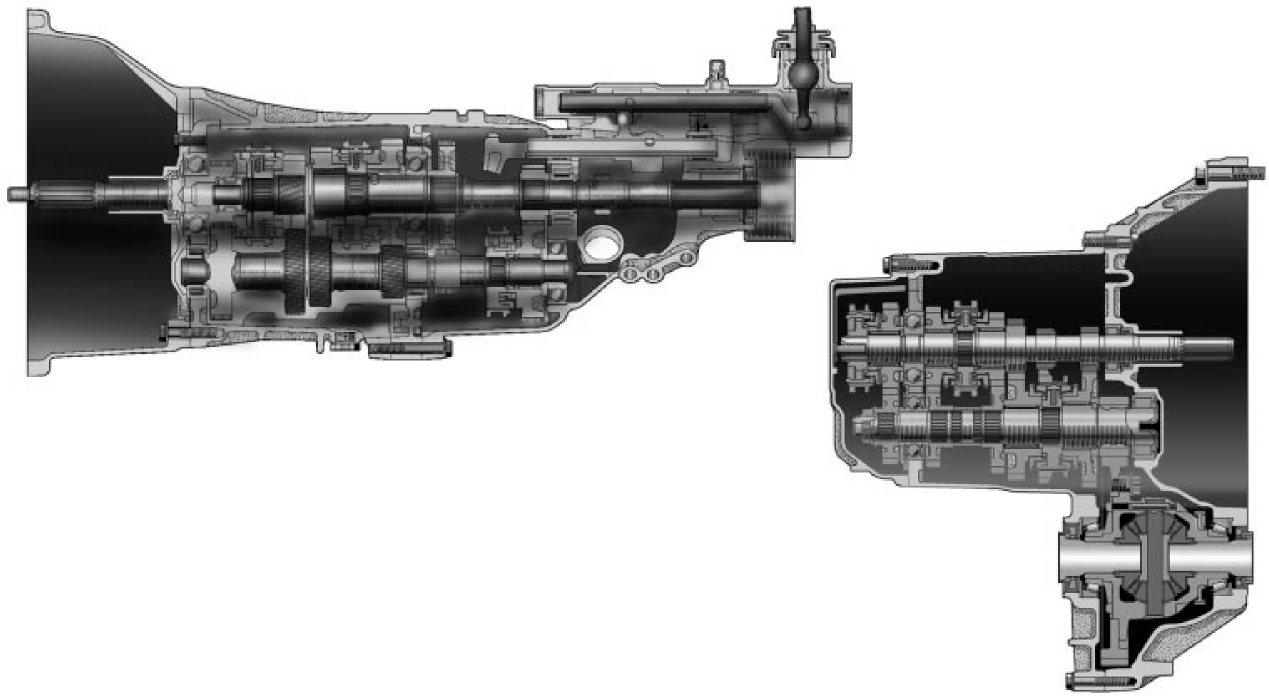
Section 1

Introduction to Manual Transmissions & Transaxles



Learning Objectives:

1. Identify the purpose and operation of transmissions.
2. Describe torque and torque multiplication.
3. Determine gear ratios.
4. Identify spur and helical gears, and describe the difference between the two.

Section 1

Introduction to Manual Transmissions & Transaxles

Drivetrain

Energy produced in the engine is transmitted to the drive wheels through the drivetrain. The components that make up the drivetrain include: a clutch mechanism, transmission, propeller shaft, differential and axles. The drivetrain allows the driver to control power flow using engine torque and allows the vehicle to move from a stop to cruising speed while maintaining engine speed within it's most efficient power band.

A drivetrain can transmit engine power to the rear wheels, front wheels or all four wheels. When the drivetrain delivers power to the rear wheels, it is referred to as **front engine rear drive (FR)**; when it delivers power to the front wheels, **front engine front drive (FF)**; and when it delivers power to all wheels, **four wheel drive (4WD)**.

Front Engine Rear Drive (FR) Drivetrain

A front engine rear drive (FR) drivetrain delivers power from a front mounted engine through the transmission and rear differential to the rear wheels.

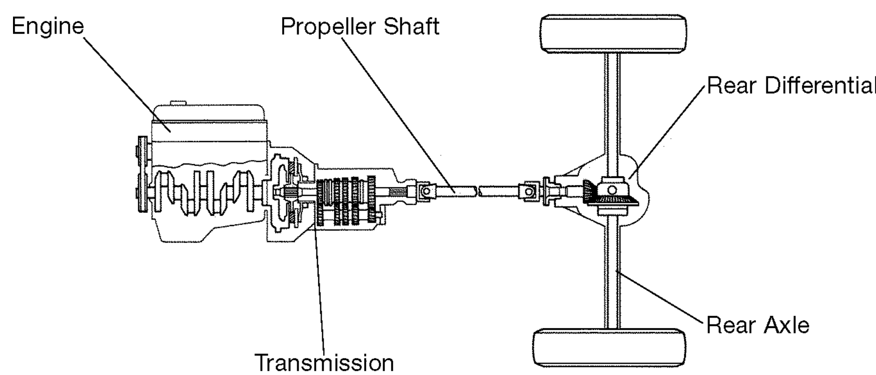


Fig. 1-1
T302f101

Front Engine Front Drive (FF) Drivetrain

A front engine front drive (FR) drivetrain delivers power from a front engine through the transaxle and differential to the front wheels. (This configuration is essentially the same for a rear mounted engine with rear wheel driver)

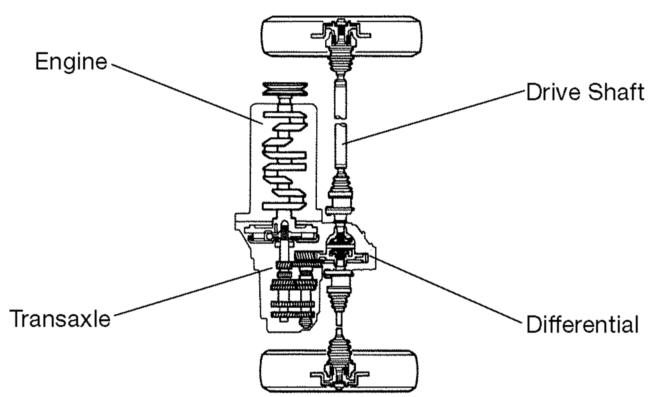


Fig. 1-2
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Four Wheel Drive (4WD) Drivetrain

A four wheel drive (4WD) drivetrain delivers power from a front mounted engine through either a transaxle to the front wheels and a transfer and a rear differential to the rear wheels; or through a transmission to the rear differential and rear wheels, and a transfer to a front differential and front wheels.

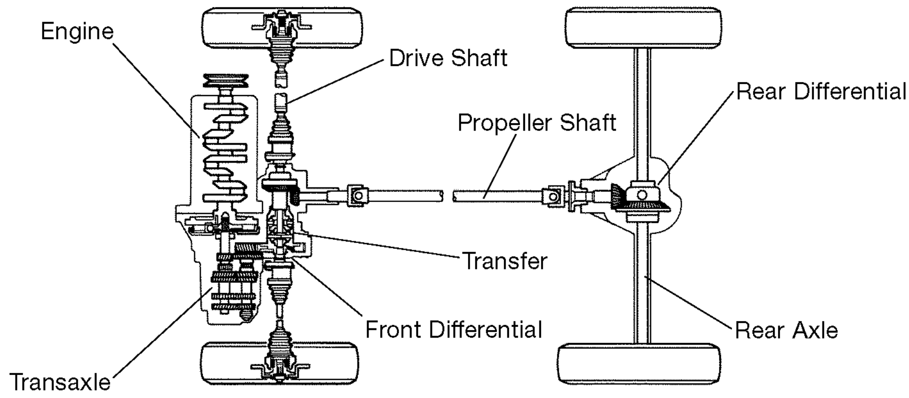

Fig. 1-3
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Torque

Rotating mechanical power produced by the drivetrain is called torque. Torque is measured in foot-pounds of force (ft-lbf) or in Newton-meters (N•m). To enable an automobile to move, the drive axle applies torque to the wheels and tires to make them rotate. The transmission and drive axle gear ratios multiply engine torque so a vehicle can be moved forward or backward from a stop.

Engine Torque

Torque, generated by the engine, is a twisting or turning force. Torque output increases proportionally with engine rpm to a certain point; This is a factor that greatly affects drivetrain design since very little torque is developed at engine speeds below 1000 rpm. A modern engine begins producing usable torque at about 1200 rpm and peak torque at about 2500 to 3000 rpm.

Torque

The transmission converts engine speed into the needed torque requirements to handle different driving situations.

When travelling on level ground at speed, engine torque is sufficient to drive the rear wheels at a constant speed. When at rest or travelling uphill, engine torque must be increased to the drive wheels to start the vehicle moving or maintain speed.

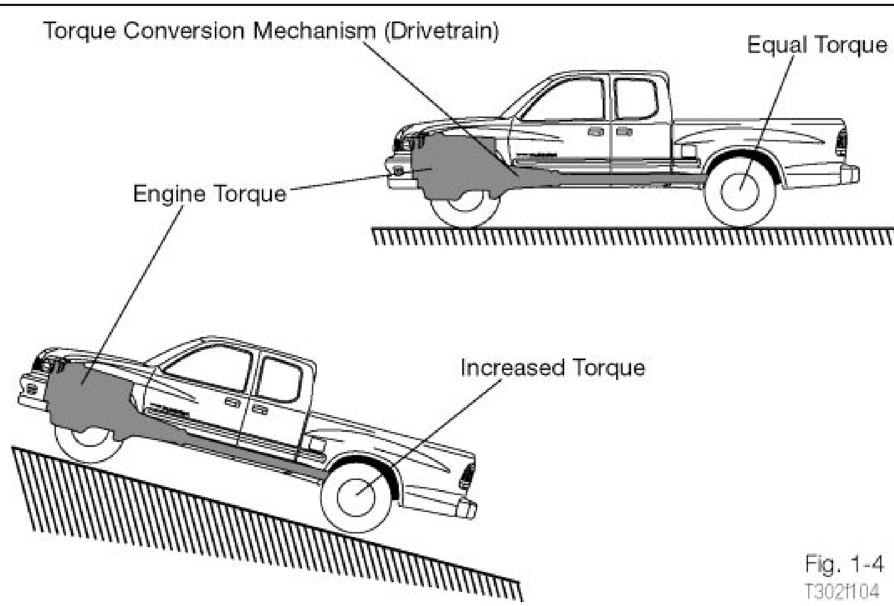

Fig. 1-4
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Torque Chart

Usable torque is produced beginning at about 1200 rpm and then increases proportionally with engine rpm to a certain point where it peaks around 2500 to 3000 rpm.

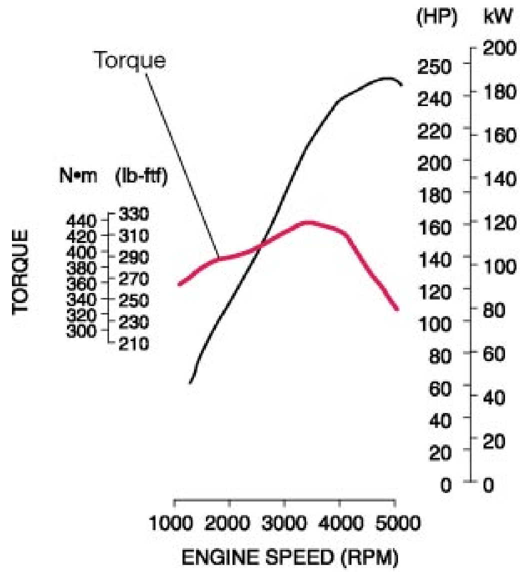

Fig. 1-5
T302f105

Torque Multiplication

The transmission converts engine speed into the needed torque output required for different driving conditions.

High torque is needed to start off from a stop and engine torque must be greatly multiplied at low engine RPM. High torque for climbing hills is provided by increased engine RPM and torque multiplication. Less torque is required to keep the vehicle moving at intermediate or high speeds, allowing engine speed to be reduced.

Changing Speed or Torque

Several devices, such as, gears, chains and sprockets can be used to change the speed or torque of a rotating output shaft. Gears with different teeth counts can be used to change the speed of a rotating shaft. Reducing the speed increases the torque proportionately; likewise, Increasing the speed reduces the torque.

The driven gear (output) always rotates in a direction opposite to the drive gear (input). If the drive gear and driven gear need to rotate in the same direction, the power can be routed through two gears sets, or through a combination of internal and external gears.

Changing the Speed or Torque of a Rotating Shaft

Gears with different teeth counts can be used to change the speed of a rotating shaft.

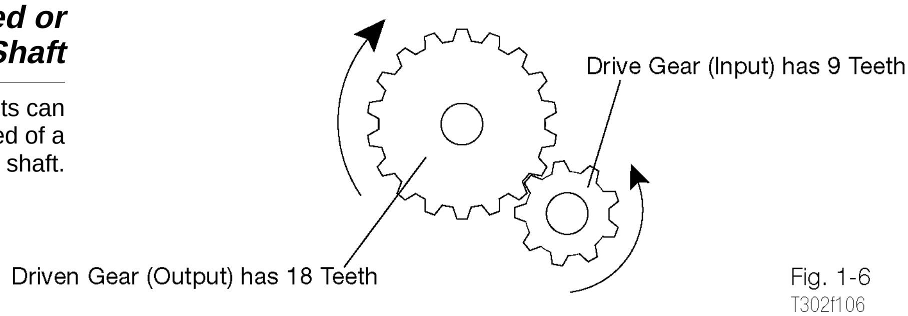

Fig. 1-6
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Gear Ratios

Gear ratio is the ratio of the size of two or more gears acting on each other. Gear teeth are cut in proportion to their diameter; if you have a drive gear that has 9 teeth and a driven gear that is twice as large as the drive gear, the driven gear will have 18 teeth. (see figure 1-7) When the drive gear rotates one revolution, the driven gear will rotate 1/2 revolution– 9 teeth of each gear will come into contact for each revolution of the drive gear.

Determining Gear Rations

Gear ratios are determined by dividing the number of teeth on the driven gear by the number of teeth on the drive gear. In the example in figure 1-7, 18 ÷ 9 = 2, therefore the ratio is 2:1.

Gear Ratio

When two gears with a gear ratio of 2:1 rotate together, the smaller drive gear will rotate one revolution to produce one-half revolution of the larger driven gear.

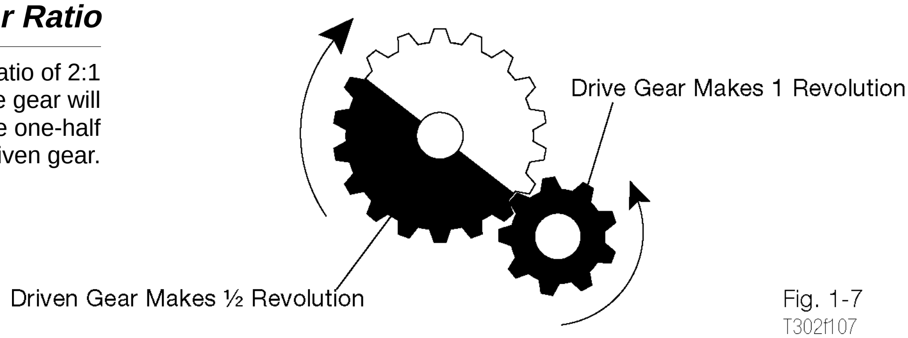

Fig. 1-7
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In this example, two revolutions of the drive gear will produce one revolution of the driven gear. This is called reduction– a reduction in speed, but an increase in torque. The higher the number of rotations on the drive gear, the lower the ratio.

If the drive gear has 9 teeth and the driven gear 6, there will be an increase in speed and a reduction in torque. This is referred to as overdrive. The ratio is determined as follows: 6 - 9 = 0.6 (6/9 = 0.6); so the ratio is 0.6:1. In this case, the drive gear turns 0.6 or three-fifths revolution for each turn of the driven gear. A gear ratio is always written so that the number 1 is to the right of the colon. This represents one turn of the output gear, while the number to the left represents the revolutions of the input.

Determining Gear Ratios

Most gear ratios are determined by dividing the number of teeth on the driven gear by the number of teeth on the drive gear.

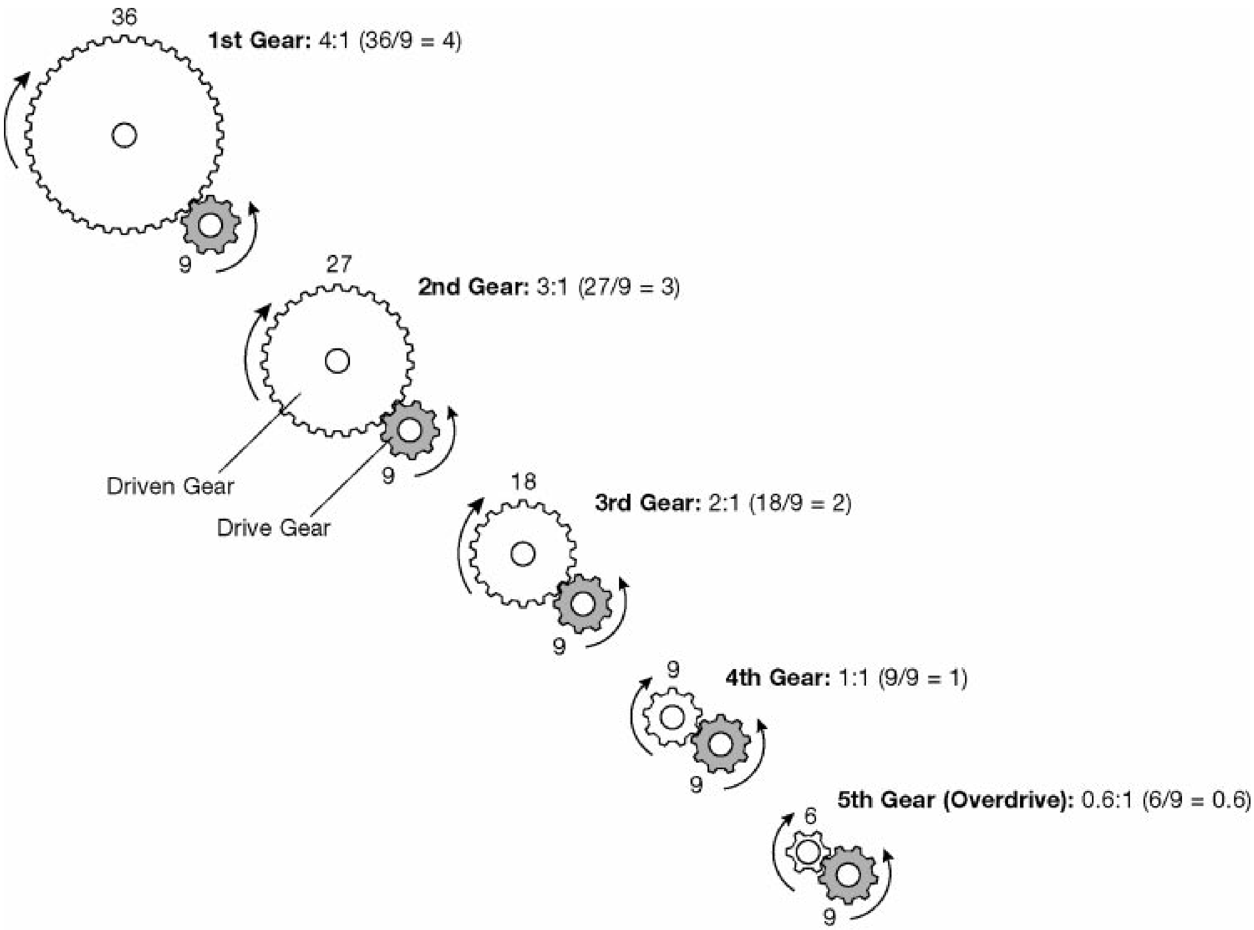

Fig. 1-8
T302f108

Simple Transmission

An example of a simple transmission would be one that consists of a drive gear and driven gear working to rotate a wheel (figure 1-9). Force is applied to a drive gear with 12 teeth to rotate a driven gear with 24 teeth, which in turn rotates a wheel; the gear ratio of this simple transmission would be: 24/12 = 2 or 2:1. The speed of the drive gear is going to be twice the speed of the driven gear. This is determined by the ratio between the number of teeth on the drive gear and the driven gear. The gear ratio or reduction ratio also determines the amount of torque transmitted from the drive gear to the driven gear. Although the driven gear is turning at half the speed of the drive gear, the torque that the driven gear has is twice that of the drive gear.

