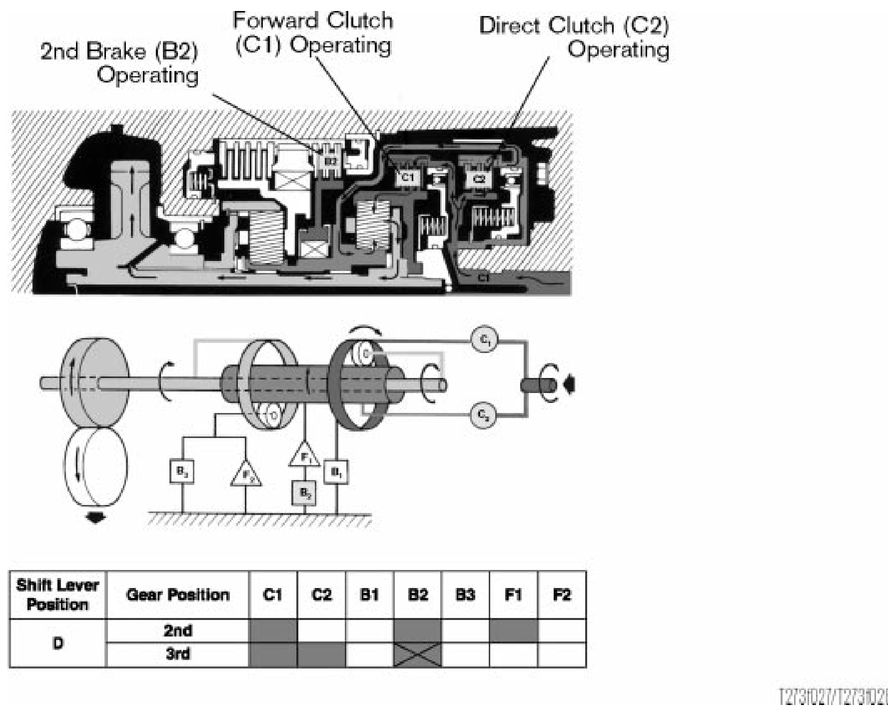
Section 1

Automatic Transmission Basics



Lesson Objectives

1. Describe the function of the torque converter.
2. Identify the three major components of the torque converter that contribute to the multiplication of torque.
3. Describe the operation of each major torque converter component.
4. Describe the operation of the lock-up mechanism of the torque converter.
5. Identify the three major components of the simple planetary gear set.
6. Describe the function of the simple planetary gear set to provide speed change, torque change and directional change.
7. Describe the operation of multi-plate clutches, brake bands and one-way clutches.
8. Describe the effect of centrifugal fluid pressure on the operation of a multi-plate clutch.
9. Given a clutch application chart and planetary gear model:
   a. identify which holding devices are applied for each gear range.
   b. identify the planetary gear components held for each gear range.
   c. use a process of elimination to determine the proper function of holding devices by testing it’s operation in another gear range.
   d. use parallel holding devices to narrow diagnosis to faulty clutch or brake.
10. Describe the difference between overdrive operation in the front wheel drive and rear wheel drive automatic transmissions.

Notes

Torque Converter Components

The torque converter provides an automatic means of coupling engine torque to the input shaft of the transmission. The torque converter's three major components are; the pump impeller, the turbine runner and the stator. The hydraulic fluid in the converter transfers torque through the kinetic energy of the transmission fluid as it is forced from the impeller to the turbine. The faster the engine rotates, the greater the torque applied to the turbine. At low engine speeds, the turbine can be held stationary as the force of the fluid's kinetic energy is not great enough to overcome the holding force of the light brake system application.

Torque Converter

Made of three major components; the pump impeller, turbine runner and the stator.

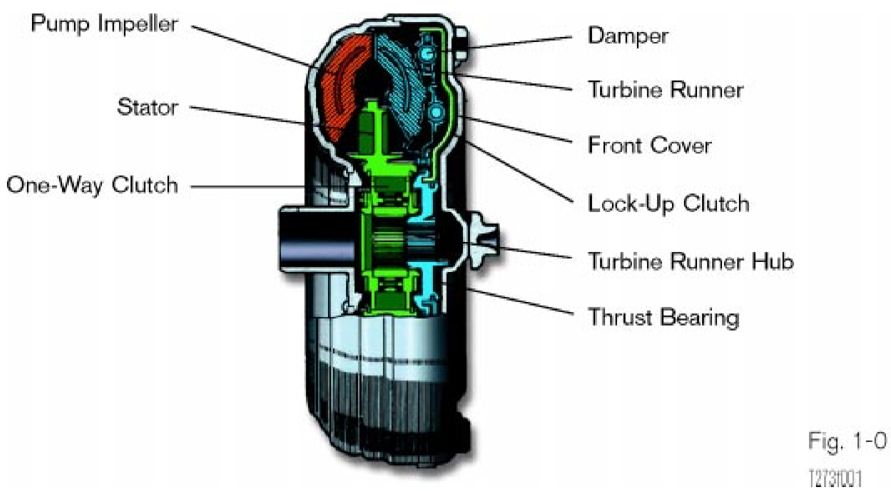


Fig. 1-01

Pump Impeller

The impeller is integrated with the torque converter case, with many curved vanes evenly spaced and mounted inside. A guide ring is installed on the inner edges of the vanes to provide a path for smooth fluid flow.

Torque Converter - Impeller

The impeller rotates whenever the engine is running, causing the fluid to flow outward toward the turbine.

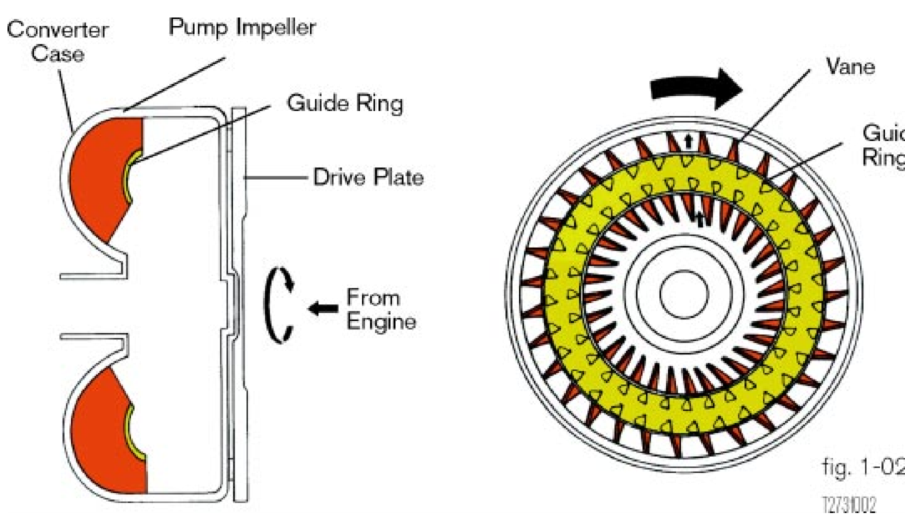


fig. 1-02

When the impeller is driven by the engine crankshaft, the fluid in the impeller rotates with it. When the impeller speed increases, centrifugal force causes the fluid to flow outward toward the turbine.

Turbine Runner

The turbine is located inside the converter case, but is not connected to it. The input shaft of the transmission is attached by splines to the turbine hub when the converter is mounted to the transmission. Many cupped vanes are attached to the turbine. The curvature of the vanes is opposite from that of the impeller vanes. Therefore, when the fluid is thrust from the impeller, it is caught in the cupped vanes of the turbine and torque is transferred to the transmission input shaft, turning it in the same direction as the engine crankshaft. A guide ring similar to the impeller is installed to the inner edge of the vanes.

Torque Converter - Turbine

Fluid is caught in the cupped vanes of the turbine and torque is transferred to the input shaft.

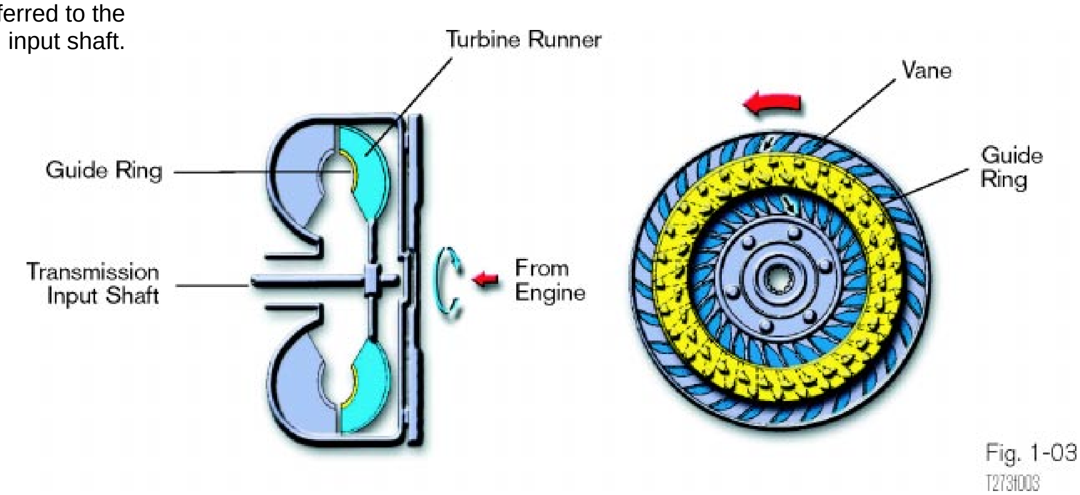


Fig. 1-03

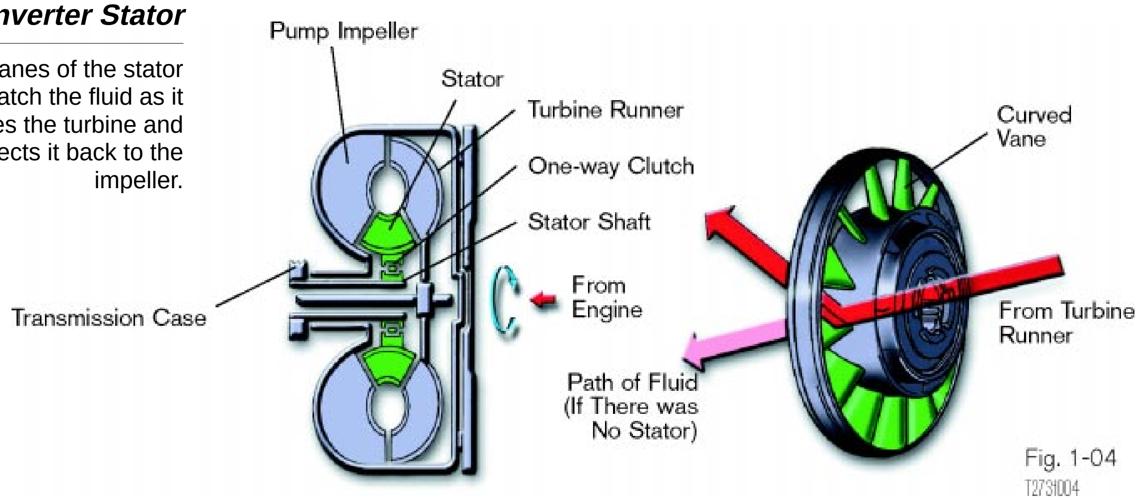
Stator

The stator is located between the impeller and the turbine. It is mounted on the stator reaction shaft which is fixed to the transmission case. The vanes of the stator catch the fluid as it leaves the turbine runner and redirects it so that it strikes the back of the vanes of the impeller, giving the impeller added boost or torque. The benefit of this added torque can be as great as 30% to 50%.

The one-way clutch mounted to the stator allows it to rotate in the same direction as the engine crankshaft. However, if the stator attempts to rotate in the opposite direction, the one-way clutch locks the stator to prevent it from rotating. Therefore, the stator is rotated or locked depending on the direction from which the fluid strikes against the vanes.

Torque Converter Stator

The vanes of the stator catch the fluid as it leaves the turbine and redirects it back to the impeller.



Converter Operation

When the impeller is driven by the engine crankshaft, the fluid around the impeller rotates in the same direction. As impeller speed increases, centrifugal force causes the fluid to flow outward from the center of the impeller and flows along the vane surfaces of the impeller. As speed increases further, fluid is forced out away from the impeller toward the turbine. The fluid strikes the vanes of the turbine causing it to rotate in the same direction as the impeller.

