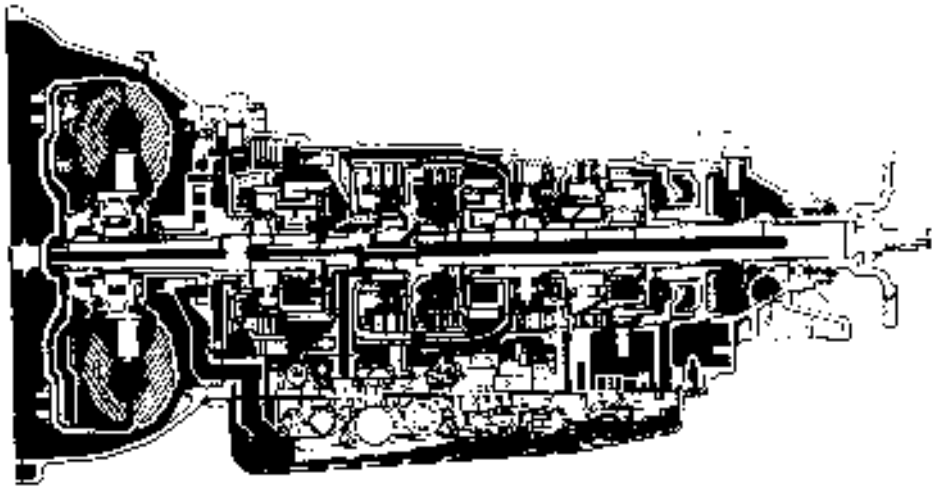
CHASSIS

A341E AUTOMATIC TRANSMISSION

■ DESCRIPTION

The Lexus LS400 has the newly developed A341E four–speed automatic transmission. The A341E automatic transmission is an ECT–i (Electronically Controlled Transmission with an intelligent control system). This system electronically controls the gear shift timing, lock–up timing, the clutch and brake hydraulic pressure, and the engine torque during shifting to achieve optimum shift feeling.

Also, to minimize the possibility of incorrect operation of the automatic transmission, a shift lock mechanism is incorporated.



▶Specifications◀

Type of Transmission		A341E
Type of Engine		1UZ–FE
Items		
Gear Ratios	1st Gear	2.531
	2nd Gear	1.531
	3rd Gear	1.000
	Overdrive Gear	0.705
	Reverse Gear	1.880
Fluid Capacity	US qts. (liters, Imp. qts.)	8.77 (8.3, 7.3)
Type of Fluid		A.T.F. TYPE T–II

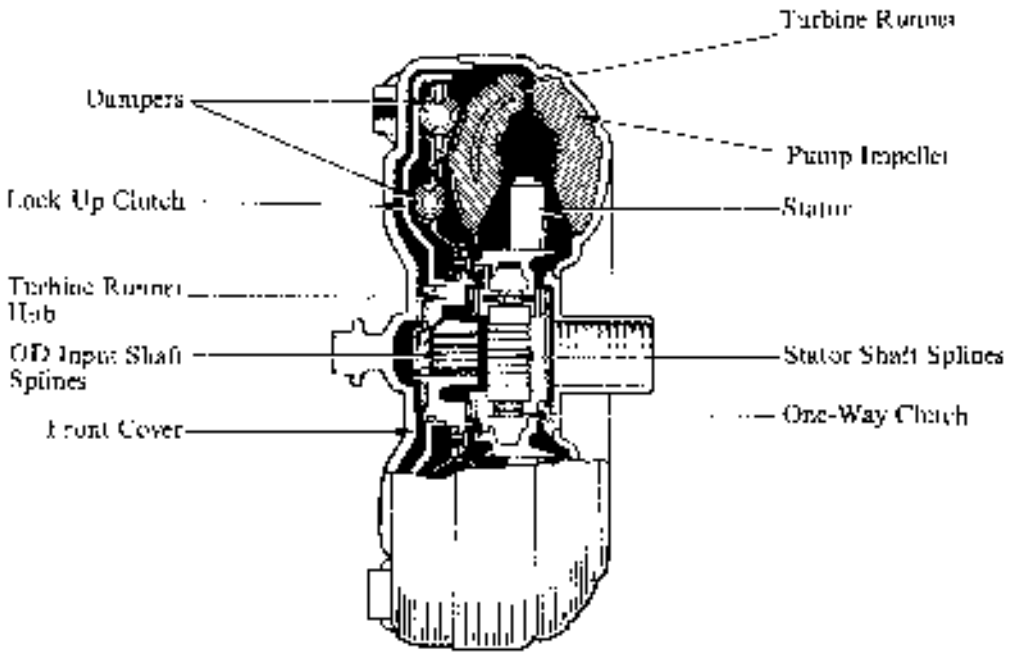
■ TORQUE CONVERTER

1. General

The torque converter is newly designed to optimally match the high–powered engine. It has optimally designed fluid passages and impeller configuration resulting in substantially enhanced torque ratio and transmission efficiency to ensure better starting, acceleration and fuel economy. Furthermore, a hydraulically operated lock–up mechanism which cuts power transmission losses due to slippage at medium and high speed, is used.

▶Specification◀

Type of Converter	3–Element, 1–Step, 2–Phase with Lock–Up Mechanism
Stall Torque Ratio	1.900
Normal Diameter in. (mm)	10.71 (272)

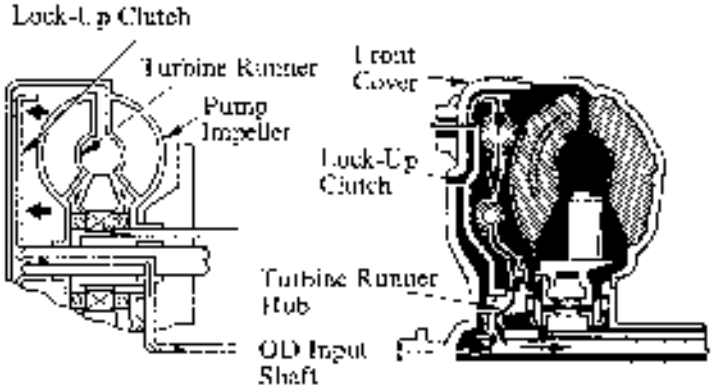


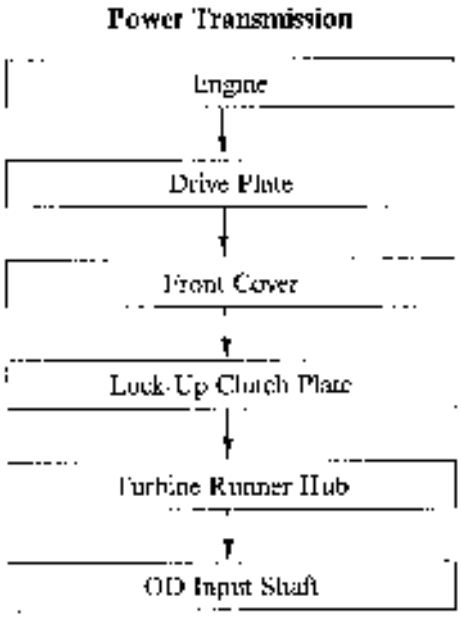
2. Lock–Up Mechanism

The lock–up clutch is provided on the same axis as the turbine runner of the torque converter. When the lock–up clutch is actuated, it rotates together with the pump impeller and turbine runner. Engagement and disengagement of the lock–up clutch is determined by changes in the flow direction of the hydraulic fluid into the torque converter.

When Lock–Up Clutch is Engaged

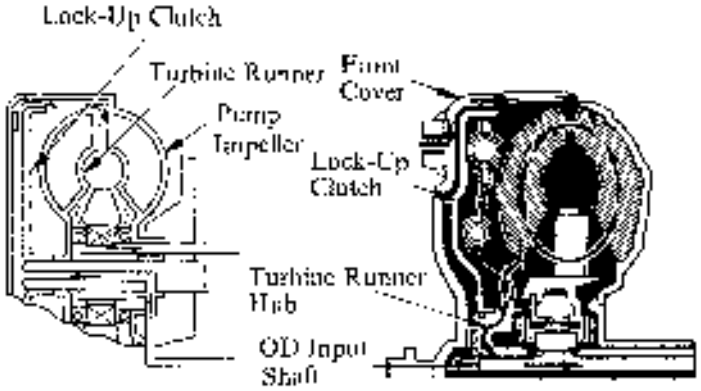
When the lock–up control valves (No. 3 solenoid valve, lock–up control valve and lock–up relay valve) operate, the fluid flows to the lock–up clutch as shown by the arrows. Since a higher hydraulic pressure acts on the right of the lock–up clutch plate than on the left, the lock–up clutch is pushed against the front cover and starts rotating with it as a unit. As a result, the engine power is transmitted directly to the OD input shaft.

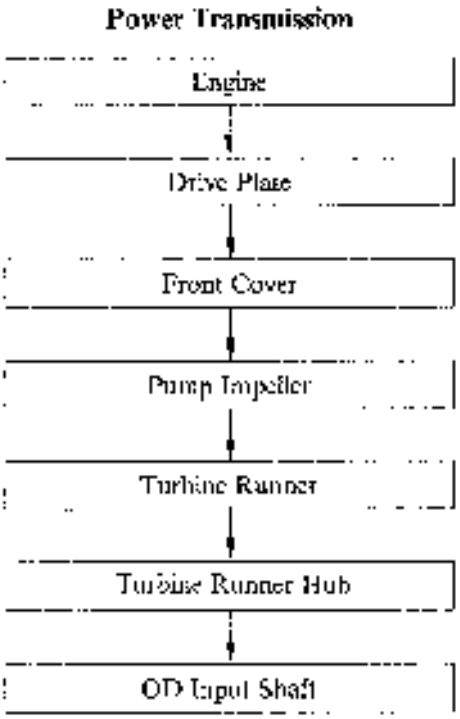




When Lock–Up Clutch is Disengaged

When the lock–up control valves are switched to inoperative, the fluid flow to the lock–up clutch reverses. Since the pressure increases higher on the left of the lock–up clutch than on the right, the lock–up clutch is moved away from the front cover. As a result, the engine power is transmitted to the pump impeller and turbine runner and the torque converter operates as usual.

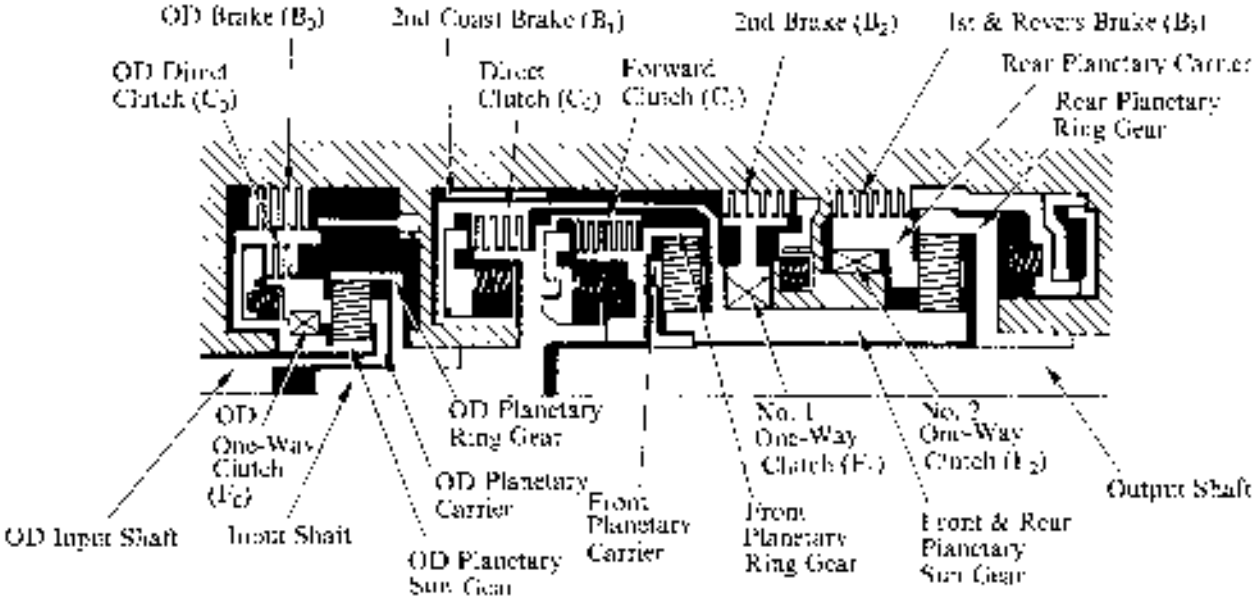




■ PLANETARY GEAR UNIT

1. Construction

- The gear train consists of three multi–plate clutches, three multi–plate brakes, a single band type brake, three one–way clutches, and three planetary gear sets each consisting of a sun gear, pinion gear and a ring gear.
- The OD input shaft and OD planetary carrier rotate together as one unit.
- The OD planetary sun gear is combined with the OD direct clutch (C_0) drum into one unit.
- The splines of the OD direct clutch (C_0) are also the hub of the OD brake (B_0).
- The outer race of the OD one–way clutch (F_0) meshes with the OD planetary carrier, while the inner race is permanently fixed to the shaft of the OD planetary sun gear.
- The input shaft is splined to the OD planetary ring gear and rotates as a unit with the direct clutch (C_2) hub and the forward clutch (C_1) drum.
- The forward clutch (C_1) hub rotates as a unit with the front planetary ring gear.
- The direct clutch (C_2) drum is meshed with the front end of the front and rear sun gear.
- The front planetary sun gear and rear planetary sun gear are combined into one unit.
- The hub of 2nd brake (B_2) is also the outer race of No. 1 one–way clutch (F_1); the inner race of No. 1 one–way clutch is combined into one unit with the front and rear sun gear.
- The inner race of No. 2 one–way clutch is splined to the transmission case and the outer race rotates as one unit with the rear planetary carrier.
- The rear planetary ring gear is splined to the output shaft.
- The front planetary carrier and rear planetary ring gear rotate as a unit with the output shaft.



▶Specifications◀

Type of Transmission			A341E
Type of Engine			1UZ–FE
Items			
C_0	OD Direct Clutch	No. of Discs	2
C_1	Forward Clutch		6
C_2	Direct Clutch		4
B_0	OD Brake	No. of Discs	5
B_1	2nd Coast Brake	Band Width in. (mm)	1.57 (40)
B_2	2nd Brake	No. of Discs	5
B_3	1st & Reverse Brake		7
F_0	OD One–Way Clutch	No. of Sprags	24
F_1	No. 1 One–Way Clutch		22
F_2	No. 2 One–Way Clutch		28
Front Planetary Gear		No. of Sun Gear Teeth	42
		No. of Pinion Gear Teeth	19
		No. of Ring Gear Teeth	79
Rear Planetary Gear		No. of Sun Gear Teeth	42
		No. of Pinion Gear Teeth	19
		No. of Ring Gear Teeth	79
OD Planetary Gear		No. of Sun Gear Teeth	33
		No. of Pinion Gear Teeth	23
		No. of Ring Gear Teeth	79

2. Function of Components

Component		Function
C_0	OD Direct Clutch	Connects OD planetary sun gear and OD planetary carrier.
C_1	Forward Clutch	Connects input shaft and front planetary ring gear.
C_2	Direct Clutch	Connects input shaft and front & rear planetary sun gear.
B_0	OD Brake	Prevents OD planetary sun gear from turning either clockwise or counterclockwise.
B_1	2nd Coast Brake	Prevents front & rear sun gear from turning either clockwise or counterclockwise.
B_2	2nd Brake	Prevents outer race of F_1 from turning either clockwise or counterclockwise, thus preventing front & rear sun gear from turning counterclockwise.
B_3	1st & Reverse Brake	Prevents rear planetary carrier from turning either clockwise or counterclockwise.
F_0	OD One–Way Clutch	When engine power is transmitted to OD input shaft, connects OD planetary sun gear and planetary carrier.
F_1	No. 1 One–Way Clutch	When B_2 is operating, prevents front & rear planetary sun gear from turning counterclockwise.
F_2	No. 2 One–Way Clutch	Prevents rear planetary carrier from turning counterclockwise.
Planetary Gears		Change power transmission route according to clutch and brake operation, and increase or decrease output shaft revolution accordingly.

3. Motive Power Transmission

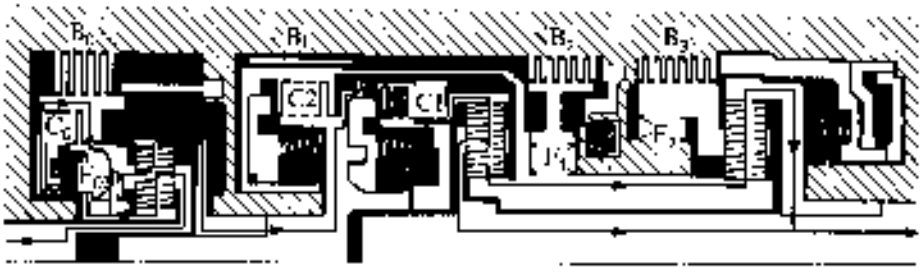
Operating Conditions

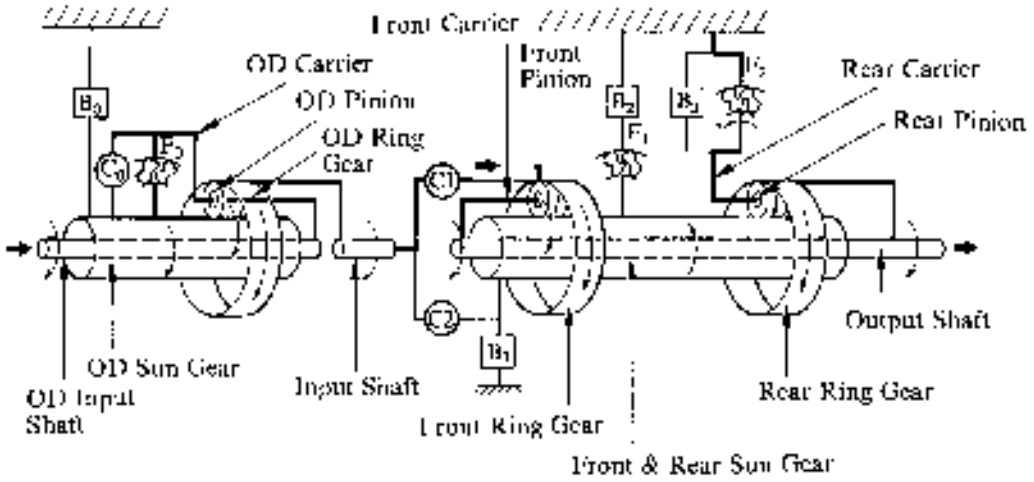
●: Operates

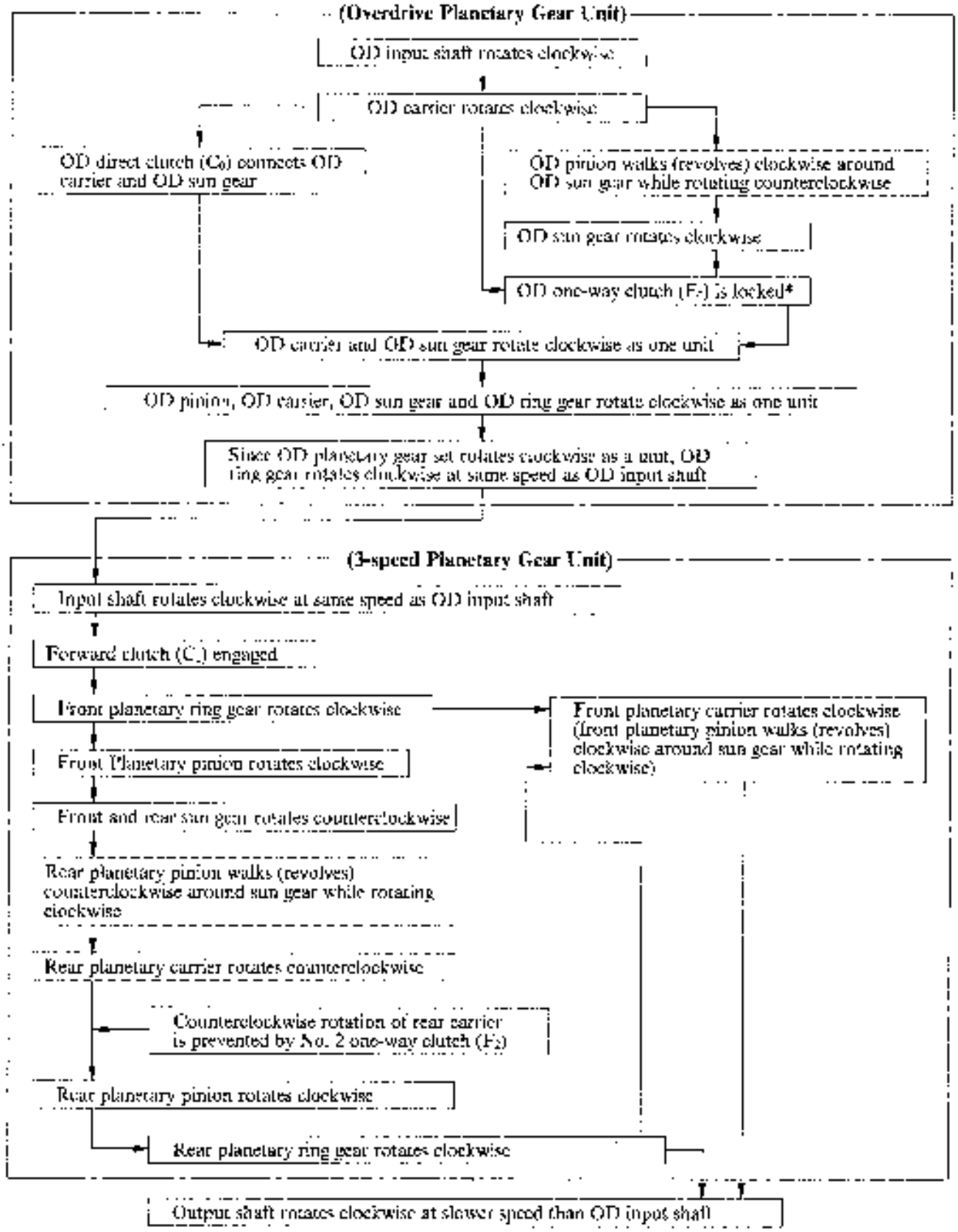
Range (i.e., Shift Lever Position)	Gear	No. 1* Solenoid Valve	No. 2* Solenoid Valve	C_0	C_1	C_2	B_0	B_1	B_2	B_3	F_0	F_1	F_2
P	Park	ON	OFF	●									
R	Reverse	ON	OFF	●		●				●	●		
N	Neutral	ON	OFF	●									
D	1st	ON	OFF	●	●						●		●
	2nd	ON	ON	●	●				●		●	●	
	3rd	OFF	ON	●	●	●			●		●		
	OD	OFF	OFF		●	●	●		●				
2	1st	ON	OFF	●	●						●		●
	2nd	ON	ON	●	●			●	●		●	●	
	3rd	OFF	ON	●	●	●			●		●		
L	1st	ON	OFF	●	●					●	●		●
	2nd	ON	ON	●	●			●	●		●	●	

*: See page 198 for details of the construction and operation of the solenoid valves.