Simple Transmission

This simple transmission demonstrates the use of gears to rotate a wheel. The drive gear in this example has 12 teeth and the driven gear has 24 teeth for a gear ratio of 2:1. The speed of the drive gear is twice that of the driven gear. Though the wheel rotates at a slower speed than the original force applied to the drive gear, it does so with more torque.

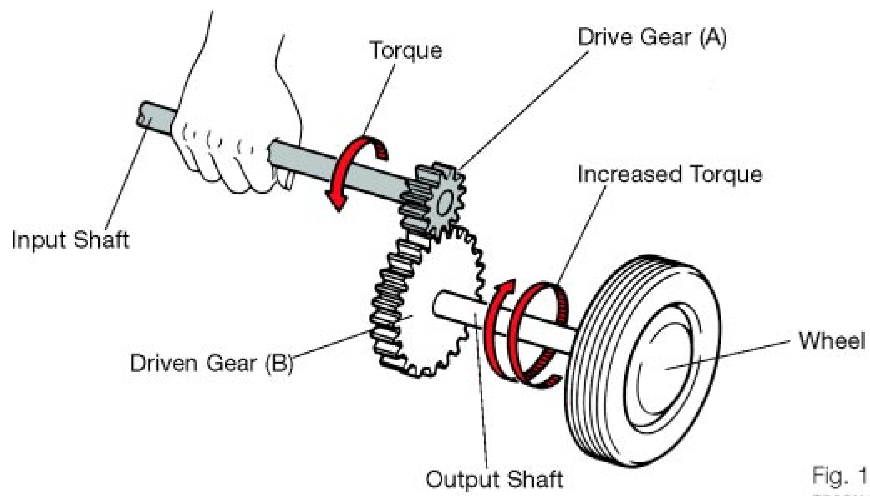

Fig. 1-9
T302f109

A simple formula using the input torque (the torque of the drive gear) and the gear ratio can be used to determine the torque applied to the wheel by the driven gear: The torque of the driven gear (B) equals the torque of the drive gear (A) multiplied by the gear ratio– the number of teeth on the driven gear divided by the number of teeth on the drive gear.

Formula to Determine Torque

The simple transmission in figure 1-9 has a gear ratio of 2:1; the drive gear (A) has a torque of 100 ft-lbf. Use this formula to determine the torque of the driven gear (B) applied to the wheel.

$$\text{TORQUE GEAR B} = \text{TORQUE GEAR A} \times \frac{\text{\# TEETH GEAR B}}{\text{\# TEETH GEAR A}}$$

$$\text{TORQUE GEAR B} = 100\ \text{ft-lbf} \times \frac{24}{12}$$

$$\text{TORQUE GEAR B} = 100\ \text{ft-lbf} \times 2$$

$$\text{TORQUE GEAR B} = 200\ \text{ft-lbf}$$

Fig. 1-10

In a simple transmission as shown in figure 1-9, the direction of rotation of the drive gear is reversed to the driven gear as power is applied. Thus, the direction of rotation of the input shaft is reversed in the output shaft.

Direction of Rotation

When two gears are combined, the direction of rotation of the input shaft for the drive gear (A) is reversed in the output shaft for the driven gear (B).

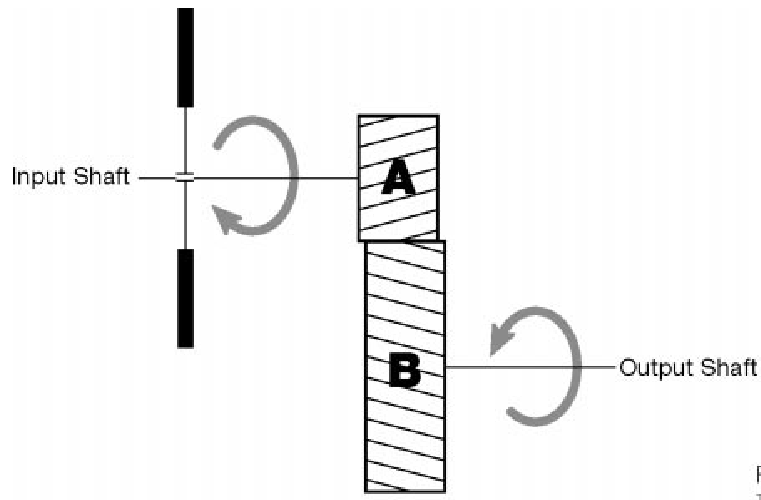

Fig. 1-11
T302f111

To maintain the same direction of rotation from the input shaft to the output shaft, two pairs of gears are used with a counter shaft connecting them. This allows the transmission to keep the direction of rotation the same between input and output shafts. Gears B and C can be called the counter shaft gears of the simple transmission diagram shown in figure 1-12.

Maintaining the same Direction of Rotation

If the direction of rotation of the output shaft needs to match that of the input shaft, a counter shaft is introduced into the gear set. The drive gear (A) drives the counter gear (B), rotating the counter shaft in the opposite direction of rotation; the counter shaft then rotates the counter gear (C), which then drives the driven gear (D) on the output shaft producing the same direction of rotation as the input shaft.

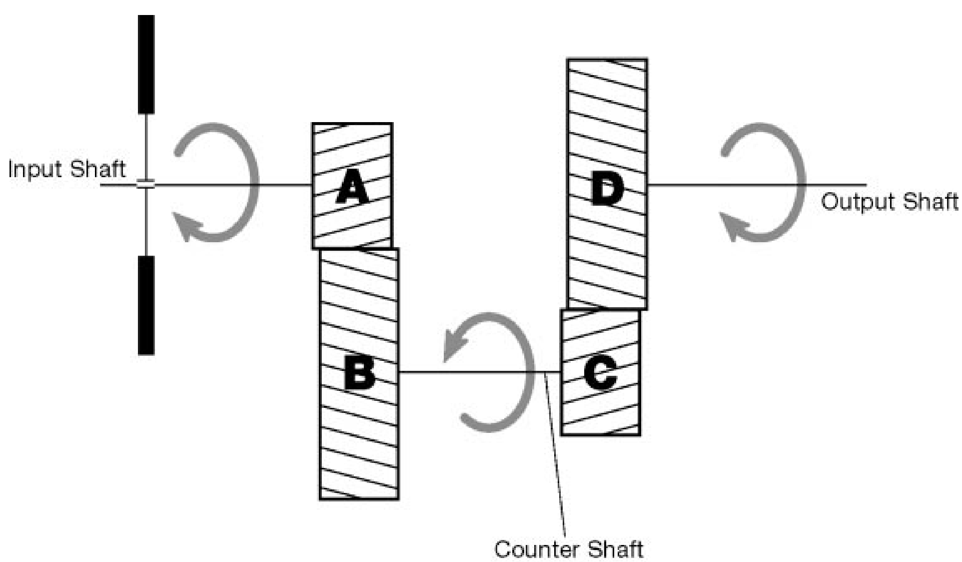

Fig. 1-12
T302f112

Final Gear Ratio

When power goes through more than one gear set, two or more ratios are involved. Usually, the simplest way to handle this is to figure the ratio of each set and then multiply one ratio by the other(s). An example is a vehicle with a first gear ratio of 2.68:1 and a rear axle ratio of 3.45:1. The overall, or final gear ratio in first gear is 2.68 x 3.45 or 9.246:1. The engine rotates at a speed that is 9.246 times faster than the rear axle shafts.

Final Gear Ratio

The final gear ratio can be expressed with these equations.

$$\text{FINAL GEAR RATIO} = \frac{\text{OUTPUT GEAR B}}{\text{OUTPUT GEAR A}} \times \frac{\text{OUTPUT GEAR D}}{\text{OUTPUT GEAR C}}$$

OR

$$\text{FINAL GEAR RATIO} = \frac{\text{\# TEETH GEAR B}}{\text{\# TEETH GEAR A}} \times \frac{\text{\# TEETH GEAR D}}{\text{\# TEETH GEAR C}}$$

Fig. 1-13

Manual transmissions contain four or five forward pairs of gears and one set of gears for reverse. In reverse, an idler gear is used to change the direction of the output shaft for reverse.

Idler Gear

An idler gear is used to change the direction of the output shaft for reverse.

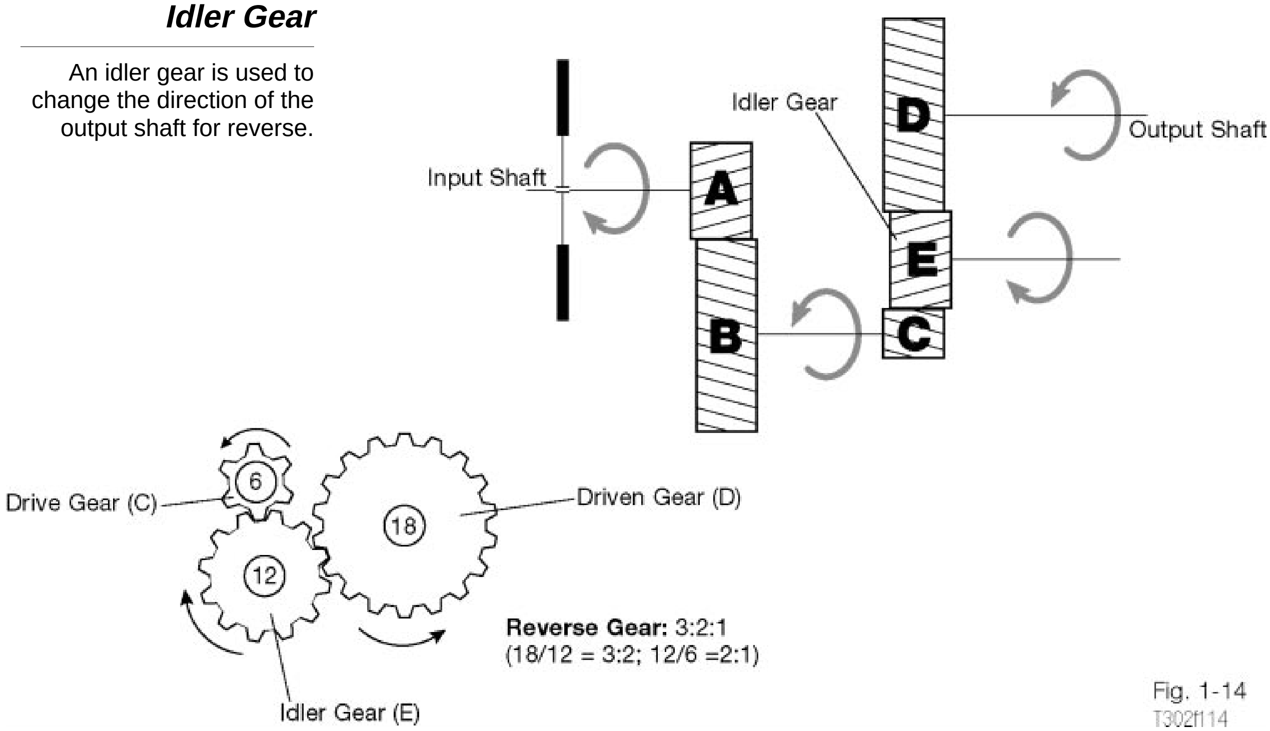

Fig. 1-14

Gear Types

There are two types of gears: spur gears and helical gears.

Spur Gears

Spur gears are cut perpendicular to the direction of travel. All thrust is transferred in the direction of rotation; but, spur gears are noisy. Spur gears are generally only used for reverse.

Helical Gears

All other gears in Toyota transmissions are helical gears, which have the teeth cut in a spiral or helix shape. Helical gears operate more quietly than spur gears, but helical gears generate axial or end thrust under a load. Helical gears are also stronger than a comparable sized spur gear.

Helical Gears

The teeth on a helical gear are cut on a slant. This produces an axial or side thrust.

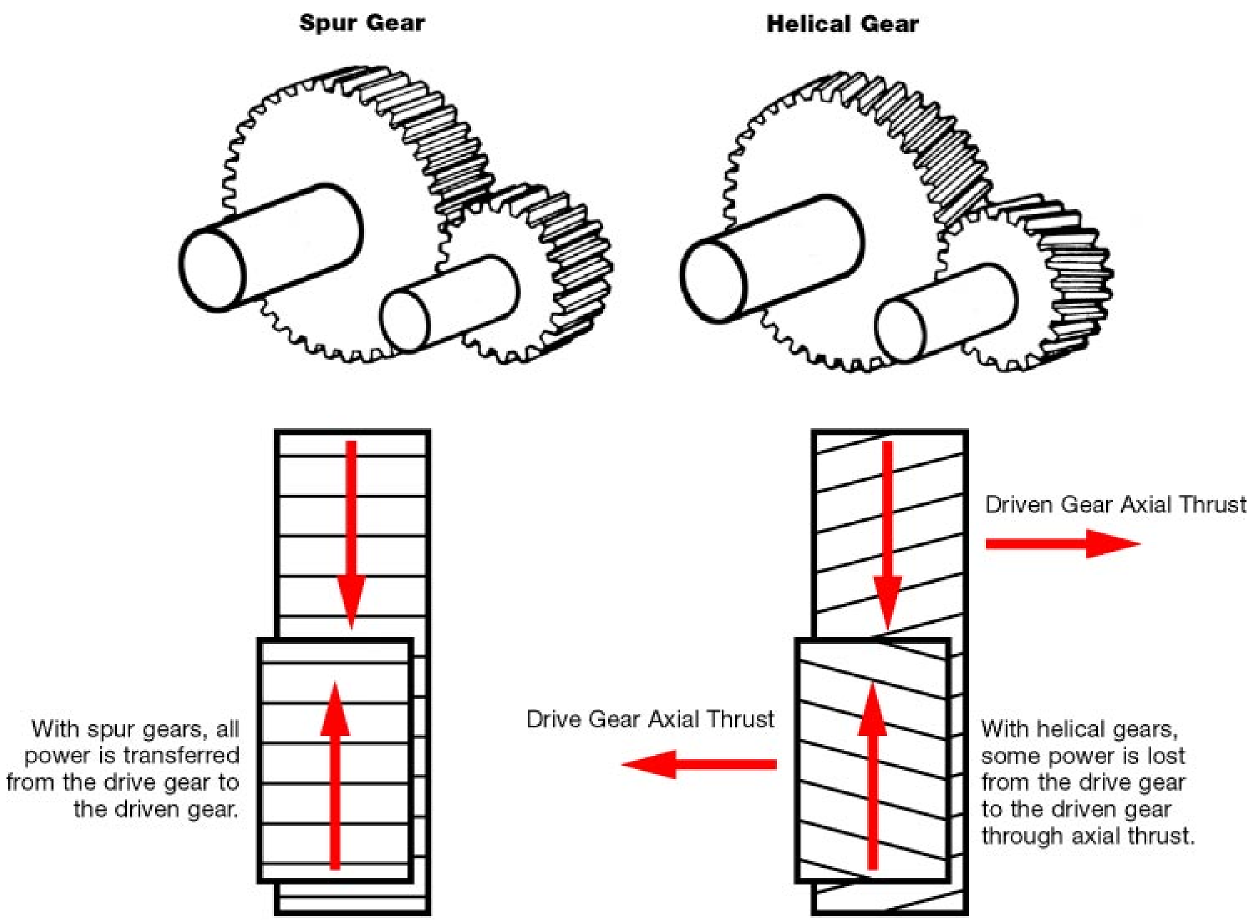

Fig. 1-15
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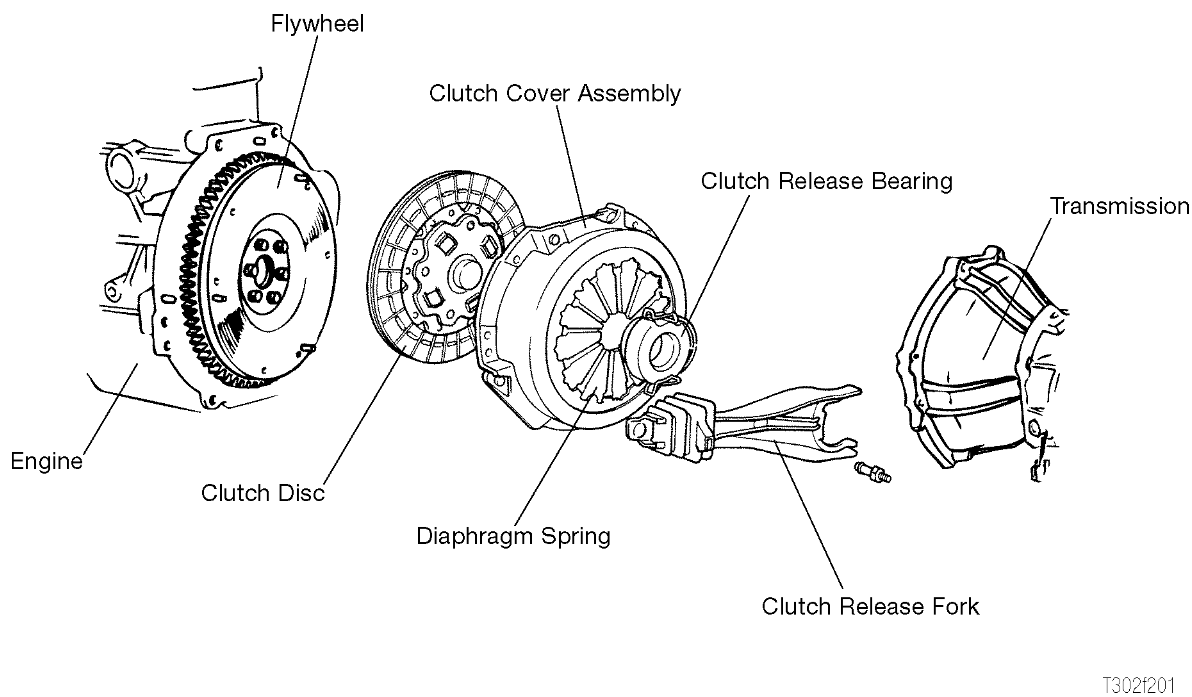
Notes

Section 2

Clutch Assembly



Learning Objectives:

1. Identify the purpose and function of the clutch
2. Identify and describe the operation of the following clutch components:
   a. Clutch disc
   b. Clutch cover assembly
   c. Flywheel
   d. Hydraulic system
   e. Release bearings and fork
   f. Clutch cover assembly
3. Identify and describe clutch service procedures
   a. Clutch pedal free travel
   b. Clutch slippage
   c. Clutch spin down
   d. Clutch pedal noise
4. Identify and describe clutch component inspection procedures
5. Identify and describe clutch removal and replacement procedures
6. Identify and describe clutch assembly procedures
7. Describe hydraulic system repair procedures

Clutch Assembly

Clutch Assembly

The **clutch assembly** interrupts the power flow between the engine and the transmission when the vehicle is brought to a stop with the engine running and when shifting gears. The clutch assembly consists of the following components:

- Clutch disc
- Flywheel
- Clutch cover assembly
- Clutch release bearing
- Clutch release fork

The **clutch disc** is connected to the input shaft of the transmission, and is located between the flywheel and clutch cover assembly. The **flywheel** is connected to the engine crankshaft and the **clutch cover assembly** is attached to the flywheel. The **clutch release fork** forces the **clutch release bearing** against the diaphragm spring of the clutch cover assembly.