After the fluid dissipates its energy against the vanes of the turbine, it flows inward along the vanes of the turbine. When it reaches the interior of the turbine, the turbine's curved inner surface directs the fluid at the vanes of the stator. Fluid strikes the curved vane of the stator causing the one-way clutch to lock the stator and redirects fluid at the impeller vanes in the direction of engine rotation, increasing engine torque.

As the impeller and turbine approach the same speed, fluid strikes the back of the stator vanes, releasing the one-way clutch and allows the stator to freewheel. Unless the stator freewheels, being mounted to the transmission body, fluid will strike the vanes of the stator and limit engine rpm and upper engine performance.

Stator Operation

The stator one-way clutch locks the stator counterclockwise and freewheels clockwise.

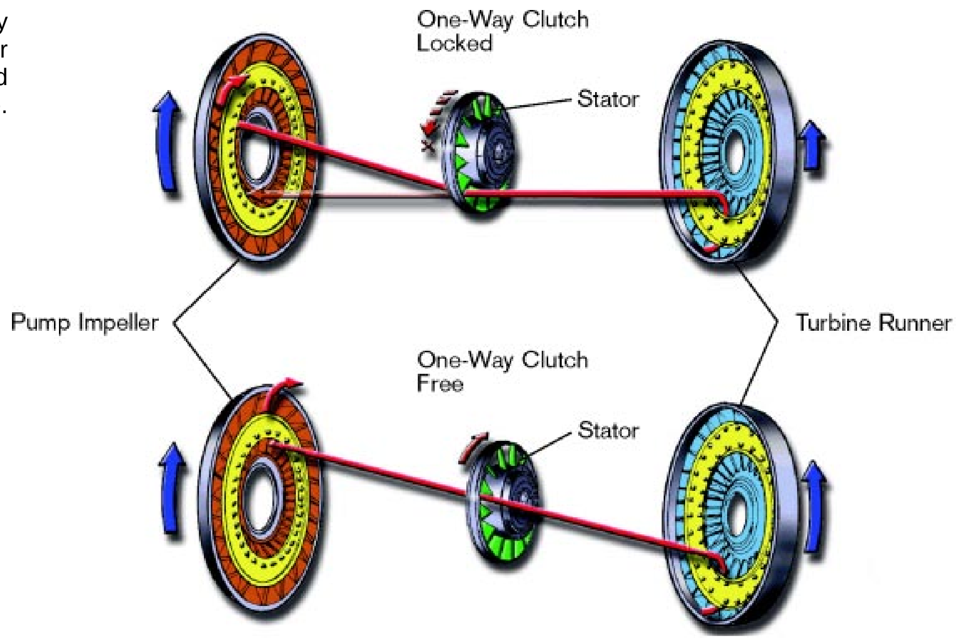


Fig. 1-05
T273f005

Converter Lock-Up Clutch

At lower vehicle speeds the torque converter provides multiple gear ratios when high torque is needed. As the impeller and the turbine rotate at nearly the same speed, no torque multiplication is taking place, the torque converter transmits the input torque from the engine to the transmission at a ratio of almost 1:1. There is, however, approximately 4% to 5% difference in rotational speed between the turbine and impeller. The torque converter is not transmitting 100% of the power generated by the engine to the transmission, so there is energy loss.

To reduce energy loss and improve fuel economy, the lock-up clutch mechanically connects the impeller and the turbine when the vehicle speed is about 37 mph or higher. When the lock-up clutch is engaged, 100% of the power is transferred through the torque converter.

Converter Lock-Up Clutch

To reduce fuel consumption, the lock-up clutch engages the converter case to lock the impeller and the turbine.

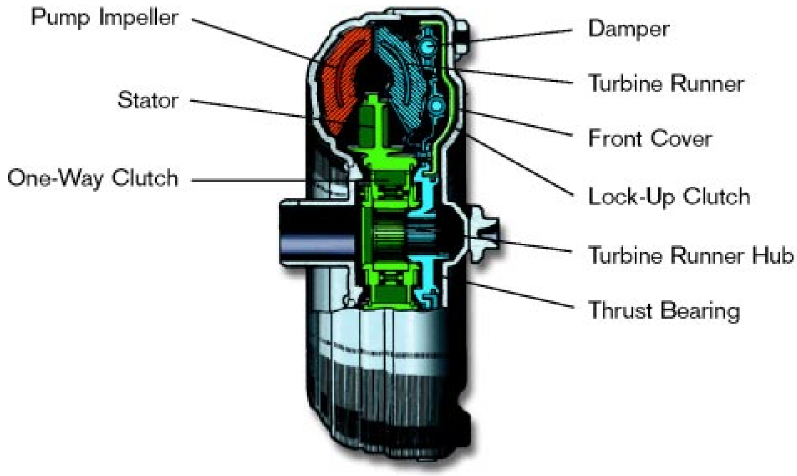


Fig. 1-06

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The lock-up clutch is installed on the turbine hub between the turbine and the converter front cover. Hydraulic pressure on either side of the converter piston causes it to engage or disengage the converter front cover. A set of dampening springs absorb the torsional force upon clutch engagement to prevent shock transfer. The friction material bonded to the lock-up piston is the same as that used on multiplate clutch disks in the transmission.

Lock-Up Operation

When the lock-up clutch is engaged, it connects the impeller and turbine. Engaging and disengaging the lock-up clutch is determined by which side of the lock-up clutch the fluid enters the torque converter. The difference in pressure on either side of the lock-up clutch determines engagement or disengagement. Fluid can either enter the body of the converter behind the lock-up clutch engaging the clutch, or in front of the lock-up clutch to disengage it.

The fluid used to control the torque converter lock-up is also used to remove heat from the converter and transfer it to the engine cooling system through the heat exchanger in the radiator.

Simple Planetary Gear

The operation of a simple planetary gear set is summarized in the chart below. Different speeds and rotational directions can be obtained by holding one of the planetary members in a fixed position, providing input torque to another member, with the third member used as an output member.

This chart represents more ratios and combinations than are used in Toyota automatics, but are represented here to show the scope of its design. The shaded areas represent the combinations used in Toyota transmissions and are, therefore, the only combination we will discuss.

Simple Planetary Gear Operation

The shaded area represents the combinations used in Toyota transmissions.

HELD	POWER INPUT	POWER OUTPUT	ROTATIONAL		ROTATIONAL DIRECTION
			SPEED	TORQUE	
Ring Gear	SunGear	Carrier	Reduced	Increased	Same direction as drive member
	Carrier	Sun Gear	Increased	Reduced	
Sun Gear	Ring Gear	Carrier	Reduced	Increased	Same direction as drive member
	Carrier	Ring Gear	Increased	Reduced	
Carrier	Sun Gear	Ring Gear	Reduced	Increased	Opposite direction from drive member
	Ring Gear	Sun Gear	Increased	Reduced	

Fig. 1-07

Forward Direction

When the ring gear or sun gear is held in a fixed position and either of the other members is an input member, the output gear rotational direction is always the same as the input gear rotational direction.

Reduction

When the internal teeth of the ring gear turns clockwise, the external teeth of the pinion gears walk around the fixed sun gear while rotating clockwise. This causes the carrier to rotate at a reduced speed.

Reduction

Example: Speed reduction - torque increase

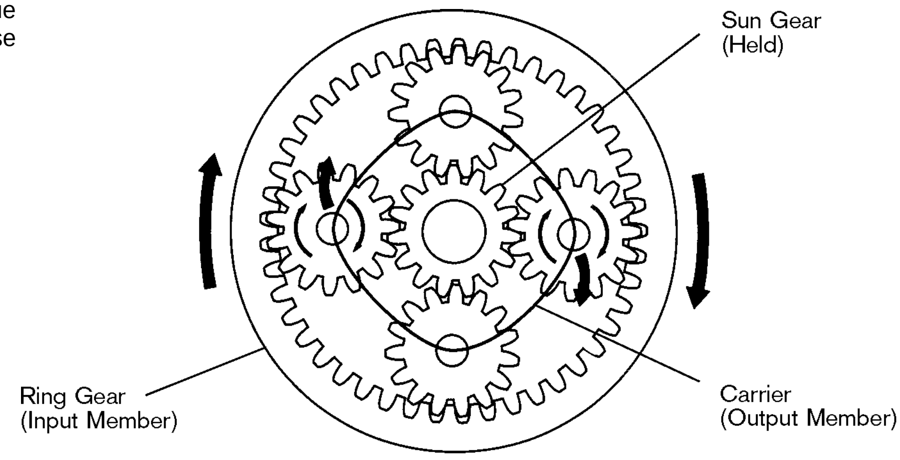

Fig. 1-08

Overdrive

When the carrier turns clockwise, the external toothed pinion gears walk around the external toothed sun gear while rotating clockwise. The pinion gears cause the internal toothed ring gear to accelerate to a speed greater than the carrier speed in a clockwise direction.

Overdrive

Example: Speed increase - torque reduction

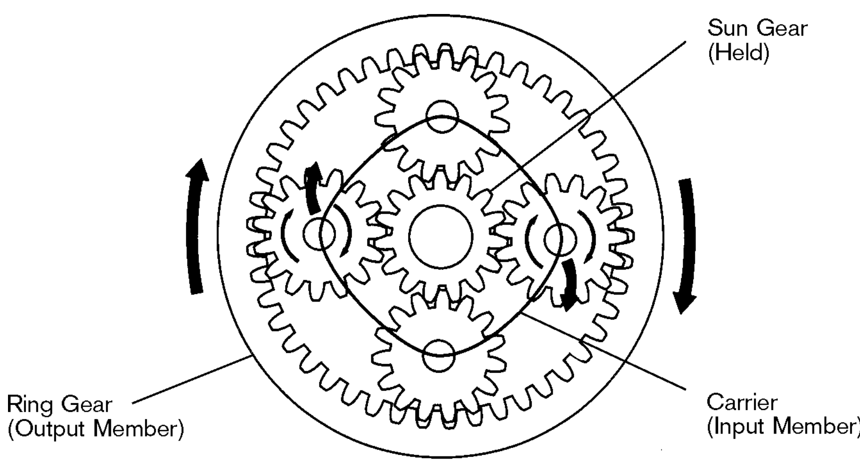

Fig. 1-09

Reverse Direction

Whenever the carrier is held and either of the other gears are input members, the output gear will rotate in the opposite direction.

With the carrier held, when the external toothed sun gear turns clockwise, the external toothed pinion gears on the carrier idle in place and drive the internal toothed ring gear in the opposite direction.

Reverse

Example: Speed reduction - torque increase

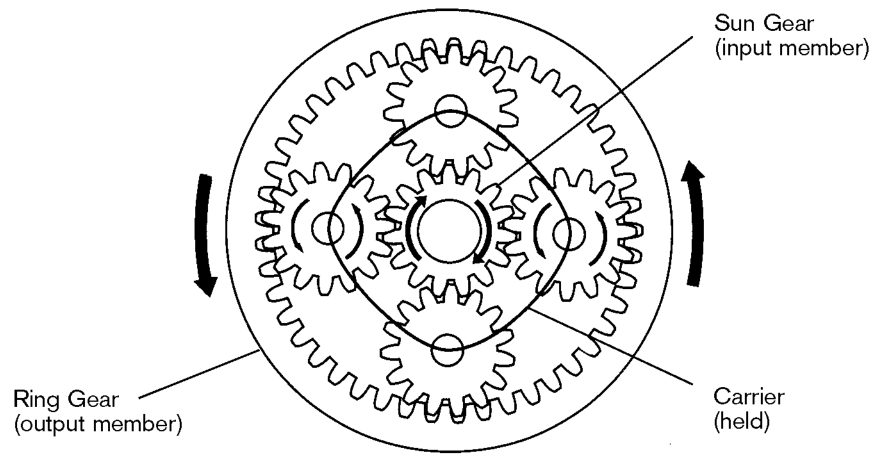

Fig. 1-10
T273f009

Direct Drive (One-To-One Ratio)

When any two members are held together and another member provides the input turning force, the entire assembly turns at the same speed as the input member.

Now the gear ratios from a single planetary set do not give us the desired ratios which take advantage of the optimum torque curve of the engine. So it is necessary to use two single planetary gear sets. This design is basic to most all automatic transmissions in production today.

Holding Devices For Planetary Gear Set

There are three types of holding devices used in the planetary gear set. Each type has its specific design advantage. The three include multiplate clutches/brakes, brake bands and one-way clutches.