1st Gear (D or 2 Range)



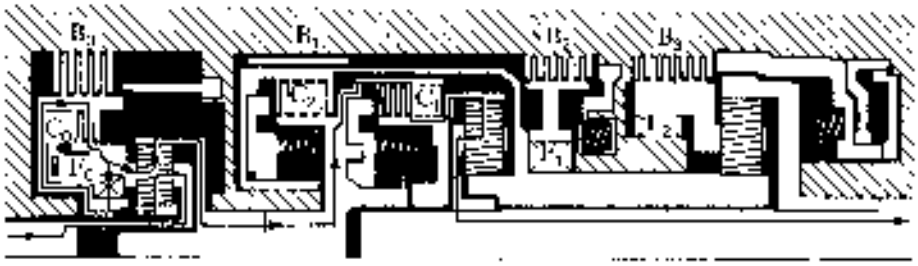


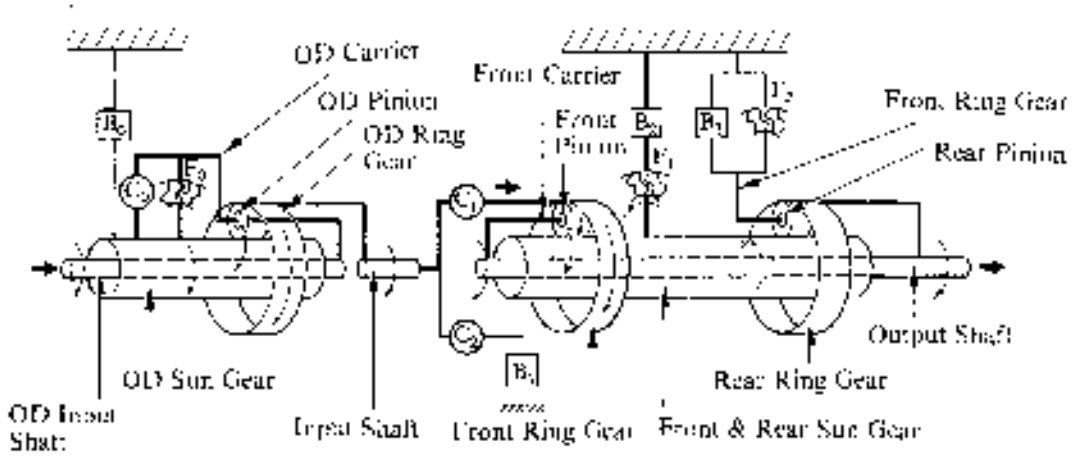


* The outer race of the OD one–way clutch (F_0) rotates clockwise as a unit with the OD planetary carrier, while the inner race rotates as a unit with the OD sun gear.

Since the inner race (OD sun gear) rotates faster than the outer race (OD carrier) by the amount of speed increment given to it by the counterclockwise rotation of the OD pinion, the OD one–way clutch (F_0) is locked, and the OD carrier and OD sun gear turn as one unit.

2nd Gear (D Range)





OD planetary gear unit (operates as in D range 1st gear)

Clockwise rotation of input shaft is transmitted to front planetary ring gear via forward clutch (C_1)

Front planetary ring gear rotates clockwise

When front planetary pinion rotates clockwise, it attempts to turn sun gear counterclockwise at same time

Counterclockwise rotation of front and rear sun gear is prevented by 2nd brake (B_2) and No. 1 one-way clutch (F_1)

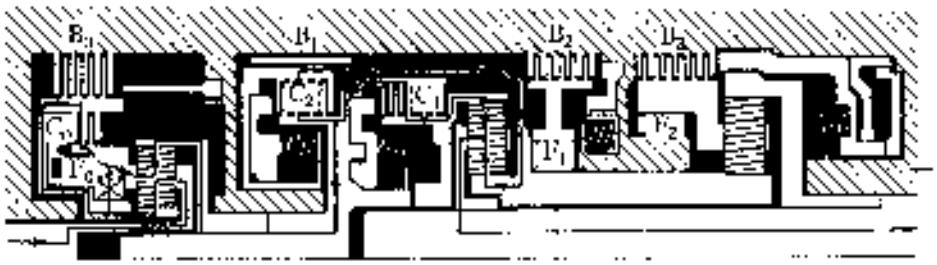
Front planetary pinion walks (revolves) clockwise around sun gear while rotating clockwise

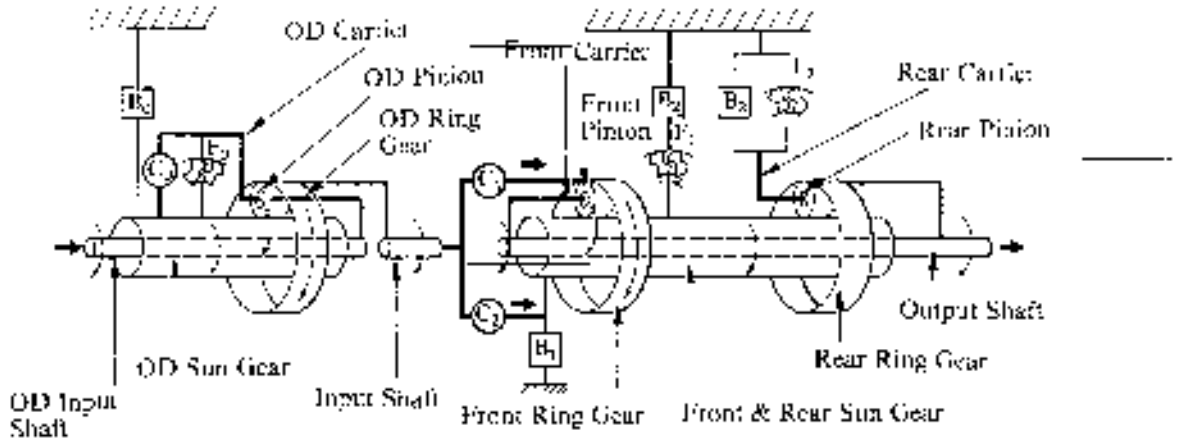
Front planetary carrier rotates clockwise

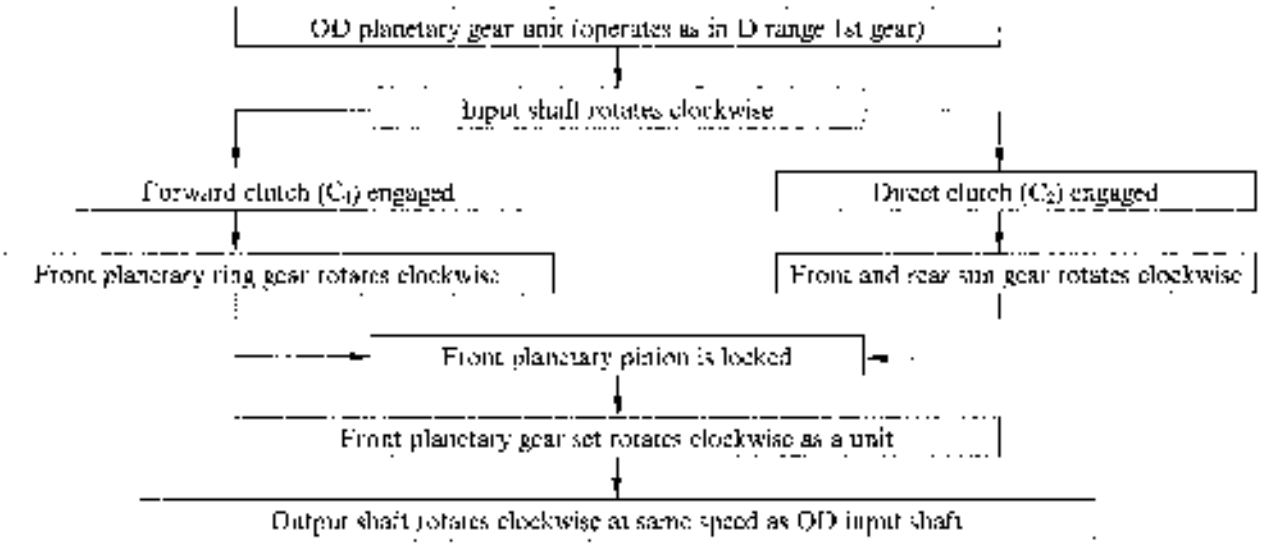
Output shaft rotates clockwise at slower speed than OD input shaft

NOTE: The power transmission in 2nd gear with the shift selector in “2” or “L” range is the same as that in “D” range 2nd gear except that 2nd coast brake (B_1) operates preventing rotation of sun gear.

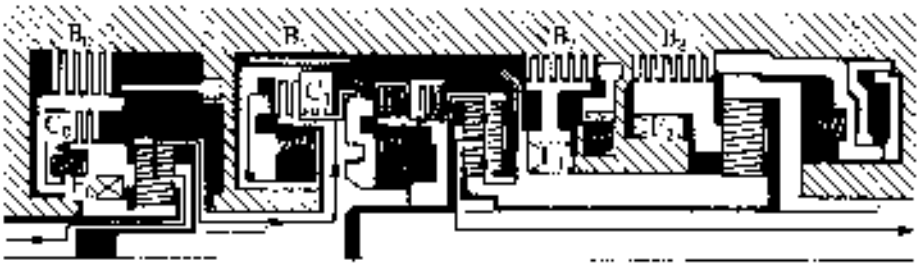
3rd Gear (D or 2 Range)

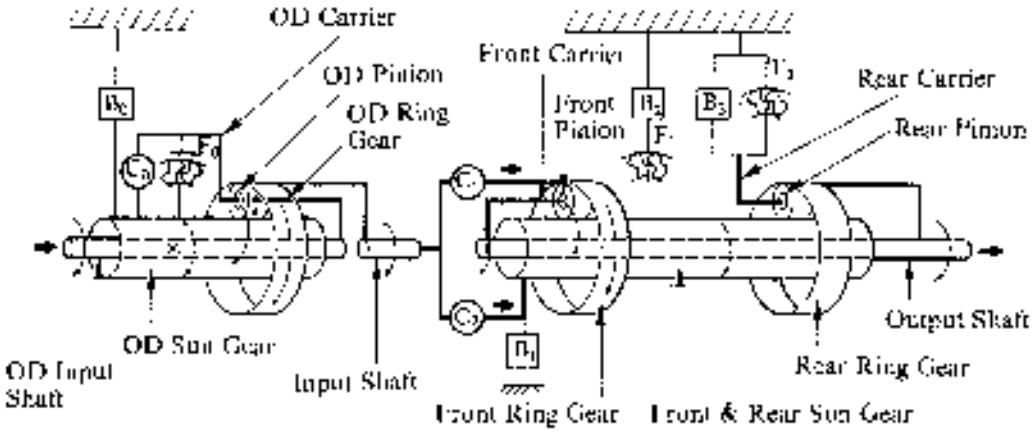


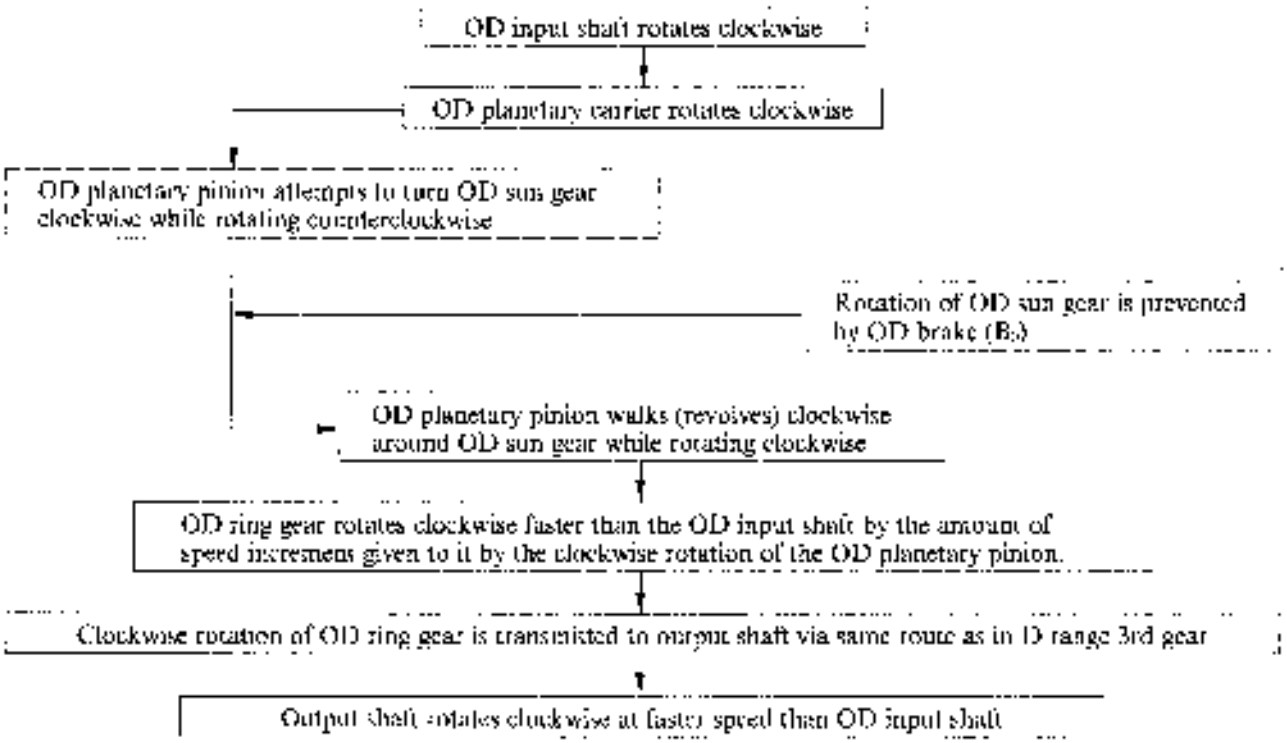




Overdrive (D Range)

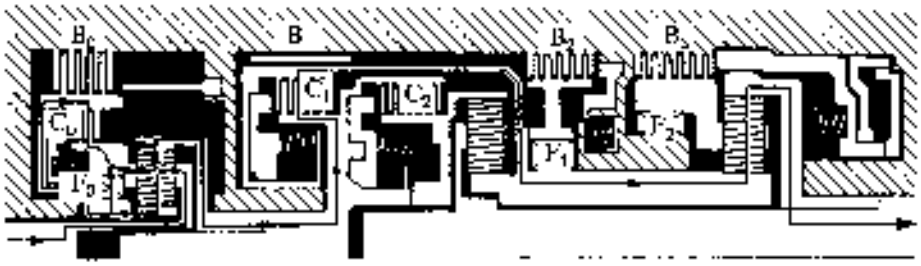


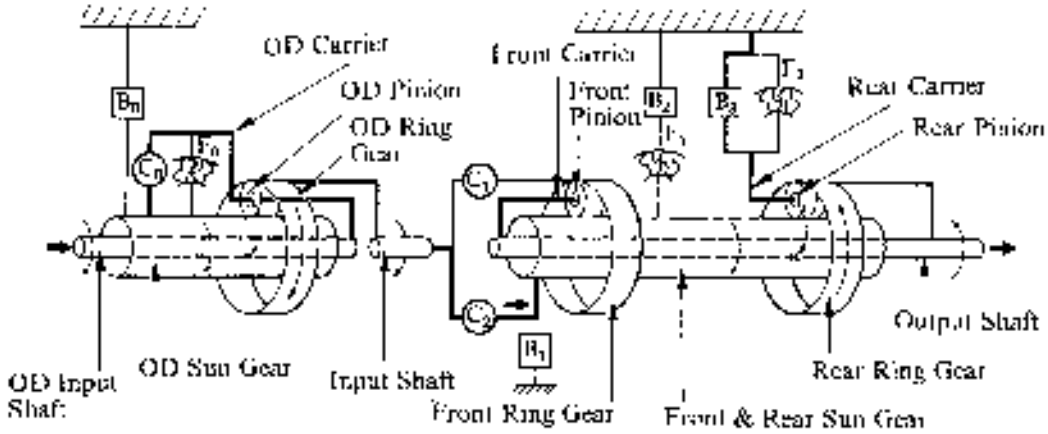




NOTE: Since the OD sun gear is held stationary by B_0, the inner race of F_0 does not rotate, but the outer race turns as a unit with the OD carrier. Therefore, F_0 freewheels when the vehicle is running in the OD mode.

Reverse Gear





OD planetary gear unit (operates as in D range 1st gear)

Input shaft rotates clockwise

Direct clutch (C_2) engaged

Front and rear sun gear rotates clockwise

Rear planetary pinion walks (revolves) clockwise around sun gear while rotating counterclockwise

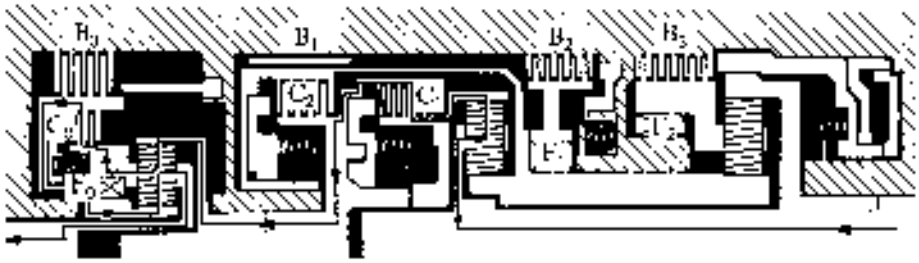
Rotation of rear carrier (axis of rear planetary pinion) is prevented by 1st & reverse brake (B_3)

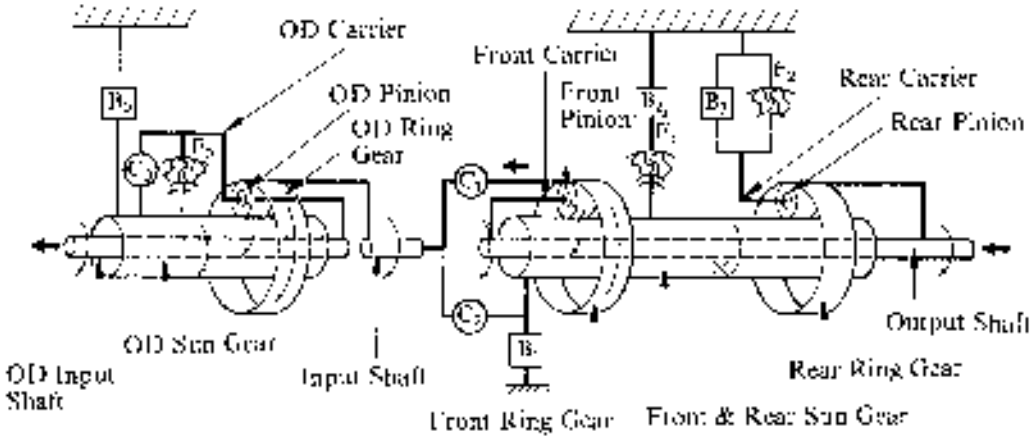
Rear planetary pinion rotates counterclockwise

Rear planetary ring gear rotates counterclockwise

Output shaft rotates counterclockwise

2nd Gear (2 or L Range), Engine Braking





Output shaft rotates clockwise

Front planetary carrier rotates clockwise

Front planetary pinion walks (revolves) clockwise around sun gear while rotating counterclockwise

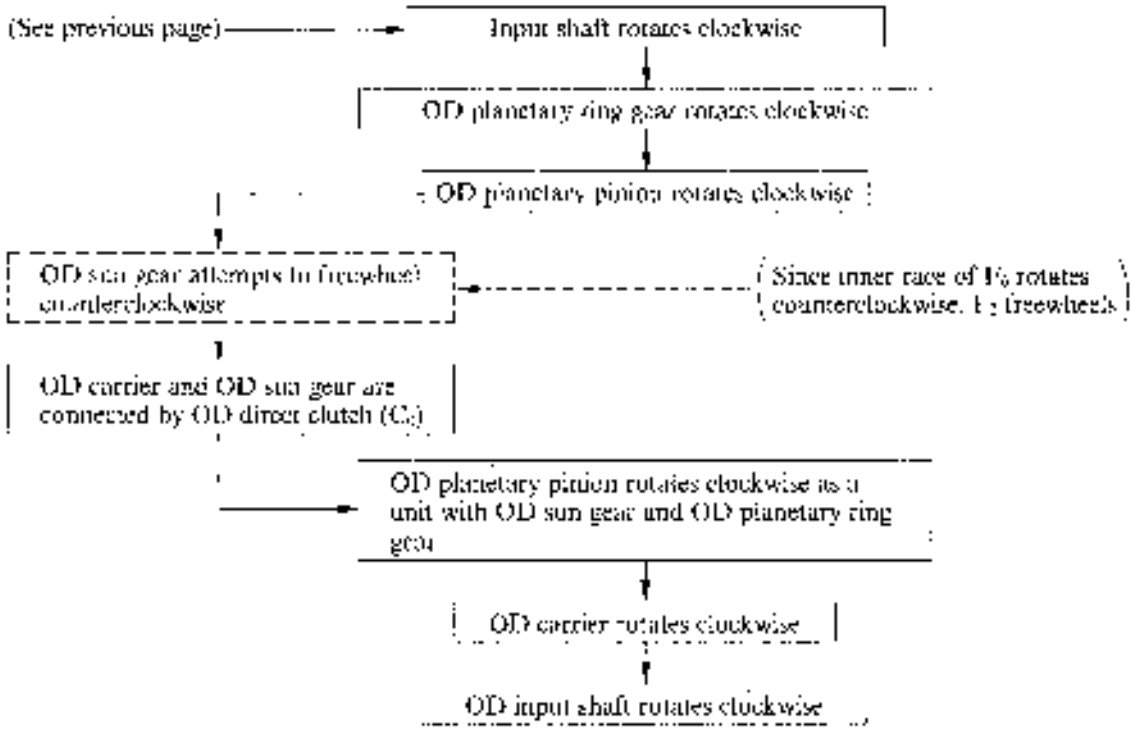
Sun gear attempts to rotate clockwise ← (F_1 freewheels)

Rotation of sun gear is prevented by 2nd coast brake (B_3)