Clutch Assembly Components

The clutch assembly contains several major parts: flywheel, clutch disc, clutch cover assembly, clutch release bearing, and clutch release fork.

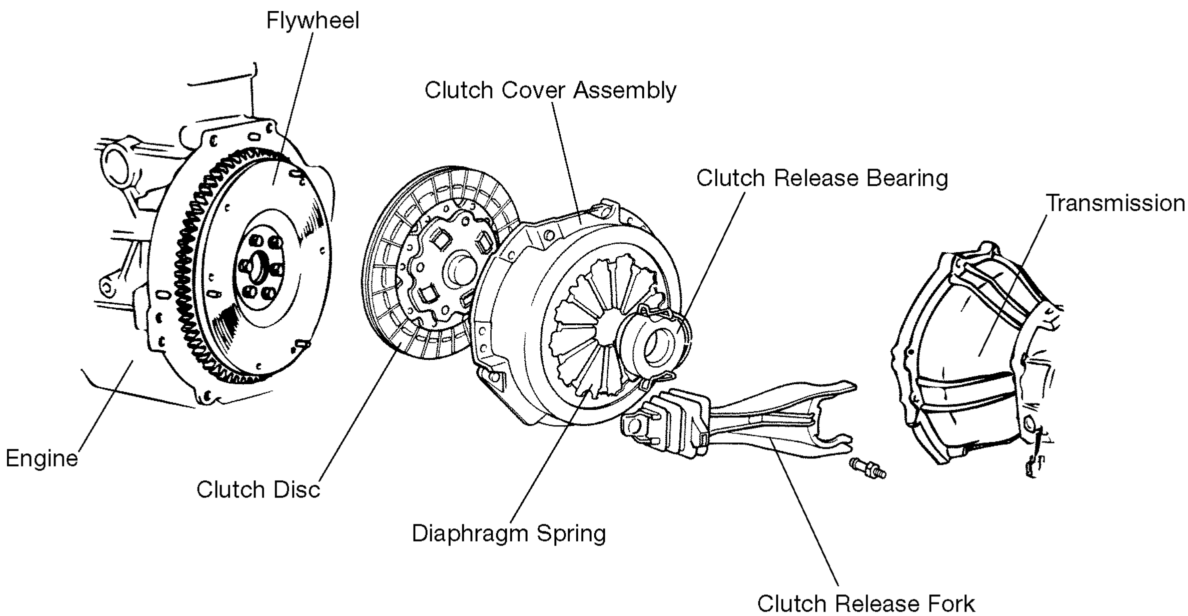


Fig. 2-1
T302f201

Flywheel The **flywheel** is connected to the engines crankshaft. A flywheel is very similar to a brake rotor in appearance. It is a large metal disc that stores and releases energy pulses from the crankshaft. It drives the clutch by providing a friction surface for the clutch disc. In addition, the flywheel provides a mounting surface for the clutch cover, and also dissipates heat.

Flywheel

A flywheel is very similar to a brake rotor in appearance. It is a large metal disc that stores and releases energy pulses from the crankshaft.

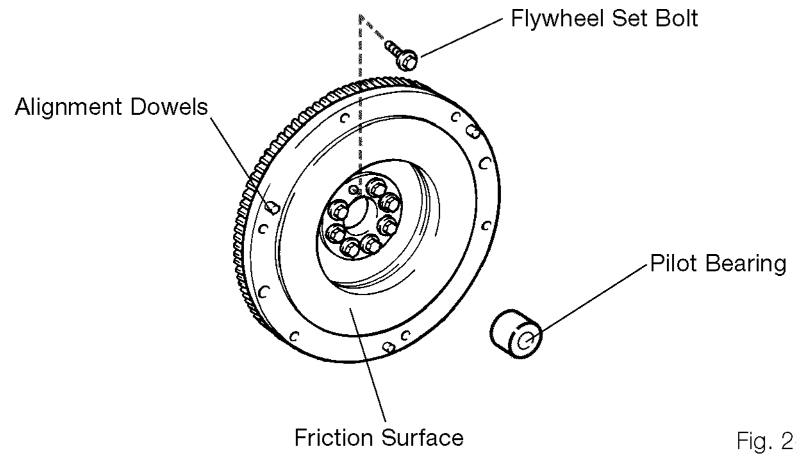


Fig. 2-2
T302f202

Pilot Bearing A pilot bearing supports the engine side of the input shaft. The pilot bearing used on Toyota vehicles is a ball bearing located in a bore in the end of the crankshaft. The pilot bearing only turns when the clutch is disengaged.

Clutch Disc The **clutch disc** is the connecting link between the engine and the transmission. A clutch disc provides a large surface area made of friction material on both sides. In the center, a damper assembly absorbs torsional vibration.

The facing, or friction material is riveted to the cushion plate on both sides and is similar to the composition of brake lining. The cushion plate has a wave design that allows the facings to compress when the pressure plate is engaged. This provides a smooth engagement of engine and transmission.

Clutch Disc

The clutch disc connects the engine and the transmission providing for smooth engagement.

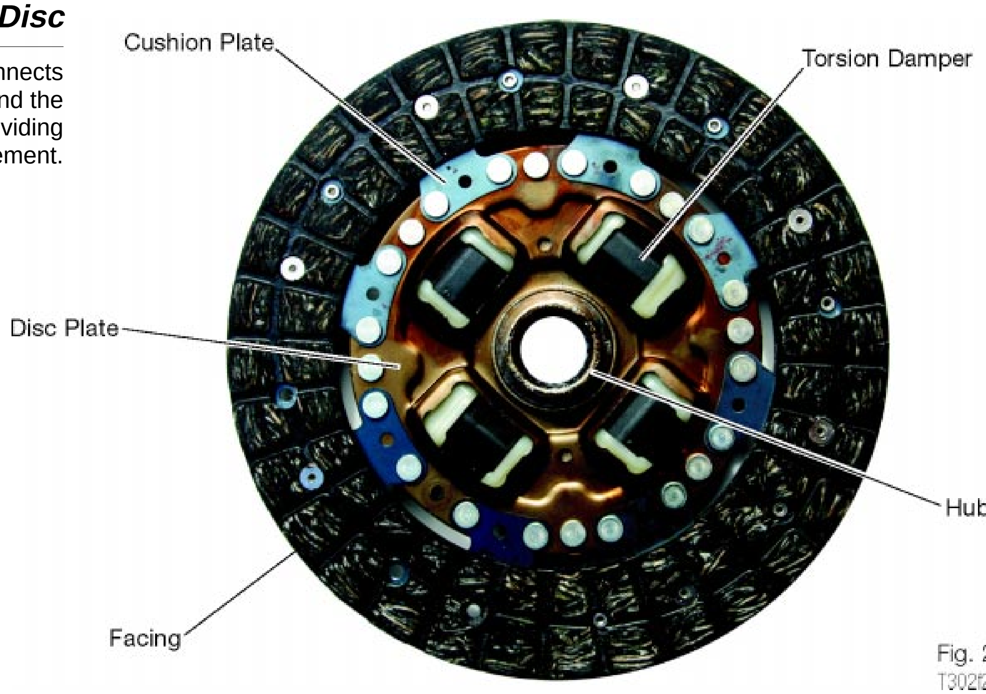


Fig. 2-3
T302f203

Grooves are provided in the clutch disc facing to eliminate the problem of the clutch disc adhering to the flywheel and the pressure plate of the clutch cover assembly. Air is trapped in the grooves when the clutch is engaged. When the clutch disc is released, the centrifugal force of the turning disc causes the trapped air to push against the flywheel and pressure plate. This action breaks the adhesion created between the flywheel, clutch disc facing and pressure plate.

Circular Groove

To eliminate the problem of the clutch disc adhering to the flywheel and pressure plate, grooves are provided in the clutch disc facing.

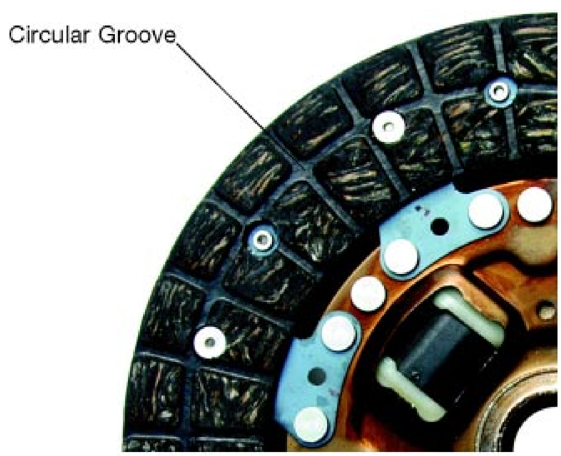


Fig. 2-4
T302f204

Clutch Hub & Damper Assembly

The internal splines of the **clutch hub** fit over the external splines of the transmission input shaft allowing the clutch hub to move back and forth smoothly. Most clutch discs include a **damper assembly** to reduce or eliminate torsional vibrations that occur from uneven engine and drivetrain power pulses.

Throughout the engine power cycle, the crankshaft speeds up and slows down during each revolution. The damper removes slight speed fluctuations, which prevent vibration, gear rattle, noise and wear to the transmission and drivetrain.

The damper assembly consists of a hub flange that pivots between the disc plate, and cover plate. Each of these components have four to six openings in which the torsion dampers are located, allowing torque to pass from the disc plate and cover plate to the hub flange and hub. The torsion dampers absorb the shock of: clutch engagement, acceleration and deceleration and power pulses from the engine.

Clutch Hub & Damper Assembly

The damper reduces or eliminates torsional vibrations that result from uneven engine and drivetrain power impulses.

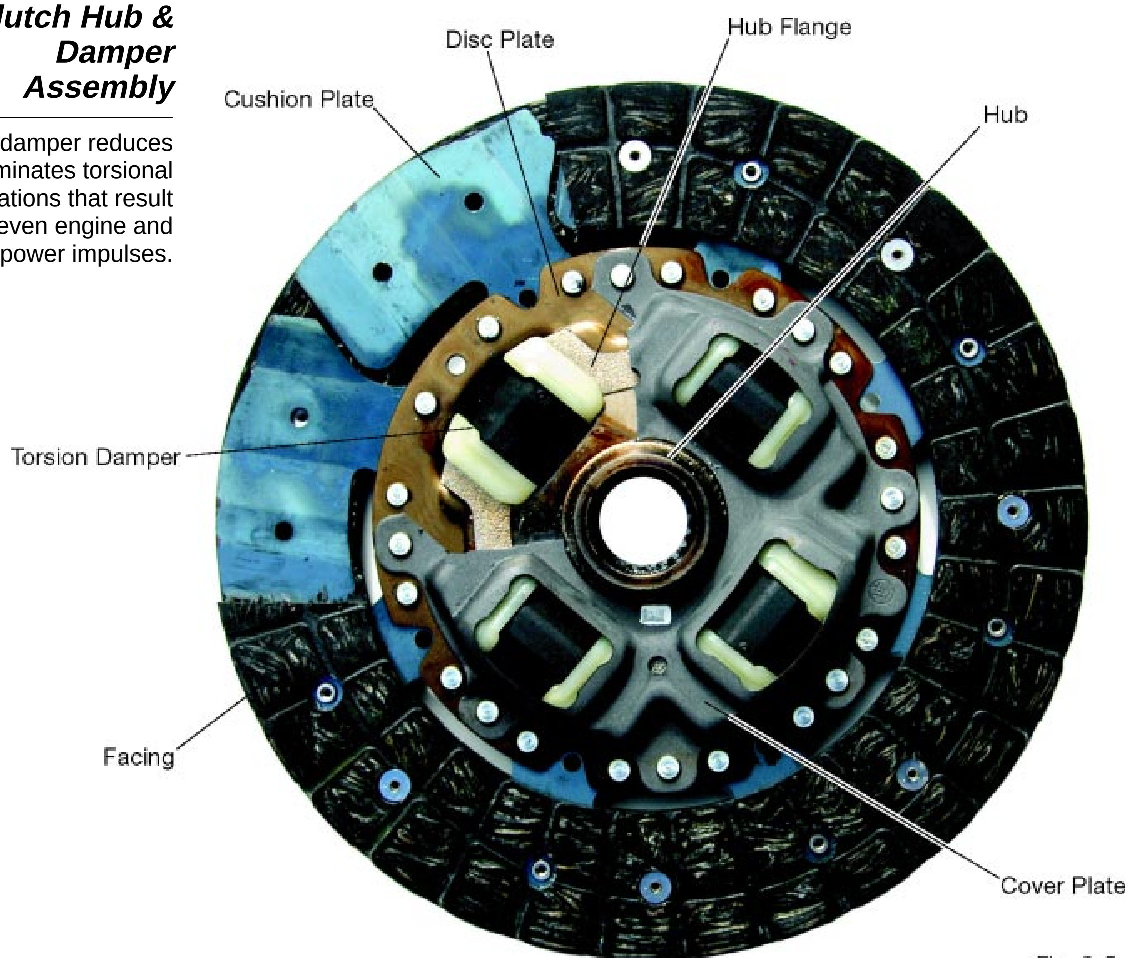


Fig. 2-5
T302f205

Clutch Cover Assembly

The **clutch cover assembly** is bolted to the flywheel and provides the pressure needed to hold the clutch disc to the flywheel for proper power transmission. It is important that the assembly be well balanced and able to radiate the heat generated when the clutch disc is engaged.

Toyota uses two types of clutch cover assemblies:

- Diaphragm spring
- Diaphragm Spring Turnover (DST)

Clutch Cover Assembly

The clutch cover assembly is bolted to the flywheel and provides the pressure needed to hold the clutch disc to the flywheel.

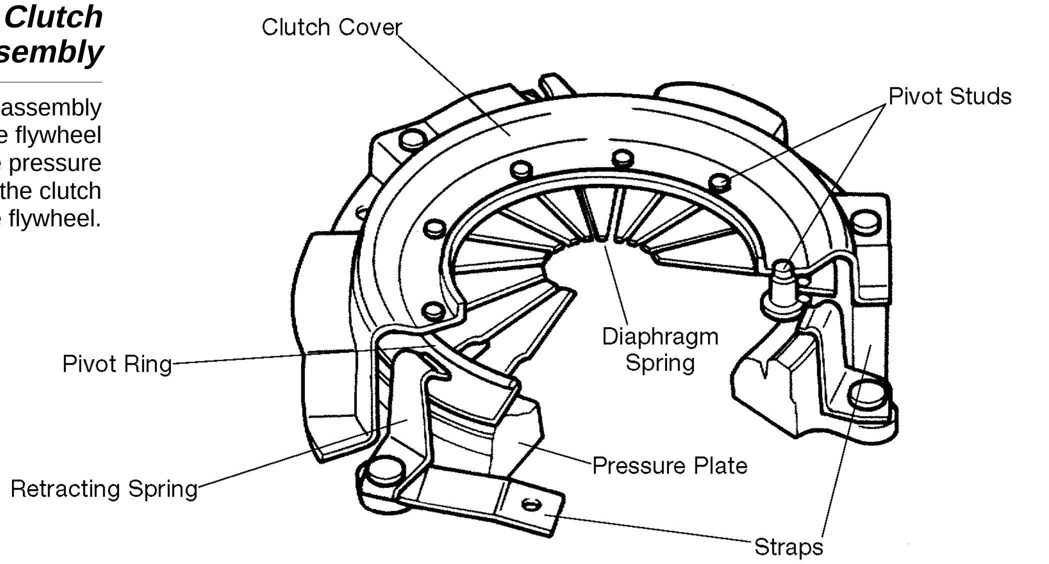


Fig. 2-6
T302f206

Diaphragm Spring

The **diaphragm spring** is a round, conical shaped spring that provides the clamping force against the pressure plate. **Pivot rings** are installed on both sides of the diaphragm spring. They serve as a pivot point when the release bearing is forced against the diaphragm spring. The pivot stud connects the diaphragm spring to the clutch cover. The **retracting springs** connect the diaphragm spring and the pressure plate. The straps connect the pressure plate to the clutch cover and do not allow the pressure plate to move out of position. When the release bearing is pushed against the diaphragm spring, the spring folds inward and the pressure plate moves away from the clutch disc.

Diaphragm Spring Turnover (DST)

The Diaphragm Spring Turnover (DST) type of clutch cover assembly differs from the conventional type only in construction. The DST cover does not use a separate pivot stud to connect the diaphragm spring to the cover. The cover is shaped so that the pivot points are part of the clutch cover. Since the **retracting springs** have been eliminated, the **strap springs** are used to disengage the **pressure plate** from the clutch disc. The diaphragm spring fingers are chrome plated in the area where the release bearing rides to help eliminate wear and noise. With this design, the clutch cover gives optimum release performance and is lightweight.

Diaphragm Spring Turnover (DST)

The DST cover does not use a separate pivot stud to connect the diaphragm spring to the cover.

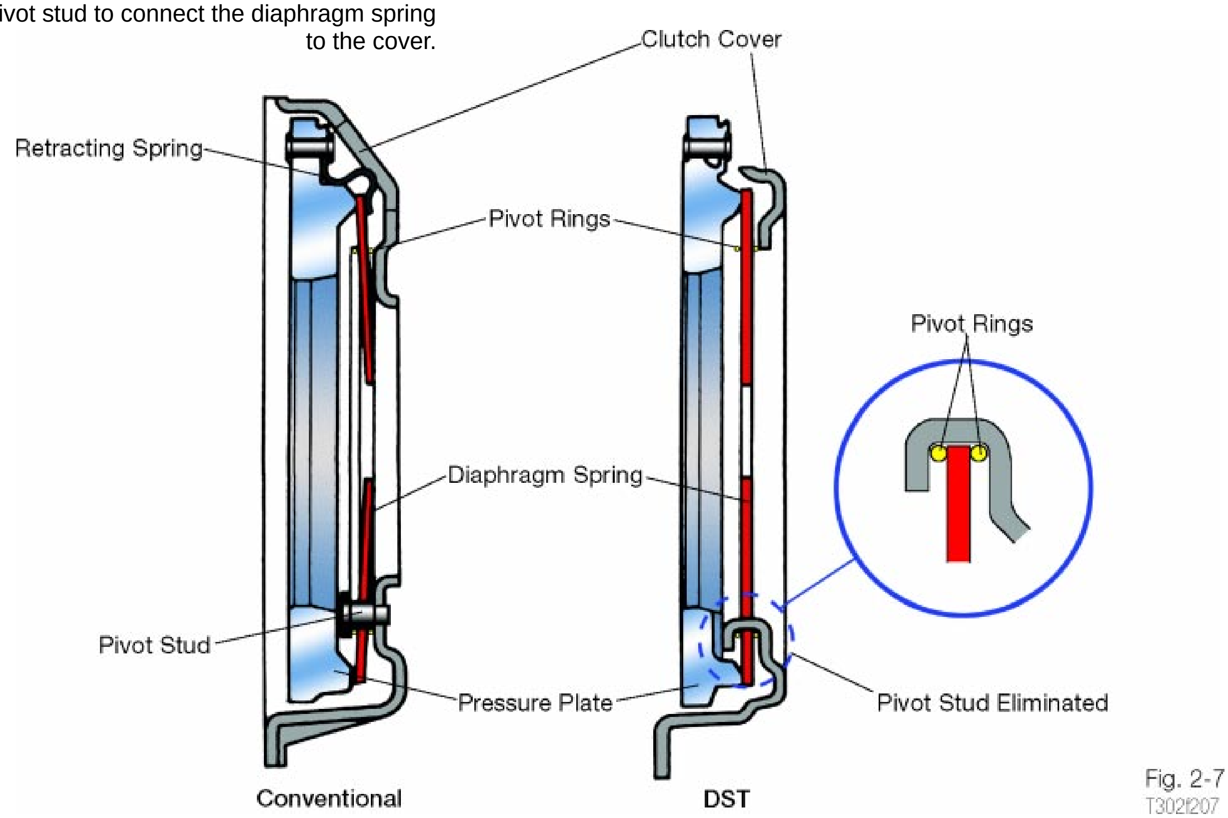


Fig. 2-7

Clutch engagement begins when the pressure plate of the clutch cover and flywheel begin to rub against the clutch disc. The amount of torque transferred to the clutch increases as spring pressure against the **pressure plate** increases. When the clutch is engaged, pressure from the **clutch cover diaphragm** forces the pressure plate against the clutch disc and flywheel.