- Multiplate Clutch — holds two rotating planetary components.
- Roller or Sprag One-Way Clutch — holds planetary components in one rotational direction and freewheels in the other direction.
- Multiplate Brake and Brake Band — holds planetary components to the transmission case.

The multiplate clutch and multiplate brake are the most common of the three types of holding devices; they are versatile and can be modified easily by removing or including more friction discs. The brake band takes very little space in the cavity of the transmission housing and has a large surface area to create strong holding force. One-way clutches are small in size and release and apply quickly, giving good response for upshifts and downshifts.

Multiplate Clutch

The multiplate clutch connects two rotating components of the planetary gear set.

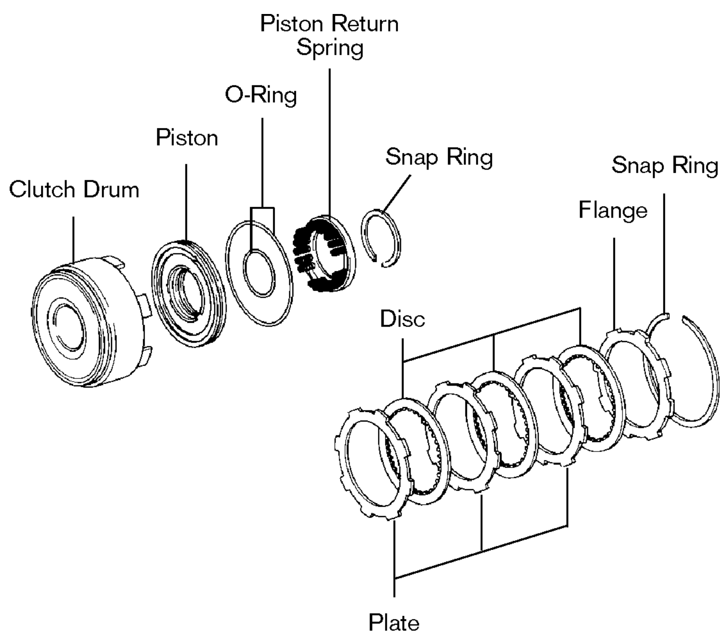

Fig. 1-11
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Multiplate Clutch

The multiplate clutch connects two rotating components of the planetary gear set. The Simpson planetary gear unit uses two multiplate clutches, the forward clutch (C1) and the direct clutch (C2). Each clutch drum is slotted on the inner diameter to engage the steel plates and transfer turning torque from the engine. The drum also provides the bore for the clutch piston.

Friction discs are steel plates which have friction material bonded to them. They are always located between two steel plates. The friction disc inner diameter is slotted to fit over the splines of the clutch hub.

Steel plates are slotted on the outer diameter to fit the slots of the clutch drum or transmission case. They provide a smooth surface for the friction discs to engage with. Steel plates can be installed next to one another to give a specific clearance for the clutch pack.

Multiplate Operation

Because this assembly rotates while the vehicle is in motion, it presents a unique challenge to ensure pressurized fluid reaches the clutch and holds the clutch engaged for many tens of thousands of miles of service. Oil seal rings seal the fluid passage between the clutch drum and oil pump stator support and transmission center support.

Seals are mounted on the piston inner and outer diameter which seal the fluid applying the piston. A relief ball valve is housed in the piston body to release hydraulic fluid when the clutch is released. As the drum rotates, some fluid remains behind the piston and centrifugal force causes the fluid to flow to the outer diameter of the drum causing pressure. This pressure may not fully engage the clutch, however, it may reduce the clearance between the discs and metal plates, promoting heat and wear.

The relief ball valve is designed to allow fluid to escape when pressure is released. As pressure drops, centrifugal force causes the ball to move away from the valve seat, allowing fluid to escape so the piston can be seated, providing proper clearance between the disc and steel plates.

Multiplate Clutch Operation

Hydraulic pressure applies the clutch, and the return springs release it.

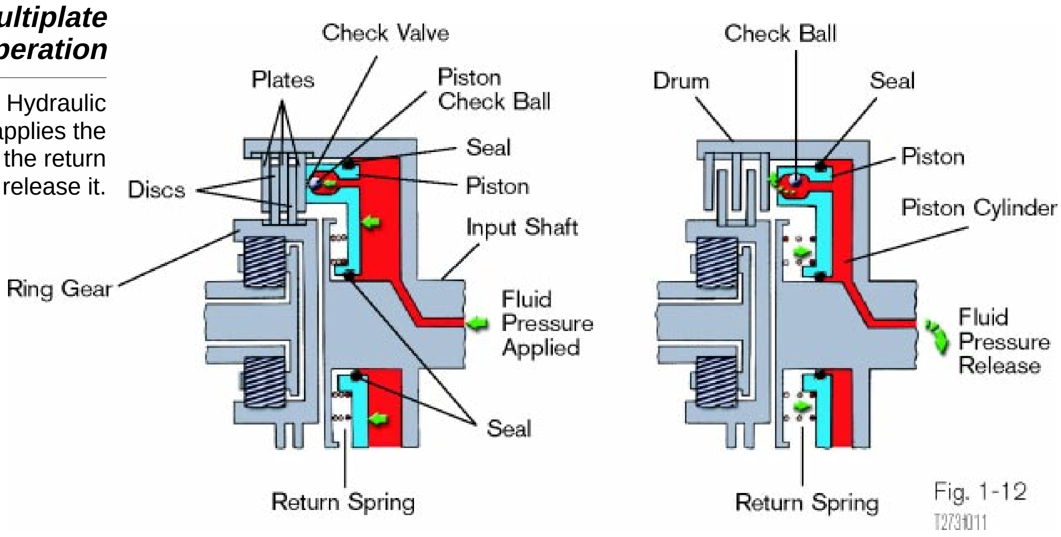

Fig. 1-12

U-Series Transmission Counter Centrifugal Force

The U-series transmissions first introduced in the 2000 Echo and Celica, utilizes centrifugal fluid pressure to cancel the effect of centrifugal force on the piston when pressure is released in the clutch. Fluid used for lubrication is caught between the clutch spring retainer and the clutch piston. As the clutch drum rotates, fluid in the canceling fluid pressure chamber counters the pressure built up inside the drum pressure chamber, canceling the pressure build-up.

Centrifugal Fluid Pressure Canceling

As the clutch drum rotates, fluid in the canceling fluid pressure chamber, counters the pressure built up inside the drum pressure chamber, and counteracts the pressure build-up.

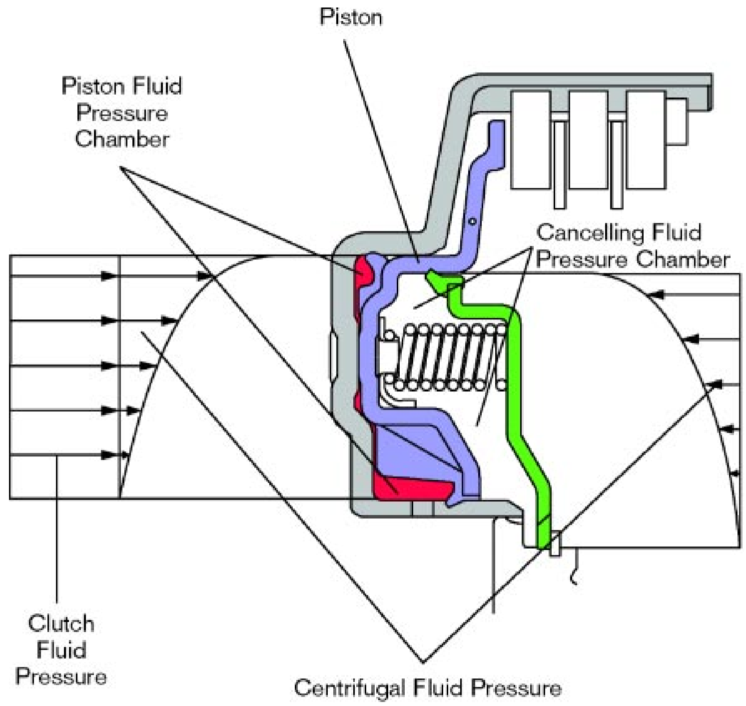

Fig. 1-13

One-Way Clutch

A one-way clutch is a holding device which requires no seals or hydraulic pressure to apply. They are either a roller clutch or sprag clutch. Their operation is similar in that they both rely on wedging the metal sprags between two races. Two one-way clutches are used in the Simpson Planetary Gear Set. The *No. 1 one-way clutch* (F1) is used in second gear and the *No. 2 one-way clutch* (F2) is used in first gear.

A one-way sprag clutch consists of a hub as an inner race and a drum, or outer race. The two races are separated by a number of sprags which look like a figure "8" when looking at them from the side view. In the illustration in figure 1-14, the side view of the sprag shows four lobes. The two lobes identified by L1 are shorter than the distance between the two races. The opposite lobes are longer than the distance between the races. As a result, when the center race turns clockwise, it causes the sprag to tilt and the short distance allows the race to turn.

One-Way Clutch

When the center race turns counterclockwise, it tries to move the sprag so that the long distance is wedged against the outer race.

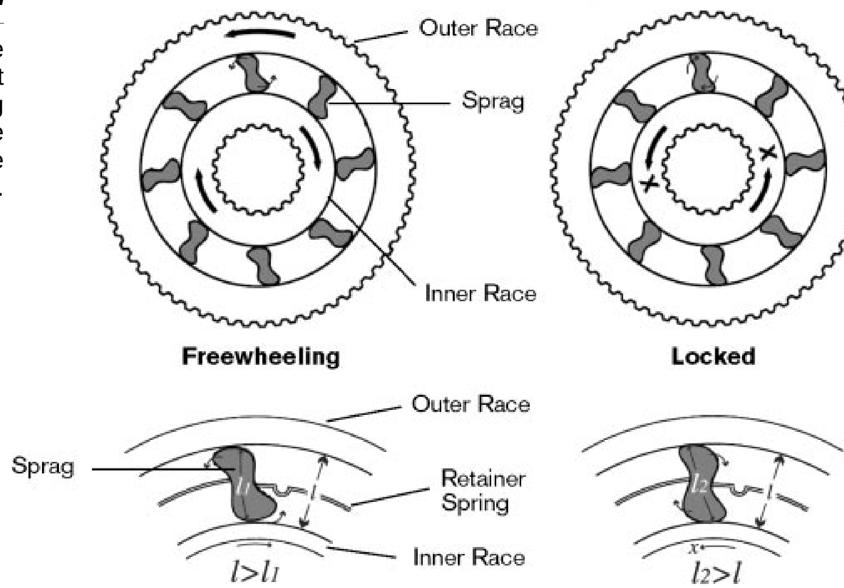

Fig. 1-14
T273f013

When the center race turns counterclockwise, it tries to move the sprag so that the long distance is wedged against the outer race. This causes the center race to stop turning. To assist the sprags in their wedging action, a retainer spring is installed which keeps the sprags slightly tilted at all times in the direction which will lock the turning race.

Although the sprag clutch is used most often in Toyota automatics, a second design can be found in the U-series transmission and other transmission models. A one-way roller clutch consists of a hub, rollers, and springs surrounded by a cam-cut drum. The cam-cut is in the shape of a wedge, smaller on one end than the other. The spring pushes the rollers toward the narrow end of the wedge. When the inner race rotates in the counterclockwise direction, the rollers compress the spring and the race is allowed to turn. If the race is rotated in the opposite direction, it forces the rollers into the narrow end of the cam cut and locks the race.

One-Way Roller Clutch

When the inner race is rotated in the clockwise direction, it forces the rollers into the narrow end of the wedge and locks the race.

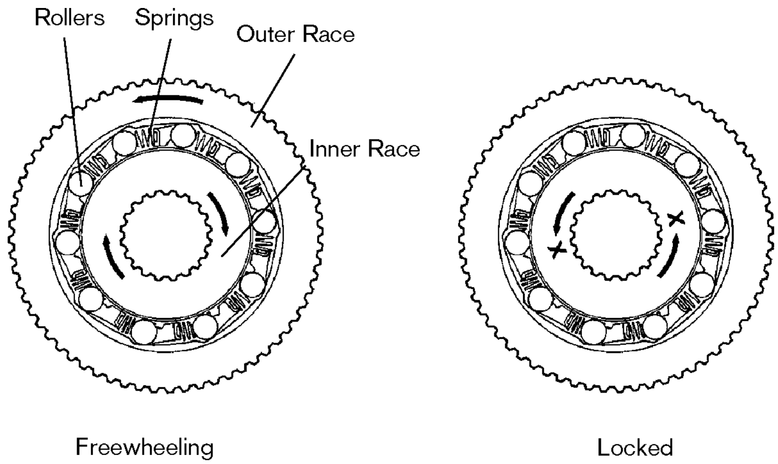

Fig. 1-15
T273f014

The *No. 1 one-way clutch* (F1) operates with the *second brake* (B2) to prevent the sun gear from turning counterclockwise. The *No. 2 one-way clutch* (F2) prevents the rear planetary carrier from turning counterclockwise.