Front planetary pinion walks (revolves) clockwise around sun gear while rotating clockwise

Front ring gear rotates clockwise

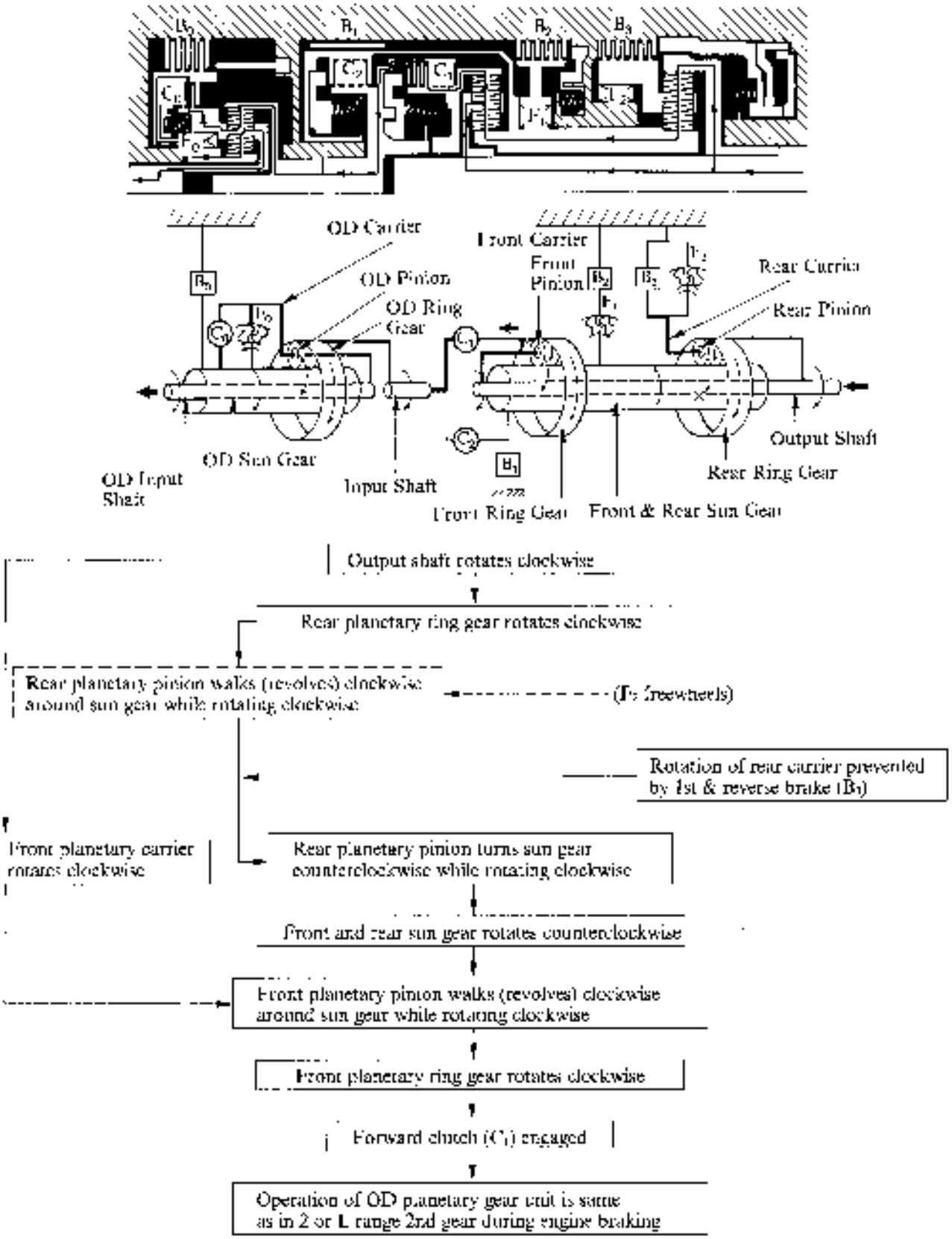
Forward clutch (C_1) engaged ← (See next page)



NOTE:

- The operation of the planetary gear sets, when the engine power is transmitted to the OD input shaft and the transmission is in 2nd gear with the shift selector in "2" or "L" range, is the same as that in "D" range 2nd gear.
- When the vehicle is running in 2nd gear with the shift selector in "D", the 2nd coast brake (B_1) does not operate. Accordingly, the front & rear sun gear can turn freely clockwise. If the vehicle then coasts under this condition, the front planetary ring gear rotates clockwise at the same speed as the OD input shaft, while the front planetary carrier rotates clockwise at the same speed as the output shaft and faster than the ring gear. As a result, the front planetary pinion rotates counterclockwise while revolving clockwise around the front & rear sun gear which is freewheeling in a clockwise direction. Accordingly, drive force (engine braking force) from the output shaft is not transmitted to the front planetary ring gear and engine braking does not occur.

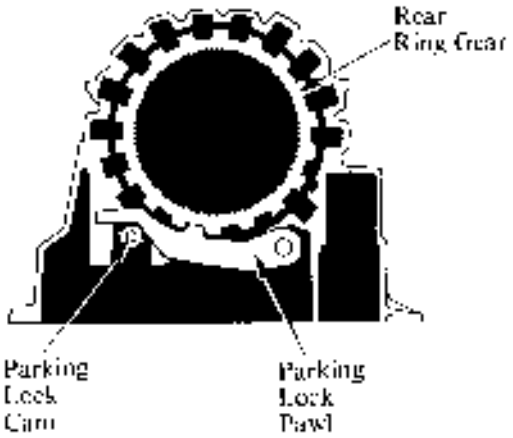
1st Gear (L Range), Engine Braking



NOTE: When the vehicle is running in 1st gear with the shift selector in “D” or “2”, the 1st & reverse brake (B_3) does not operate. As a result, rotation of the front and rear planetary gear units is the same as when running in 2nd gear with the shift selector in “D”, so engine braking does not occur during coasting.

"P" or "N" Range

When the shift lever is in "P" or "N", the forward clutch (C_1) and direct clutch (C_2) do not operate. The drive power from the overdrive input shaft, therefore, is not transmitted to the output shaft. In addition, when the shift lever is in "P", the parking lock pawl engages with the rear planetary ring gear which is splined to the output shaft. The vehicle, therefore, is prevented from moving.

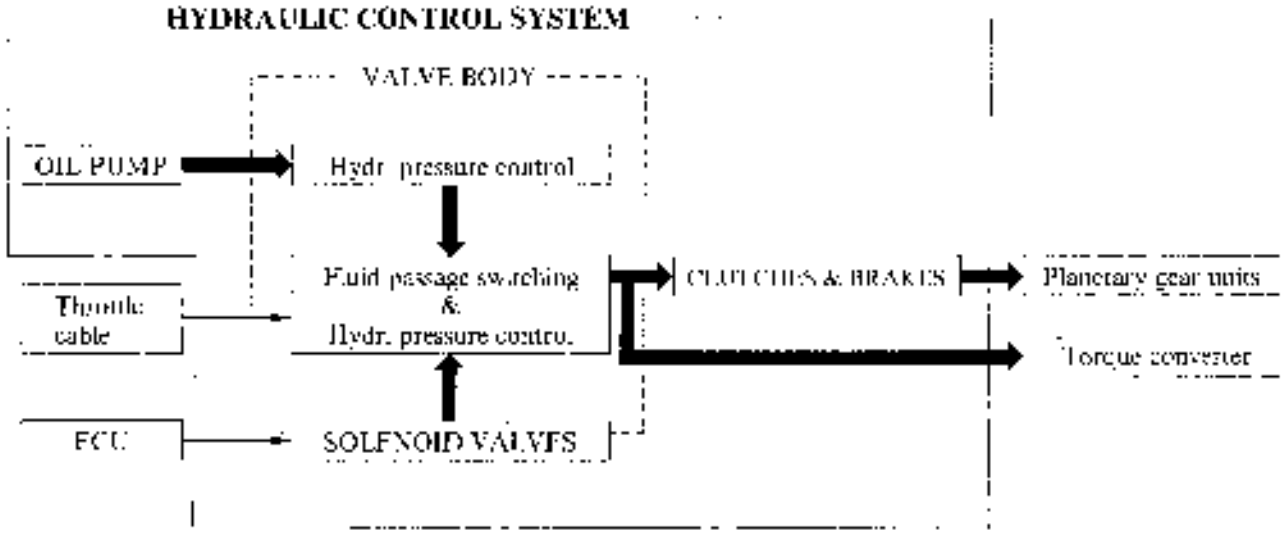


■ HYDRAULIC CONTROL SYSTEM

1. General

The hydraulic control system is composed of the oil pump, the valve body, the solenoid valves, the accumulators, and clutches and brakes, as well as the fluid passages which connect all of these components. Based on the hydraulic pressure created by the oil pump, the hydraulic control system governs the hydraulic pressure acting on the torque converter, clutches and brakes in accordance with the vehicle conditions.

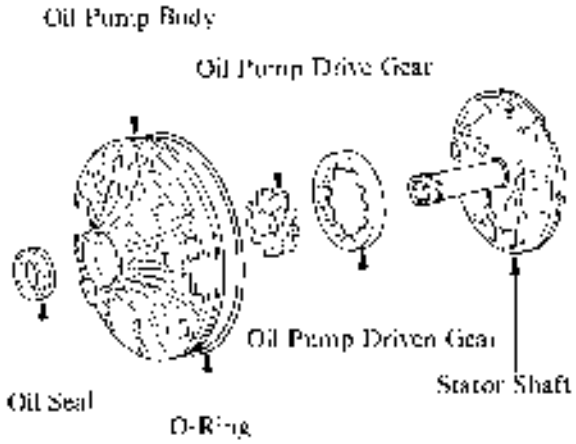
There are four solenoid valves on the valve body. The No. 1 and No. 2 solenoid valves are turned on and off by signals from the ECU to operate the shift valves, and change the gear shift position. The No. 3 solenoid valve is operated by signals from the ECU to engage or disengage the lock–up clutch of the torque converter. The No. 4 solenoid valve is operated by signals from the ECU to control the accumulator back pressure for smooth engagement of the clutches and brakes, and gear shifting. (Note: Except for control by the solenoid valves, the hydraulic control system of the ECT–i is basically the same as that of the hydraulically–controlled transmission.)



2. Construction and Operation

Oil Pump

The oil pump, combined with the torque converter, lubricates the planetary gear units and supplies operating pressure to the hydraulic control system. The drive gear of the oil pump is continually driven by the engine via the torque converter pump impeller. The pump has sufficient capacity to supply the necessary fluid pressure throughout all speed ranges, as well as in reverse.



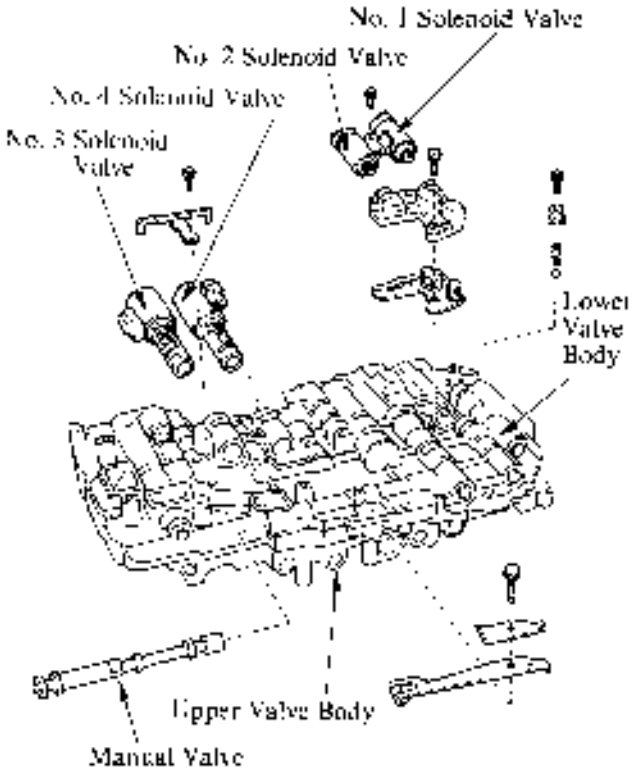
NOTICE

When the vehicle is towed, the engine does not operate, so the automatic transmission oil pump will not operate either. This means that no hydraulic control fluid will be sent to the transmission. Therefore, if the vehicle is towed at high speed or for a long distance, the protective fluid film coating the various rotating parts of the transmission may disappear and the transmission seizes up. For this reason, the vehicle should be towed at low speed (no more than 30 mph [48 km/h]) and no further than 50 miles (80 km) at one time. Furthermore, if the transmission itself malfunctions or begins leaking fluid badly, the vehicle should be towed with its drive wheels (rear wheels) lifted clear off the ground.

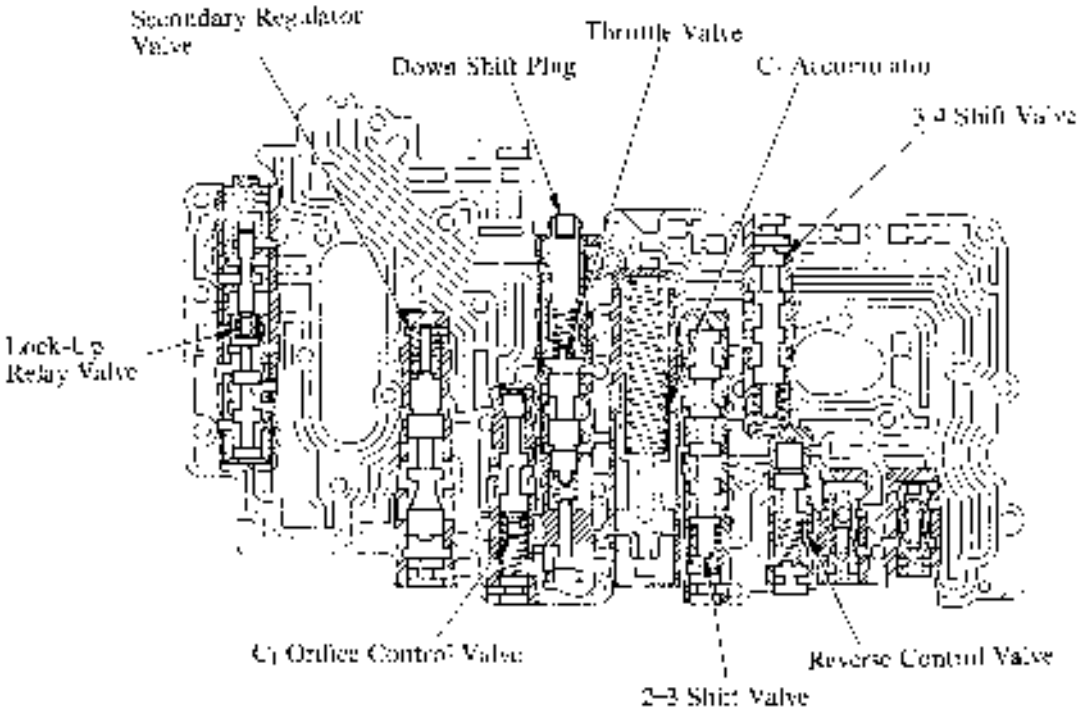
Valve Body

The valve body consists of an upper valve body and lower valve body. The valve contained therein controls fluid pressure and functions to switch fluid from one passage to another.

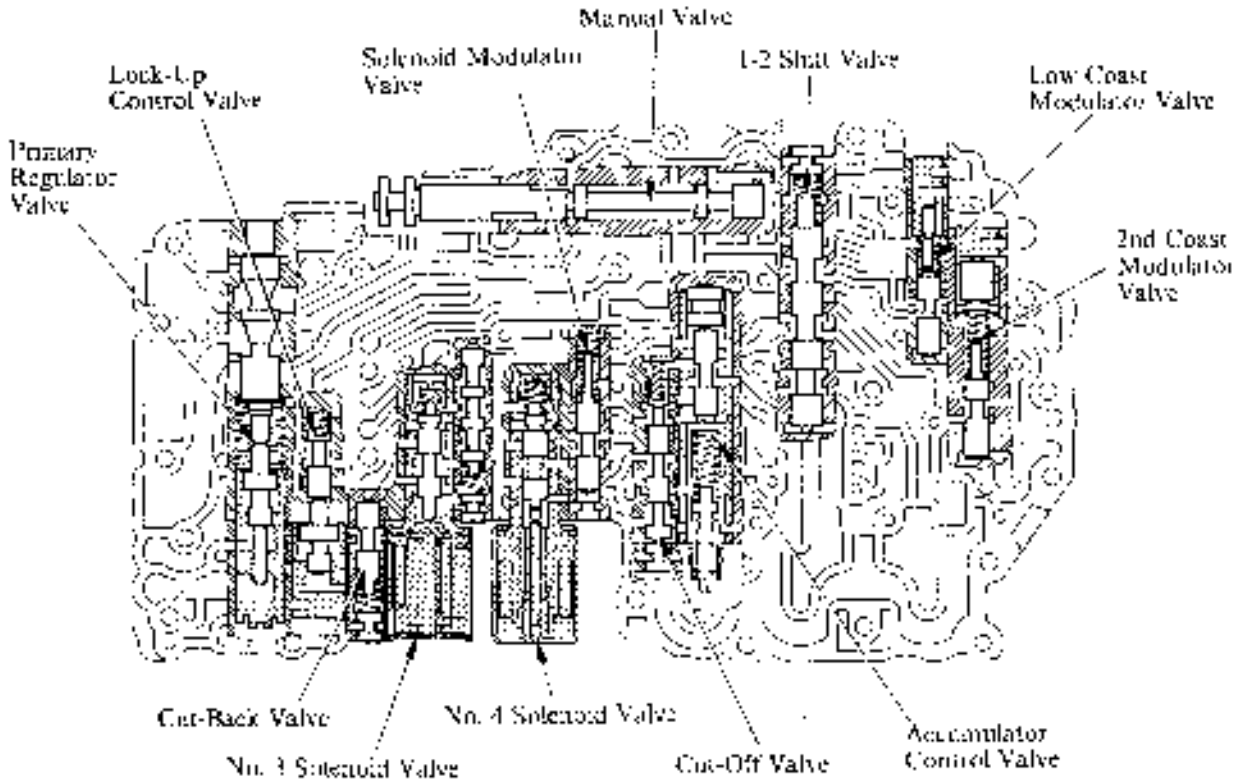
A valve body plate is provided between the upper and lower valve bodies to regulate the fluid passage. The gaskets are glued to both sides of the plate for good serviceability.



▶Upper Valve Body◀

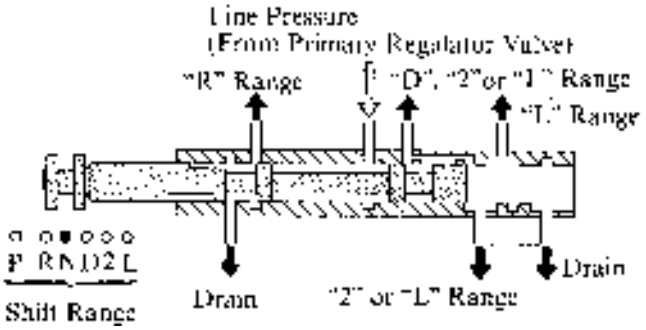


▶Lower Valve Body◀



1) Manual Valve

This valve serves to divert hydraulic fluid from one circuit to another. It is linked to the transmission shift lever and diverts the fluid to the "P", "R", "N", "D", "2" or "L" circuit depending upon the lever position.



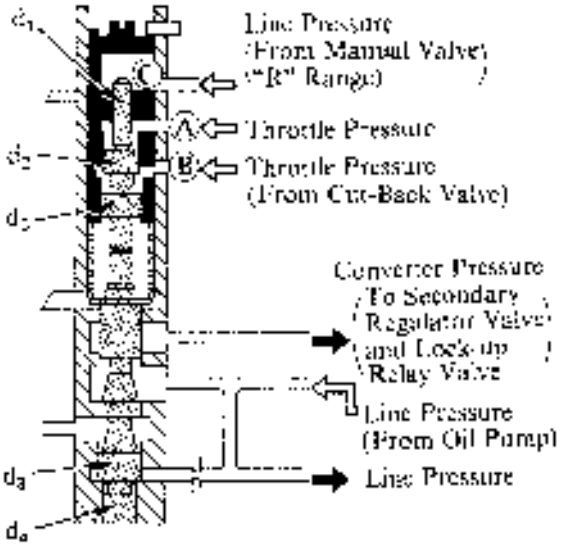
2) Primary Regulator Valve

The primary regulator valve uses throttle pressure to change the hydraulic pressure created by the oil pump into line pressure in accordance with the engine load. In other words, when there is a heavy load on the engine (throttle valve opening is large or throttle pressure is high), the primary regulator valve raises the line pressure to increase positive engagement of the clutches and brakes. On the other hand, when there is less of a load on the engine (small throttle valve opening or low throttle pressure), the line pressure is lowered to reduce shift shock and engine power loss.

At the upper portion of the primary regulator valve, spring tension and hydraulic pressure (d_2 x throttle pressure) which acts on portion (A) , always function as a downward force.

At the lower portion, {(d_3–d_4) x line pressure} always acts as an upward force. The line pressure is regulated by the balance of these upward and downward forces.

When the vehicle is running int he 1st, reverse or "2" range 2nd gear, the throttle pressure acts on portion (B) from the cut–back valve. A downward force equal to {d_2 x throttle pressure + (d_5–d_2) x throttle pressure} acts on the valve causing it to move downward. This creates a higher line pressure than that occurring in other ranges. When the vehicle is running in the reverse gear, the line pressure from the manual valve acts on portion (C) and the downward force (d_1 x line pressure) becomes greater. Due to this, the line pressure increases also.



—REFERENCE—

Line Pressure

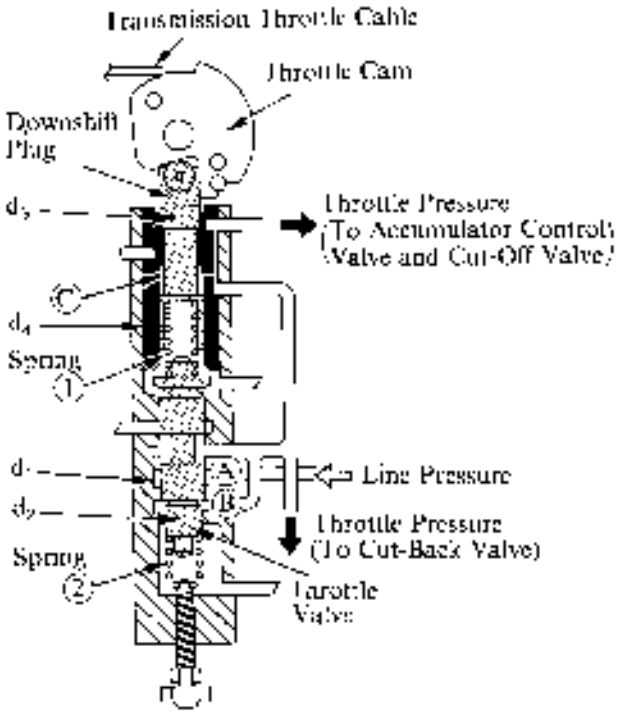
Line pressure is the most basic and important pressure used in the automatic transmission, because it is used to operate all of the clutches and brakes in the transmission. If the primary regulator valve does not operate correctly, line pressure will be either too high or too low. Line pressure that is too high will lead to shifting shock: line pressure that is too low will cause slippage of clutches and brakes. Therefore, if either of these problems are noted, the line pressure should be measured to see if it is within standard.