Clutch Release Bearing & Clutch Release Fork

The purpose of the **clutch release bearing** is to transfer the movement of the **clutch release fork** into the rotating diaphragm spring and clutch cover to disengage the clutch disc. There are two major types of release bearings used by Toyota. They are:

- Conventional
- Self-centering

Conventional Release Bearing

A sealed ball bearing is pressed on the release hub, which is attached to the release fork. The hub and release bearing slide on the transmission front bearing retainer sleeve. As the clutch pedal is depressed, the release fork moves the hub and release bearing toward the diaphragm spring of the clutch cover. When the release bearing comes in contact with the rotating diaphragm spring, the outer race of the bearing will begin to rotate. The outer race is made of a sintered alloy to reduce wear and noise during contact. The release fork continues to move the release bearing into the clutch cover and the pressure being applied to the clutch disc is released. On self adjusting clutches, the release bearing is in constant contact with the diaphragm spring. The outer race of the bearing is always rotating with the clutch cover.

Conventional Release Bearing

The main components of the conventional release bearing are the release bearing, clutch release bearing hub, retaining clip and clutch release fork.

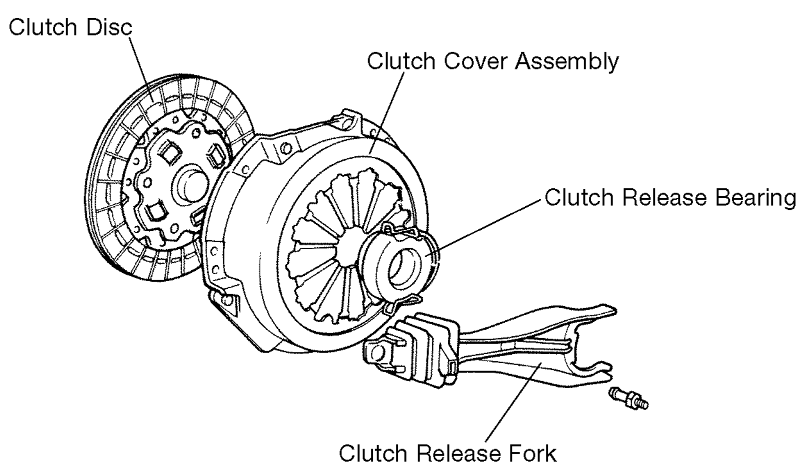


Fig. 2-8
T302f208

Self-Centering Release Bearing

A **self centering release bearing** is used to prevent noise caused by the release bearing pressing unevenly on the diaphragm spring. This noise occurs when the **centerline** between the crankshaft, clutch cover assembly, transaxle input shaft and release bearing is not the same. It is used on transaxles because the input shaft does not fit into a pilot bearing in the crankshaft like a transmission input shaft does. The transaxle input shaft is supported by bearings in the case. The self centering release bearing automatically compensates for this by aligning itself with the centerline of the diaphragm spring. This helps prevent noise associated with clutch disengagement.

Self-Centering Release Bearing

A self centering release bearing is used to prevent noise caused by the release bearing pressing unevenly on the diaphragm spring.

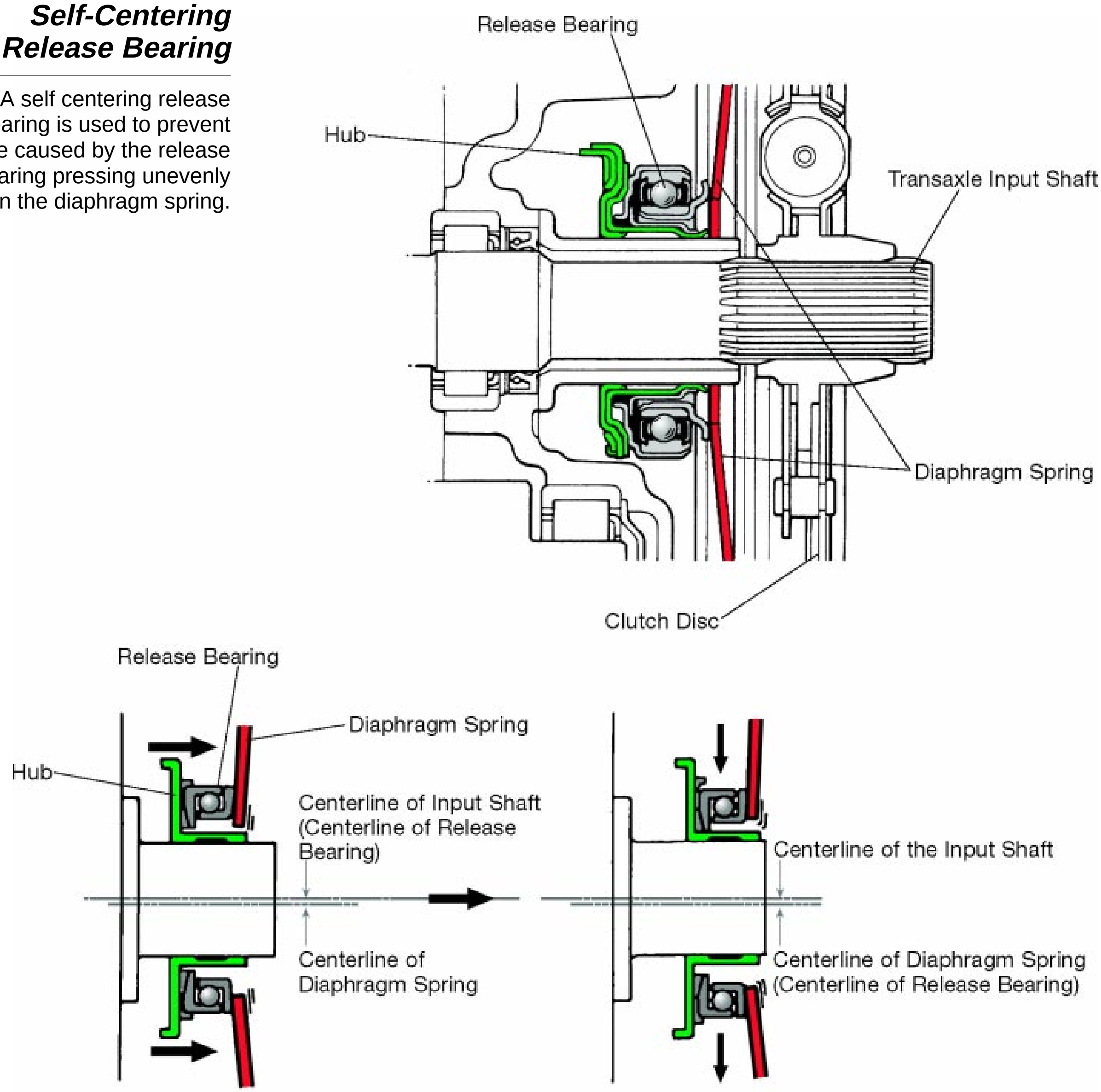


Fig. 2-9
T302f209

The hub of the self centering release bearing is made of **pressed steel**. The **bearing** is not pressed onto the hub as with the conventional release bearing. A **rubber seat**, **resin seat**, **bearing**, and **wave washer** are secured to the hub with a **snap ring**. The inner diameter of the release bearing (“B” in figure 2-10) is 1 to 2mm greater than the outer diameter of the hub (“A” in figure 2-10). This clearance allows the release bearing to move and self center to avoid wear.

Self-Centering Release Bearing

The hub of the self centering release bearing is made of pressed steel; a rubber seat, resin seat, bearing, and wave washer are secured to this hub with a snap ring. The inner diameter of the release bearing (A) is 1-2mm greater than that of the outer diameter of the hub (B).

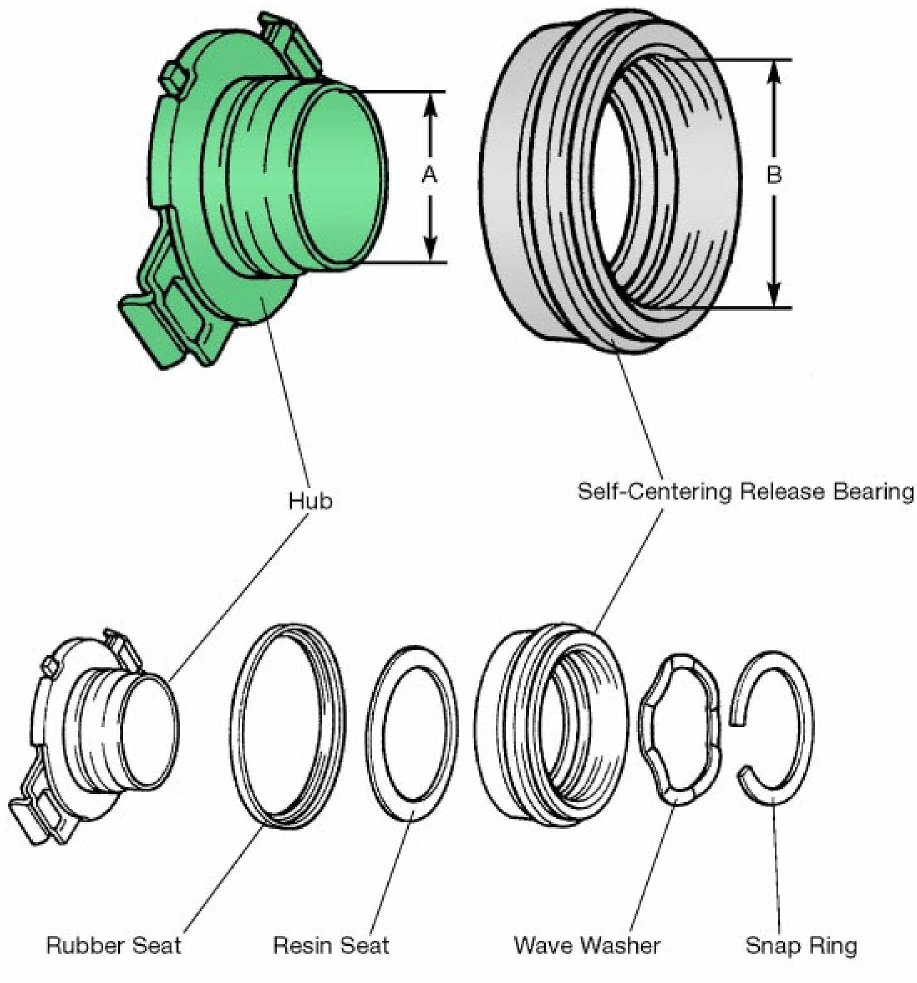


Fig. 2-10
T302f210

Hydraulic Clutch System

In a hydraulic clutch system, there are three major components:

- Master cylinder
- Release cylinder
- Clutch pedal

The **master cylinder** stores hydraulic fluid in the reservoir and provides pressure for system operation. When the **clutch pedal** is depressed, pressure is built up in the master cylinder forcing fluid into the **release cylinder**, which causes the clutch release fork to move. The release fork and release bearing compress the diaphragm spring of the clutch cover to disengage the clutch disc.

Hydraulic Clutch System

The hydraulic system consists of a clutch master cylinder, clutch release cylinder, and clutch pedal.

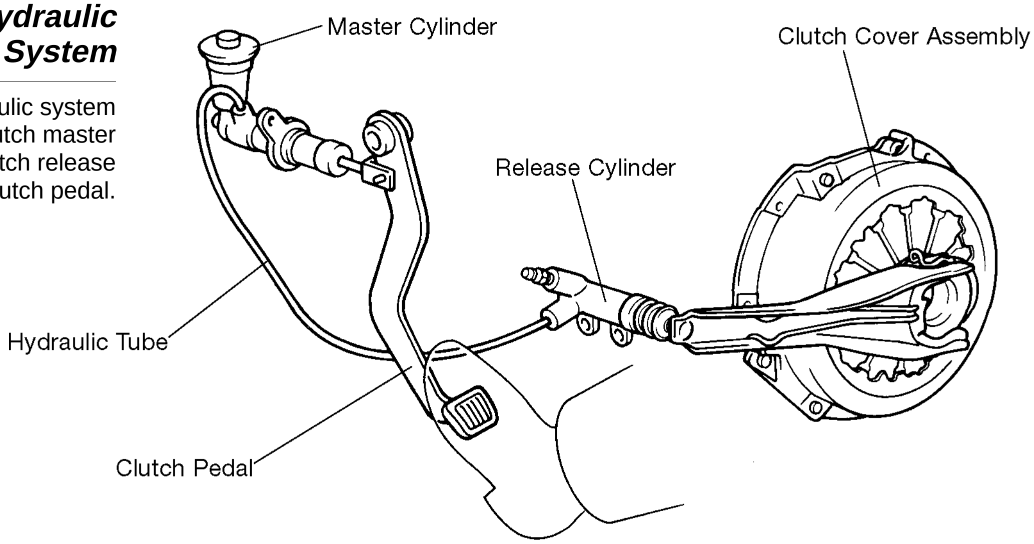


Fig. 2-11
T302f211

Master Cylinder

When force is applied to the pushrod, the piston displaces hydraulic fluid in chamber A of the master cylinder (as shown in figure 2-12). During initial piston travel, the compensating port in the master cylinder is closed by the piston. Further piston travel allows fluid to be displaced, transmitting force through the clutch line to the release cylinder located at the transmission. When the pushrod is released, the piston is returned to its initial position by a spring. With the compensating port open, pressure in chamber A equalizes with the reservoir. If the compensating port is blocked, any expansion of the fluid due to heat could cause pressure in chamber A to increase. During normal clutch wear, this condition may eventually cause the clutch to slip.

Master Cylinder

When the clutch pedal is depressed, the push rod forces the piston to move in the bore of the cylinder. When the clutch pedal is released, the return spring pushes the piston back in the bore of the cylinder.

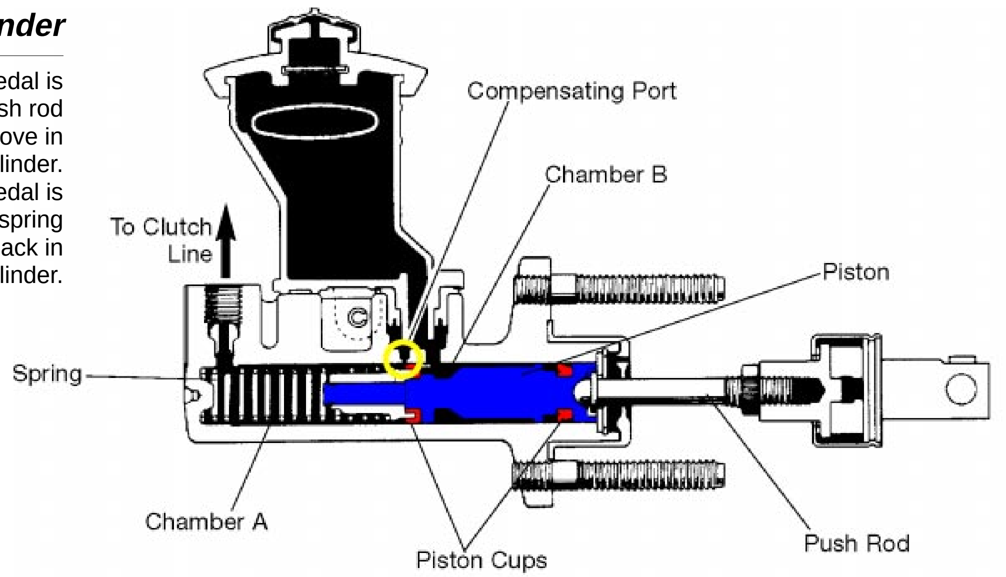


Fig. 2-12
T302f212

Clutch Release Cylinder

When the master cylinder directs fluid to the release cylinder, the piston in the release cylinder moves the push rod out against the release fork. Since the release bearing is connected to the release fork, the force is transmitted to the diaphragm spring of the clutch cover. The clutch disc is then disengaged. When the clutch pedal is released, the diaphragm spring in the clutch cover moves the push rod and piston back in the bore of the release cylinder. A conical spring exerts pressure against the release fork. So, the release bearing is in constant contact with the diaphragm spring.

Self-Adjusting Release Cylinder

The piston moves the push rod out against the release fork. The clutch disc is then disengaged.

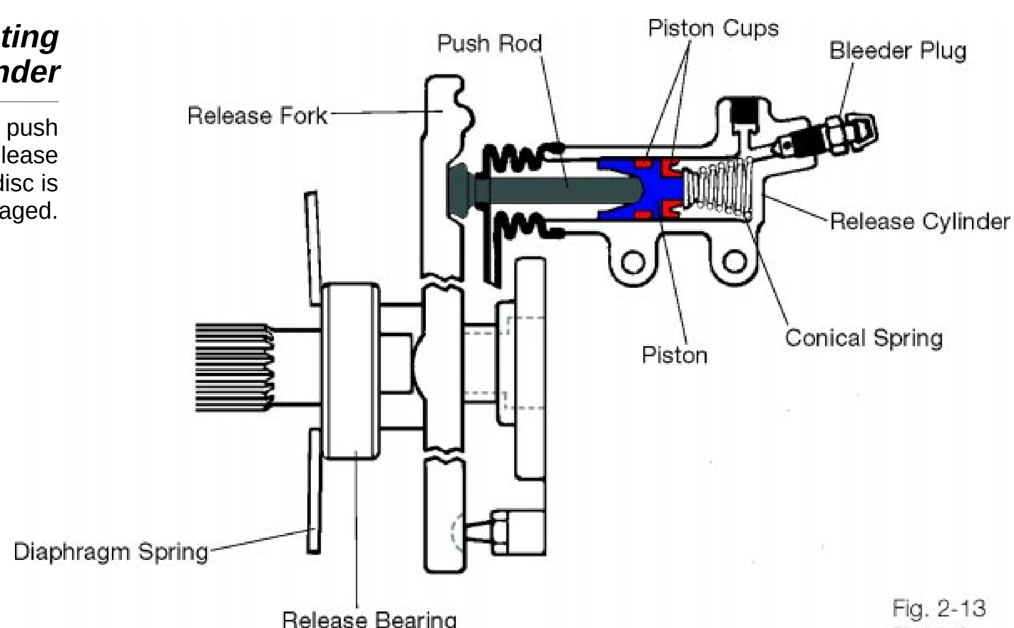


Fig. 2-13
T302f213

Since there is no free play, there is no need for adjustment since clutch wear causes the diaphragm spring to force the pushrod further into its bore. Any fluid displaced by the piston is pushed into the clutch master cylinder reservoir. The bleeder screw is used to remove air from the system.

NOTE

Although Toyota has not used mechanical clutch systems in recent years, understanding the contrast in how disc wear affects clutch pedal end play may be helpful for ASE testing.

Mechanical Clutch System

The mechanical clutch system consists of:

- Clutch pedal and release lever
- Clutch release cable
- Release fork
- Release bearing

The clutch pedal is mechanically connected to the release fork through a cable. Clutch pedal free play is indicated by the amount of clearance between the release bearing and diaphragm fingers.

In a mechanical system, disc wear causes the diaphragm spring fingers to move closer to the release bearing, which reduces free play. As normal disc wear continues, the clutch may begin to slip when there is no free play.

Free play adjustment is accomplished by changing the length of the cable housing. Shortening the cable housing increases clutch pedal free play.

Mechanical Clutch System

Disc wear causes the diaphragm spring fingers to move closer to the release bearing, which reduces free play.