No. 1 and No. 2 One-Way Clutch

F1 operates with the second brake (B2) to hold the sun gear from turning counterclockwise. F2 prevents the rear planetary carrier from turning counterclockwise.

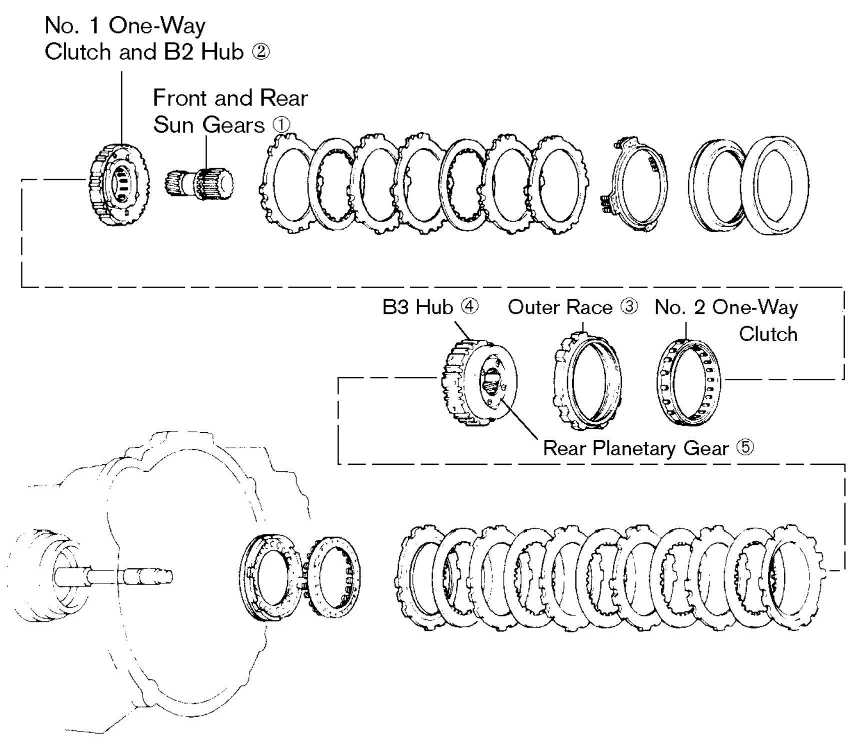

Fig. 1-16
T273f018

Brakes

There are two types of brakes; the wet multiplate type and the band type. The multiplate type is used on the *overdrive brake* (B0), *second coast brake* (B1), *second brake* (B2), and the first and reverse brake (B3).

Multiplate Brakes

The multiplate brake is constructed in a similar manner to the multiplate clutch. It locks or holds a rotating component of the planetary gear set to the case of the transmission.

Hydraulic pressure actuates the piston and return springs return the piston to the rest position in the clutch drum when pressure is released. Friction discs are steel plates to which friction material is bonded. They are always located between two steel plates. The friction disc inner diameter is slotted to fit over the splines of the clutch hub, similar to the multiplate clutch; however, the steel plates spline to the transmission case, thus providing an anchor.

Multiplate Brake

The multiplate brake locks a planetary gear component to the case of the transmission.

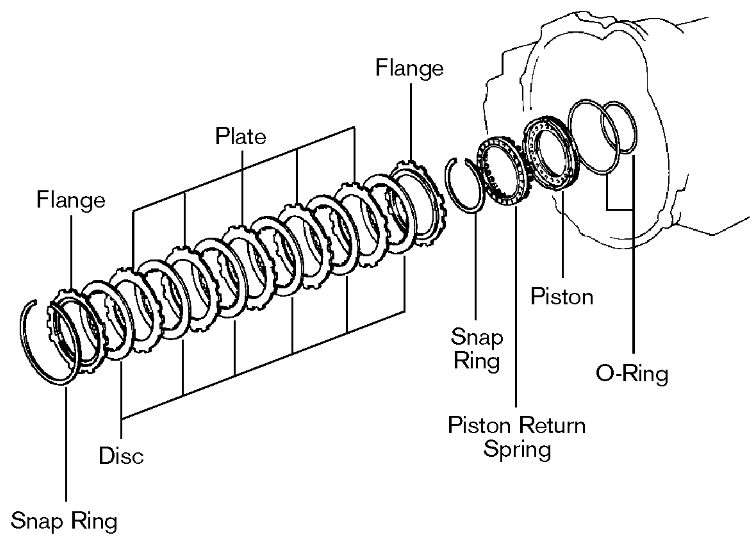

Fig. 1-17
T273f015

Brake Band The brake band performs the same functions as the multiplate brake and is located around the outer circumference of the direct clutch drum. One end of this brake band is anchored to the transmission case with a pin, while the other end contacts the brake piston rod which is controlled by hydraulic pressure and spring tension.

Band Type Brake

The brake band locks a planetary gear component to the case of the transmission.

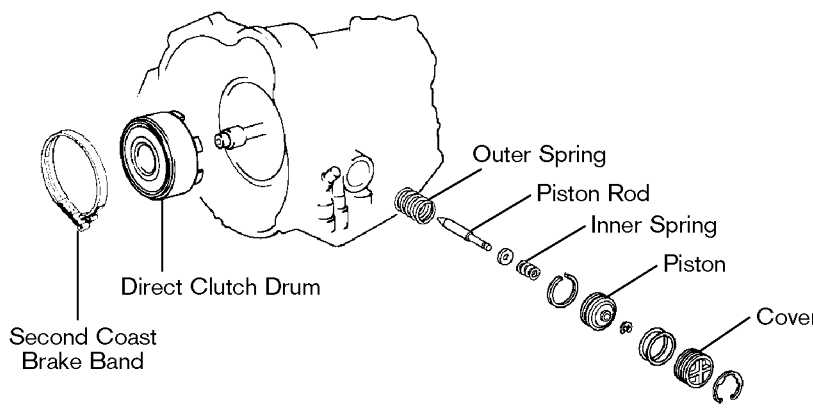

Fig. 1-18
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Band Operation

The inner spring transfers motion from the piston to the piston rod, applying pressure to the end of the brake band.

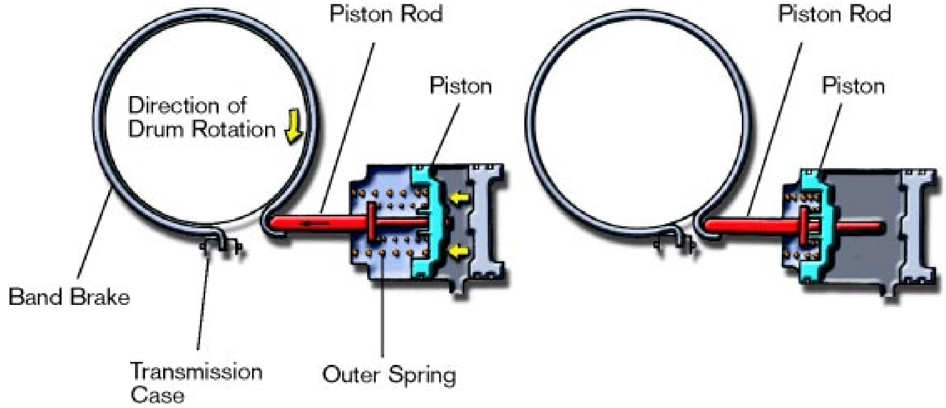


Fig. 1-19
T273f0D17

Band Operation

The band is applied by a piston and piston rod located in the transmission case. When hydraulic pressure is applied to the piston, the piston moves to the left compressing the outer spring. The inner spring transfers motion from the piston to the piston rod, applying pressure to the end of the brake band. As the inner spring compresses, the piston comes in direct contact with the piston rod shoulder and a high frictional force is generated between the brake band and drum. The brake band clamps down on the drum which causes the drum and a member of the planetary gear set to be held to the transmission case.

When the pressurized fluid is drained from the cylinder, the piston and piston rod are pushed back by the force of the outer spring so the drum is released by the brake band.

Power Flow Model

The planetary gear set cutaway and model shown below are found in Toyota Repair Manuals and New Car Features Books. The model will help you visualize the workings of the holding devices, gear shafts and planetary gear members for all gear positions.

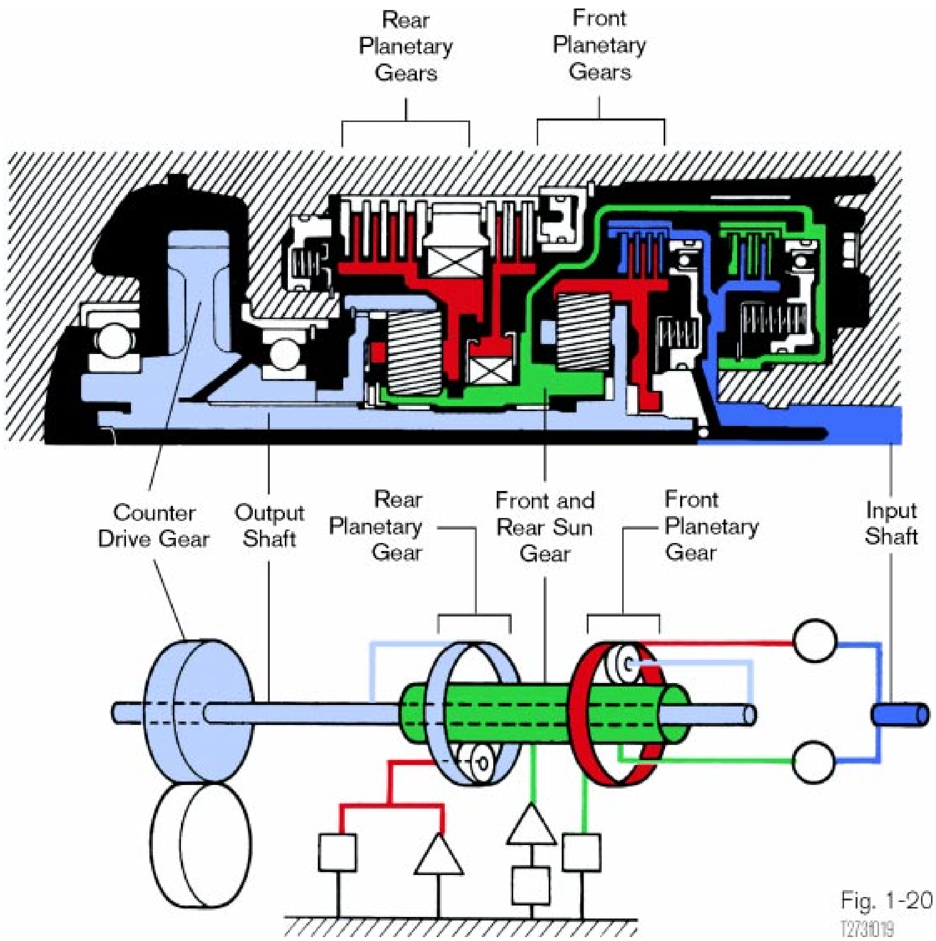
Gear Train Shafts

There are three shafts in the Simpson planetary: the input shaft, sun gear, and the output shaft. The input shaft is driven from the turbine in the torque converter. It is connected to the front planetary ring gear through the multiplate clutches. The sun gear, which is common to both the front and rear planetary gear sets, transfers torque from the front planetary set to the rear planetary set. The output shaft is splined to the carrier of the front planetary gear set and to the ring gear of the rear planetary and then provides turning torque to the rear wheels or the overdrive unit.

The output shaft, for the purposes of power flow, refers to the output of the Simpson planetary gear set. It may be referred to as the intermediate shaft in other references. However, for our purposes in discussing power flow, it will be referred to as the output shaft.

Planetary Gear Shafts

The planetary gear set cutaway and model will help visualize the workings of holding devices, gear shafts, and planetary gear member.