3) Throttle Valve

The throttle valve acts to produce throttle pressure in response to changes in the throttle opening or engine torque.

When the accelerator pedal is depressed, the downshift plug is pushed down via the transmission throttle cable and throttle calm. Thus, the throttle valve is also moved down by the spring ①, thereby opening the pressure passage Ⓐ for creation of throttle pressure. Meanwhile, this throttle pressure also acts on portion Ⓑ of the throttle valve, and the force of the spring ② pushes the throttle valve up. The throttle valve therefore closes off the line pressure passage Ⓐ when the force pushing up the throttle valve and the force of the spring ① (which is determined by the position of the downshift plug, i.e., the opening angle of the throttle valve) are balanced. In this way, the throttle pressure is determined by the balance between the forces pushing the throttle valve down and up.

Consequently, throttle pressure is always kept in accordance with the opening angle of the engine throttle valve. This throttle pressure acts on the primary regulator valve and the line pressure is regulated in response to the throttle valve opening.



NOTE:
- In the hydraulically controlled automatic transmission, throttle pressure is used for regulating line pressure and as signal pressure for uplifting and downshifting of the transmission. In the ECT–i, however, throttle pressure is used only for regulating line pressure. Consequently, improper adjustment of the transmission throttle cable may result in a line pressure that is too high or too low. This, in turn, will lead to shifting shock or clutch and brake slippage.
- Although it is possible in hydraulically controlled transmissions to adjust the shift points by adjusting the length of the throttle cable, this is not possible in the ECT–i.

4) Downshift Plug

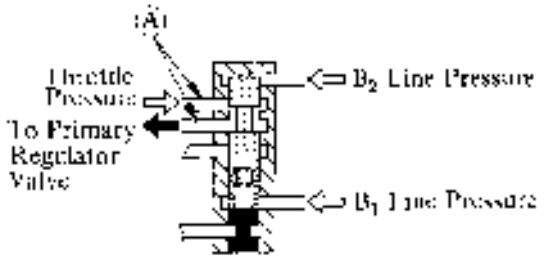
Throttle pressure acts on portion Ⓒ of the downshift plug, which is pushed down by the force {(d_4–d_3) x throttle pressure} in order to lower the contact pressure on the throttle cam and downshift plug.

5) Cut–Back Valve

When the transmission is in 1st reverse or "2" range 2nd gear, this valve opens the passage (A) and the throttle pressure acts on the primary regulator valve. This valve is regulated by B_1 line pressure, B_2 line pressure and spring tension. By applying throttle pressure to the primary regulator valve in this manner, the line pressure is increased to secure engagement of the clutches and brakes.

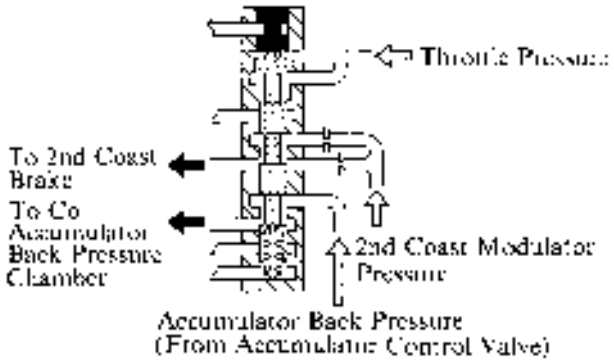
B_2 line pressure acts on the upper portion of the valve and as the valve is pushed downward, a passage from the throttle valve is closed and throttle pressure is not applied.

When B_1 line pressure and B_2 line pressure act simultaneously, the valve is pushed up by the spring force. Therefore, passage (A) from the throttle valve is opened and throttle pressure is applied to the primary regulator valve.



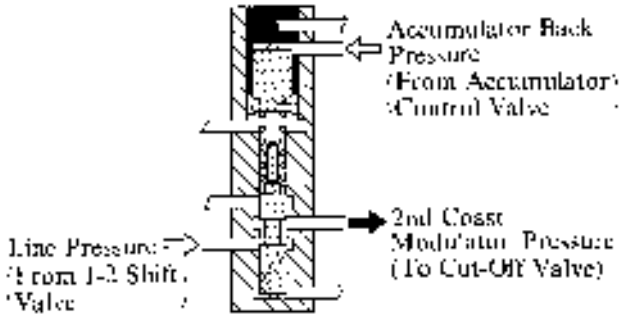
6) Cut–Off Valve

This valve diverts passage of the 2nd coast modulator pressure that acts from the 2nd coast modulator valve on the 2nd coast brake (B_1) according to the throttle pressure, and thus controls the engaging pressure of B_1.



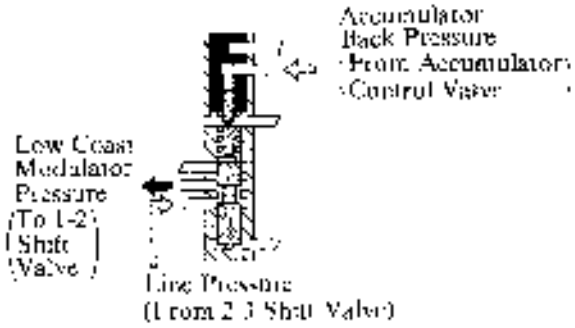
7) 2nd Coast Modulator Valve

In the "2" range 2nd gear, this valve reduces line pressure from the 1–2 shift valve (2nd coast modulator pressure) by the accumulator back pressure from the accumulator control valve. 2nd coast modulator pressure acts on the 2nd coast brake (B_1) via the cut–off valve to engage smoothly.



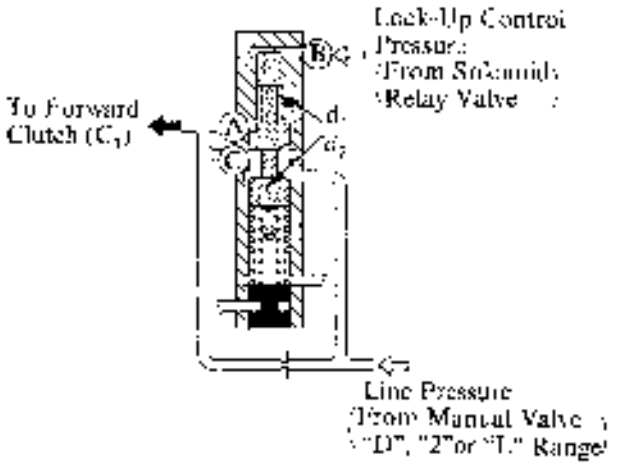
8) Low Coast Modulator Valve

In the "L" range, the low coast modulator valve reduces line pressure from the 2–3 shift valve (low coast modulator pressure) by the accumulator back pressure from the accumulator control valve. Low coast modulator pressure acts on the 1st and reverse brake (B_3) via the 1–2 shift valve to engage smoothly.



9) C_1 Orifice Control Valve

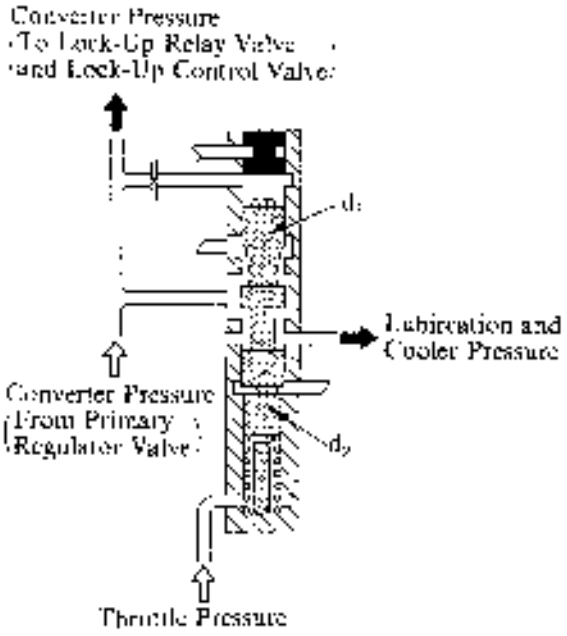
The C_1 orifice control valve diverts passage of the line pressure acting from the manual valve on the forward clutch (C_1) according to the line pressure and lock–up control pressure, and thus controls the engaging speed of C_1.



10) Secondary Regulator Valve

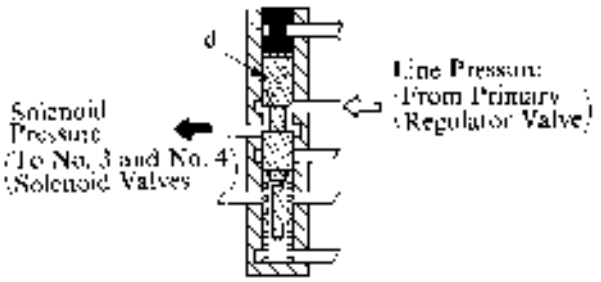
The secondary regulator valve serves to maintain stable converter, lubrication and cooler pressure. Converter pressure, regulated by the primary regulator valve, constantly acts on the upper portion of the secondary regulator valve. This creates a force (d_1 x converter pressure) that pushes the valve downward. The lower portion of the valve is pushed upward by spring tension and force (d_2 x throttle pressure). The valve moves to a point where these downward and upward forces are balanced.

When the converter pressure becomes larger than the throttle pressure, the downward force becomes greater than the upward force and the valve is pushed down as a result. It opens the drain port and releases the hydraulic pressure. If the upward force becomes greater, it pushes up the valve and closes the drain port. It is repetition of the foregoing operation that the secondary regulator valve maintains a stable converter and lubrication pressure.



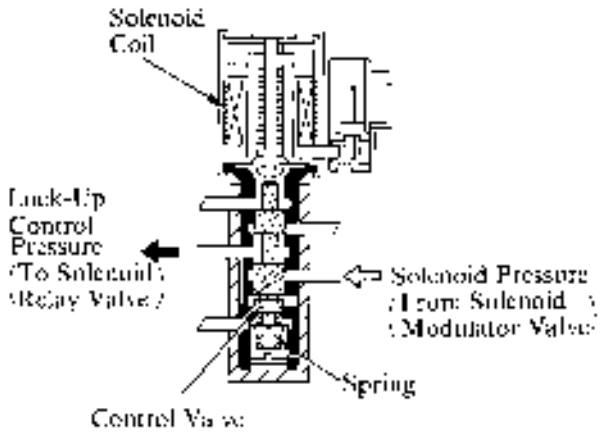
11) Solenoid Modulator Valve

The solenoid modulator valve serves to maintain stable solenoid pressure acting on the No. 3 and No. 4 solenoid valves. When the line pressure rises above the specified valve, the force pushing the valve downward (d x line pressure) overcomes the valve spring tension, causing the valve to move downward. As the valve is pushed downward, the drain port, which has been closed, opens to release hydraulic pressure. When this happens, the spring tension pushes the valve upward, again closing the drain port.



12) No. 3 Solenoid Valve

This valve modulates solenoid pressure into lock–up control pressure by means of magnetic force generated at the center of the solenoid coil in accordance with the amount of current sent to the solenoid coil from the ECU, together with the tension balance of the spring at the end of the control valve. The lock–up control pressure acts on the lock–up relay valve and lock–up control valve via the solenoid relay valve. As a result, it controls lock–up ON/OFF operation and provides smooth lock–up clutch engagement and disengagement.

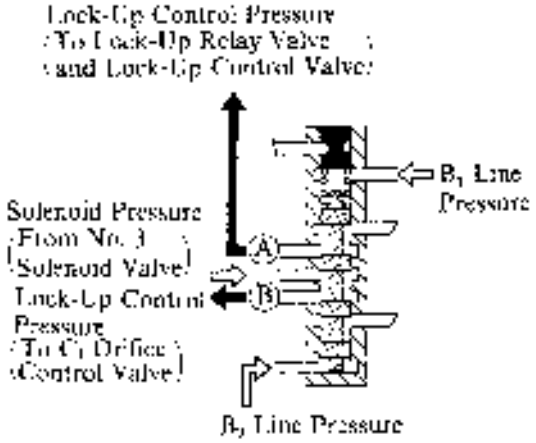


13) Solenoid Relay Valve

When the transmission is in forward range 2nd, 3rd or OD gear except for "2" range 2nd gear, this valve functions as a lock–up control pressure acting on the lock–up relay valve and lock–up control valve; it is actuated by the B_1 line pressure, B_2 line pressure and spring tension and permits or prohibits lock–up operation accordingly.

B_2 line pressure acts on the lower portion of the valve and as the valve is pushed upward, a passage (A) to the lock–up relay valve and lock–up control valve is opened and lock–up control pressure is applied.

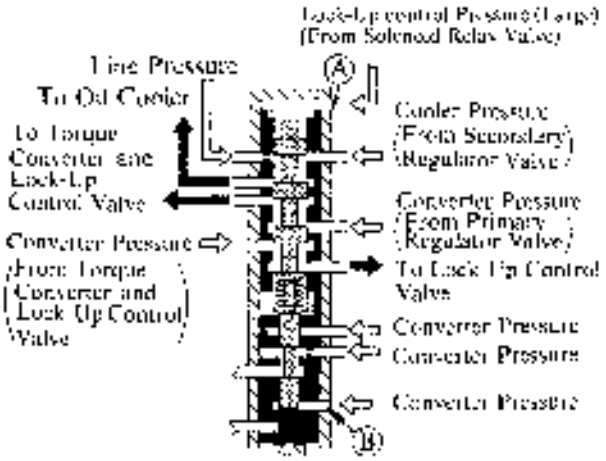
When both B_1 and B_2 line pressures act simultaneously, the valve moves upward by the spring tension. Passage (A) is closed and the lock–up control pressure acting on the lock–up relay valve and lock–up control valve is drained. At the same time, passage (B) is opened to apply the lock–up control pressure from No. 3 solenoid valve to the C_1 orifice control valve.



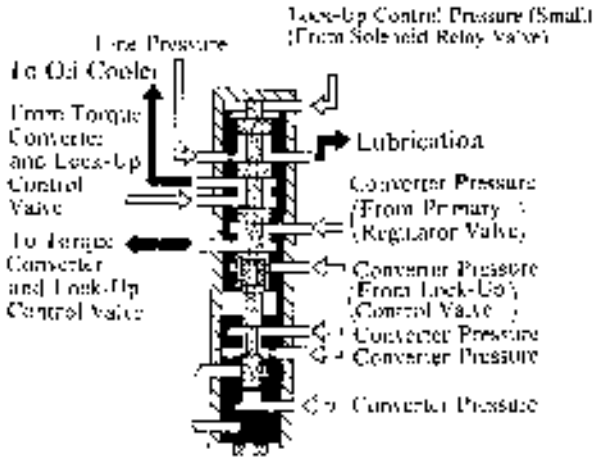
14) Lock–Up Relay Valve

In accordance with a lock–up control pressure from No. 3 solenoid valve via the solenoid relay valve, the lock–up relay valve reverses the fluid flow to the converter (lock–up clutch).

When No. 3 solenoid valve operates, lock–up control pressure modulated by No. 3 solenoid valve acts on portion (A) forcing it downward to engage the lock–up clutch. When No. 3 solenoid valve stops operation, lock–up control pressure acting on portion (A) of this valve is reduced. Therefore, the lock–up relay valve is pushed upward by the converter pressure acting on portion (B) and the spring force to disengage the lock–up clutch.



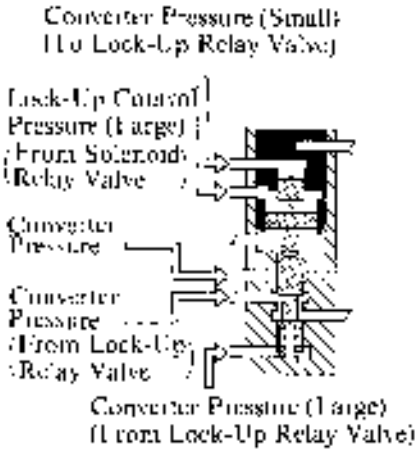
Lock-Up Clutch Engaged



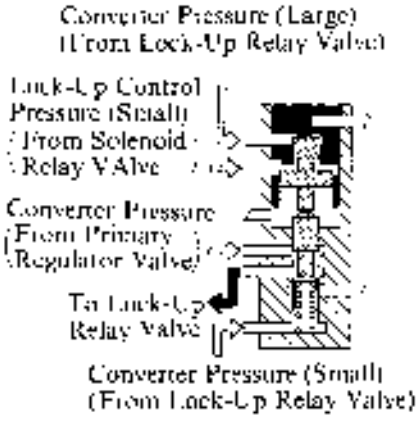
Lock-Up Clutch Disengaged

15) Lock–Up Control Valve

In accordance with the lock–up control pressure from No. 3 solenoid valve, the lock–up control valve reverses the fluid flow to the converter (lock–up clutch) via the lock–up relay valve. When No. 3 solenoid valve operates to engage the lock–up clutch, the lock–up control pressure modulated by No. 3 solenoid valve acts on portion (A) via the solenoid relay valve and forces it downward to drain the converter pressure of the converter lock–up "OFF" side. When No. 3 solenoid valve stops operation to disengage the lock–up clutch, the lock–up control pressure acting upon portion (A) is reduced. Therefore, the lock–up control valve is pushed upward by the force of the spring and applied the converter pressure to the converter lock–up "OFF" side.



Lock-Up Clutch Engaged



Lock-Up Clutch Disengaged

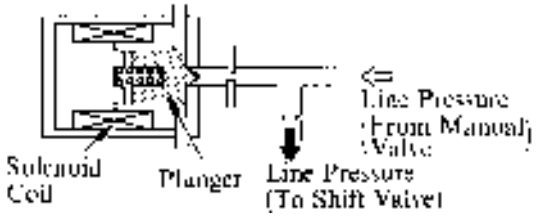
16) No. 1 and No. 2 Solenoid Valves

No. 1 and No. 2 solenoid valves turn on and off by signals sent from the ECU to the solenoid coil, and operate the 1–2, 2–3 and 3–4 shift valves to perform gear shifting.

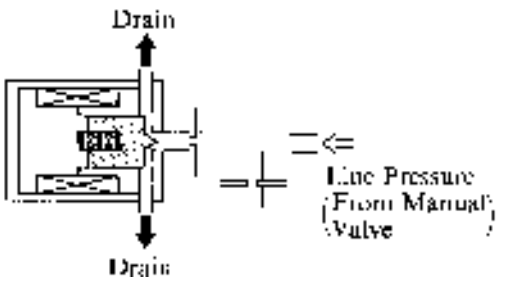
The line pressure is acting on No. 1 solenoid valve in any forward gear range and on No. 2 solenoid valve in all ranges. When the solenoid valve is turned off, the drain port is closed by a plunger causing the line pressure to act on the shift valve. The shift valve moves as a result. When a solenoid valve is turned on, the drain port opens and drains the line pressure. As a result, the shift valve returns to the original position by the return spring.

The table below shows the relationship between solenoid valves and transmission gear positions.

▶When the solenoid valve is turned off◀



▶When the solenoid valve is turned on◀



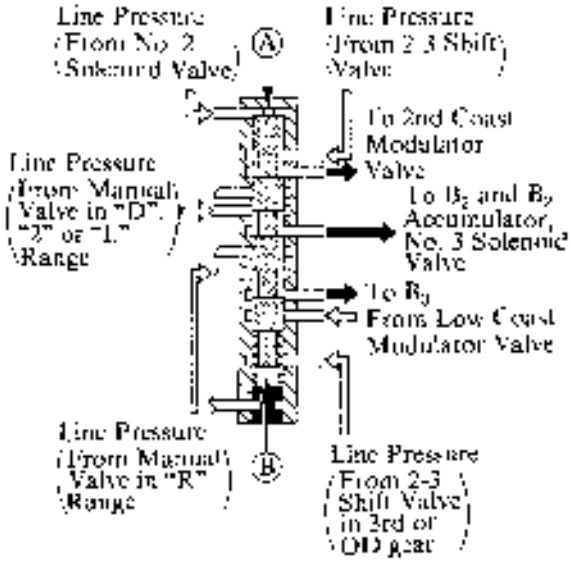
No. 1 Solenoid	ON	ON	OFF	OFF
No. 2 Solenoid	OFF	ON	ON	OFF
Shift Range				
P	Park	—	—	Park*
R	Reverse	—	—	Reverse*
N	Neutral	—	—	Neutral*
D	1st	2nd	3rd	OD
2	1st	2nd	3rd	3rd*
L	1st	2nd	2nd*	1st*

*: When a malfunction has occurred in the solenoid valve.

17) 1–2 Shift Valve

The 1–2 shift valve performs shifting between 1st and 2nd gears. When the ECU turns off No. 2 solenoid valve, line pressure acts on portion Ⓐ of the 1–2 shift valve, forcing it downward and shifting the transmission into 1st gear. When the ECU turns on No. 2 solenoid valve, the line pressure, which has been acting on portion Ⓐ of the valve, is released through the No. 2 solenoid valve drain port. Consequently, spring tension forces the 1–2 shift valve back upward, shifting the transmission into 2nd gear.

When the transmission is in OD, No. 2 solenoid valve is off, as in 1st gear, and line pressure acting on portion Ⓐ of the valve. However, as line pressure from the 2–3 shift valve is acting on portion Ⓑ of the 1–2 shift valve, (as No. 1 shift valve control solenoid valve is off), it remains pushed upward by spring tension.