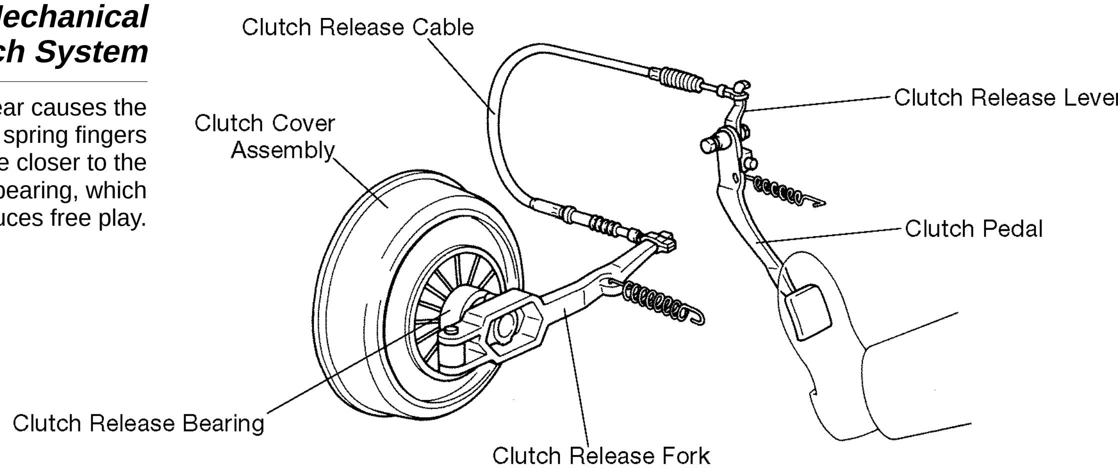


Fig. 2-14
T302f214

Clutch Component Inspection

Experienced technicians know the importance of visually inspecting each clutch component as it is disassembled. This helps determine if a part failed earlier than it should have, and helps locate any condition that needs correcting before the clutch is reassembled.

During disassembly, the flywheel, clutch cover assembly, clutch disc, release bearing and pilot bearing should be checked to determine if they were the cause of the failure. During each phase of reassembly, remember to check for proper clearances and operation. This ensures that any faulty parts or assemblies can be corrected early in the reassembly process.

Flywheel Inspection

The flywheel must have a flat surface to prevent chatter, and the proper surface finish to provide the necessary coefficient of friction. The wear of the friction surface is usually concave. The new flat clutch disc will not seat completely against a worn flywheel. This can cause premature clutch wear, chatter or even clutch disc failure. Grooves, heat checks, and warping can occur if there is excessive slippage,

The flywheel should be checked for excessive runout if there is vibration or an odd wear pattern at the hub of the disc or clutch cover release levers.

Axial Runout

To measure flywheel axial runout:

- With the dial indicator mounted with the measuring stem pointing directly toward the flywheel, adjust the indicator to read zero.
- While observing the dial indicator, rotate the flywheel; to eliminate crankshaft end play, maintain an even pressure during rotation.
- The amount of Axial runout is indicated by the variation in reading.

If the flywheel is to be removed:

- Place index marks at the crankshaft flange for faster alignment during reassembly.
- Inspect the starter ring gear teeth. If damaged, replace either the starter ring gear or flywheel.

Measuring Flywheel Axial Runout

Rotate flywheel and observe dial indicator. Axial runout is measured by the variation in the reading.

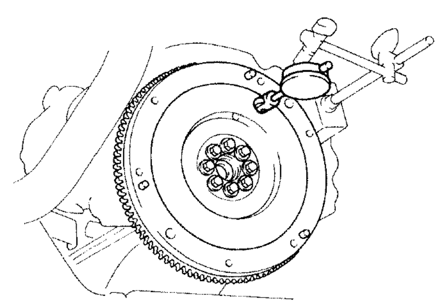


Fig. 2-15
T302f215

Clutch Cover Assembly Inspection

A used clutch cover assembly should be visually inspected for cover distortion and friction surface damage. The friction surface of the clutch cover assembly tends to polish or glaze from normal use. Excessive slippage can cause grooves, heat checks, and warping.

Set the clutch cover on the flywheel. The flywheel and clutch cover mounting points should meet evenly and completely. Inspect for gaps, as they indicate a distorted clutch cover. Additionally, inspect the clutch diaphragm for wear at the contact surface with the release bearing. Clutch diaphragm wear occurs at the contact point with the release bearing. Measure the width and depth of the wear to determine if it is within tolerable limits.

Clutch Cover Assembly Inspection

Measure the width and depth of the wear to determine if it is within tolerable limits.

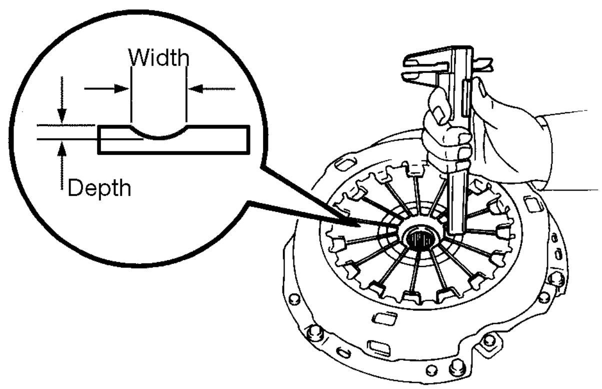


Fig. 2-16
T302f216

Inspect diaphragm spring finger alignment. Installed finger height should be within 0.020 in. Improper alignment may cause noise between the release bearing and the diaphragm spring fingers.

Clutch Disc Inspection

Always check a used clutch disc for facing thickness, damper spring condition, hub spline wear, and warpage or axial runout by measuring the height of the facing surface above the rivets. The minimum depth should be 0.012 in. (0.3mm). The hub splines and damper springs should be visually checked for rust and shiny worn areas, and broken or missing springs.

Clutch Disc Inspection

To check facing thickness, measure the height of the facing surface above the rivets. The minimum depth should be 0.012 in. (0.3mm).

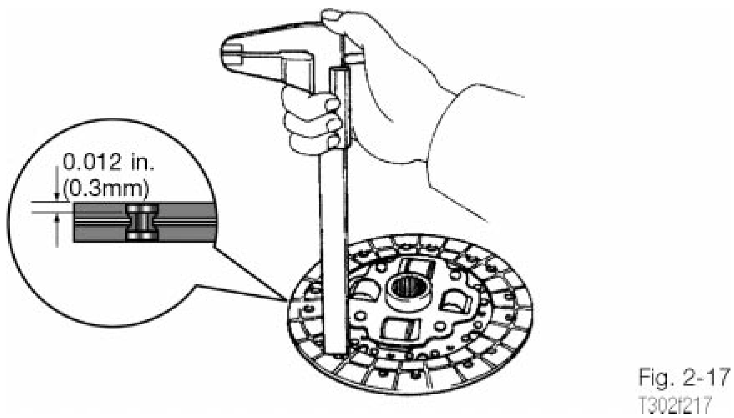


Fig. 2-17
T302f217

Disc Runout

Disc warpage is checked by completing an axial runout check. The disc is rotated while watching for wobbling (runout) of the facing surfaces. More than 0.031 in. (0.8mm) is excessive, and the disc should be replaced.

Axial Runout Check

The disc is rotated while watching for wobbling (runout) of the facing surfaces. More than 0.031 in. (0.8mm) is excessive, and the disc should be replaced.

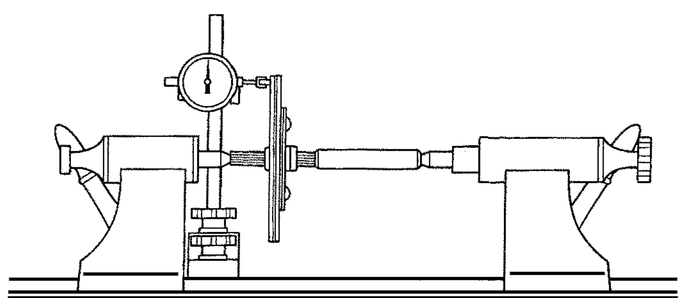


Fig. 2-18
T302f218

Disc warpage can also be checked by setting the disc against the flywheel. The disc facing should make even contact all around the flywheel.

Release Bearing Inspection

Release bearings are checked by feeling for roughness and visually checked for obvious wear. They are normally replaced with the disc and clutch cover.

Release Bearing Inspection

Release bearings are checked by feeling for roughness and visually checked for obvious wear.

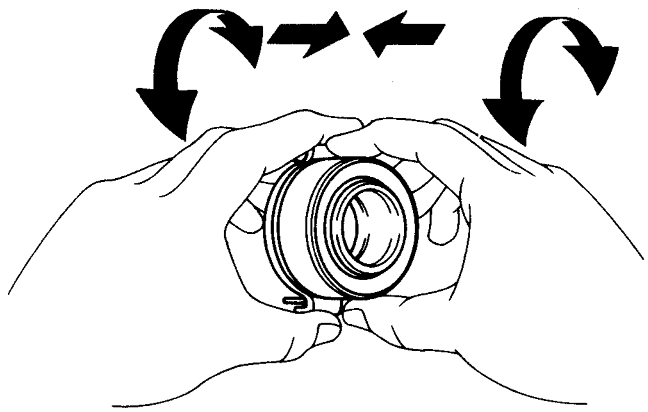


Fig. 2-19
T302f219

On self-adjusting release bearings, also check that the self-centering system is not sticking.

Self-Adjusting Release Bearing Inspection

On self-adjusting release bearings, also check that the self-centering system is not sticking.

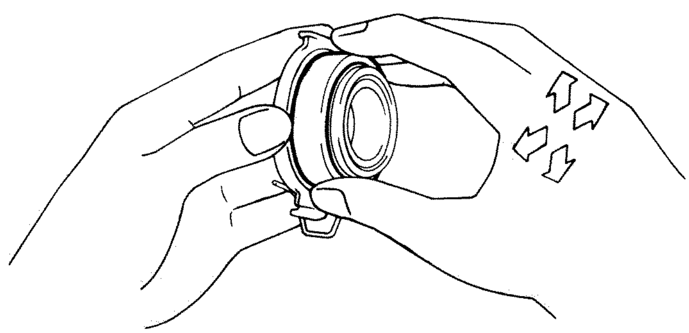


Fig. 2-20
T302f220

Clutch Pedal Adjustment

Normal service for a clutch includes checking the mechanical linkage systems for clutch pedal height and free play, and checking the hydraulic systems fluid levels.

Clutch Pedal Height

To check for clutch pedal height, measure the distance from the vehicle floor (asphalt sheet under the carpet) to the top of the clutch pedal. Refer to the appropriate repair manual for vehicle specifications.

If the clutch pedal requires a height adjustment, it is adjusted using the pedal height adjust point. Always adjust clutch pedal height before adjusting clutch pedal free play.

Clutch Pedal Free Play

To check and adjust clutch pedal free play, push the clutch pedal downward by hand until all play is removed and resistance is felt. The distance from this point to the pedal top position is free play.

Free play travel that is less than specifications indicates the need for adjustment of the push rod. Too little free play may result in the clutch master cylinder compensating port being blocked, preventing the return of fluid. This will result in difficulty in bleeding the hydraulic circuit and may also cause the clutch to slip as under hood temperatures cause fluid to expand pushing the release cylinder piston and release bearing.

Clutch Pedal Adjustment

Clutch pedal height is adjusted first, and then free play is adjusted.

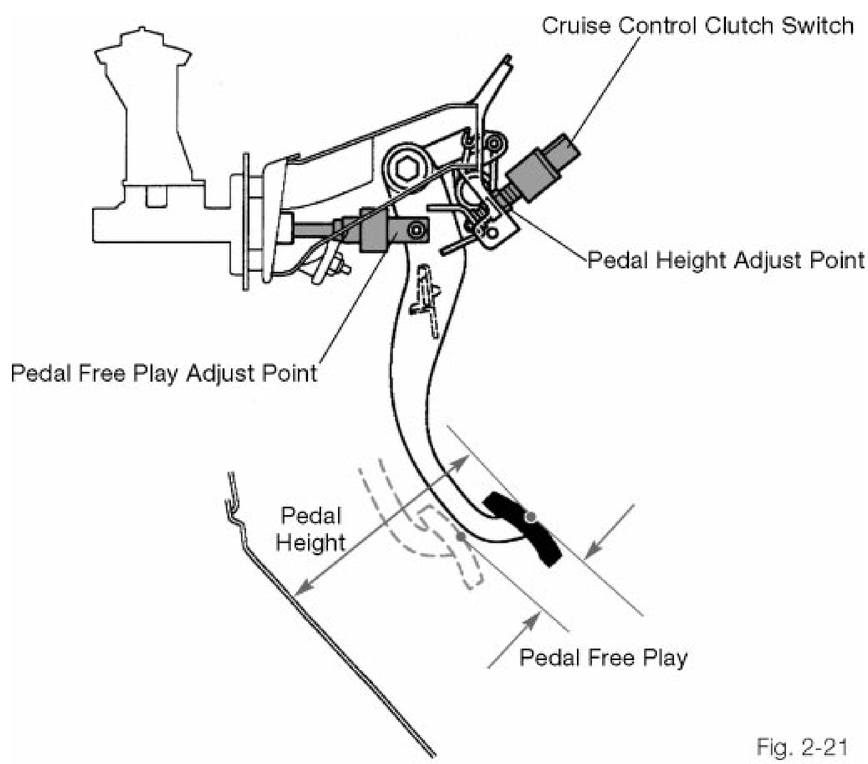


Fig. 2-21
T302f221

Clutch Release Point

To check the clutch release point:

- Pull the parking brake lever and install the wheel stopper.
- Start and idle the engine.
- Place the transmission in high gear and slowly engage the clutch.
- When the clutch begins to engage (tachometer speed begins to drop), this is the release point.
- Measure the stroke from the release point to the full stroke end position.
- Standard distance: 0.98 in. (25mm) or more (from pedal stroke end position to release point).
- If the distance is not as specified, perform the following checks:
  - Check pedal height.
  - Check push rod play and pedal free play.
  - Bleed clutch line.
  - Check clutch cover and disc.

Clutch Release Point Inspection

Measure the stroke from the release point to the full stroke end position.

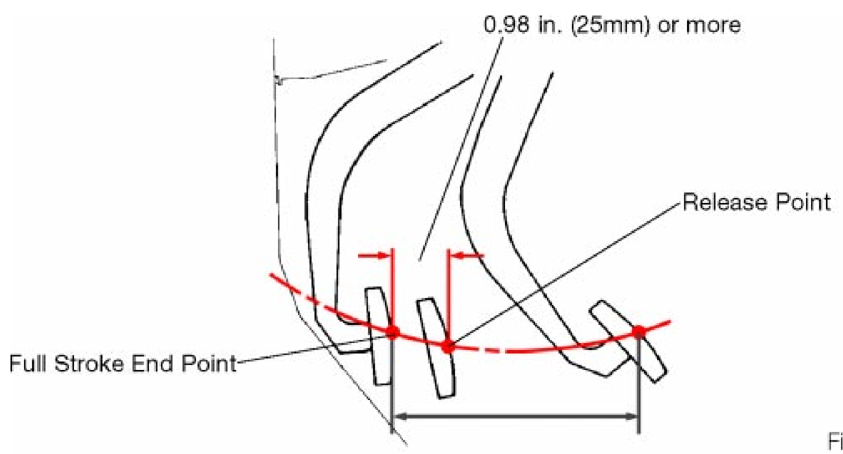


Fig. 2-22
T302f222

Clutch Start System Check

To check the clutch start system:

- Check that the engine does not start when the clutch pedal is released.
- Check that the engine starts when the clutch pedal is fully depressed. If the engine does not start, verify clutch start switch operation with a DVOM; replace as necessary.

Clutch Start System Check

Check that the engine starts when the clutch pedal is fully depressed, but not when fully released.

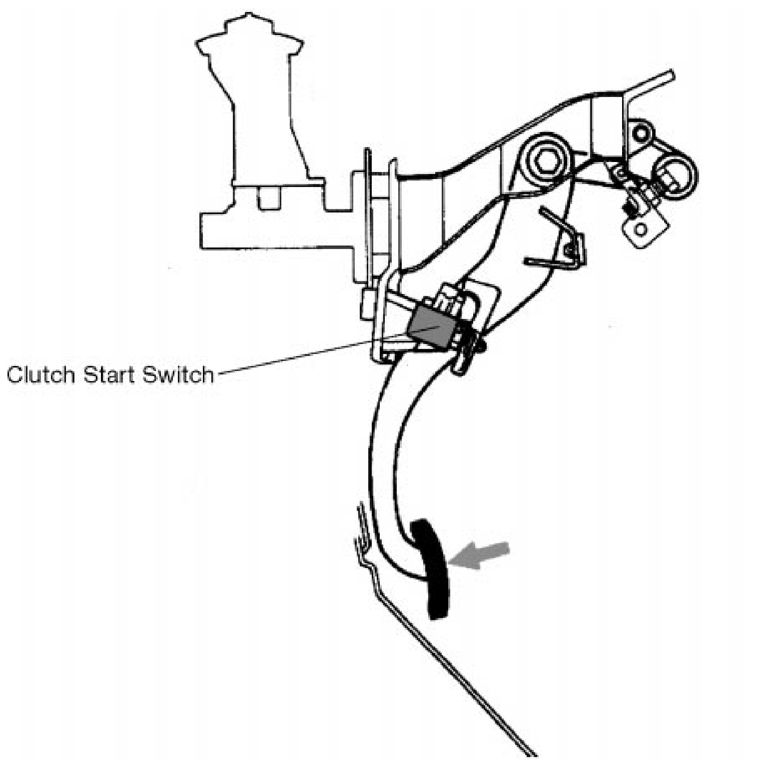


Fig. 2-23
T302f223

Clutch Service & Diagnosis

Clutch service can be broken into three operations:

- **Preventive maintenance** – check pedal free play, check fluid levels, and perform necessary adjustments to ensure correct system operation.
- **Problem diagnosis** – determine the cause of a concern in order to specify appropriate repair procedures.
- **Repair** – perform appropriate repair or component replacement tasks to attain proper vehicle operation.

This section describes normal maintenance, adjustments, and diagnostic procedures for common clutch system concerns.

Clutch Slippage

Stationary check:

- Start the vehicle and warm up the engine to normal operating temperature, block the wheels, and apply the parking brake.
- Shift the transmission into the highest gear and release the clutch pedal in a smooth, normal motion. If the clutch is engaging correctly, the engine should stall immediately. A delay in engine stalling indicates slow engagement and a slipping clutch condition.

Road test:

- Once normal operating temperature is achieved, slowly accelerate to 15 - 20 mph in the highest transmission gear.
- Depress the accelerator completely to make a full throttle acceleration. The engine speed should increase steadily and smoothly as the vehicle speeds up. If engine rpm increases without a corresponding increase in vehicle speed, the clutch is slipping and needs service.

Clutch Chatter

Clutch chatter is caused by a clutch that grabs and slips repeatedly, eventually marring the clutch cover pressure plate and flywheel surfaces. A grabbing or chattering clutch produces a severe vibration while engaging the clutch and the vehicle is accelerated from a stop. The vibration can be felt as well as heard and may transfer to the vehicle body causing secondary noise.

Clutch chatter may be caused by oil or grease on the clutch disc, glazed, loose or broken disc facings, worn torsion dampers, bent or distorted clutch disc, a loose clutch cover, missing flywheel dowel pins, or excessive flywheel runout. Hot spots on the flywheel or pressure plate can cause the clutch disc to be clamped unevenly resulting in chatter.

Influences outside of the clutch assembly may cause chattering such as; broken engine or transmission mounts, worn or damaged constant velocity (CV) axle joint or universal joints. Wear in the joints or loose motor mounts can cause the clutch to slip after initial engagement while the clutch pedal is released and the component reaches the end of its play. The abrupt change in rotational speed feeds back to the clutch causing slippage.

Clutch Drag

Clutch drag is a condition where the clutch does not release completely. Symptoms can include hard shifting into gear from neutral and gear clash. A clutch spin down test checks for complete clutch disengagement. The clutch disc, input shaft and transmission gears should come to a complete stop within a few seconds after disengaging the clutch.