Holding Devices

Multiplate clutches and brakes were discussed in detail earlier, and in the cutaway model on the next page, we can identify their position and the components to which they are connected. The holding devices for the Simpson planetary gear set are identified below with the components they control:

Function of Holding Devices

Each holding device and the component it controls is identified in this chart.

Holding Device		Function
C0	O/D Direct Clutch	Connects overdrive sun gear and overdrive carrier.
B0	O/D Brake	Prevents overdrive sun gear from turning either clockwise or counterclockwise.
F0	O/D One-Way Clutch	When transmission is being driven by engine, connects overdrive sun gear and overdrive carrier.
C1	Forward Clutch	Connects input shaft and front planetary ring gear.
C2	Direct Clutch	Connects input shaft and front and rear planetary sun gear.
B1	2nd Coast Brake	Prevents front and rear planetary sun gear from turning either clockwise or counterclockwise.
B2	2nd Brake	Prevents outer race of F1 from turning either clockwise or counterclockwise, thus preventing front and rear planetary sun gear from turning counterclockwise.
B3	1st and Reverse Brake	Prevents rear planetary carrier from turning either clockwise or counter clockwise.
F1	No. 1 One-Way Clutch	When B2 is operating, prevents front and rear planetary sun gear from turning counterclockwise.
F2	No. 2 One-Way Clutch	Prevents rear planetary carrier from turning counterclockwise.

Fig. 1-21

The value of this model can be appreciated when observing the control of the rear carrier and the sun gear. The *first and reverse brake* (B3) and the *No. 2 one-way clutch* (F2) control the rear carrier in parallel. Together they provide a great holding force on the carrier to prevent it from turning during low first gear.

The *second brake* (B2) and the *No. 1 one-way clutch* (F1) control the sun gear in series. This allows the sun gear to turn clockwise only when B2 is applied

The *second coast brake* (B1) holds the sun gear, preventing it from turning in either direction. This feature provides for engine braking on deceleration while in 2-range second gear.

Planetary Holding Devices

The first and reverse brake (B3) and No. 2 one-way clutch (F2) both hold the rear planetary carrier.

The second brake (B2) and the No. 1 one-way clutch (F1) work together to hold the sun gear.

The second coast brake (B1) holds the sun gear also.

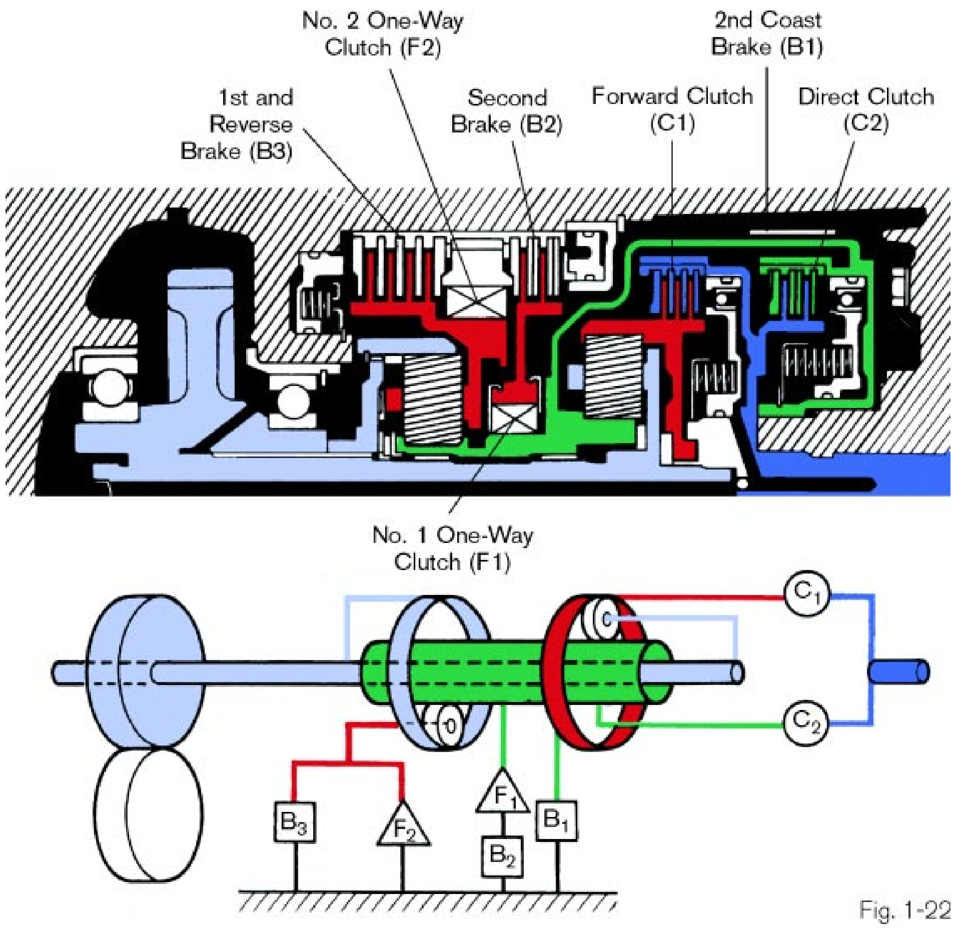


Fig. 1-22
T273f021

Three Speed Clutch Application Chart

The gear position in which these holding devices are applied can be found on the clutch application chart below. The chart describes which holding devices are applied for a given gear position. If you follow down the left side of the chart to shift lever position “D” and “first” gear position, the shaded boxes to the right of the gear position indicate the holding devices used in drive first gear. At the top of the column above the shaded box you will find the code designation for the holding device. For example, in drive first gear, the *forward clutch* (C1) and the *No. 2 one-way clutch* (F2) are applied to achieve first gear. The clutch

Clutch Application Chart for A130 Transmission

The chart describes which holding devices are applied for a given gear position.

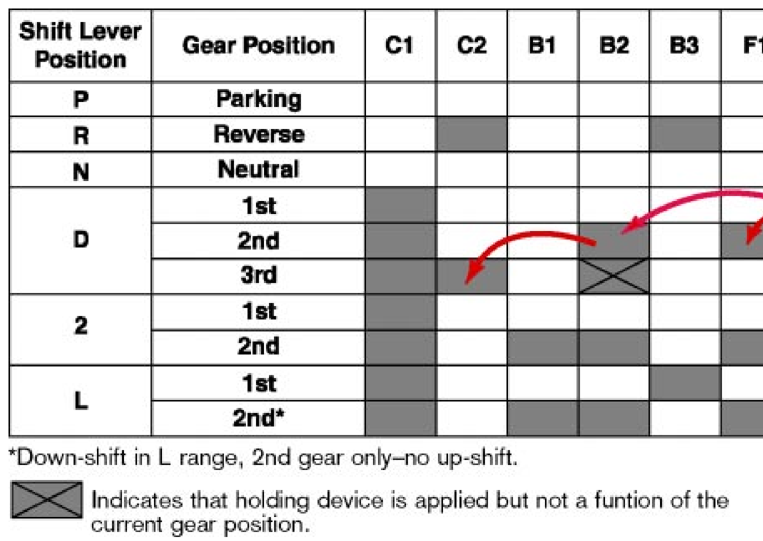


Fig. 1-23
T273f022

application chart shows that as the transmission upshifts to the next gear, an additional holding device is engaged in addition to those clutches and brakes already applied. For example, when upshifting to second gear, B2 is applied while C1 remains applied; and when upshifting to third gear, C2 is applied while B2 and C1 remain applied. The one way clutches are the only holding devices to release as an upshift occurs, but they remain ready to automatically apply when the rotating member turns in a counterclockwise direction.

This stacking feature allows the transmission to remain in the lower gear when a clutch/brake fails to engage on an upshift and also provides a downshift by simply disengaging one clutch.

The clutch application chart is your key to diagnosis. When a transmission malfunction occurs and the diagnosis leads you to a specific gear, you can refer to this chart to pinpoint the faulty holding device. When the holding device you suspect is used in another gear position, you should be able to detect a failure in that gear position also while either accelerating or decelerating. If that gear position does not exhibit a problem, look for another device shared with another gear position and look for a malfunction to occur. Using a process of elimination, you can pinpoint the holding device which is causing the malfunction.

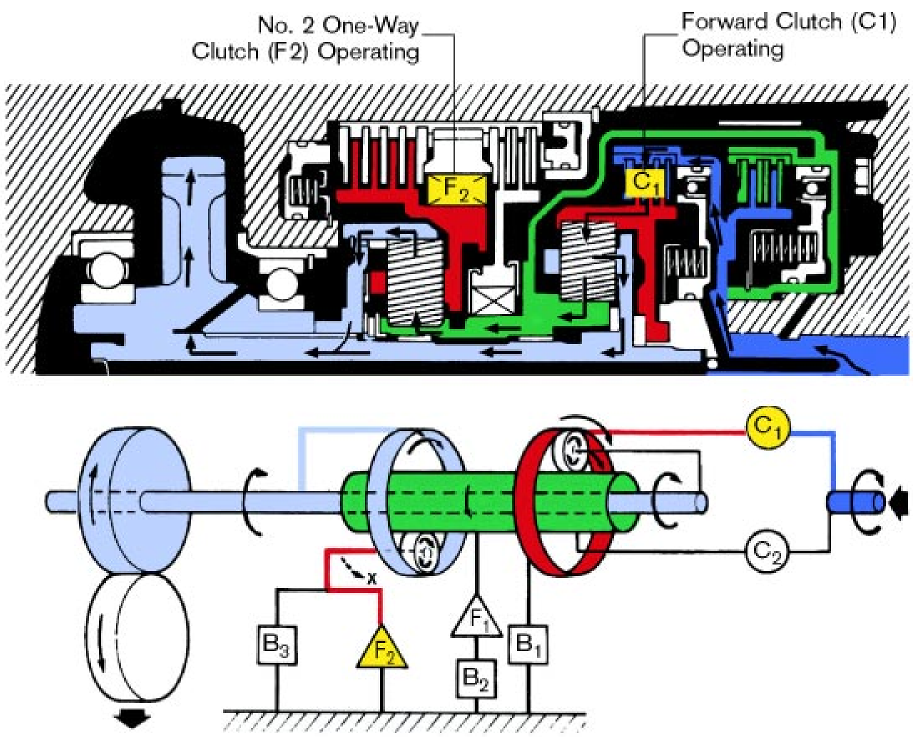
Power Flow Through Simpson Planetary Gear Set - D or 2-Range First Gear

First gear is unique because it uses both the front and rear planetary gear sets. The *forward clutch* (C1) is applied in all forward gears and drives the ring gear of the front planetary gear set. When the ring gear rotates clockwise, it causes the pinions to rotate clockwise since the sun gear is not held to the case. The sun gear rotates in a counterclockwise direction. The front planetary carrier, which is connected to the output shaft, rotates, but more slowly than the ring gear; so for practical purposes, it is the held unit.

In the rear planetary gear set, the carrier is locked to the case by the *No. 2 one-way clutch* (F2). Turning torque is transferred to the rear planetary by the sun gear, which is turning counterclockwise. With the carrier held, the planetary gears rotate in a clockwise direction and cause the rear planetary ring gear to turn clockwise. The rear planetary ring gear is connected to the output shaft and transfers torque to the drive wheels.

D or 2-Range First Gear

First gear is unique because it uses both the front and rear planetary gear sets.