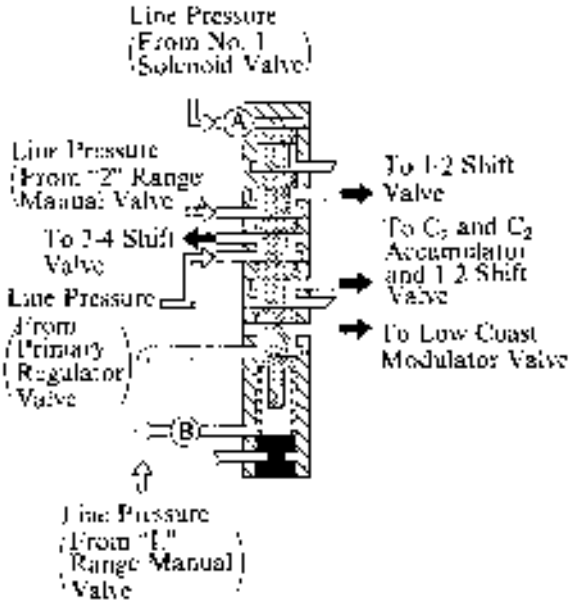


18) 2–3 Shift Valve

The 2–3 shift valve performs shifting between 2nd and 3rd gears. When the ECU turns on No. 1 solenoid valve, the line pressure acting on portion Ⓐ of the 2–3 shift valve is released through the No. 1 solenoid valve drain port. Therefore, the 2–3 shift valve is forced upward by spring force and the transmission is shifted into 2nd gear.

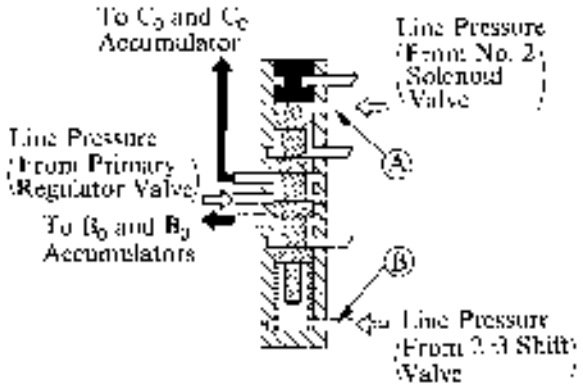
When the ECU turns off No. 1 solenoid valve, line pressure acts on portion Ⓐ of the valve, forcing it downward and shifting the transmission into 3rd gear.

When the transmission is in "L" range, however, line pressure from the manual valve is acting on portion Ⓑ of the valve, so it remains in an upward position and the transmission does not shift into 3rd gear.



19) 3–4 Shift Valve

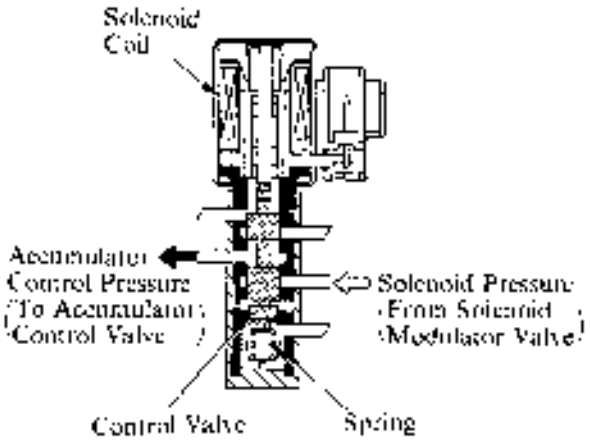
The 3–4 shift valve performs shifting between 3rd and OD gears. When the ECU turns on No. 2 solenoid valve, the line pressure acting on portion Ⓐ of the 3–4 shift valve is released through the No. 2 solenoid valve drain port. Therefore, the 3–4 shift valve is forced upward by spring force and the transmission is shifted into 3rd gear. When the ECU turns off No. 2 solenoid valve, line pressure acts on portion Ⓐ of the valve, forcing it downward and shifting the transmission into OD gear. However, when the transmission is in any gear of the "2" or "L" ranges, or in 1st or 2nd gear of the "D" range, line pressure from the 2–3 shift valve is always applied to portion Ⓑ of the valve, so it remains in an upward position and the transmission will not upshift to OD gear.



20) No. 4 Solenoid Valve

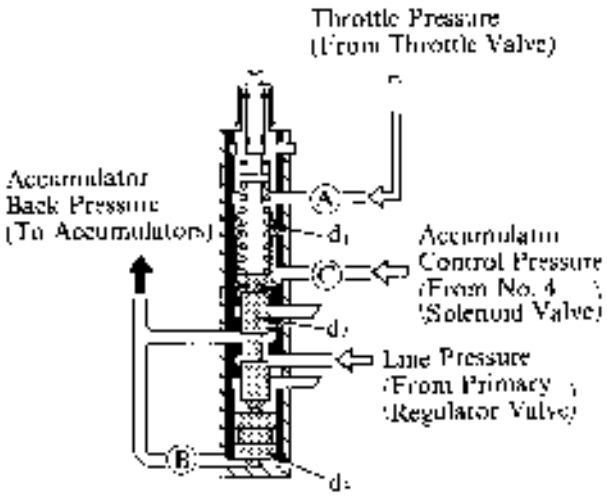
By means of the magnetic force generated at the center of the solenoid coil in accordance with the amount of current sent to the solenoid coil by the ECU, together with the tension balance of the spring at the end of the control valve, this valve modulates solenoid pressure into accumulator control pressure which acts on the accumulator control valve.

This valve increases the accumulator control pressure in accordance with the gear shifting, temporarily weakens the accumulator back pressure being regulated by the accumulator control valve, and thus operates smooth clutches and brakes engagement. When gear shifting is completed, the accumulator control pressure decreases to increase the engaging pressure of clutches and brakes.



21) Accumulator Control Valve

This valve operates to smoothly engage the clutches and brakes by controlling back pressure of the accumulators. The throttle pressure is acting constantly on portion Ⓐ of the accumulator control valve creating a force (d_1 x throttle pressure) that pushes the valve down. The accumulator back pressure regulated by the accumulator control valve is acting constantly on portion Ⓑ creating a force (d_3 x accumulator back pressure) that pushes the valve upward. Normally, the accumulator back pressure is regulated by a balance between these upward and downward forces and the spring force that pushes the valve downward also. When gear shifting is performed, the accumulator control pressure acts upon portion Ⓒ in addition.



The additional upward force {(d_1–d_2 x accumulator control pressure} acts on the valve as a result. Therefore, the valve moves upward and opens the drain port. For this reason, the accumulator back pressure drops below a normal level so that clutches and brakes are engaged smoothly.

Accumulator

The accumulators act to smoothly engage the clutches and brakes. The A341E has five accumulators: one each for the forward clutch (C_1), the direct clutch (C_2), the OD direct clutch (C_0), the 2nd brake (B_2) and the OD brake (B_0). The accumulators for the C_2, C_0, B_2 and B_0 are located in the transmission case and the C_1 is provided in the valve body. Functions of each accumulator are shown on the right table.

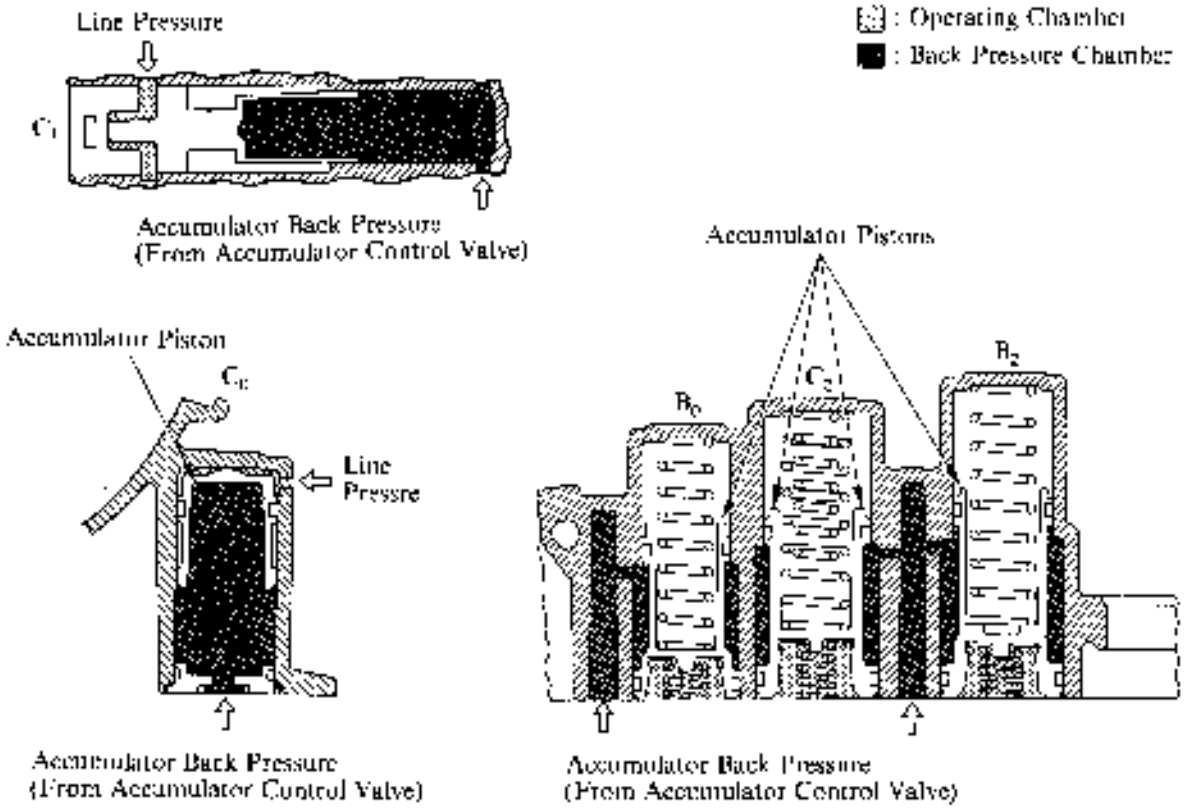
▶Functions◀

Accumulator	Smooth Engagement for
C_1	"N" Range → "D" Range
C_2	2nd → 3rd
C_0	OD → 3rd
B_2	1st → 2nd
B_0	3rd → OD

Accumulator back pressure is always acting on the back pressure chambers of the accumulators, and this pressure, along with spring tension, pushes the piston. This makes the movements of the accumulator pistons the most suitable for the throttle valve opening angle, gear shifting mode and others.

Accumulators are provided in parallel with the clutch and brake circuits. When the line pressure is applied to the operating chamber, the piston is pushed slowly and accumulates the line pressure in the operating chamber. As a result, the line pressure (engaging pressure) acting on the clutches and brakes decreases so that clutches and brakes are engaged smoothly.

▶Accumulators◀



NOTE: The engaging pressure of clutches and brakes is low at first immediately after the line pressure begins to act on the operating chamber (when the piston is moving fast and accumulating a large amount of line pressure). The piston speed decreases gradually because its movement causes the spring tension to increase. As a result, accumulation of the line pressure becomes less and causes the engaging pressure to gradually increase. When the movement of the piston stops, the entire line pressure acts on the clutches and brakes.

■ ELECTRONIC CONTROL SYSTEM

1. General

The A341E automatic transmission is an ECT–i (Electronically Controlled Transmission with an intelligent control system) in which the gear shift timing, lock–up timing the clutch and brake hydraulic pressure and the engine torque during shifting are controlled accurately by an ECU according to the vehicle driving conditions and engine operating conditions as detected by various sensors.

In addition, the A341E has a self–diagnosis function which diagnoses and notifies of a malfunction in the electronically controlled components, and a fail–safe function which enables continuous vehicle running even when a malfunction has occurred.

Shift Timing Control

The ECU selects one of four shift patterns stored in its memory based on signals from the pattern select switch (Normal or Power) and the neutral start switch.

Based on the select shift pattern, current then flows to the No. 1 and/or No. 2 (shift control) solenoid valve(s) according to the vehicle speed and throttle valve opening angle, to control gear shift timing.

Lock–Up Timing Control

The ECU selects one of the two lock–up patterns stored in its memory in accordance with the pattern (Normal or Power) signal selected by the pattern select switch.

Based on the select shift pattern, current flows to the No. 3 (lock–up control) solenoid valve according to the vehicle speed and throttle valve opening angle, to control lock–up timing. When the gear is shifted up or down while the lock–up clutch is engaged, the lock–up clutch is disengaged momentarily. It is re–engaged when an up or down gear shift is completed to enable smooth gear shifting.

Engine Torque Control

When the ECU judges an up or down gear shift is required, it momentarily delays the engine ignition timing and thus controls the engine torque, enabling smooth gear shifting.

Lock–Up Pressure Control

Hydraulic pressure acting on the lock–up clutch is modulated by the No. 3 (lock–up control) solenoid valve, thus the lock–up clutch is engaged and disengaged smoothly.

Accumulator Back Pressure Control

Hydraulic pressure acting on the accumulator back chamber is modulated by the No. 4 (accumulator control) solenoid valve. Thus, the pressure acting on the clutches and brakes is controlled during gear shifting to smoothly engage them.

Self–Diagnosis

If a short or open wire occurs in the following areas, the OD (Overdrive) OFF indicator light blinks to inform the driver (when the OD OFF indicator light is off).

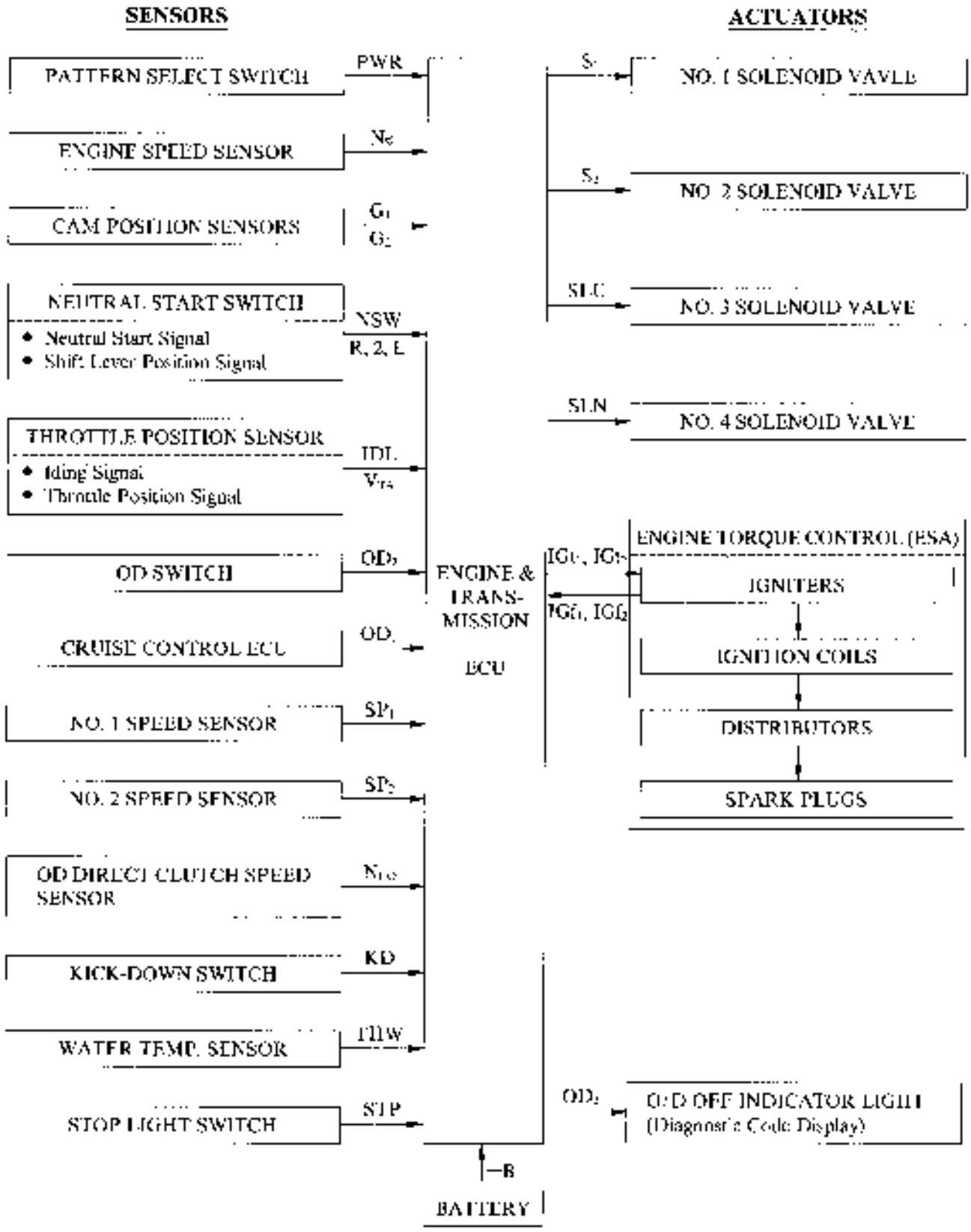
- No. 1, No. 2 or OD direct clutch speed sensors
- No. 1, No. 2, No. 3 and No. 4 solenoid valves
- Kick–down switch

Fail–Safe

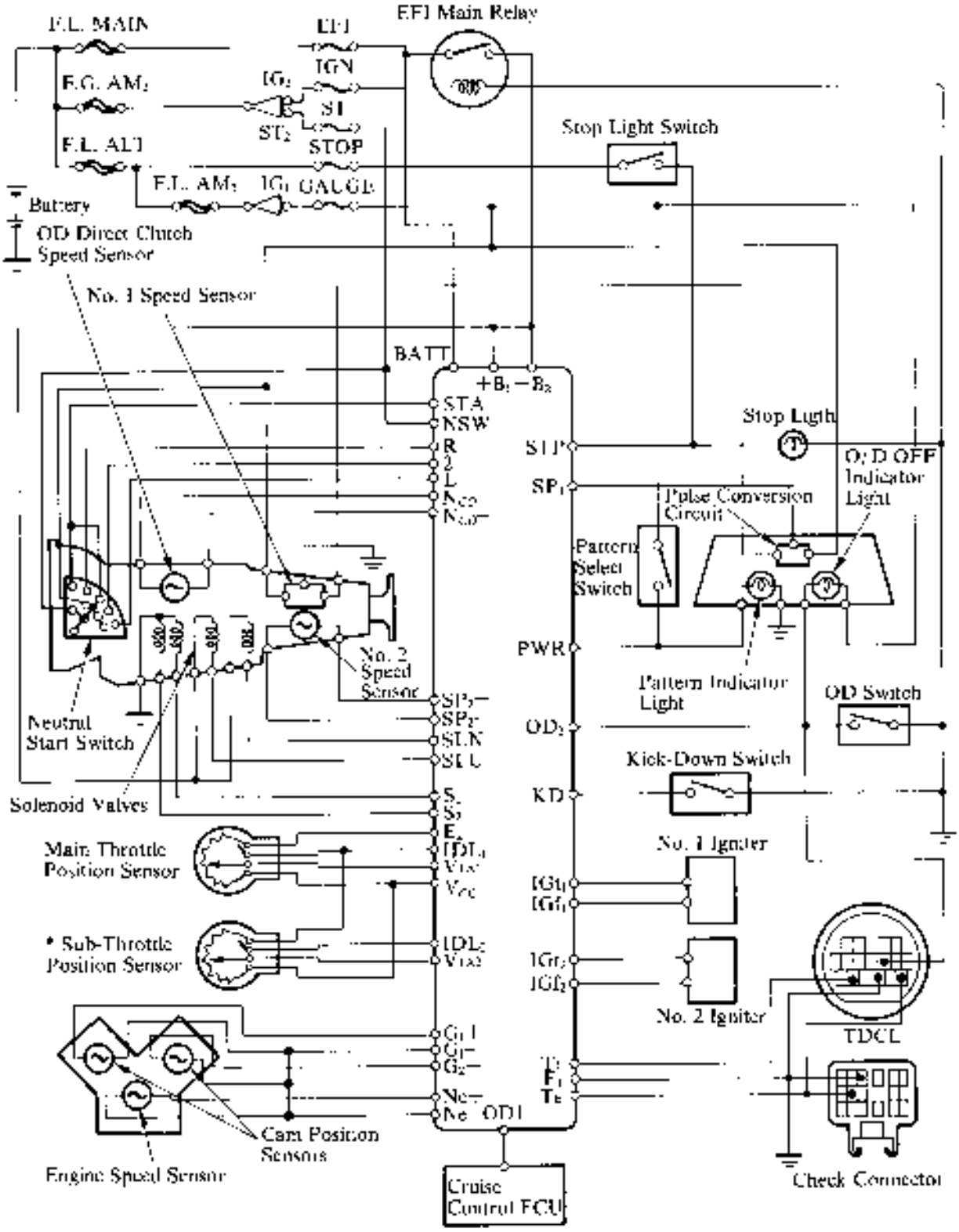
A solenoid valve back–up function, speed sensor back–up function and manual operation function make driving possible even when an electrical circuit is malfunctioning.

2. Construction

The electronic control system can be broadly divided into three groups; the sensors, ECU and actuators.

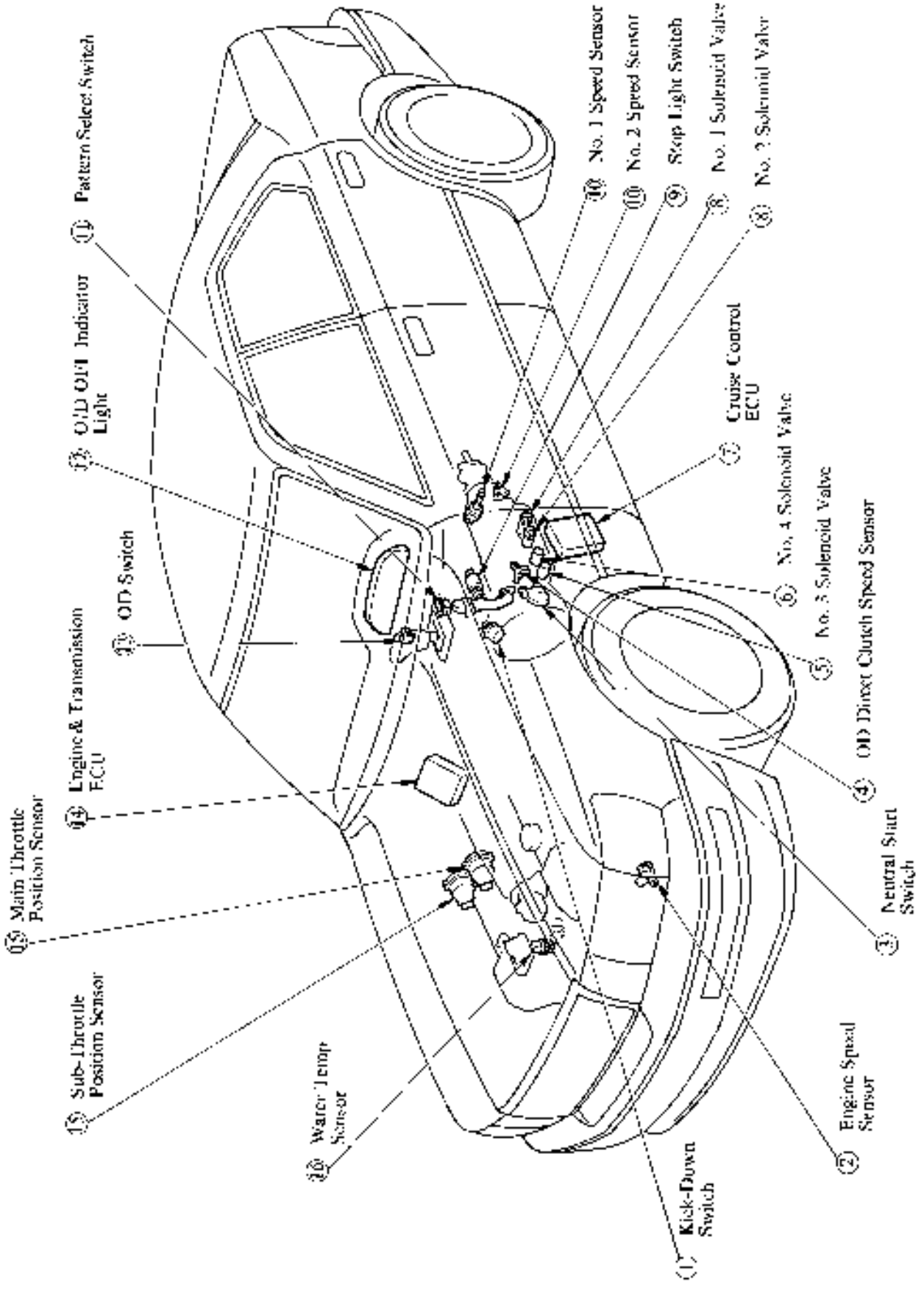


3. System Diagram



*: The sub–throttle position sensor is only provided with the optional TRAC (Traction Control) system.