Checking clutch spin down:

- Start the vehicle and warm up the engine and transmission to operating temperature.
- With the transmission in neutral and the engine running at idle speed, push in the clutch pedal, wait nine seconds, and shift the transmission into reverse.
- Gear clash or grinding indicates a clutch that hasn’t completely released.

If a vehicle fails the spin down test, the fault could be faulty clutch release controls, binding or seized pilot bearing, leaking oil seal, dragging clutch splines, or a faulty clutch disc or cover.

Clutch Assembly Noise Check

The clutch assembly noise check is used to pinpoint the cause(s) of noises that happen as the clutch pedal is depressed. Common clutch bearing noise problems fall into four categories:

- **Transmission bearing or noise problem** – noise stops as the pedal is depressed.
- **Faulty release bearing** – noise starts as pedal is depressed beyond free play.
- **Faulty clutch cover to release bearing contact** – noise and vibration occur at one-fourth to one half pedal travel.
- **Faulty pilot bearing** – noise after clutch pedal is fully depressed.

To prepare for this check, the engine should be running at idle speed and the clutch linkage should be adjusted for correct free play:

- If noise is noticed as the clutch pedal is fully depressed and the transmission gears spin down, either the pilot bearing or release bearing causes it. To ensure the gears are completely stopped, shift the transmission into gear. If the noise becomes worse, the pilot bearing is the cause, because the crankshaft turns and the input shaft is stopped.
- Place the transmission in neutral and release the clutch pedal slightly until the gears are spinning. At this time the pilot bearing stops spinning but the release bearing is still turning. If the noise stops, it confirms that the pilot bearing is faulty. If the noise continues, a faulty release bearing causes it.
- When diagnosing a release bearing for noise, be sure to check the installed clutch cover diaphragm tip alignment as shown in the repair manual. Uneven alignment may cause slippage between the release bearing and the diaphragm resulting in noise.
- Some noises can be caused by vibration and a lack of lubrication at the pivot point of the release fork, release cylinder push rod contact to the release fork or the release fork to release bearing contact points. Be certain to lubricate these points with molybdenum disulfide grease.

Clutch Assembly Service

When a clutch assembly service is needed, a considerable time is required to remove and replace the transmission. The clutch disc and clutch cover assembly are often worn or damaged and require replacement. The release bearing and pilot bearing are replaced to ensure proper operation for the life of the clutch disc and clutch cover.

Clutch Removal

When removing the clutch to confirm your diagnosis use the following procedures:

- Mark the flywheel and clutch cover with index marks for later realignment if the clutch cover assembly is to be reused.
- Remove the bolts securing the clutch cover to the flywheel two turns at a time, in an alternating fashion, across the clutch cover. Using this procedure prevents warping the clutch cover.
- Use a puller to remove the pilot bearing from the crankshaft.

Removing the Pilot Bearing from the Crankshaft

Remove the pilot bearing by securing it with an expanding-type puller.

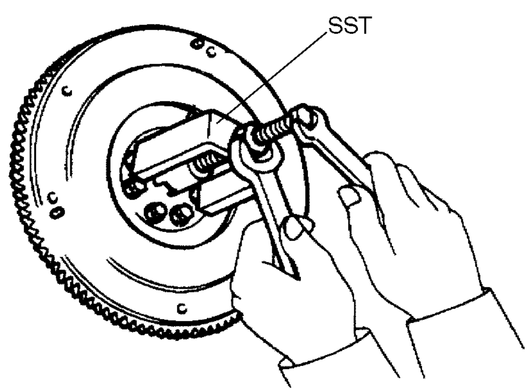


Fig. 2-24
T302f224

Clutch Reassembly

Reassembly Tips:

- Check the flywheel bolts to make sure they are torqued to specifications. Also check the pilot bearing recess to ensure it is clean. Using the appropriate driver tool against the outer race, drive the new pilot bearing into the crankshaft recess.
- Place the new clutch disc over the transmission clutch shaft and ensure that it slides freely over the splines. Make sure the correct side of the disc is placed against the flywheel. If the damper assembly is not marked “flywheel side”, it normally goes to the pressure plate side.
- Place the disc alignment tool through the disc and into the pilot bearing so that they are centered to each other.

Install Clutch Disc

Make sure the correct side of the clutch disc is placed against the flywheel. Place the disc alignment tool through the disc and into the pilot bearing so that they are centered to each other.

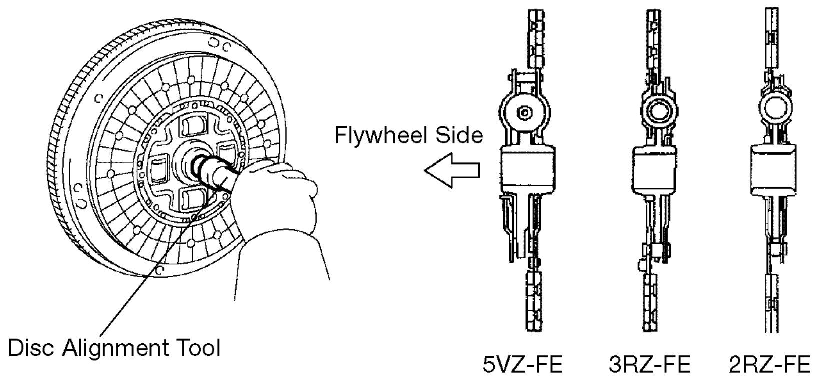


Fig. 2-25
T302f225

- Install the clutch cover over the disc, by properly aligning it with the dowel pins and mounting bolt holes. Install the mounting bolts.
- Tighten the mounting bolts in an alternating fashion, two turns at a time across the clutch cover.

Install Clutch Cover Assembly

Tighten the mounting bolts in an alternating fashion, two turns at a time across the clutch cover.

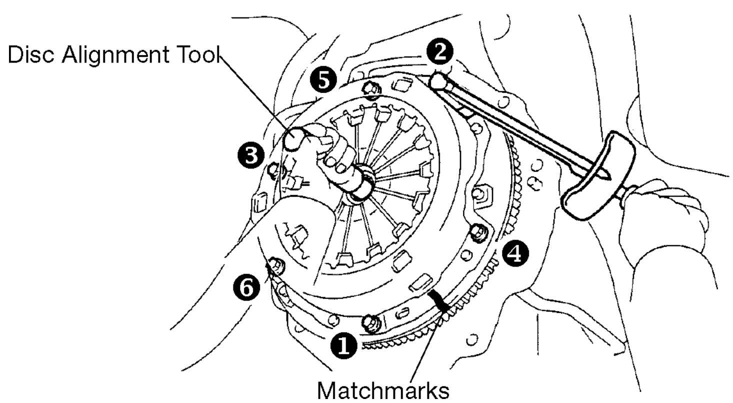


Fig. 2-26
T302f226

- Apply high temperature molybdenum disulphide grease to the fork pivot and the fork contact areas. Fill the groove inside of the release bearing collar with grease.
- Place the release bearing over the transmission bearing retainer and check for smooth movement of the bearing collar.

Grease Release Bearing, Release Fork, & Drive Shaft

Use high temperature molybdenum disulphide grease.

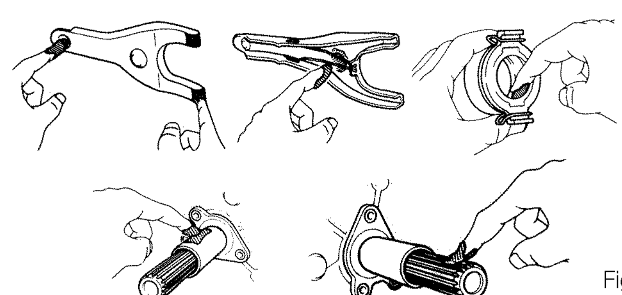


Fig. 2-27
T302f227

Transmission Replacement

To replace the transmission:

- Place a thin film of high temperature molybdenum disulphide grease on the clutch splines.
- Support the transmission while it is slid into place. **Never let the transmission hang on the clutch splines!** In order to make this installation easier, use a pair of alignment dowels to support the transmission.
- Place the transmission in low gear and rotate the output shaft or turn the flywheel to align the input shaft splines with the clutch hub.
- Push the transmission into position until the front of the transmission is flush against the engine block. **Do not force the transmission into place.**
- Install the transmission mounting bolts until lightly seated, and then tighten them to the proper torque.

Transmission Installation

Support the transmission while it is slid into place. Never let the transmission hang on the clutch splines!

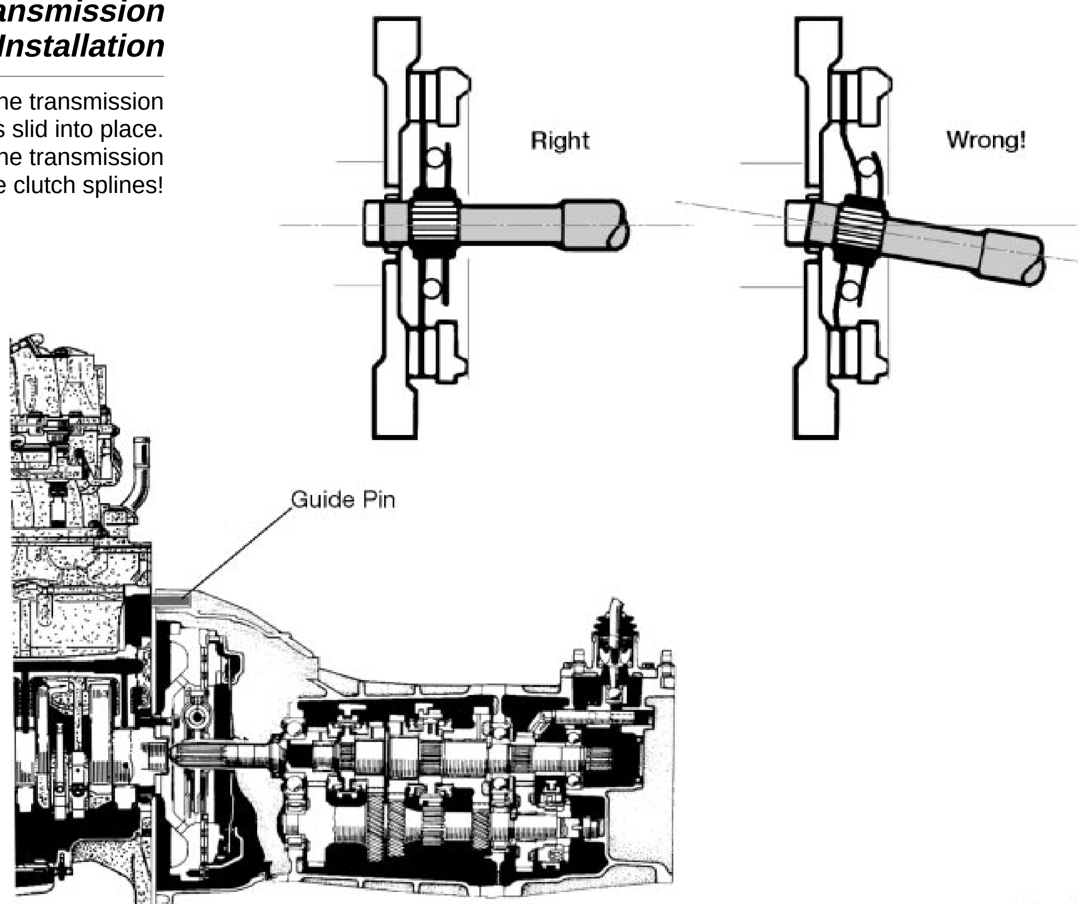


Fig. 2-28
T302f228

Supra Pull Release

The pull release style of clutch cover was introduced on the 1987 Toyota Supra, both naturally aspirated and turbo models. The early clutch cover is made of cast iron for increased strength and rigidity. With high engine power output, greater diaphragm spring pressures are required. By using the **pull release mechanism**, the diaphragm spring lever ratio can be increased to minimize additional pedal force required to disengage the clutch disc.

In 1990, the naturally aspirated Supra went to a conventional push type DST clutch cover; in the 1993.5 model year, the turbo Supra went to a stamped steel clutch cover with the pull release mechanism and flywheel damper.

The construction differences of the pull release mechanism compared to the conventional diaphragm clutch covers are:

- The release bearing and hub are fit into the diaphragm spring.
- The diaphragm spring is pulled out instead of pushed in.
- The pivot points are changed for releasing the clutch disc. (Pivot points are located near the outer diameter of the diaphragm spring).

Pull Release Mechanism

By using the pull release mechanism, the diaphragm spring lever ratio can be increased to minimize additional pedal force required to disengage the clutch disc.

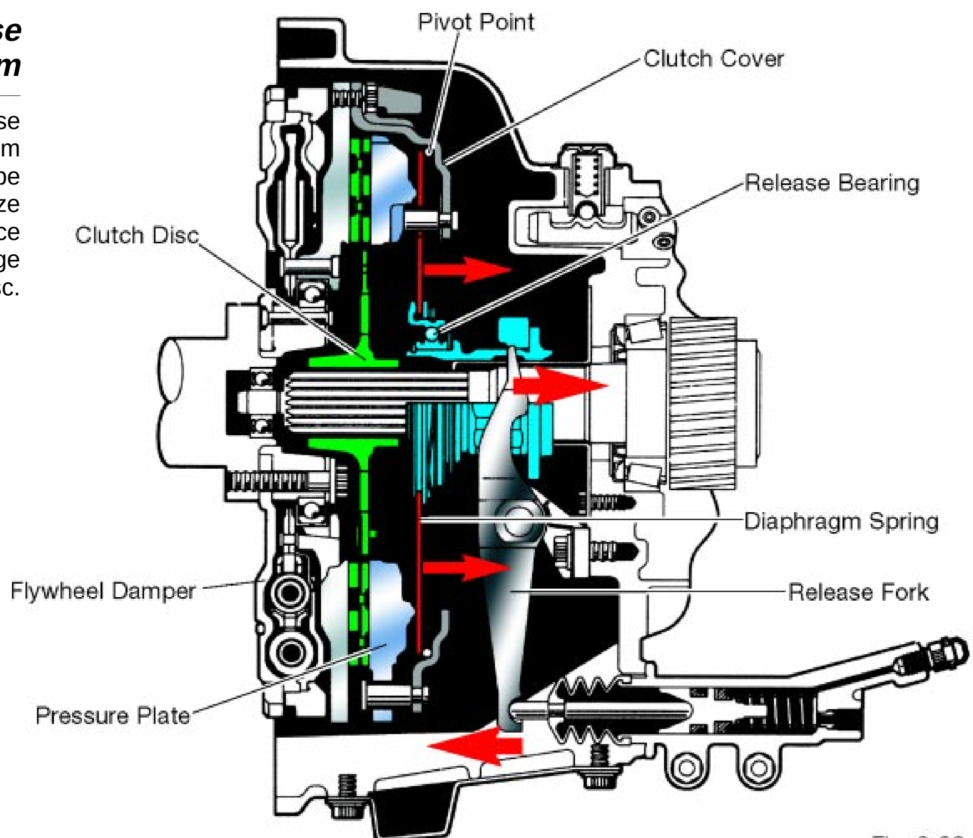


Fig. 2-29
T302f229

Pull Release Bearing

The **pull release bearing** is used with the pull release mechanism clutch cover. The bearing is mounted on the clutch release bearing hub along with a thrust cone spring and plate washer. A snap ring is used to secure the parts on the hub. The assembly is installed in the diaphragm spring with a plate and wave washer. A snap ring is used to secure the assembly in the diaphragm spring.

Pull Release Bearing

This assembly is installed in the diaphragm spring with a plate and wave washer. A snap ring is used to secure the assembly.

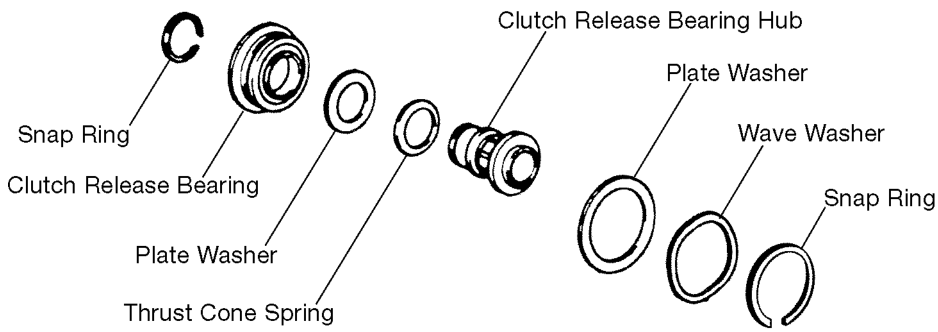


Fig. 2-30
T302f230

Flywheel Damper

The **flywheel damper** sometimes referred to as the **energy absorbing flywheel**, or **dual mass flywheel (DMF)**, is designed to isolate torsional crankshaft spikes created by engines with high compression ratios. By separating the mass of the flywheel between the engine and the transmission, torsional spikes can be isolated, eliminating potential damage to transmission gear teeth.

In 1993, the 2JZ-GTE engine model of the Supra used a super-long travel type flywheel damper. It contains a de-coupling mechanism, consisting of springs, which divides the flywheel into the engine and transmission sections. By decreasing the fluctuation of torque transmitted from the engine to the transmission, these springs help reduce drivetrain vibration and noise. The clutch disc is a solid type, in which the hub and plate are integrated.

NOTE This assembly is replaced as a unit.

Construction

The flywheel damper is fastened to the crankshaft via bolts, in the same way as conventional flywheels. The flywheel damper consists of the primary flywheel, which receives direct torque from the engine, arc springs and inner springs positioned in-line using a flange, and side plates riveted onto the secondary flywheel. The clutch disc and cover are attached to the secondary flywheel.

Flywheel Damper

The flywheel damper consists of the primary flywheel, arc springs and inner springs positioned in-line using a flange, and side plates riveted onto the secondary flywheel.

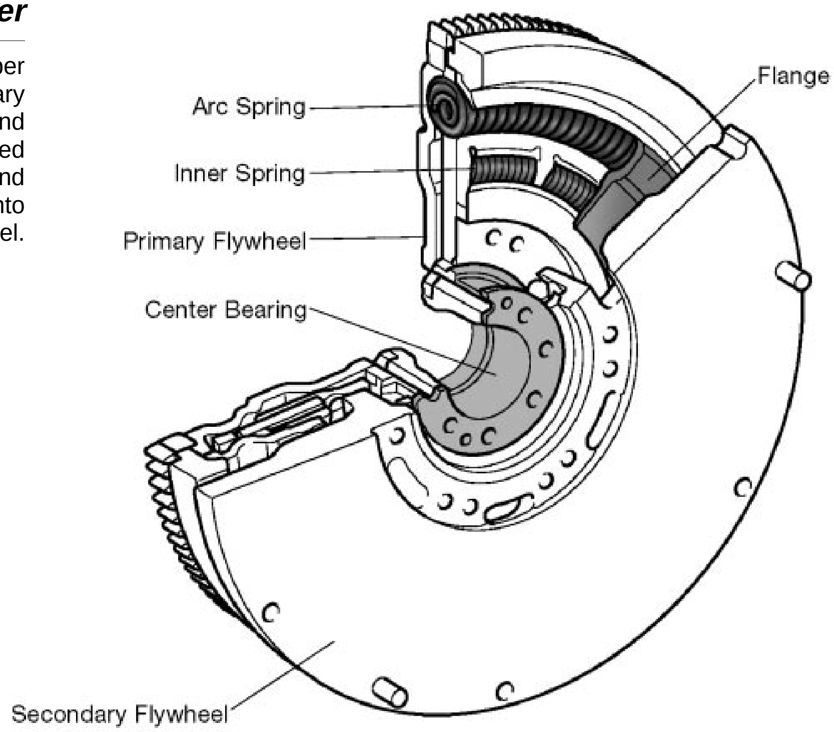


Fig. 2-31
T302f231

Center Bearing The **center bearing** a sealed double row center ball bearing carries the load between the inner and outer halves of the flywheel damper.

