/reverse switching device which is provided in the first drive-force transmitting path and which is disposed between the gear mechanism and the engine in the first drive-force transmitting path,

wherein the forward/reverse switching device is constituted by a planetary gear device, and

wherein the first clutch is configured to connect two rotary elements of the planetary gear device to each other and to disconnect the two rotary elements from each other.

4. The drive-force transmitting apparatus according to claim **1**,

wherein each of the mode switching clutch and the lock-up clutch control valve is connected to the switching solenoid valve through a fluid passage through which the switching pressure outputted by the switching solenoid valve is to be supplied to the mode switching clutch and the lock-up clutch control valve.

5. The drive-force transmitting apparatus according to claim **1**,

wherein the lock-up clutch is to be placed in the engaged state when a lock-up pressure is supplied through the lock-up clutch control valve to a fluid chamber defined in the torque converter, and is to be placed in the released state when the lock-up pressure is discharged through the lock-up clutch control valve from the fluid chamber,

wherein the lock-up clutch control valve is to be switched between a first communicating state and a second communicating state, such that the lock-up clutch control valve allows supply of the lock-up pressure through the lock-up clutch control valve to the fluid chamber, when the lock-up clutch control valve is placed in the first communicating state, and such that the lock-up clutch control valve allows discharge of the lock-up pressure through the lock-up clutch control valve from the fluid chamber, when the lock-up clutch control valve is placed in the second communicating state, and

wherein, when the switching pressure is supplied from the switching solenoid valve to the lock-up clutch control valve, the lock-up clutch control valve is placed in the second communicating state, whereby the lock-up pressure is discharged through the lock-up clutch control valve from the fluid chamber so as to place the lock-up clutch in the released state.

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