4. Arrangement of Components



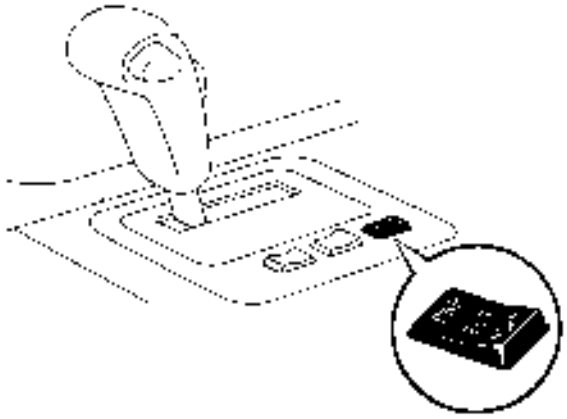
5. Function of Components

No.	Components	Functions
1	Kick–Down Switch	Detects the accelerator pedal position depressed beyond full throttle valve opening.
2	Engine Speed Sensor	Detects the engine speed.
3	Neutral Start Switch	Detects the shift lever position.
4	OD Direct Clutch Speed Sensor	Detects OD input shaft speeds from 1st through 3rd gears.
5	No. 3 Solenoid Valve	Controls the hydraulic pressure applied to the lock–up clutch and controls lock–up timing.
6	No. 4 Solenoid Valve	Controls the hydraulic pressure applied to the lock–up clutch and controls lock–up timing.
7	Cruise Control ECU	Prohibits vehicle running in OD gear and lock–up control when vehicle speed drops lower than a predetermined level of the auto drive set speed.
8	No. 1 and No. 2 Solenoid Valves	Controls the hydraulic pressure applied to each shift valve, and controls gear shift position and timing.
9	Stop Light Switch	Detects the brake pedal depression.
10	No. 1 and No. 2 Speed Sensors	Detects the vehicle speed. Ordinarily, ECT control uses signals from the No. 2 speed sensor, and the No. 1 speed sensor is used as a back–up.
11	Pattern Select Switch	Selects the shift and lock–up timings by the Power mode or the Normal mode.
12	O/D OFF Indicator Light	Blinks and warns the driver, while the OD main switch is pushed in, when the electronic control circuit is malfunctioning.
13	OD Switch	Prevents up shift to the OD gear if the OD switch is off.
14	Engine & Transmission ECU	Controls the engine and transmission actuators based on signals from each sensor.
15	Throttle Position Sensor	Detects the throttle valve opening angle.
16	Water Temp. Sensor	Detects the engine coolant temperature.

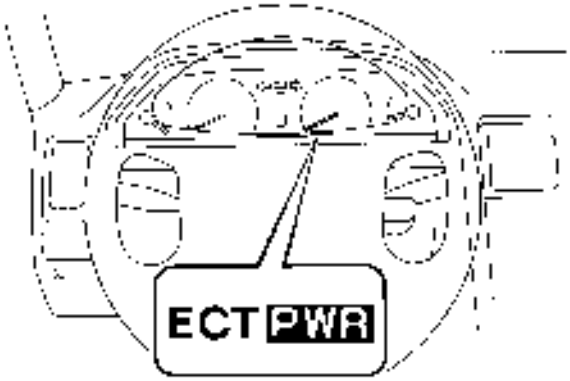
6. Construction and Operation of Main Components

Driving Pattern Select Switch and Indicator Light

Two shift modes (Normal and Power) are programmed in the ECU and one of these modes is selected according to a signal selected by the driving pattern select switch. The switch is located in the shift lever plate. When the POWER mode is selected, an indicator light goes on inside the combination meter.



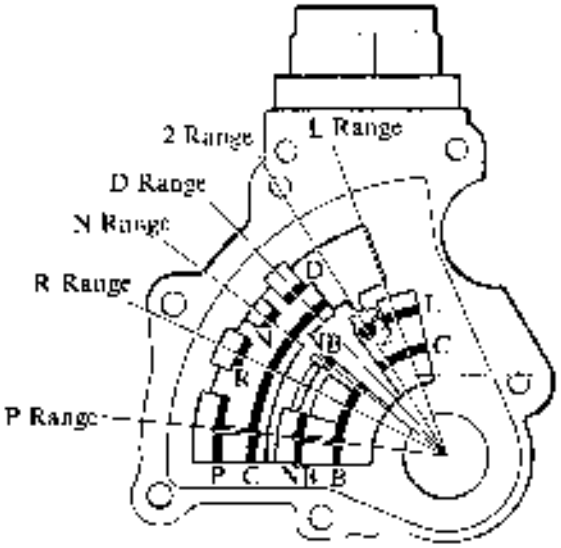
Pattern Select Switch



Indicator Light

Neutral Start Switch

The neutral start switch informs the ECU of the transmission shift lever position. If terminal R, 2 or L are electrically connected to terminal C, the ECU judges that the transmission is in either the R, 2 or L range, respectively. When the shift lever is shifted to the P or N range, terminals B and NB are electrically connected and an NSW signal is sent to the ECU. When terminals R, 2 or L and C or terminals B and NB are not electrically connected, the ECU judges that the shift lever is in the D range.



The connection of each contact is as shown in the following table:

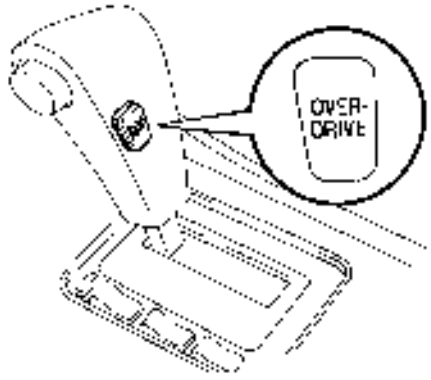
Terminal / Shift Position	For Neutral Starting		For Detection of Shift Lever Position						
	B	NB	C	P	R	N	D	2	L
P	⊙	⊙	○—○						
			⊙	⊙					
R	⊙	⊙	○		○				
N			○			○			
D			○				○		
2			⊙					⊙	
L			⊙						⊙

○—○ : Indicates that terminals are electrically connected.

OD (Overdrive) Switch and Indicator Light

The OD switch is built into the shift lever knob. Depressing this switch shifts the transmission to the OD gear. Depressing it again (pushed out) prohibits shifting to the OD gear and turns on the O/D OFF indicator light on the combination meter.

The O/D OFF indicator light blinks and warns when a malfunction is detected by a self–diagnosis. See page 204 for details.



OD Switch

Indicator Light

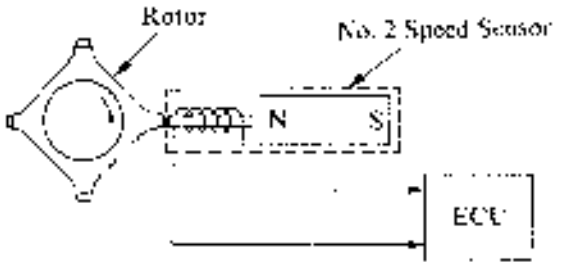
No. 2 Speed Sensor (Main Sensor)

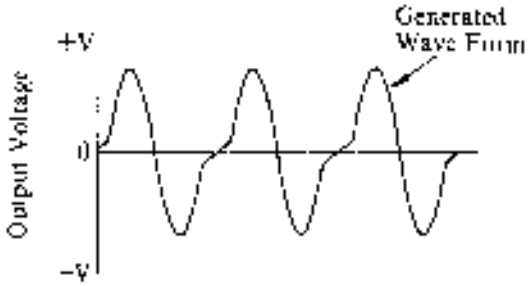
The No. 2 speed sensor is fitted to the transmission extension housing and detects the rotation speed of the transmission output shaft.

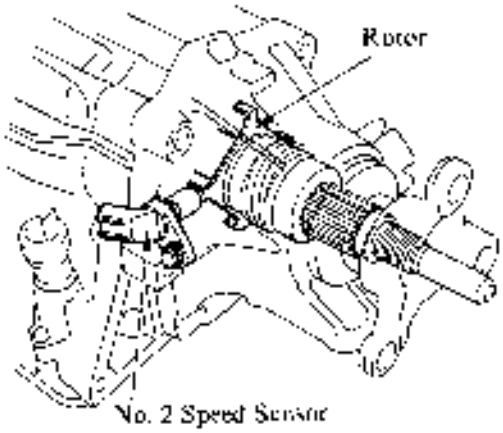
This sensor consists of a permanent magnet, coil and yoke. A rotor having four teeth is installed to the transmission output shaft and rotates as a unit.

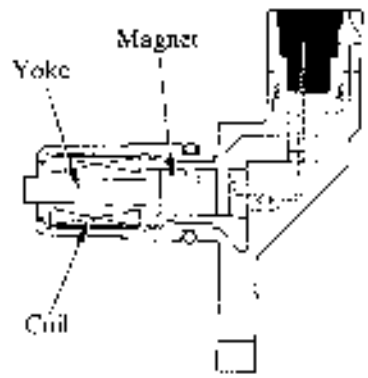
When the transmission output shaft rotates, the clearance between the yoke (front end) and the rotor decreases and increases because of the teeth. Accordingly, the number of lines of magnetic force passing through the yoke increases or decreases, and the AC voltage is generated in the coil.

The frequency of this AC voltage is proportional to the speed of the rotor and is used to detect the vehicle speed.



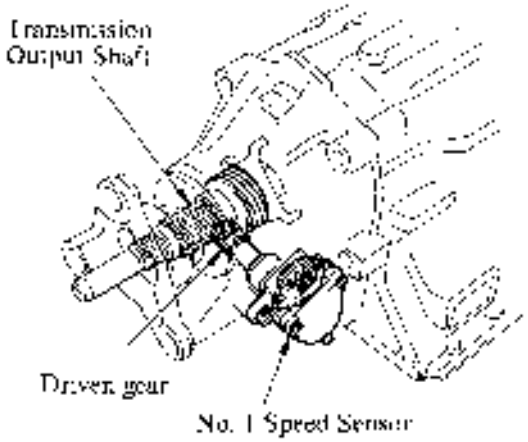






No. 1 Speed Sensor (Back–Up Sensor)

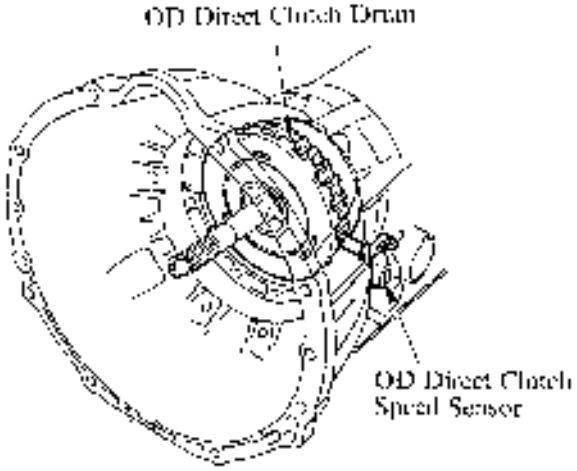
The No. 1 speed sensor generates twenty signals per one rotation of the rotor shaft which is driven by the transmission output shaft via the driven gear. The frequency of the signals is converted to four signals per one rotation of rotor shaft by the pulse conversion circuit in the speedometer. In the ECT–i, this sensor is used as a back–up sensor in case of malfunction of the No. 2 speed sensor. For more details about this sensor, refer to the speedometer section on page 405.



OD Direct Clutch Speed Sensor

This sensor is fitted to the transmission case. It detects revolution of the OD input shaft from 1st through 3rd gears based on revolution of the OD direct clutch drum.

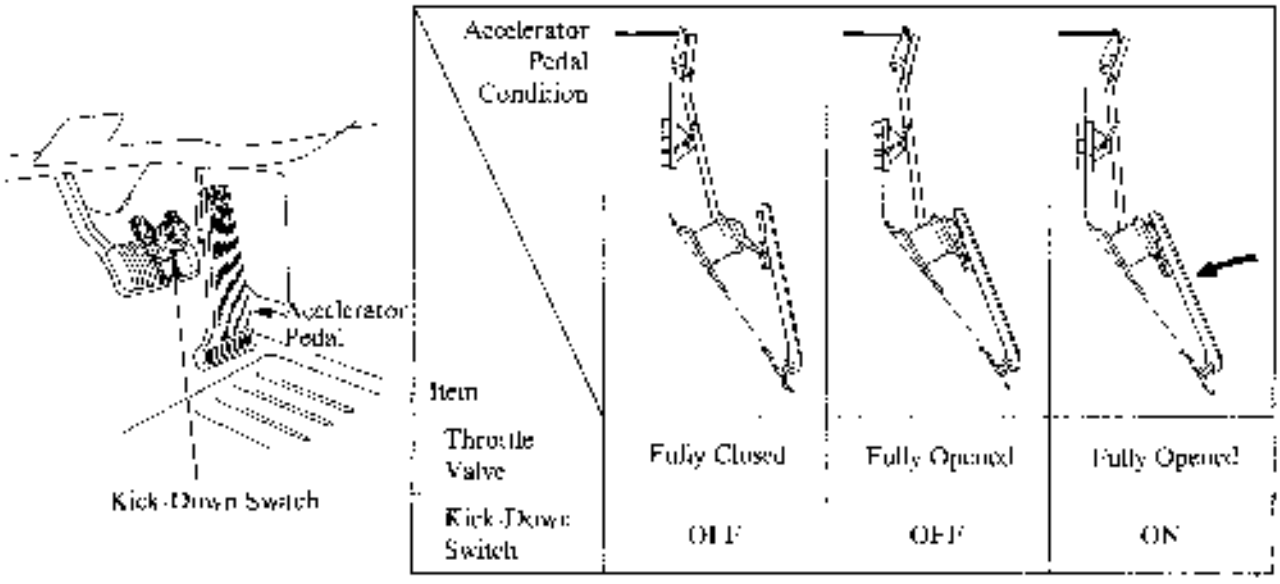
This sensor is constructed and operates the same way as the No. 2 speed sensor.



Kick–Down Switch

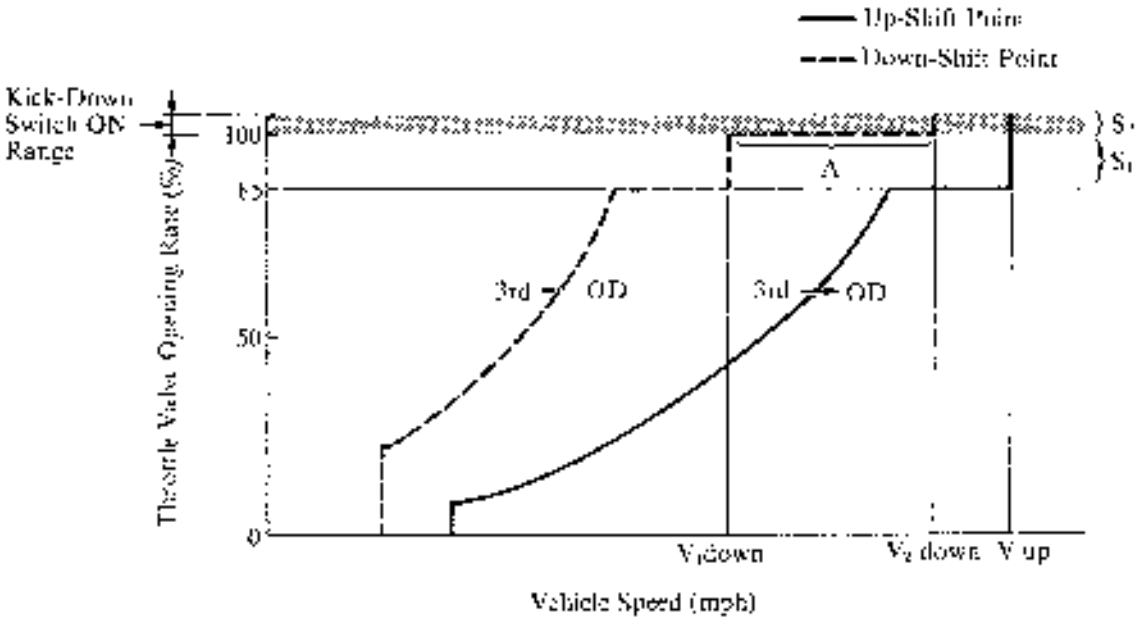
1) Function

The kick–down switch is fitted to the floor panel directly under the accelerator pedal. When the accelerator pedal is depressed beyond the full–throttle opening, the pedal presses and thus turns on the kick–down switch. The accelerator pedal is designed in such a way that a greater pedal effort is necessary to activate the kick–down switch than to depress the pedal to the full–throttle position. When the kick–down switch is turned on, the ECU controls gear shifting according to programmed shift diagrams.



2) Operation of Gear Shift Change

The engine and transmission ECU controls the No. 1 and No. 2 shift control solenoid valves to turn them on and off based on the signals from the throttle position sensor, kick–down switch and vehicle speed sensor.



a. S_1 Range (Throttle Valve Opening 85% or more, Kick–Down Switch OFF)

When the vehicle is running in S_1 range, the gear is shifted to the OD gear when the vehicle reaches the V up speed. The kick–down switch to the 3rd gear is not allowed even if the throttle valve opening is changed. Down–shifting to the 3rd gear is made as soon as the vehicle speed drops to the V_1 down speed.

b. S_2 Range (Throttle Valve Opening 100% or more, Kick–Down Switch ON)

When the vehicle is running in S_2 range, up–shifting to the OD gear is made when the vehicle reaches the V up speed and kick–down to the 3rd gear is not allowed. Down–shifting to the 3rd gear is made as soon as the vehicle speed drops to the V_2 down speed.

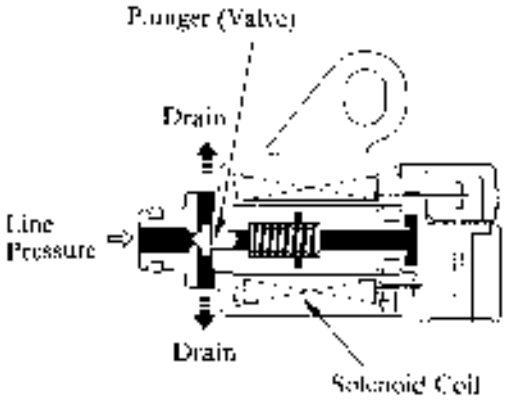
c. When the accelerator pedal is depressed S_1 to S_2

When the accelerator pedal is further depressed and the kick–down switch is turned on, the gear can be kicked down from the OD gear to the 3rd gear if the vehicle speed falls within the range “A” from the V up speed or more in the diagram.

In this way, kick–down from the OD gear to the 3rd gear is prohibited when the vehicle is running at a high speed with the throttle valve opening more than 85%.

Nos. 1 and No. 2 Solenoid Valves (For Shift Control)

Nos. 1 and 2 solenoid valves are fitted to the transmission valve body. The ECU controls ON–OFF combinations of these valves to regulate transmission gear shifting. The valve ON–OFF combination for each gear shifting is shown in the table below. When the plunger is pulled by the electromagnetic force of the solenoid coil to the right in the drawing below, this opens the valve and allows line pressure to drain.



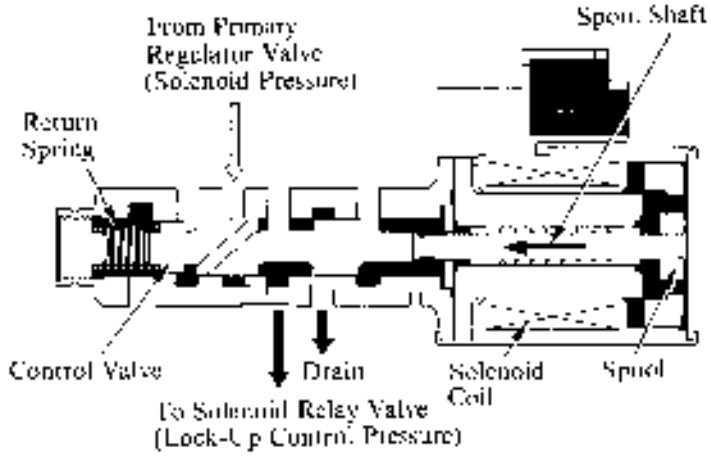
No. 1 Solenoid	ON	ON	OFF	OFF
No. 2 Solenoid	OFF	ON	ON	OFF
Shift Range				
D	1st	2nd	3rd	OD
2	1st	2nd	3rd	3rd*
L	1st	2nd	2nd*	1st*

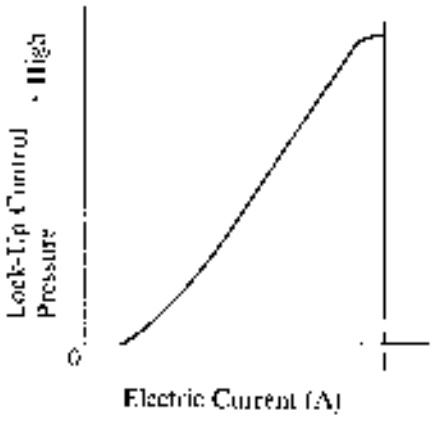
*: When a malfunction has occurred in the solenoid valve.