Shift Lever Position	Gear Position	C1	C2	B1	B2	B3	F1	F2
D	1st							

Fig. 1-24
T2731023/T2731024

D-Range Second Gear

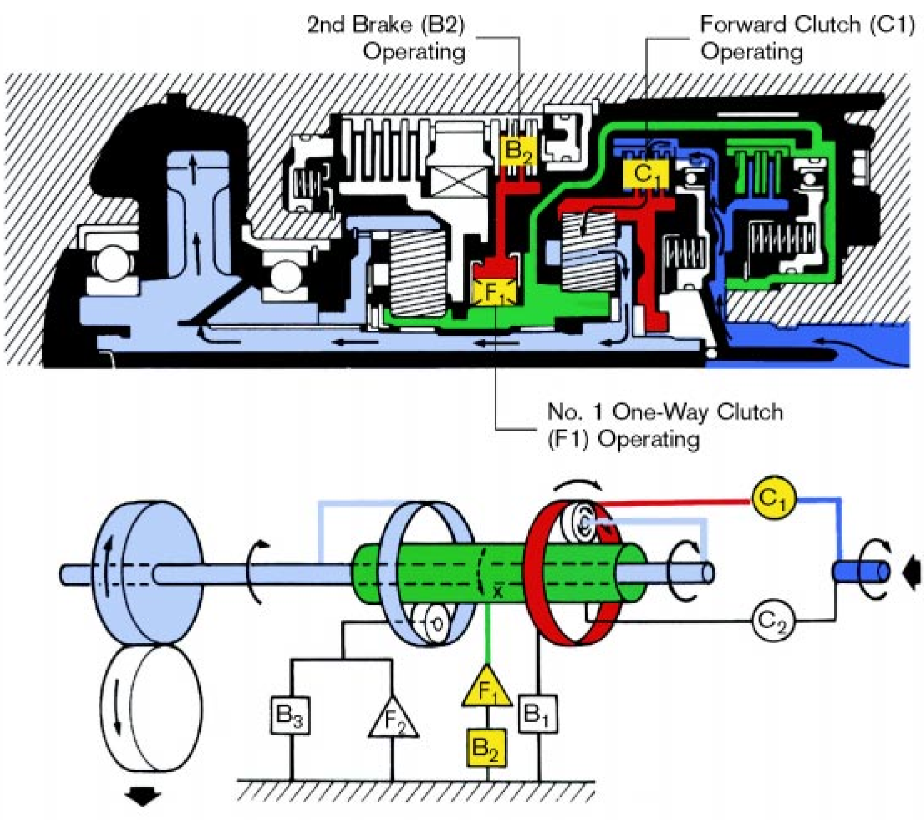
The *forward clutch* (C1) connects the input shaft to the front planetary ring gear. The sun gear is driven in a counterclockwise direction in first gear and by simply applying the *second brake* (B2) the sun gear is stopped by the *No. 1 one-way clutch* (F1) and held to the case. When the sun gear is held, the front pinion gears driven by the ring gear walks around the sun gear and the carrier turns the output shaft.

The advantage of the *No. 2 one-way clutch* (F2) is in the automatic upshift and downshift. Only one multiplate clutch is applied or released to achieve an upshift to second gear or downshift to first gear.

Notice how the *second brake* (B2) and the *one-way clutch* (F1) both hold the sun gear in series. The *second brake* holds the outer race of the *one-way clutch* to the transmission case when applied. The *one-way clutch* prevents the sun gear from rotating counterclockwise only when the *second brake* is applied.

D-Range Second Gear

Second gear uses the front planetary gear set only.



Shift Lever Position	Gear Position	C1	C2	B1	B2	B3	F1	F2
D	1st							
	2nd							

Fig. 1-25
T273f025/T273f026

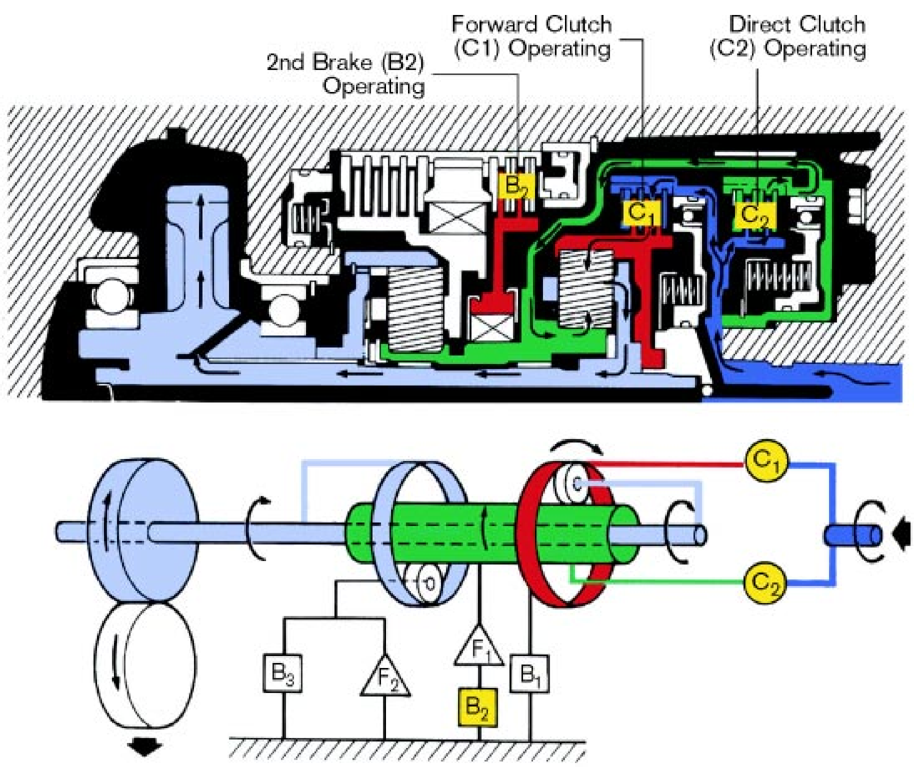
D-Range Third Gear

The *forward clutch* (C1) is applied in all forward gears and connects the input shaft to the front planetary ring gear as it does in all forward gears. The *direct clutch* (C2) connects the input shaft to the common sun gear. By applying both the *direct clutch* and the *forward clutch*, we have locked the ring gear and the sun gear to each other through the *direct clutch* drum and the input sun gear drum. Whenever two members of the planetary gear set are locked together direct drive is the result.

Notice that the *second brake* (B2) is also applied in third gear; however, since the *No. 1 one-way clutch* (F1) does not hold the sun gear in the clockwise direction, the *second brake* has no effect in third gear. So why is it applied in third gear? The reason lies in a downshift to second gear. All that is necessary for a downshift to second gear is to release the *direct clutch* (C2). The ring gear provides input torque and the sun gear is released. The carrier is connected to the output shaft and final drive so the output shaft tends to slow the carrier. The pinion gears rotate clockwise turning the sun gear counterclockwise until it is stopped by the *No. 1 one-way clutch.* The carrier provides the output to the final drive.

D-Range Third Gear

Third gear uses the front planetary gear set only.



Shift Lever Position	Gear Position	C1	C2	B1	B2	B3	F1	F2
D	2nd	■			■		■	
	3rd	■	■		X			

Fig. 1-26
T273f027/T273f028

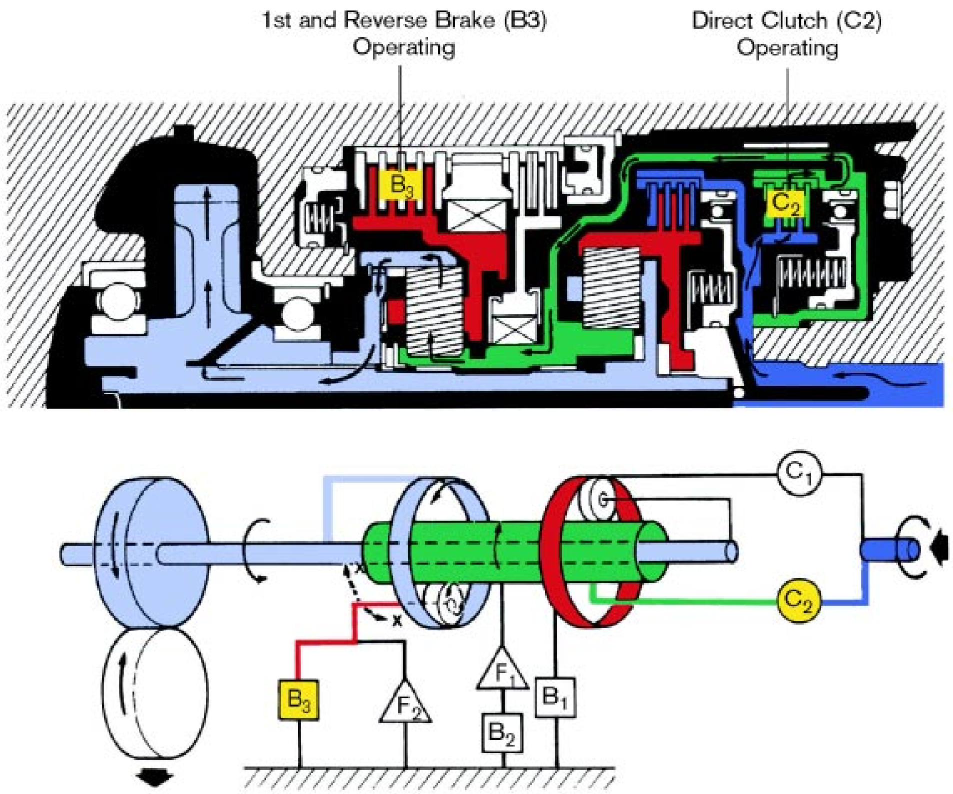
Reverse Range

The *direct clutch* (C2) is applied in reverse, which connects the input shaft to the sun gear. The *first and reverse brake* (B3) is also applied, locking the rear carrier to the case. With the carrier locked in position, the sun gear turning in the clockwise direction causes the planetary gears to rotate counterclockwise. The planetary gears will then drive the ring gear and the output shaft counterclockwise.

Up to this point we have examined reverse gear and those forward gear positions which are automatic. That is, with the gear selector in D-position all forward gears are upshifted automatically. The gears can also be selected manually, utilizing additional holding devices. This feature not only provides additional characteristics to the drivetrain but also allows a means of diagnosis for faults in certain holding devices.

Reverse Range

Reverse gear uses the rear planetary gear set only.



Shift Lever Position	Gear Position	C1	C2	B1	B2	B3	F1	F2
P	Parking							
R	Reverse		■			■		

Fig. 1-27
T273f029/T273f030

Comparison of D and L-Range First Gear

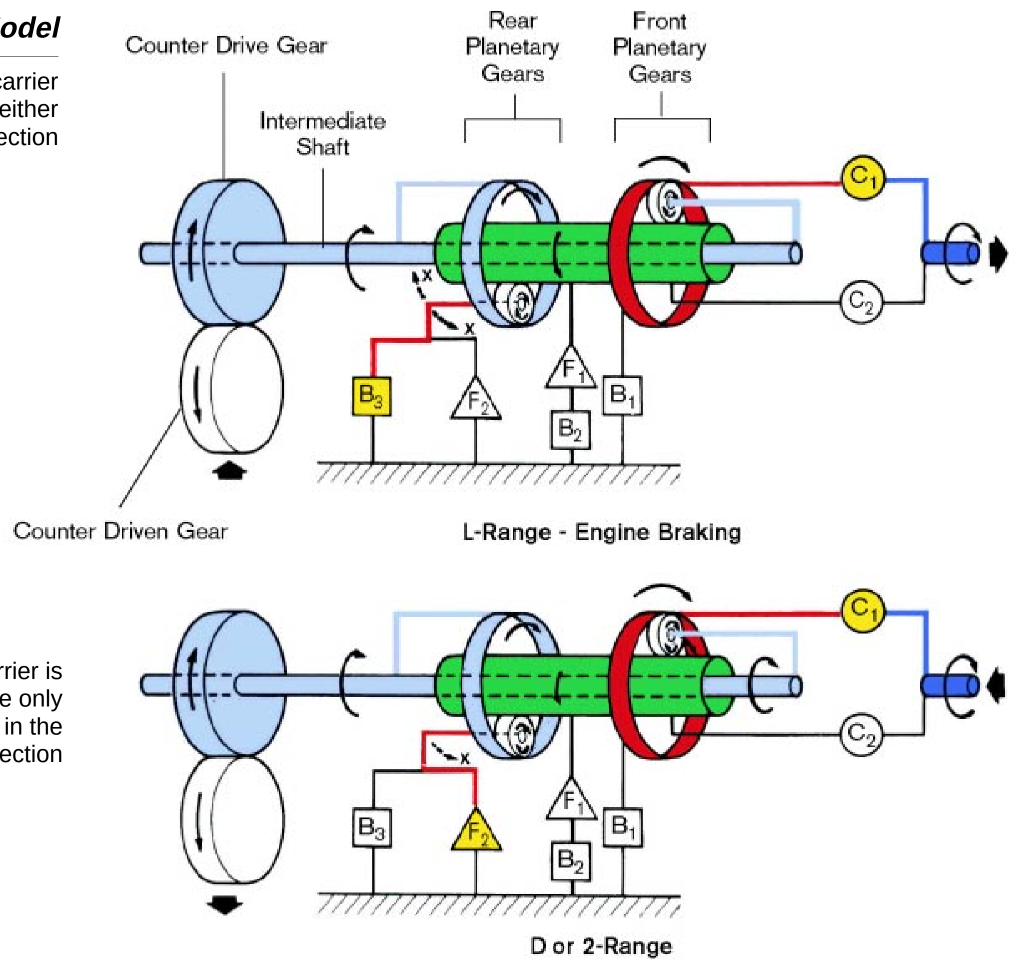
When the gear selector is placed in the L-position, the *first and reverse brake* (B3) is applied through the position of the manual valve. The *first and reverse brake* performs the same function as the *No. 2 one-way clutch* (F2) does in the forward direction. When the *first and reverse brake* (B3) is applied it holds the rear planetary gear carrier from turning in either direction, whereas the *No. 2 one-way clutch* holds the carrier in the counterclockwise direction only.