Operation The driving force of the engine is first transmitted from the primary flywheel to the arc springs. It is then transmitted from the arc springs to the flange and inner springs, causing the inner springs to be pressed against the side plates. The driving force is then transmitted to the clutch since the side plates are riveted onto the secondary flywheel. These processes help restrain torque fluctuation. The inner springs and arc springs provide an overall low spring force, while allowing for a high torque capacity sufficient for all driving conditions.

Flywheel Damper Operation

The driving force of the engine is first transmitted from the primary flywheel to the arc springs. It is then transmitted from the arc springs to the flange and inner springs, causing the inner springs to be pressed against the side plates and secondary flywheel.

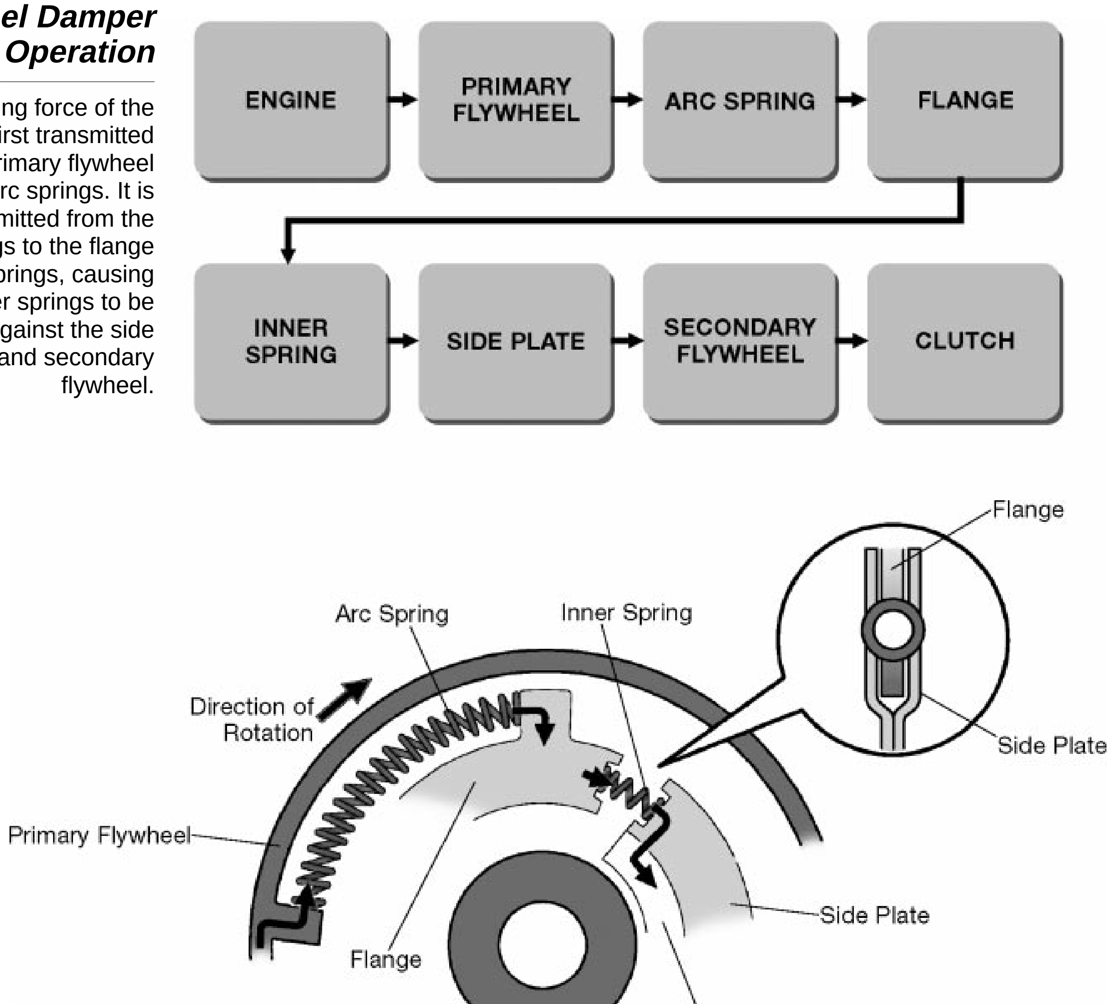


Fig. 2-32
T302f232

The flywheel damper cannot be disassembled. In case of a malfunction, it is necessary to determine whether the source of the problem is in the engine, drivetrain, or in the flywheel damper itself. For troubleshooting and diagnostic procedures, refer to the appropriate repair manual. The flywheel damper is not serviceable and should be replaced if worn or damaged.

WORKSHEET 2-1
Clutch Inspection

Vehicle:	Year/Prod. Date:	Engine	Transmission:

Worksheet Objectives

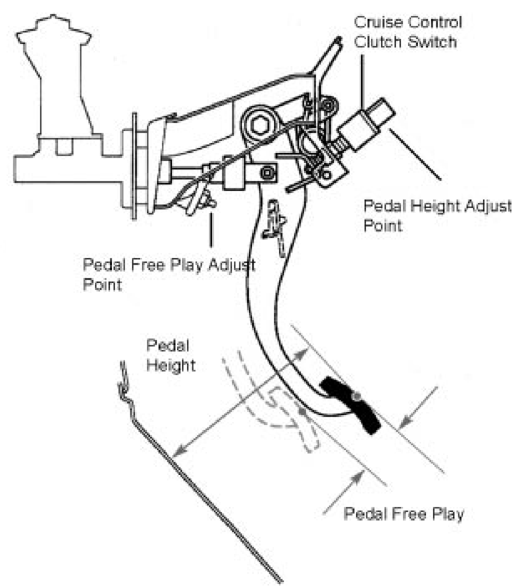
With this worksheet, you will learn where to measure and adjust clutch pedal height, pedal free play, and reserve distance from the clutch release point to the full stroke end position using the repair manual for serviceinformation.

Tools and Equipment

- Vehicle Repair Manual

Section 1: Clutch Pedal Height and Free Play

Pedal height is the first measurement and establishes the starting point for clutch pedal inspection. From thepedal height position, pedal free play and full stroke end position are determined.



1. With the clutch pedal in the full at-rest position, pedal height is the distance from the top of the clutch pedal pad to the asphalt sheet (under the carpet). What is the pedal height specification?

   ____

2. Where is the adjustment for changing clutch pedal height?

   ____

   ____

3. The distance from the full at-rest position, while pressing the clutch pedal down by hand, until clutch resistance is felt is pedal free play. What is the recommended clutch pedal free play?

____

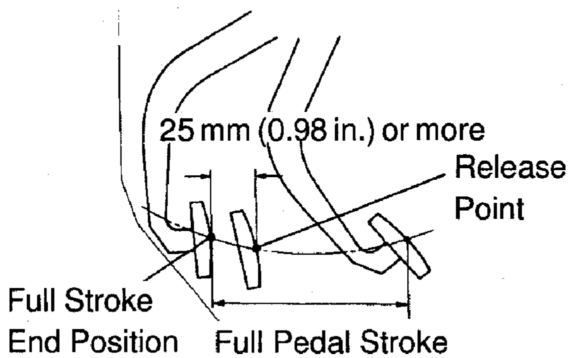
4. What affect might too little clutch pedal free play have on the clutch system operation?

____

____

____

Section 2: Clutch Pedal Reserve Distance Measurement



1. Inspect the clutch pedal release point by blocking the drive wheels, placing the transmission in 4th gear and slowly releasing the clutch pedal until the clutch just begins to engage; this is the release point. The reserve distance is the distance between the release point and the full stroke end position. What is the specified distance recommended by the repair manual?

____

2. What affect would too much clutch pedal free play have on the release point?

____

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Section 3: Effect of Clutch Disc Wear

1. When the clutch disc wears in a mechanical clutch system, what affect will it have on clutch pedal free play?

2. When the clutch disc wears in a hydraulic clutch system, what affect will it have on clutch pedal free play?

Notes

Clutch Inspection

Name: ____ Date: _____________________

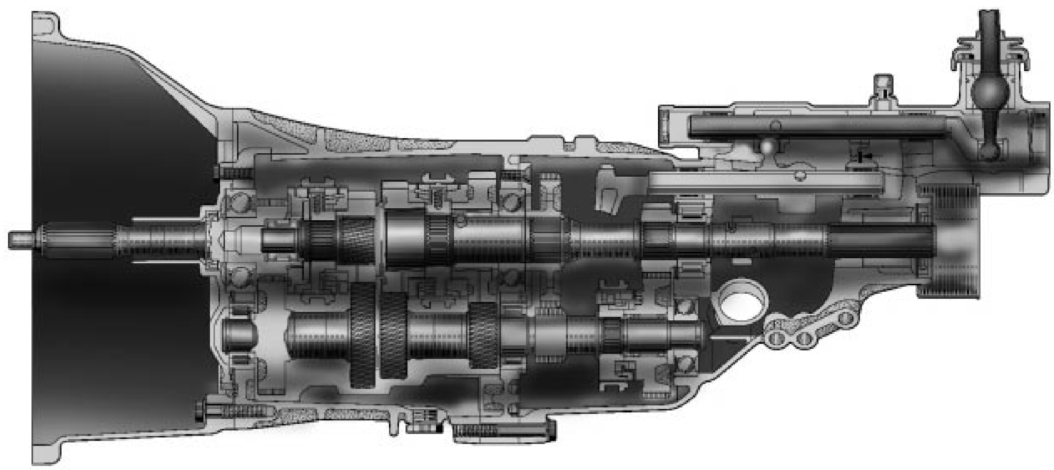
Review this sheet as you are doing the Clutch Inspection worksheet. Check each category after viewing the instructor's presentation and completing the worksheet. Ask the instructor if you have questions regarding the topics provided below. Additional space is provided under Topic for you to list any other concerns that you would like your instructor to address. The comments section is provided for your personal comments,

Topic	I have questions	I know I can	Comment
Locate the clutch pedal height specification and adjustment.			
Locate the clutch pedal free play specification and adjustment.			
Locate clutch pedal reserve distance specification.			
Explain the effect of clutch disc wear on clutch pedal free play.			

Notes

Section 3

Manual Transmissions



T302f300

Learning Objectives:

1. Identify and describe manual transmission design features and operation.
2. Describe transmission powerflow.
3. Describe manual transmission construction.
4. Identify and describe the operation of the following transmission components:
    a. Synchronizers
    b. Shift mechanisms
    c. Key inertia lock mechanism
5. Identify and describe gear shift control.
6. Describe transmission lubrication.

Section 3
Manual Transmissions

Introduction

The manual transmission transfers power from the engine to the propeller shaft. It converts and multiplies rotational speed, allowing engine RPM to remain in it's limited optimal power range while providing a wide range of RPM to the propeller shaft; which, in turn, controls vehicle speed.

Multiple gear sets within the transmission provide gear ratios to best utilize the engine's torque. A gear ratio of about 4:1 in first gear provides high torque to begin moving the vehicle. In contrast, a higher gear ratio of about 1:1 reduces engine speed at higher vehicle speeds when less torque is required to maintain momentum.

Understanding manual transmission design features increases your knowledge of transmission operation, and provides for easier and more accurate problem diagnosis.

Components

The rear wheel drive transmission is constructed with three shafts, five forward gears, and a reverse gear.

Transmission Components

The rear wheel drive transmission is constructed with three shafts, five forward gears, and a reverse gear.

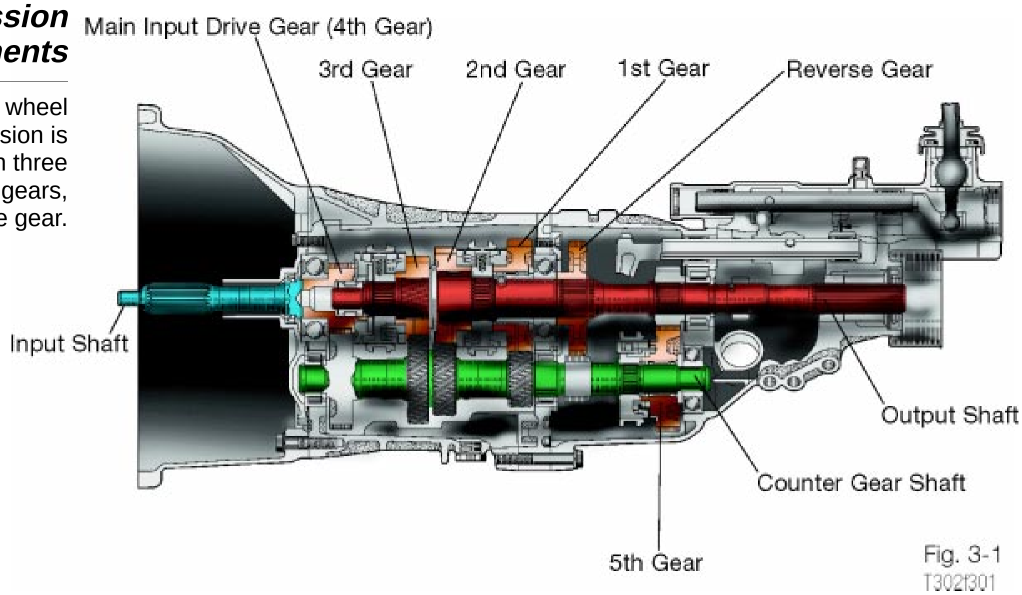


Fig. 3-1
T302f301

Input Shaft

The **input shaft** also known as a main drive gear or clutch shaft is driven by the clutch disc and drives the counter gear shaft. The input shaft is supported by the pilot bearing at the end of the crankshaft and a bearing at the front of the transmission case.

Counter Gear Shaft

The **counter gear shaft** also known as a cluster gear drives the gears (1st, 2nd, 3rd, and 5th) on the output shaft. This shaft is supported by bearings in the intermediate plate, at the front of the transmission case, and in the extension housing.

Output Shaft

The **output shaft** also known as the mainshaft drives the propeller shaft. It is splined at the rear to allow a sliding connection to the propeller shaft. The output shaft gears rotate on the shaft and are locked to the shaft by synchronizers. The synchronizers are splined to the output shaft. The output shaft is supported by a pocket bearing at the rear of the input shaft, a bearing at the intermediate plate and a bearing at the extension housing of the transmission.

Transmission Construction

A rear wheel drive transmission has three sections: the clutch housing, the transmission case, and the extension housing.

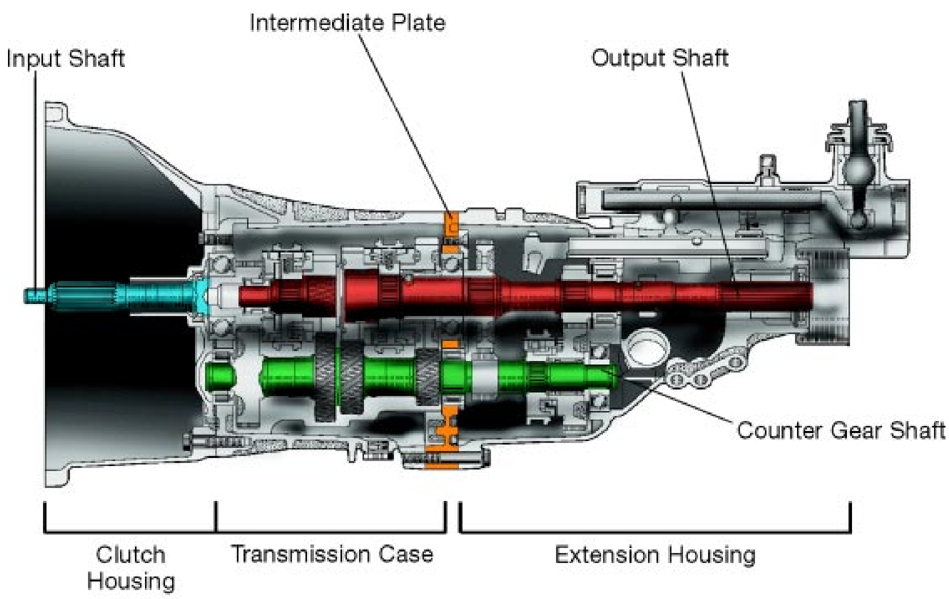


Fig. 3-2
T302f302

Gears

Gears transfer engine power from the input shaft, through the counter gear shaft, to the output shaft. There are five forward gears and one reverse gear. Only one gear is engaged at a time.

Forward Gears

All forward motion gears are helical gears because of their smooth and quiet operating characteristics. Helical gears create end thrust under load, and therefore have a thrust surface on the side of the gear. Gear side clearance is limited to reduce noise and potential damage, which could result from gear motion.

Reverse Gears

Reverse requires an additional gear in the gear train. A reverse idler gear is used to change the direction of the output shaft for reverse.

The reverse gear is a straight cut spur gear and does not have a synchronizer. Spur gears are suitable for this application because they shift into mesh more easily than helical gears, and they don't generate end thrust under load.

Straight cut gears may create a whine or light growl during operation.

Reverse Idler Gear

An idler gear is used to change the direction of the output shaft for reverse.

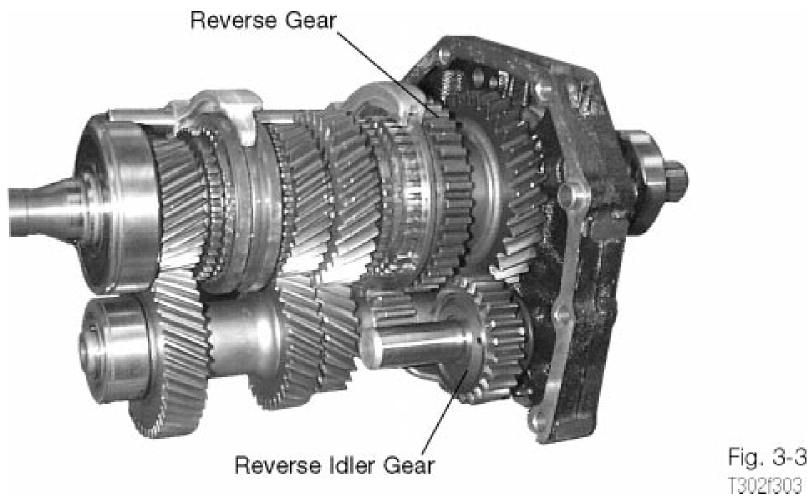


Fig. 3-3
T302f303

Bearings

Bearings and bushings are used to support shafts in the transmission. Depending upon design, transmissions use a wide variety of bearings, including:

- **Needle bearings** – can support large side loads but are unable to control end thrust loads. Individual needles are housed in a single enclosure or a split bearing holder. They are used in most forward speed gears.
- **Ball bearings** – can support moderate to high side and thrust loads and are commonly used for the input shaft and output shaft.
- **Roller bearings** – can support large side loads but are unable to control end thrust loads. Individual rollers are housed in a single enclosure.
- **Plain bushings** – can support large side loads and allow free in-and-out movement. Bushings are used on the reverse gear and to support the propeller shaft slip yoke in the extension housing.

Transmission Bearings

Depending upon design, transmissions use a wide variety of bearings.