No. 3 Solenoid Valve (For Lock–Up Control Pressure Modulation)

The No. 3 solenoid valve is fitted to the transmission valve body. In accordance with the amount of current sent from the ECU to the solenoid coil, the No. 3 solenoid valve modulates solenoid pressure into lock–up control pressure acting on the lock–up relay valve and the lock–up control valve via the solenoid relay valve. The current flow to the solenoid coil is controlled by the ON–OFF ratio (duty ratio) of the signal output from the ECU. It varies in direct proportion to the ON ratio per cycle. The solenoid valve and control valve operate as follows:

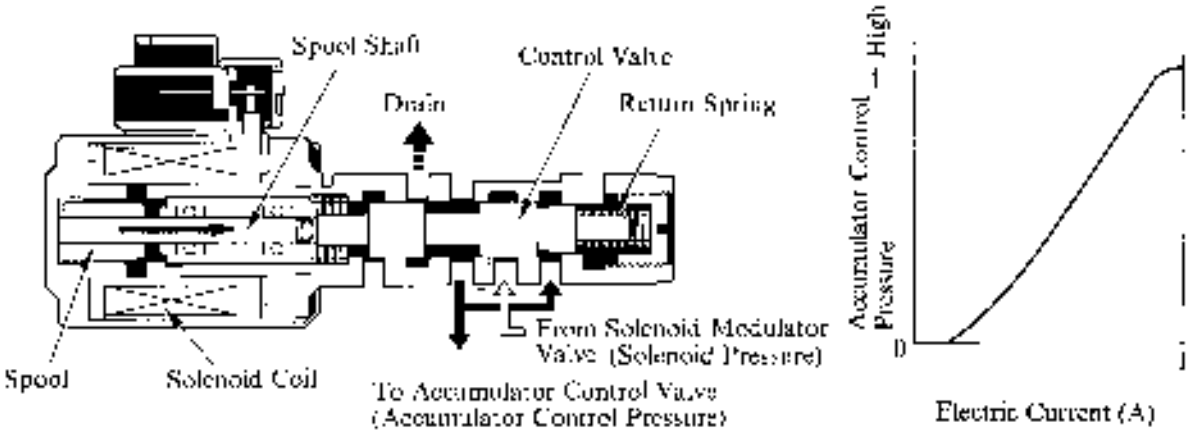
The current flow to the solenoid coil generates a magnetic field which pulls the spool in the coil center direction. The control valve which is constantly pushed against the spool shaft by a spring, also moves toward the coil center together with the spool. At this point, the tension balance of the return spring at the end of the control valve modulates the solenoid pressure from the solenoid modulator valve into lock–up control pressure.





No. 4 Solenoid Valve (For Accumulator Back Pressure Modulation)

The No. 4 solenoid valve is fitted to the transmission valve body. In accordance with the amount of current sent from the ECU to the solenoid coil, the No. 4 solenoid valve modulates solenoid pressure into accumulator control pressure acting on the accumulator control valve in the valve body. The accumulator control valve modulates accumulator back pressure acting on the accumulator back pressure chamber according to the pressure. The No. 4 solenoid valve is constructed and operates the same way as the No. 3 solenoid valve.



7. Function of the ECU

The ECU receives signals from various sensors and determines a proper shift and lock–up timing accordingly. In addition, it regulates the hydraulic pressure for gear shifting and lock–up operation to make them smoother.

It also has a built–in diagnostic function and fail–safe function.

Shift and Lock–Up Timing Control

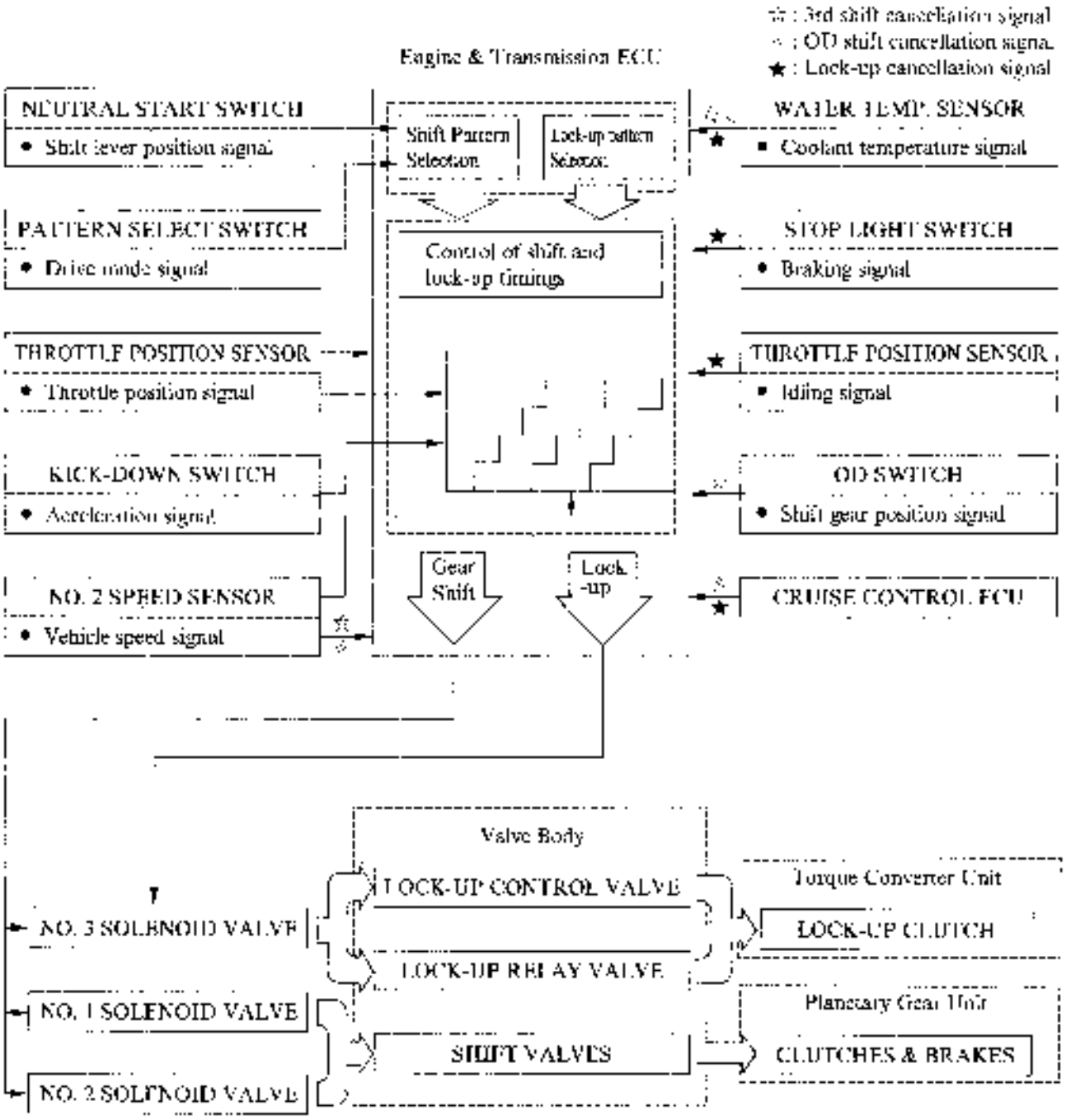
1) Outline

The ECU has programs in its memory, optimum transmission shift and lock–up patterns for the pattern select switch and transmission shift lever positions.

In the shift control, the ECU turns Nos. 1 and 2 shift control solenoid valves on and off based on the throttle position signal, which is received from the throttle position sensor and kick–down switch, and the vehicle speed signal received from the No. 2 (or No. 1) speed sensor. In this manner, the ECU operates each shift valve to open or close fluid passages to the clutches and brakes to permit up–shifting or down–shifting.

In the lock–up clutch control, the ECU operates lock–up control solenoid valve based on the throttle position signal, vehicle speed signal and gear shift position. By the solenoid valve operation, the lock–up relay valve and lock–up control valve switch fluid passages of the converter pressure acting on the torque converter to engage or disengage the lock–up clutch.

2) Block Diagram



3) 3rd Gear Shift Prohibit Control

When the engine coolant temperature and the vehicle speed are below 95°F (35°C) and 25 mph (40 km/h) respectively at the same time, shifting to the 3rd gear is prohibited to maintain good drivability.

RELEVANT SIGNALS

- Coolant temperature (THW)
- Vehicle speed (SP_2)

4) OD Gear Shift Prohibit Control

Overdrive is possible only when the OD switch is on (pushed in) and the transmission shift lever is in the "D" range. When the vehicle is cruising in the OD gear with the cruise control system activated, and if the actual vehicle speed drops about 5 mph (8 km/h) below the cruise control set speed, the cruise control ECU sends a signal to the engine and transmission ECU and suspends the OD gear shifting until the vehicle speed increases again to the cruising speed setting memorized in the ECU.

Up–shifting to the OD gear is prohibited also when the coolant temperature is below 140°F (60°C) and the vehicle speed is below 37 mph (60 km/h) in order to maintain good drivability.

RELEVANT SIGNALS

- OD switch position (OD_2)
- Cruise control system (OD_1)
- Coolant temperature (THW)
- Vehicle speed (SP_2)
- Transmission shift position (NSW, R, 2, L)

5) Lock–Up Operation Prohibit Control

Whenever any of the following conditions are met, the ECU turns the lock–up control solenoid valve off and disengages the lock–up clutch:

i) The stop light switch comes on (brake pedal is depressed).

ii) The IDL points of the throttle position sensor are closed (accelerator pedal is fully released) except for during operation of the cruise control system.

iii) During cruising, the vehicle speed drops 5 mph (8 km/h) or more below the cruise control setting speed.

iv) The coolant temperature is below 140°F (60°C) and the vehicle speed is below 37 mph (60 km/h).

The purpose of i) and ii) above is to prevent the engine from stalling if the rear wheels lock up.

The purpose of iii) is to cause the torque converter to operate to obtain torque multiplication.

The purpose of iv) is to maintain drivability.

Engine Torque Control

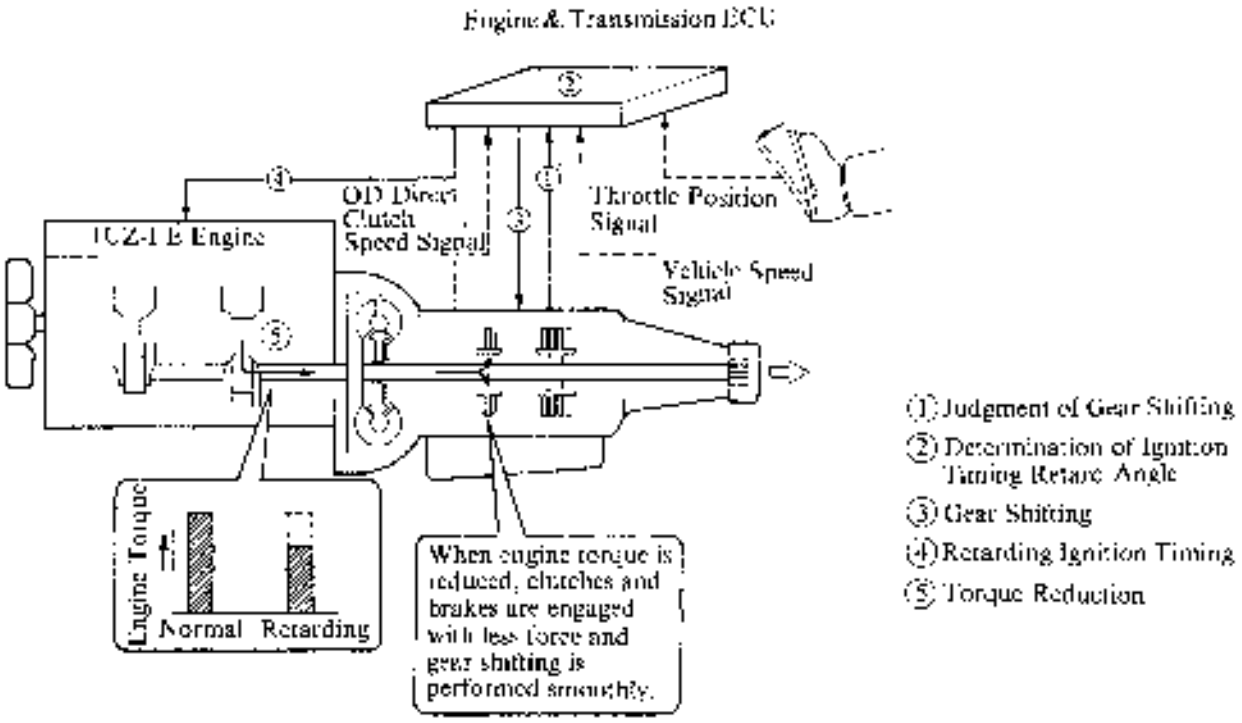
Engagement of the clutches and brakes of the planetary gear unit in the transmission is controlled smoothly by momentarily retarding the engine ignition timing when gears are shifted up or down in the transmission.

When the ECU judges a gear shift timing according to signals from various sensors, it activates the shift control solenoid valves to perform gear shifting. When the gear shifting starts, the ECU retards the engine ignition timing to reduce the engine torque. As a result, engagement force of the clutches and brakes of the planetary gear unit is weakened and the gear shift change is performed smoothly.

RELEVANT SIGNALS

- Vehicle speed (SP_2)
- OD direct clutch speed (N_{CO})
- Throttle position (S_1, S_2)
- Coolant temperature (THW)
- Battery voltage (+B)

An outline of the engine torque control is illustrated below. For more details about the ignition timing control, refer to the ESA (Electronic Spark Advance) section on page 133.



Lock–Up Pressure Control

Lock–up control is performed by electronically controlling the lock–up control valve which modulates the engagement pressure acting on the lock–up clutch, and lock–up pressure which activates the lock–up relay valve that switches engagement and disengagement of the clutch. As a result, these valves are activated gradually and smooth engagement and disengagement are performed.

Lock–up pressure control is performed by changing the duty signal to the No. 3 solenoid valve which is sent to the valve body from the ECU. When the ECU, according to the memorized lock–up pattern selected based on the gear shift position and throttle valve opening angle, implements lock–up ON or OFF, it changes the duty ratio of the signals to the solenoid valve, and engages or disengages the clutch smoothly.

However, the clutch is disengaged immediately when the foregoing lock–up prohibit conditions are present while the lock–up clutch is engaged.

RELEVANT SIGNALS

- Throttle position (V_{TA}, IDL)
- Stop light switch (STP)
- Cruise Control System(OD_1)
- Coolant temperature (THW)
- Vehicle speed (SP_2)

Accumulator Back Pressure Control

During gear shifting, the accumulator temporarily accumulates the line pressure according to a difference between the line pressure (which acts on the operation chamber of the piston and engages the clutches and brakes of the planetary gear unit) and the accumulator back pressure acting on the back pressure chamber. The accumulator then gradually applies the stored line pressure to the clutches and brakes to perform gear shifting smoothly. In the A341E automatic transmission, the accumulator back pressure that acts on the back pressure chamber is controlled electronically. Therefore, gear shifting is performed smoothly regardless of a fluctuation in the engine torque or a change in the friction characteristics.

The accumulator back pressure is controlled by the No. 4 solenoid valve fitted to the valve body. The solenoid valve itself is controlled by the ECU changing the duty ratio to the valve according to the gear shifting mode, the throttle valve opening angle, the OD direct clutch drum speed and the vehicle speed.

RELEVANT SIGNALS

- Throttle position (V_{TA})
- OD direct clutch drum speed (N_{CO})
- Vehicle speed (SP_2)

Self–Diagnosis

1) Outline

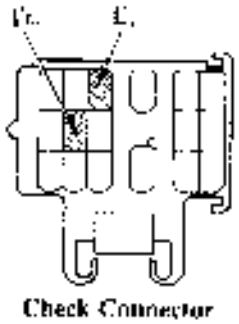
The ECU constantly monitors sensors, actuators and the ECU itself, and detects and warns that a malfunction has occurred. The A341E automatic transmission has two self–diagnosis functions; an on–board self–diagnosis and an off–board self–diagnosis function. In the on–board self–diagnosis, when a malfunction in the system has occurred, the ECU blinks the O/D OFF indicator light on the combination meter and displays the section of the malfunction by code No(s). In the off–board diagnosis, the ECU diagnoses operation of sensors and actuators, converts the check results into voltage, and outputs them to terminal T_T of the TDCL (Total Diagnostic Communication Link).

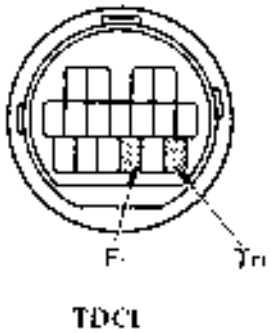
2) On–Board Diagnosis

When the ECU detects an open or short circuit in the speed sensors or solenoid valve circuits, it blinks the O/D OFF indicator light to alert the driver. At the same time, the ECU stores the malfunction in the form of a code number in its memory. The ECU memory is maintained by a back–up power supply.

The malfunction codes will be displayed by the O/D OFF indicator light by turning the ignition switch ON and connecting the T_{E1} and E_1 terminals of the check connector or TDCL.

NOTE: When the OD switch is OFF, the O/D OFF indicator light does not blink. The OD switch must be in the ON position.



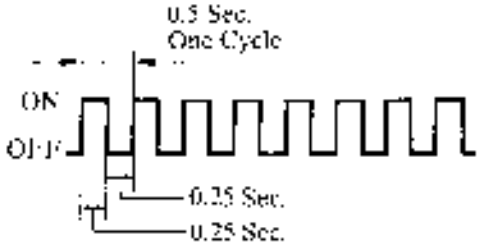


Diagnostic Result

A diagnostic result is indicated by the blinking of the O/D OFF indicator light shown below.

- **Normal**

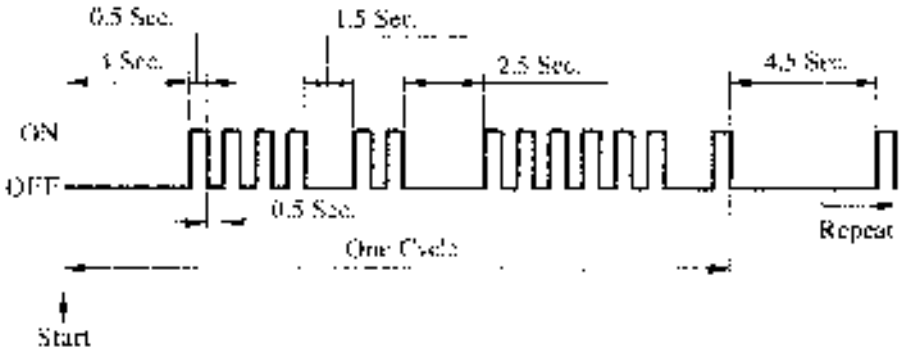
  The light will flash 2 times per second as shown on the right.



- **Indication of Malfunction**

The appropriate diagnostic code(s) will be indicated by the light as shown below. In this case, codes 42 and 61 are indicated.

If two or more malfunctions are indicated at the same time, the lowest–numbered diagnostic code will be displayed first.



▶Diagnostic Code◀

Code No.	Diagnosis	Trouble Area
42	No. 1 speed sensor signal malfunction	• Wire harness and connector of No. 1 speed sensor • No. 1 speed sensor • Speedometer • ECU
46	Open or short circuit in No. 4 solenoid valve	• Wire harness and connector of No. 4 solenoid valve • No. 4 solenoid valve • ECU
61	No. 2 speed sensor signal malfunction	• Wire harness and connector of No. 2 speed sensor • No. 2 speed sensor • ECU
62	Open or short circuit in No. 1 solenoid valve	• Wire harness and connector of No. 1/No. 2 solenoid valve • No. 1/No. 2 solenoid valve • ECU
63	Open or short circuit in No. 2 solenoid valve	
64	Open or short circuit in No. 3 solenoid valve	• Wire harness and connector of No. 3 solenoid valve • No. 3 solenoid valve • ECU
67	OD direct clutch speed sensor signal malfunction	• Wire harness and connector of OD direct clutch speed sensor • OD direct clutch speed sensor • ECU
68	Short circuit in kick–down switch	• Wire harness and connector of kick–down switch • Kick–down switch • ECU

NOTE:
- Malfunctions with code No. 64 and No. 68 are not indicated to the driver. But the code numbers are stored in the memory.
- If a malfunction returns to normal, the O/D OFF indicator light stops blinking and the light goes off. The malfunction code No(s)., however, is stored in the memory until it is cleared by the following method:
- Malfunction code No. in the ECU memory can be cleared by removing the EFI fuse for 10 seconds or longer.

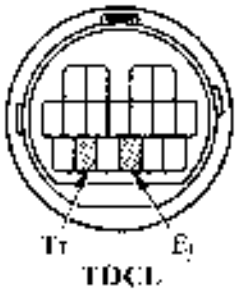
3) Off–Board Diagnosis

By connecting a volt/ohmmeter to the T_T and E_1 terminals and measuring the voltage, the following part and functions can be checked:

- Throttle position sensor
- Brake signal
- Shift timing

NOTICE

Use a volt/ohmmeter with a high–impedance (10 kΩ/V minimum).



a. Checking Throttle Position Sensor

If the accelerator pedal is depressed from the fully closed to the fully open position when all the conditions shown at right are satisfied, the ECU outputs voltages to the T_T terminal in 1V steps from 0V to 8V.

CONDITIONS

- Vehicle halted
- Ignition switch on
- Brake light switch off (brake pedal not depressed)

b. Checking Brake Signal

When all conditions shown at right are satisfied, the ECU outputs 8V to the T_T terminal when the stop light switch is off (brake pedal is not depressed) and outputs 0V to the T_T terminal when the stop light switch is on (brake pedal is depressed).

CONDITIONS

- Vehicle halted
- Ignition switch on
- Accelerator pedal fully depressed

c. Check Shift Timing

If the condition shown at right is satisfied while the vehicle is being driven, voltages corresponding to the gear position and lock–up clutch operation are output to the T_T terminal as shown in the table at right.

CONDITIONS

Vehicle speed more than 6 mph (10 km/h).

Gear	1st	2nd	3rd		OD	
Lock–up	—	OFF	OFF	ON	OFF	ON
Voltage	0	2	4	5	6	7

Fail–Safe

The fail–safe function allows the vehicle to be driven even with a malfunction in the sensors or solenoid valves.

1) Shift Control Solenoid Valve Malfunction

If either No. 1 or No. 2 solenoid valve malfunctions, the ECU can still control the transmission by operating the remaining solenoid to shift the transmission in a gear that will allow the vehicle to be operated.