The advantage that the *first and reverse brake* has, is that engine braking can be achieved to slow the vehicle on deceleration. In "D1," only the *No. 2 one-way clutch* holds the carrier, so while decelerating, the *one-way clutch* would release and no engine braking would occur.

First Gear Model

The rear planetary carrier cannot rotate in either direction

The rear planetary carrier is held counterclockwise only and freewheels in the clockwise direction



Shift Lever Position	Gear Position	C1	C2	B1	B2	B3	F1	F2
D	1st	■						■
L	1st	■				■		■

Fig. 1-28

T273f031/T273f033

Comparison of D2 and 2-Range Second Gear

When the gear selector is placed in the 2-position, the *second coast brake* (B1) is applied by way of the manual valve. When the *second coast brake* is applied, it holds the sun gear from rotating in either direction. Power flow is the same with the selector in "2," as when the selector is in "D" because the *second coast brake* is parallel to the *second brake* and *No. 1 one-way clutch*.

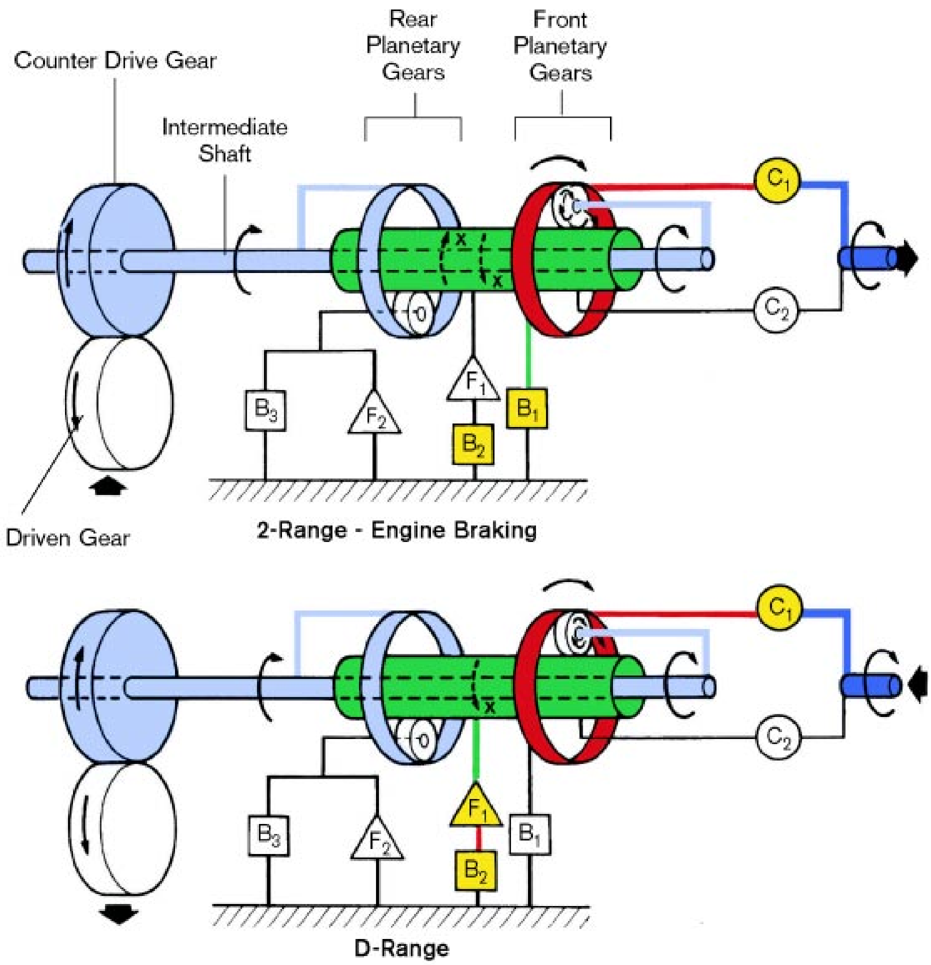
However, when the transmission is being driven by the wheels on deceleration, the force from the output shaft is transmitted to the front carrier, causing the front planetary pinion gears to revolve clockwise around the sun gear. Since the sun gear is held by the *second coast brake*, the planetary gears walk around the sun clockwise and drive the front planetary ring gear clockwise through the input shaft and torque converter to the crankshaft for engine braking. In contrast, while in second gear with the selector in D-position, the sun gear is held in the counterclockwise direction only and the sun gear rotates in a clockwise direction and there is no engine braking.

The advantage that 2-range has over "D2" is that the engine can be used to slow the vehicle on deceleration, and this feature can be used to aid in diagnosis. For example, a transmission which does not have second gear in D-position but does have second gear while manually shifting can be narrowed to the *second brake* (B2) or *No. 1 one-way clutch* (F1). These components and related hydraulic circuits become the primary focus in our diagnosis.

Second Gear Model

The sun gear cannot rotate in either direction.

The sun gear is held in the counterclockwise direction only in a clockwise direction.



Shift Lever Position	Gear Position	C1	C2	B1	B2	B3	F1	F2
D	2nd	■			■		■	
2	2nd	■		■	■		■	

Fig. 1-29
T273f034/T273f035
T273f036

Power Flow Through O/D Unit

One simple planetary gear set is added to the 3-speed automatic transmission to make it a 4-speed automatic transmission (three speeds forward and one overdrive). This additional gear set can be added in front of or behind the Simpson Planetary Gear Set to accomplish overdrive. When the vehicle is driving in overdrive gear, the speed of the output shaft is greater than that of the input shaft.

O/D Planetary Units

This simple planetary gear set can be in front of the Simpson planetary gear set or behind it.

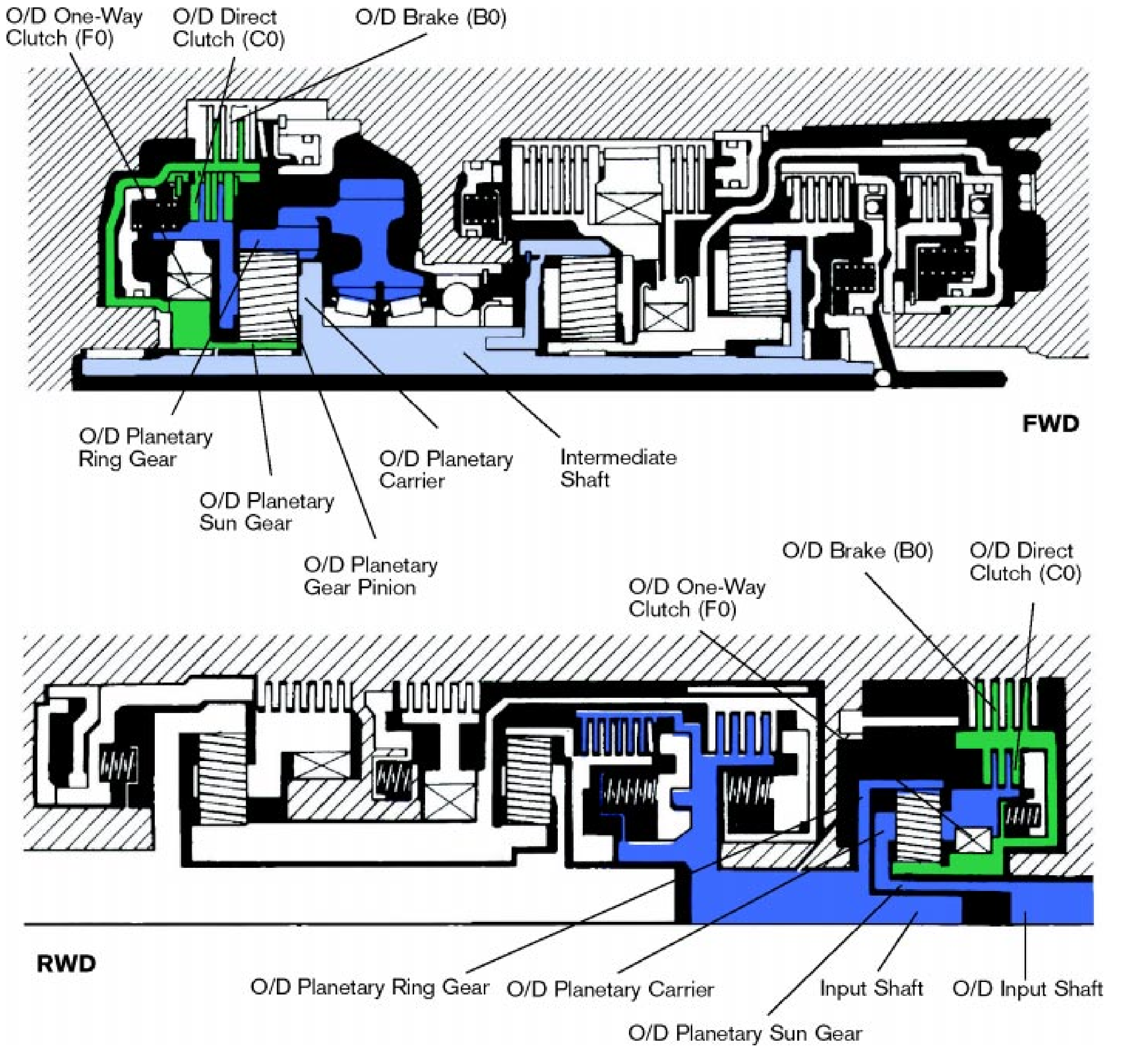


Fig. 1-30
T273f037

Four Speed Clutch Application Chart

The clutch application chart is similar to the one seen earlier while discussing power flow through the Simpson planetary gear set, however, three additional holding devices for overdrive have been added. The *overdrive direct clutch* (C0) and the *overdrive one-way clutch* (F0) are applied in reverse and forward gears through third gear. In overdrive, the *overdrive brake* (B0) is applied and the *overdrive direct clutch* (C0) is released.

Four Speed Clutch Application Chart

Three additional holding devices are required for overdrive

Shift Lever Position	Gear Position	C0	C1	C2	B0	B1	B2	B3	F0	F1	F2
P	Park	■									
R	Reverse	■		■				■			
N	Neutral	■									
D	1st	■	■						■		■
	2nd	■	■				■		■	■	
	3rd	■	■	■			⊠		■		
	O/D		■	■	■		⊠				
2	1st	■	■						■		■
	2nd	■	■			■	■		■	■	
	3rd*	■	■	■			⊠		■		
L	1st	■	■					■	■		■
	2nd**	■	■			■	■		■	■	

* Does Not Apply to A-140L ** Downshift only - no upshift

⊠ Indicates that holding device is applied but not a funtion of the current gear position.

Fig. 1-31
T273f039

O/D Operation

Overdrive is designed to operate at vehicle speed above 25 mph in order to reduce the required engine speed when the vehicle is operating under a light load. Power is input through the overdrive planetary carrier and output from the overdrive ring gear. The operation of holding devices and planetary members in the forward direction is the same whether it is a front wheel drive or rear wheel drive vehicle. In reverse, however, the *overdrive one-way clutch* (F0) in the front wheel drive transmission does not hold.

The direction of rotation in the front-mounted O/D unit is always clockwise. The direction of rotation in the rear-mounted O/D units is mostly clockwise, with the exception of reverse, in which case the intermediate shaft rotates counterclockwise. When the input torque comes into the overdrive unit in a counterclockwise direction, the *overdrive one-way clutch* (F0) free-wheels. Therefore, when a vehicle with the rear-mounted O/D unit is placed in reverse, the *overdrive direct clutch* (C0) is the only unit holding the O/D unit in direct drive. For this reason, when the *overdrive direct clutch* fails, the vehicle will go forward but will not go in reverse and there is no engine braking in low or D2.

O/D Planetary Gear Unit

Power is input through the overdrive planetary carrier and output from the overdrive ring gear.

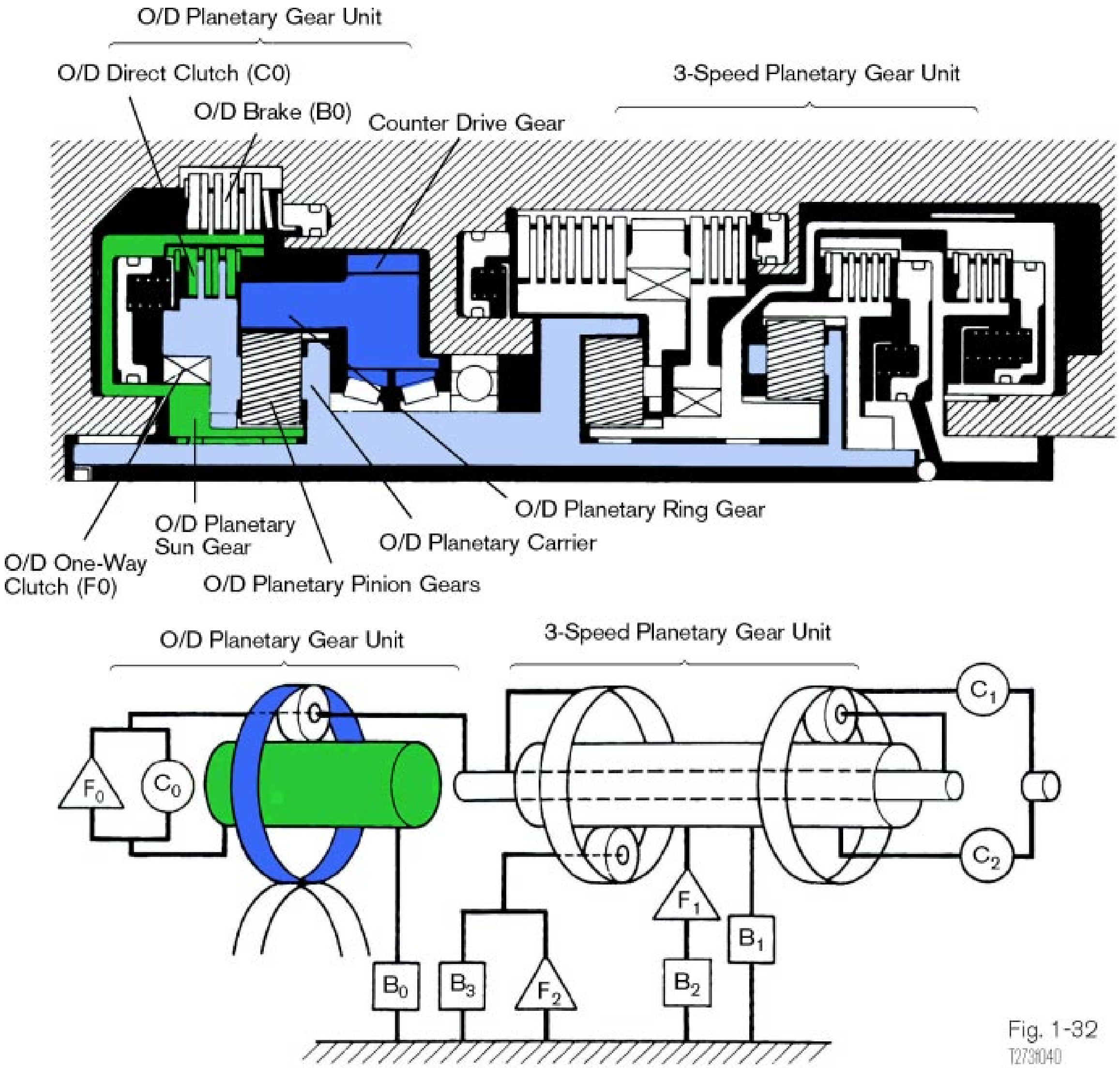


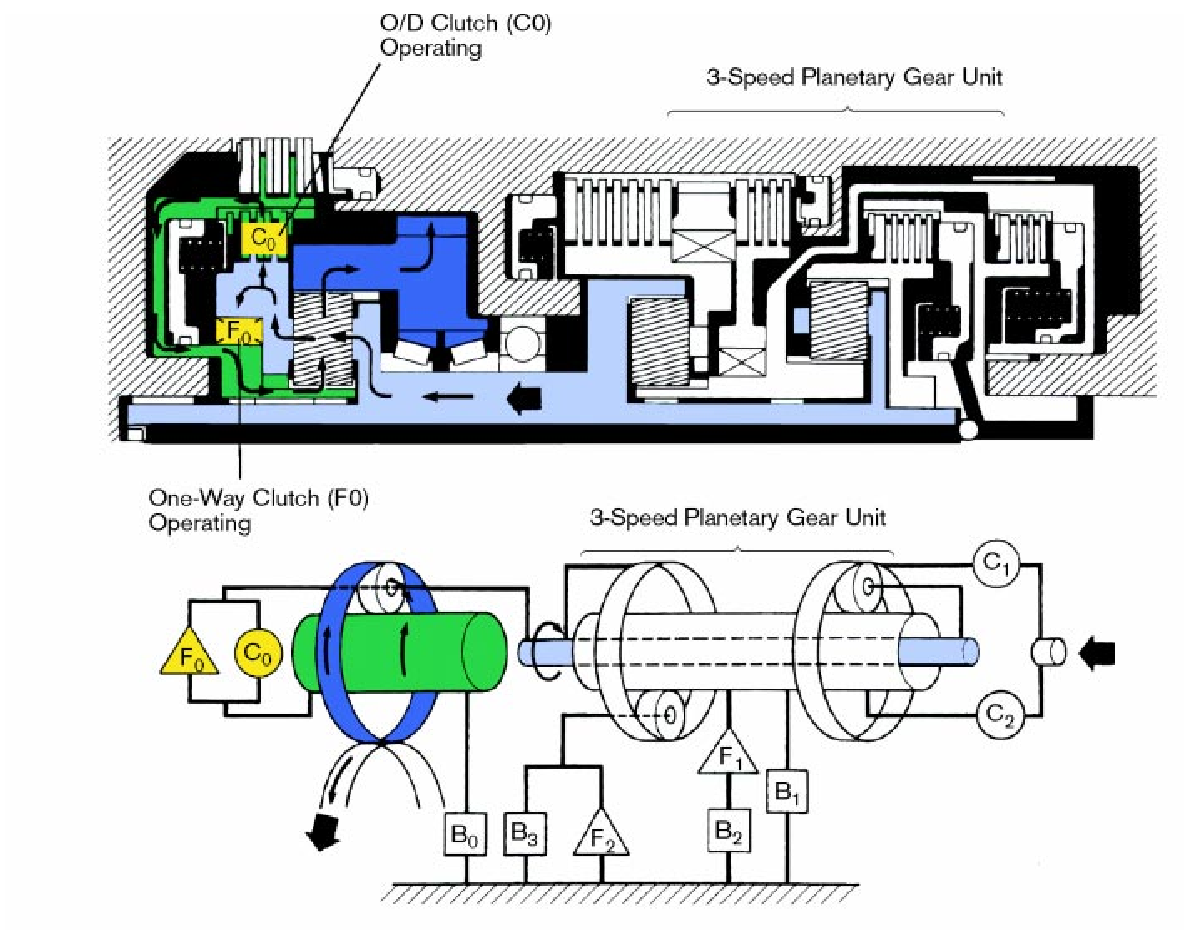
Fig. 1-32
T273f040

Direct Drive (Not in Overdrive)

The overdrive planetary unit is in direct drive (1:1 gear ratio) for reverse and all forward gears except overdrive. In direct drive the *overdrive direct clutch* (C0) and *overdrive one-way clutch* (F0) are both applied locking the sun gear to the carrier. With the sun gear and carrier locked together, the ring gear rotates with the carrier and the O/D assembly rotates as one unit.

Direct Drive

The overdrive planetary unit is in direct drive for reverse and all forward gears except overdrive.



Shift Lever Position	Gear Position	C0	C1	C2	B0	B1	B2	B3	F0	F1	F2
D	1st	●	●						●		●
	2nd	●	●				●		●	●	
	3rd	●	●	●			⊠		●		
	O/D		●	●	●		⊠				

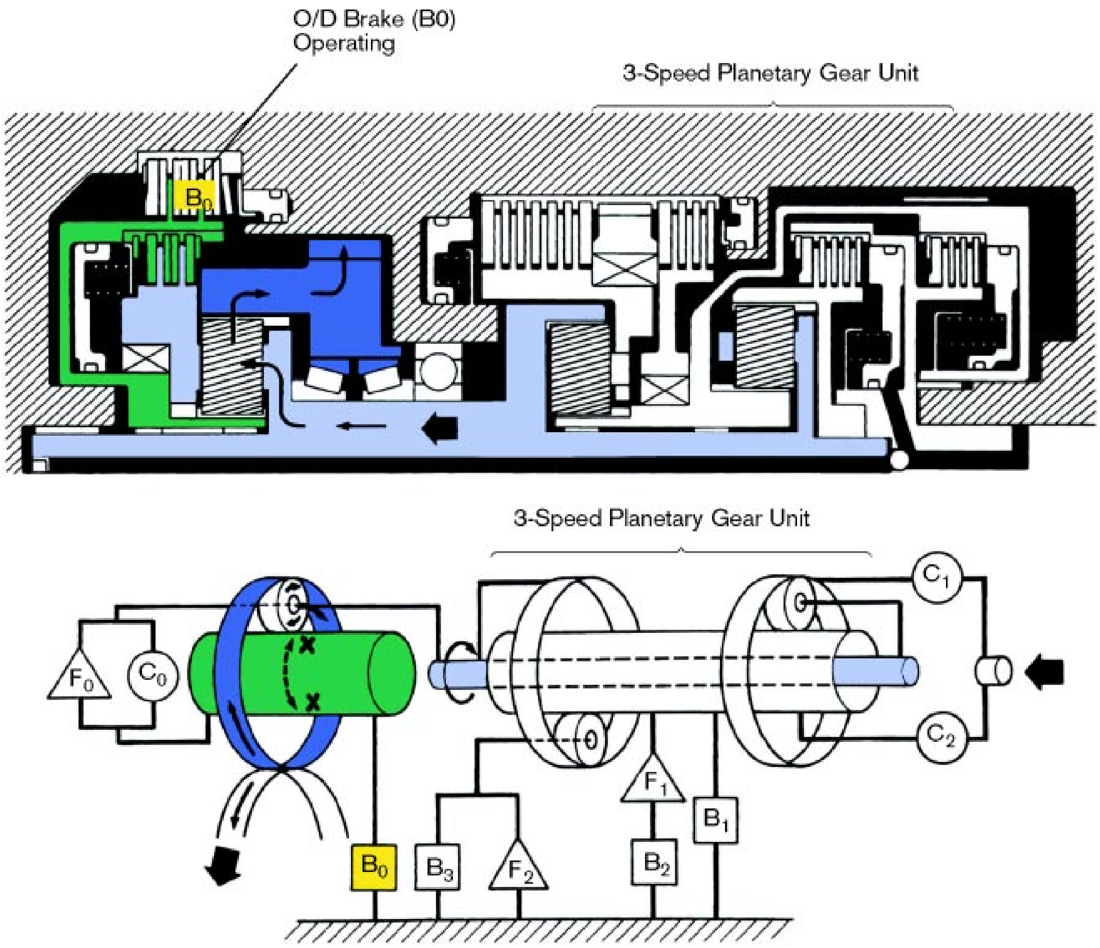
Fig. 1-33
T2731041/T2731042

Overdrive

In overdrive, the *overdrive brake* (B0) locks the O/D sun gear, so when the overdrive carrier rotates clockwise, the overdrive pinion gears revolve clockwise around the sun gear, carrying the overdrive ring gear clockwise at a speed faster than the overdrive carrier.

Overdrive

The overdrive ring gear rotates clockwise at a speed faster than the overdrive carrier.



Shift Lever Position	Gear Position	C0	C1	C2	B0	B1	B2	B3	F0	F1	F2
D	1st	●	●						●		●
	2nd	●	●				●		●	●	
	3rd	●	●	●			⊠		●		
	O/D		●	●	●		⊠				

Fig. 1-34
T273f043/T273f044