For example, if No. 1 solenoid valve malfunctions while the vehicle is running in 1st gear with the transmission in the “D” range, the fail–safe function causes the transmission to shift into 3rd gear. Furthermore, if both solenoid valves malfunction, the driver can still safely drive the vehicle by operating the shift lever manually.

Range	Normal			No. 1 Solenoid Malfunctioning			No. 2 Solenoid Malfunctioning			Both Solenoids Malfunctioning
	Solenoid Valve		Gear	Solenoid Valve		Gear	Solenoid Valve		Gear	Gear when shift selector is manually operated
	No. 1	No. 2		No. 1	No. 2		No. 1	No. 2		
D	ON	OFF	1st	x	ON	3rd	ON	x	1st	OD
	ON	ON	2nd	x	ON	3rd	OFF	x	OD	OD
	OFF	ON	3rd	x	ON	3rd	OFF	x	OD	OD
	OFF	OFF	OD	x	OFF	OD	OFF	x	OD	OD
2	ON	OFF	1st	x	ON	3rd	ON	x	1st	3rd
	ON	ON	2nd	x	ON	3rd	OFF	x	3rd	3rd
	OFF	ON	3rd	x	ON	3rd	OFF	x	3rd	3rd
L	ON	OFF	1st	x	OFF	1st	ON	x	1st	1st
	ON	ON	2nd	x	ON	2nd	ON	x	1st	1st

x: Malfunctions

2) Vehicle Speed Sensor Malfunction

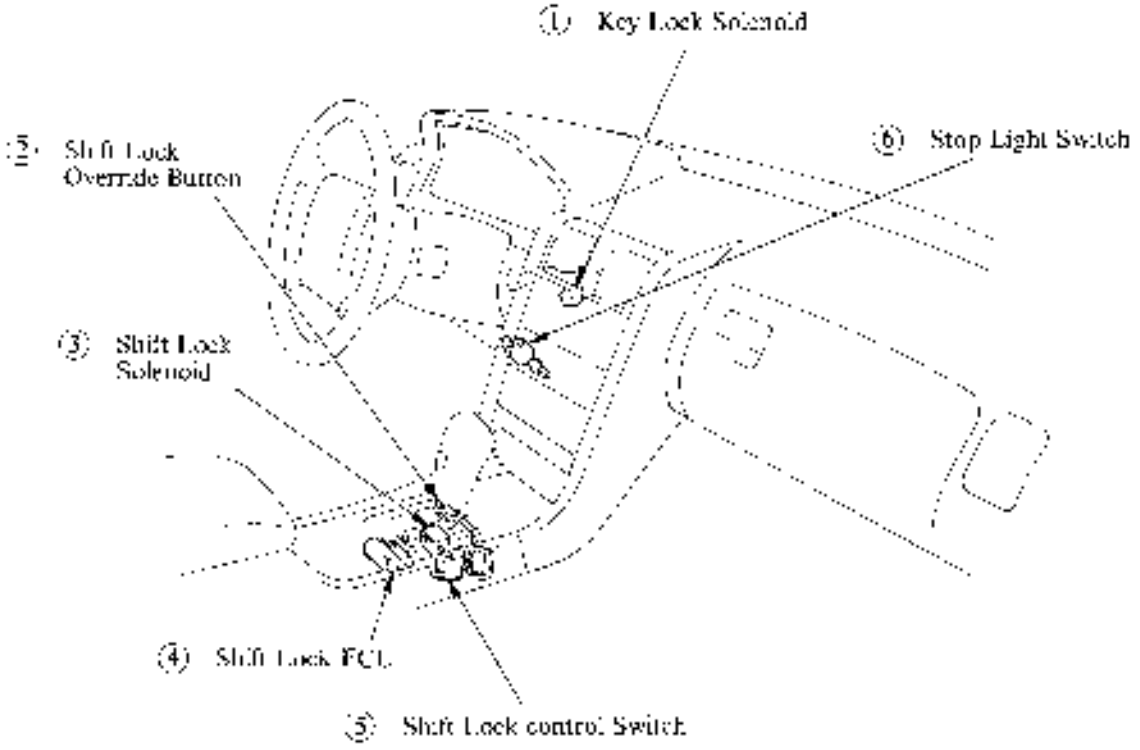
There are two vehicle speed sensors: a main sensor (No. 2) and a back–up sensor (No. 1). Consequently, even if the main sensor malfunctions, the ECU can continue to operate normally by keeping itself informed of the vehicle speed by the use of the signals from the back–up sensor (No. 1). If both vehicle speed sensors No. 1 and No. 2 malfunction and no signals are sent to the ECU, the ECU is programmed to detect this as a vehicle speed 0 mph (0 km/h) and causes the transmission to shift into 1st gear, but not to shift into other gears.

■ SHIFT LOCK SYSTEM

1. General

To minimize the possibility of incorrect operation of automatic transmissions, a shift lock system is incorporated. Unless the driver is depressing the brake pedal, it prevents the shift lever shifting from "P" to other ranges. A key interlock device is also incorporated. The ignition key cannot be removed unless the shift lever is set in "P" range.

2. Layout of Components



3. Function of Components

No.	Component	Function
①	Key Lock Solenoid	Restricts ignition key movement according to signals from shift lock ECU.
②	Shift Lock Override Button	Manually cancels shift lock mechanism when battery is discharged or in any other emergency condition.
③	Shift Lock Solenoid	Restricts shift lever movement according to signals from shift lock ECU.
④	Shift Lock ECU	Turns on and off shift lock and key lock solenoids according to shift lever and brake pedal conditions.
⑤	Shift Lock Control Switch	Detects shift lever position and shift lever button condition.
⑥	Stop Light Switch	Detects operating condition of brake pedal.

4. System Operation

The following describes operation condition of the shift lock mechanism and the key interlock device.

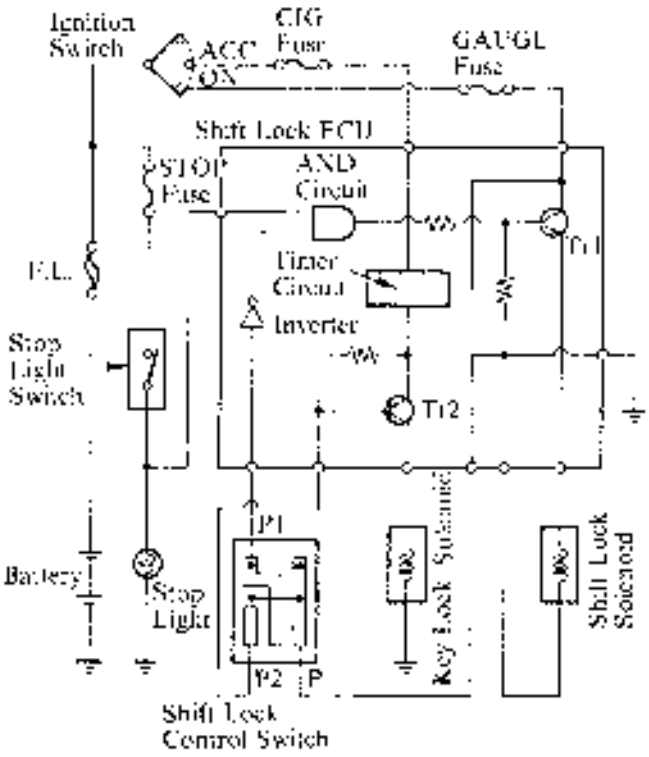
▶Shift Lock Mechanism◀

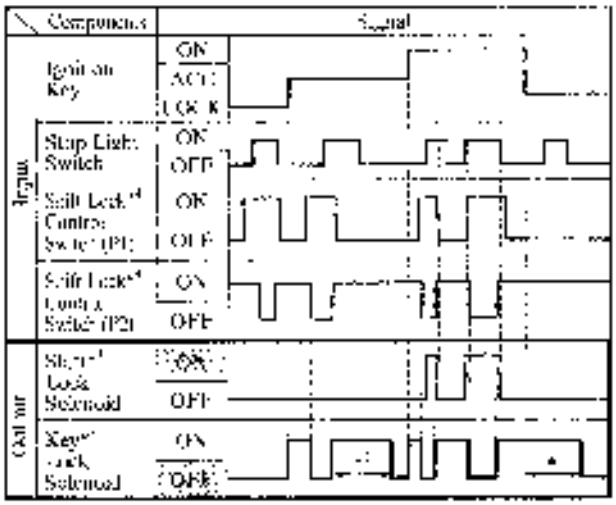
Condition / Item	Shift Lever Locked if (When shift lock solenoid is OFF)	Shift Lever Free if (When shift lock solenoid is ON)
Shift Lever (In "P" Range)	① Ignition switch in LOCK or ACC position or ② Stop light switch OFF (when brake pedal is not depressed)	① Ignition switch in ON position and ② Stop light switch ON (when brake pedal is depressed)

▶Key Inter Lock Device◀

Condition / Item	Will Not Turn to LOCK Position (When key lock solenoid is ON)	Will Turn to LOCK Position (When key lock solenoid is OFF)
Ignition Key (In a position other than LOCK)	① Shift lever in a range other than "P" range or ② Shift lever is in "P" range but shift lever button is depressed)	① Shift lever in "P" range and ② Shift lever button is not depressed

5. System Diagram and Input/Output Signal Characteristics of ECU





*1 The shift lever can be changed form "P" to any other range only when the shift lock solenoid is turned on.

*2 The ignition key can be turned on from "ACC" to "LOCK" positions when the key lock solenoid is turned off.

*3 When the ignition key is left in "ACC" position in any shift range other than "P" range, the key lock is released after about one hour.

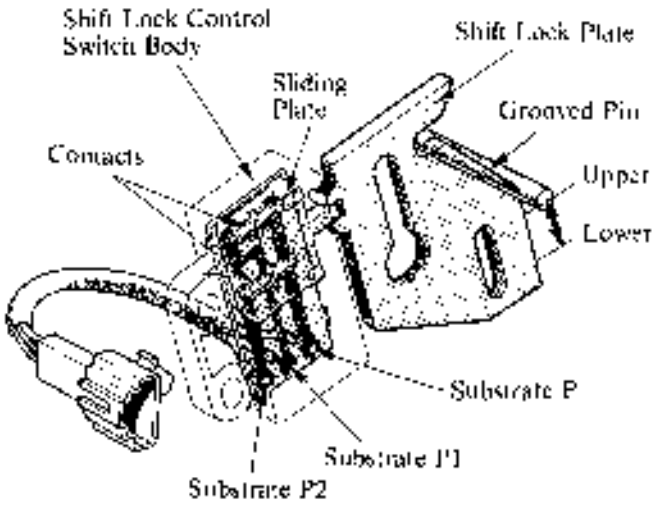
*4 When the shift lever button is not pushed in, P1 is ON and P2 is OFF.
When the shift lever button is pushed in fully, P1 is OFF and P2 is ON.

6. Construction and Operation

Shift Lock Control Switch

The shift lock control switch has a sliding plate that moves up and down to turn on and off the substrates (P and P1 or P and P2). By doing this, the switch detects the position of the shift lever and the shift lever button.

The sliding plate is connected to a shift lock plate and they move up and down as a unit. When the shift lever is in the “P” range, a grooved pin is meshed with the shift lock plate. The grooved pin moves up and down according to the movement of the shift lever button. The grooved pin comes off from the shift lock plate in ranges other than the “P” range, and the shift lock plate remains stopped at the lower position.



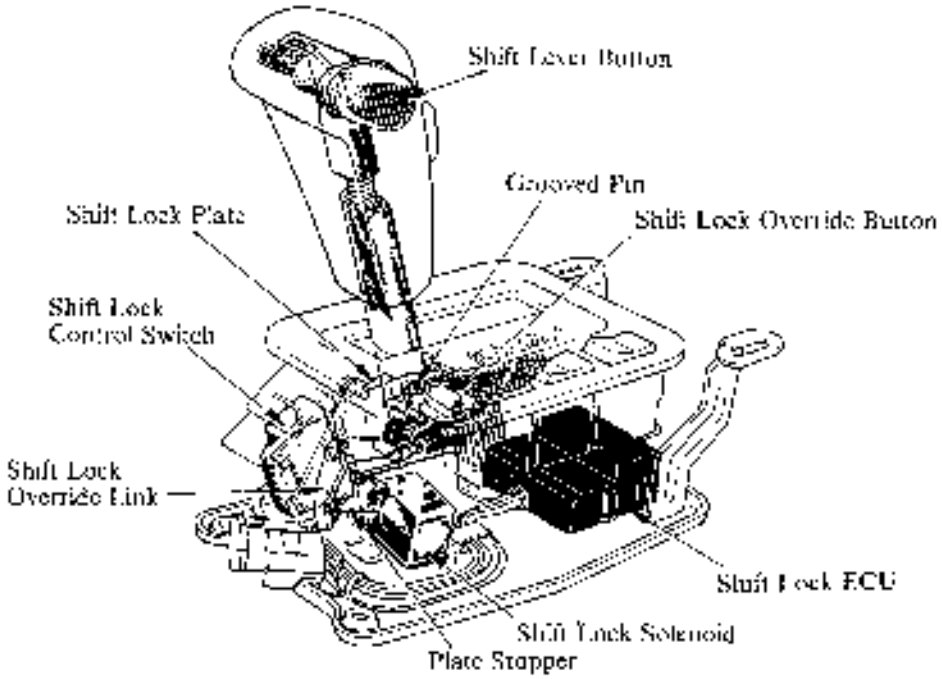
Shift Range / Control Switch		P*3	P*2	P*1	R	N	D	2	L
P and P1	ON								
	OFF								
P and P2	ON								
	OFF								

*1: When the shift lever button is not pushed in
*2: When the shift lever button is pushed half way.
*3: When the shift lever button is pushed in completely.

Shift Lock Mechanism

1) Construction

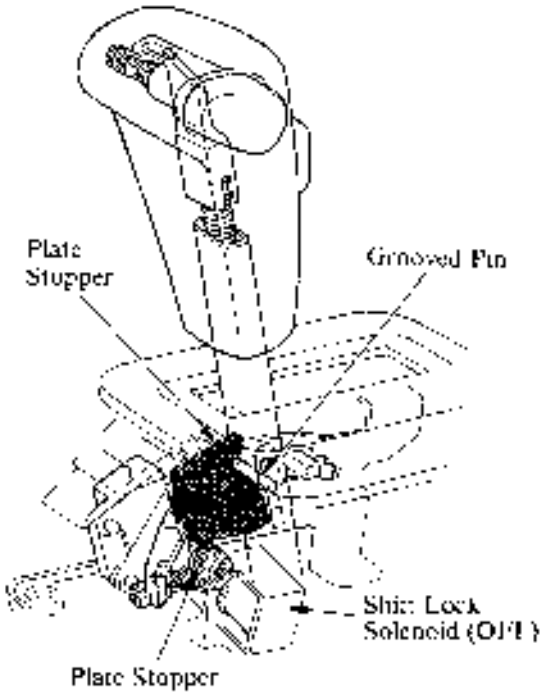
This mechanism is designed to prevent the shift lever from moving from “P” to other ranges unless the brake pedal is depressed. The plate stopper, which is interlocked with the shift lock solenoid, limits the movement of the shift lever.



2) Operation

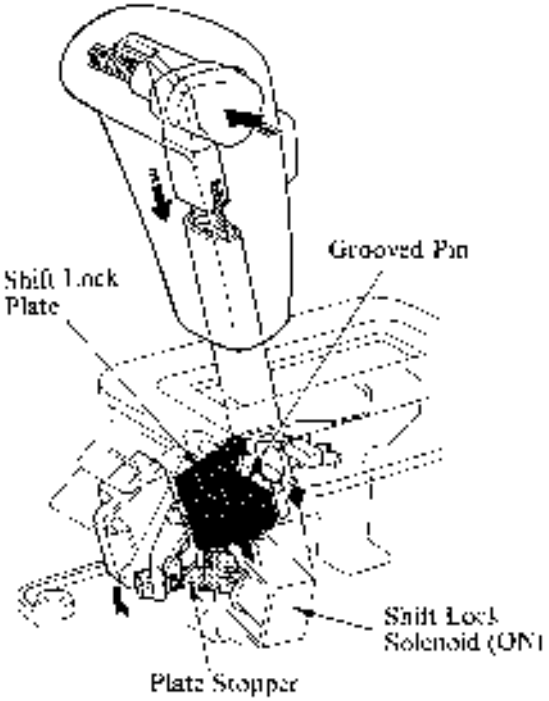
a. When the shift lever is in "P" range but brake pedal is not depressed (stop light switch is off).

In this condition, the shift lock solenoid is turned off regardless of the ignition switch position. Therefore, the plate stopper which is connected to the shift lock solenoid contacts the lower part of the shift lock plate and locks it. Since the grooved pin is engaged with the groove in the shift lock plate, the pin cannot go down. Therefore, the shift lever button cannot be fully pushed in and the shift lever cannot be moved to other ranges from the "P" range.



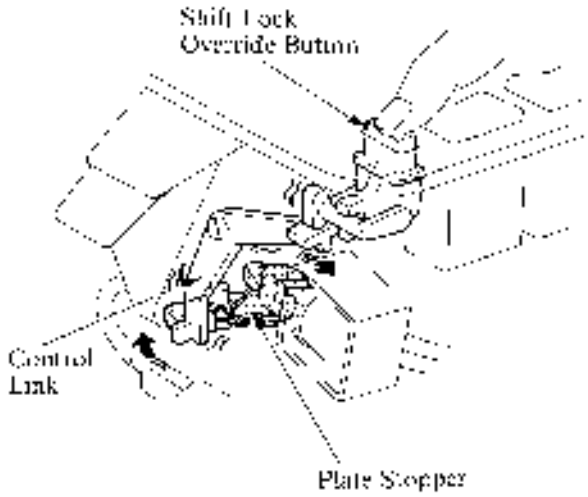
b. When the shift lever is in "P" range and brake pedal is depressed (stop light switch is on).

In this condition, the shift lock solenoid is turned on when the ignition switch is turned to ON position. Therefore, the plate stopper is disengaged from the shift lock plate and the grooved pin is allowed to move. As a result, the shift lever can be moved to other ranges from "P" range.



3) Shift Lock Override Button

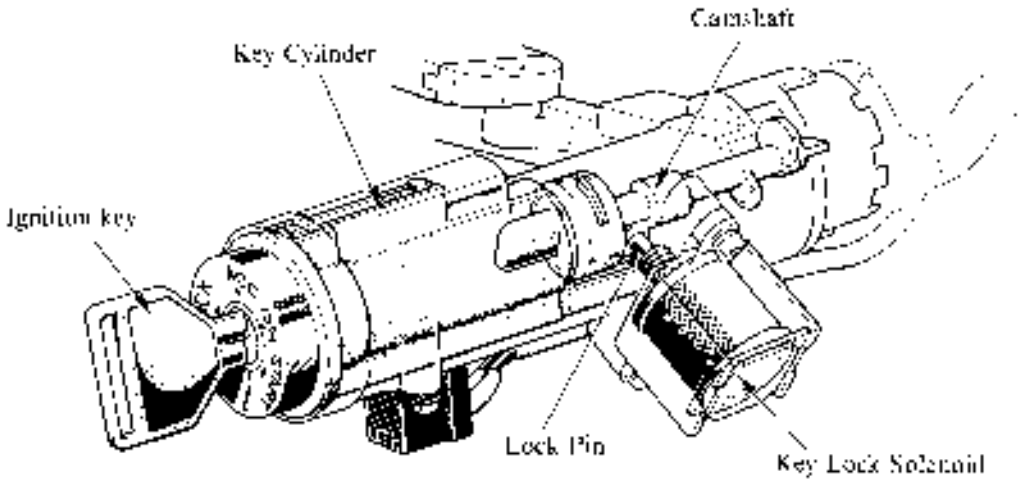
If the shift lock solenoid becomes inoperative due to a battery discharge, etc., the shift lever cannot be moved to any other range than "P" and the vehicle cannot be moved. In this case, the shift lock override button may be pressed to release the plate stopper from the shift lock plate and move the shift lever from "P" to other ranges.



Key Interlock Device

1) Construction

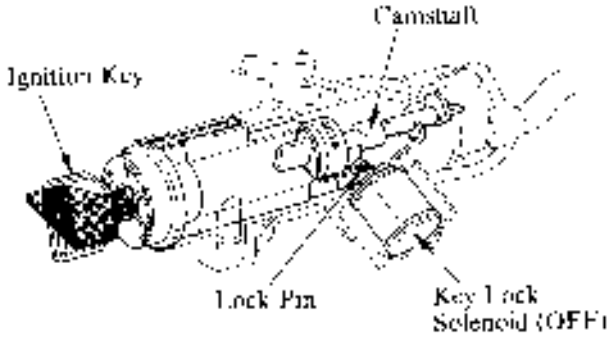
This device prevents the ignition key from being removed unless the shift lever is set in "P" range. The key lock solenoid, which is fitted to the steering lock body, pushes out the lock pin and engages it in the groove of the camshaft. The camshaft is located at the end of the key cylinder. The movement of the key cylinder is restricted as a result.



2) Operation

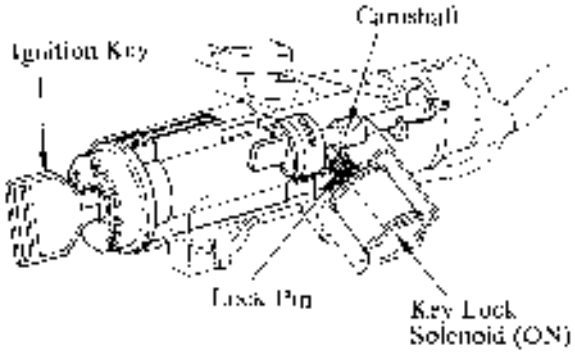
a. When the shift lever is in "P" range and the ignition key is in LOCK position.

In this condition, the shift lock solenoid is turned off and the ignition key can be turned from LOCK to ACC, ON and START positions. It is also possible to return it from ACC to the LOCK position.



b. When the shift lever is in a range other than "P" and the ignition key is in a position other than LOCK.

The shift lock control switches (P and P1 OFF, P and P2 ON) detect that the shift lever is in a range other than "P". Thus, the key lock solenoid goes on, pushing out the lock pin and engaging with the groove in the camshaft. As a result, the key cylinder cannot be turned to LOCK position.



c. Shifting from other range to "P" range.

When the shift lever is moved to "P" range, the grooved pin engages with an moves the shift lock plate upward, the shift lock control switch (P and P2) turns off. As a result, the lock solenoid turns off, the lock pin is disengaged from the groove in the camshaft, and the key cylinder can be turned from ACC to LOCK position.