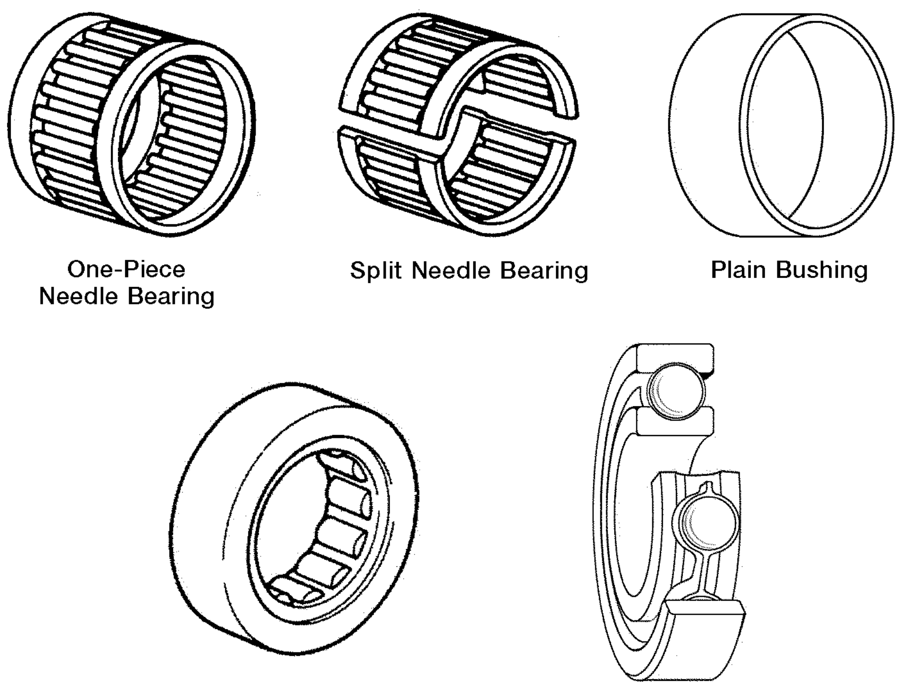


Fig. 3-4
T302f304

Synchronizer Assemblies

Synchronizer assemblies are used to make all forward shifts and to assist reverse gear engagement. The role of the synchronizer is to allow smooth gear engagement. It acts as a clutch, bringing the gears and shaft to the same speed before engagement occurs. Synchronizer components help make the speeds equal while synchronizing the shift.

Gears on the output shaft are in mesh (contact) with gears on the counter gear shaft at all times. Consequently, when the counter shaft turns, the gears on the output shaft rotate. When shifting gears, the synchronizer ring supplies the friction force, which causes the speed of the gear that is being engaged to match the speed of the hub sleeve. This allows the gear shift to occur without the gear and hub sleeve splines clashing or grinding.

Synchronizer Assemblies

Synchronizers are used to make all forward shifts and to assist with reverse.

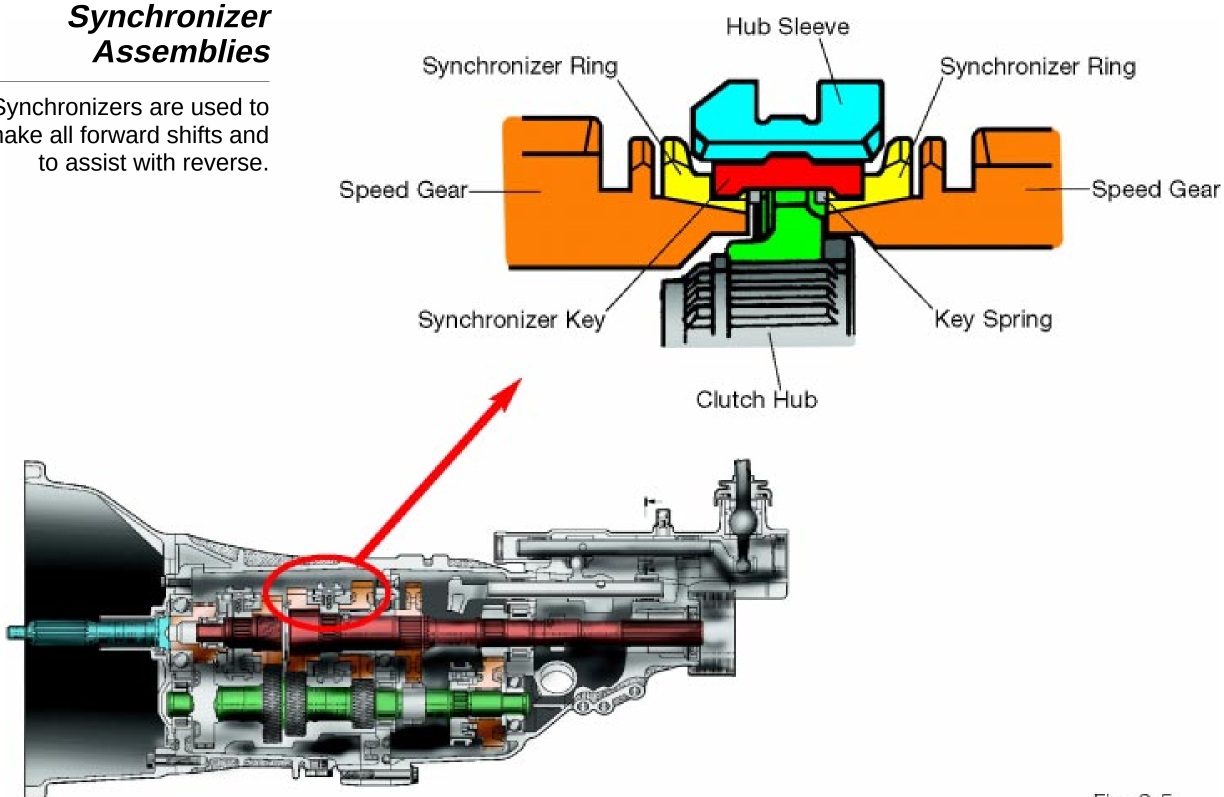


Fig. 3-5
T302f305

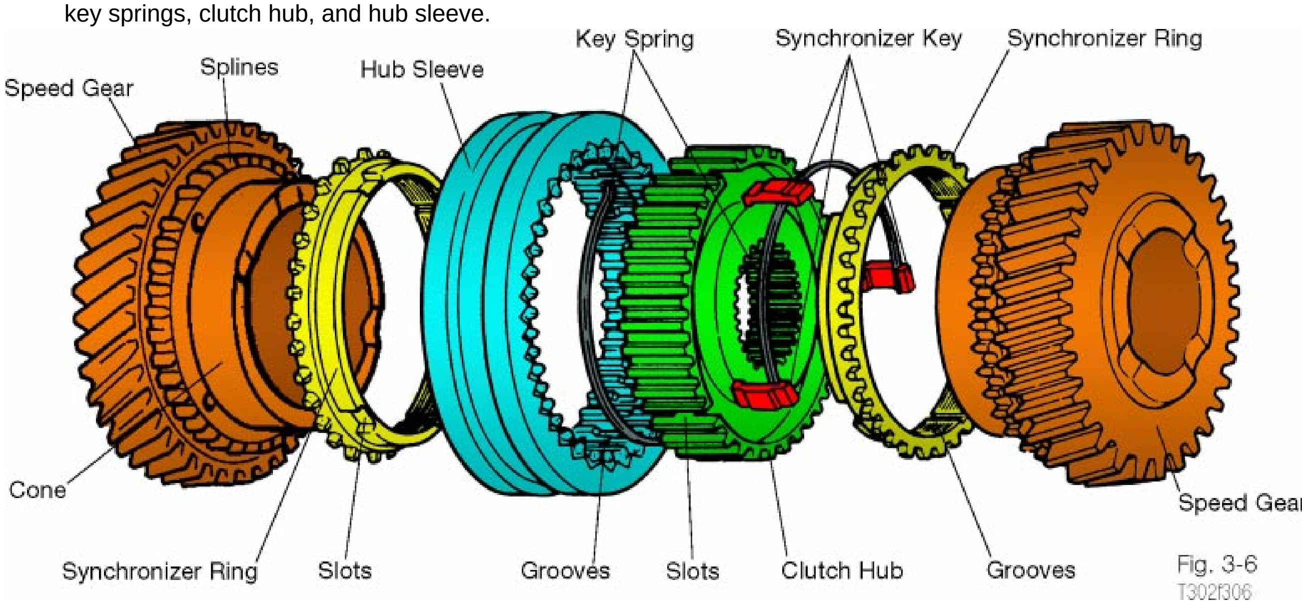
Synchronizer Components

The synchronizer mechanism is constructed of the following components:

- The **speed gear** is mounted on the output shaft. A needle roller bearing is installed between the speed gear and the output shaft, allowing the gear to rotate freely on the shaft.
- The **synchronizer ring** – also called a **blocker ring** – is made of brass and is installed on the conical portion of the gear. Narrow grooves are cut in the inside area of the synchronizer ring to provide the necessary clutch action of the gear. Three equally spaced slots are cut on the outside surface for the synchronizer keys to fit into.
- Two **key springs** are installed, one on each side of the clutch hub to hold the synchronizer keys in place against the hub sleeve.
- The **clutch hub** is fit to the output shaft on splines and is secured by a snap ring.
- Three **synchronizer keys** are installed in the three equally spaced slots in the clutch hub and are aligned with the slots in the synchronizer ring.
- The **hub sleeve** has internal splines that slip over the clutch hub splines, engaging the spline teeth of the speed gear. An internal groove cut in the center of the hub sleeve splines centers the hub sleeve. The hub sleeve is indexed by the three spring loaded synchronizer keys.

Synchronizer Components

The Synchronizer is made up of the speed gear, synchronizer ring, synchronizer keys, key springs, clutch hub, and hub sleeve.



Synchronizer Operation

When the transmission is in neutral, the hub sleeve groove fits onto the synchronizer key detent. This allows the gears to free wheel on the output shaft. As the clutch pedal is depressed and the shift lever is moved into a gear, three stages are involved for the gearshift to occur.

1st Stage - Initial Synchronization

As the shift lever moves, the shift fork moves the hub sleeve to the right causing the spring-loaded keys to push the synchronizer ring against the cone clutch surface of the gear.

Engagement of the synchronizer ring to the cone clutch on the faster spinning gear cause the synchronizer ring to rotate, about one-half the width of a spline.

Rotation of the ring causes the sleeve to be out of alignment with the splines preventing further movement, while pressure applied to the cone clutch by the sleeve creates a braking action to slow the gear.

Synchronized Gear Shift - 1st Stage

When the transmission is in neutral, the synchronizer key detents hold the hub sleeve in the neutral position.

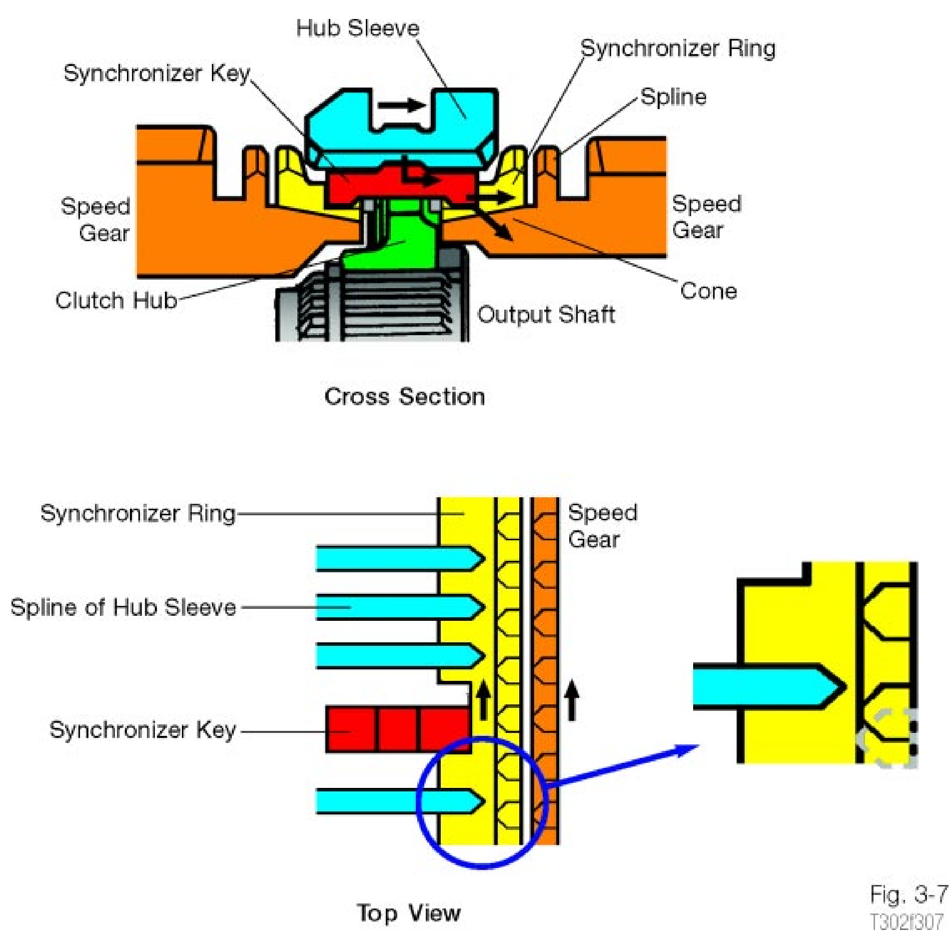


Fig. 3-7
T302f307

2nd Stage - Synchronization

When the shift lever is moved further, the force (which is applied to the hub sleeve) overcomes the force of the synchronizer key springs. The hub sleeve moves over the detents of the keys. This movement also causes more pressure to be exerted on the synchronizer ring and gear.

The grooves on the inside surface of the ring help to cut through the oil film on the conical surface of the gear. This ensures that the ring will provide the needed clutching action for engagement.

The taper of the sleeve spline pushes against the taper of the ring teeth, causing added pressure to the gear cone.

As the gear slows to the same speed as the hub and sleeve, it will rotate slightly backward to allow alignment of the splines.

The synchronizer ring and gear splines line up at this time and the splines of the hub sleeve are ready to engage.

Synchronized Gear Shift - 2nd Stage

The taper of the sleeve spline pushes against the taper of the ring teeth to exert more pressure on the gear cone.

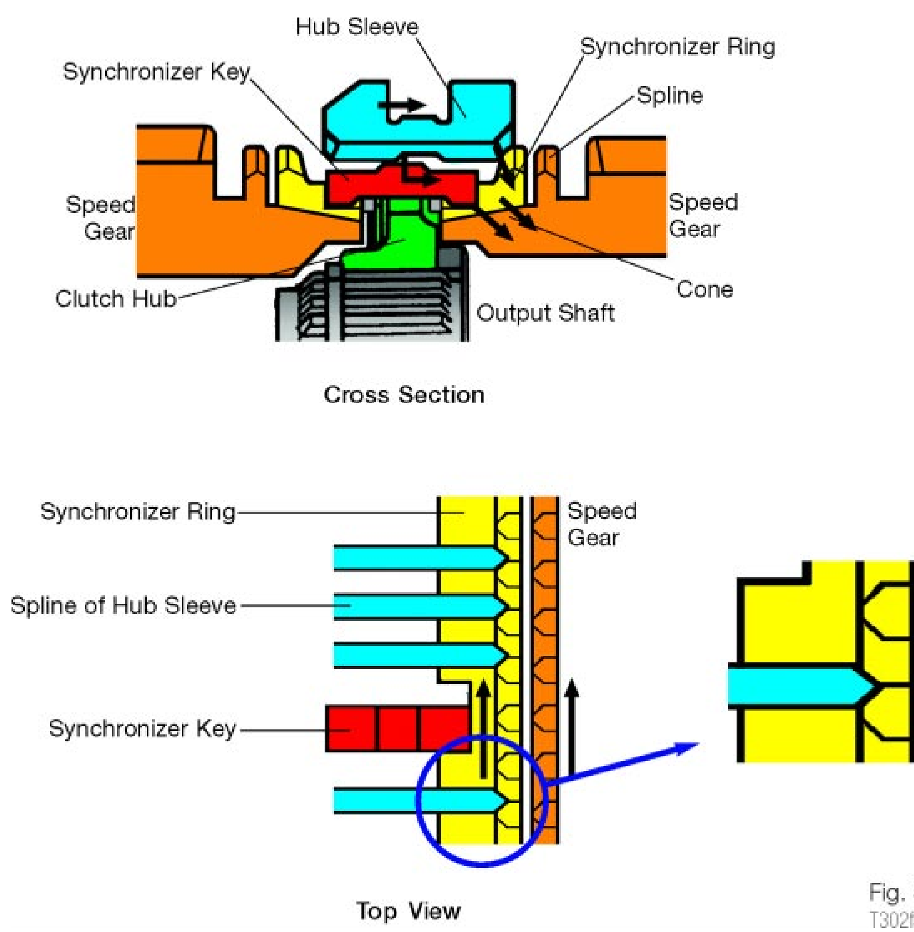


Fig. 3-8
T302f308

3rd Stage - Synchronized Meshing

When the speeds of the hub sleeve and the gear become equal, the synchronizer ring is not in contact with the key. The ring and gear are free to move and the splines of the hub sleeve can engage smoothly.

The sleeve continues to move over the splines of the speed gear, locking the key to the gear, completing gear engagement.

Synchronized Gear Shift - 3rd Stage

When the speed of the hub sleeve and the gear become equal the hub sleeve engages the splines of the gear.

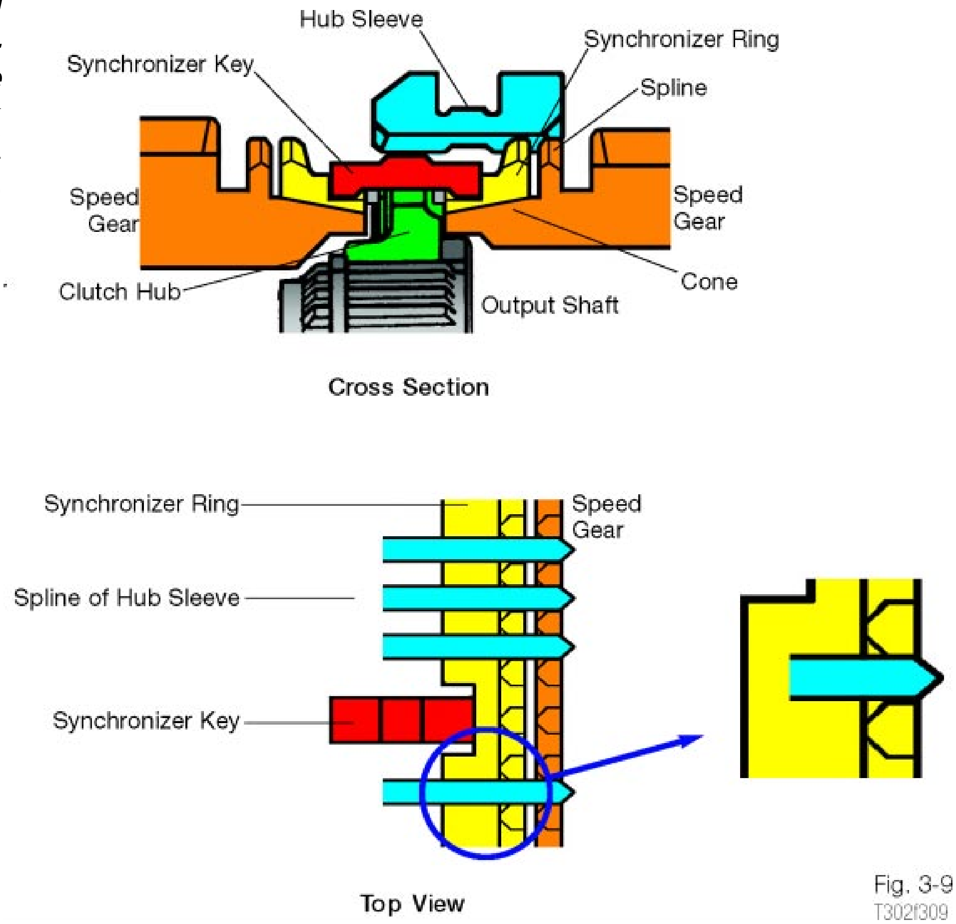


Fig. 3-9
T302f309

Synchronizer Hub Sleeve & Splines

Synchronizer hub sleeves have a slight back cut at the ends of the splines. This cut matches a similar cut on the spline gear teeth of the speed gears. This locks the gears in engagement and prevents the sleeve from jumping out of mesh.

Synchronizer Hub Sleeve and Splines

Hub sleeve splines are back cut to lock the gears in engagement, preventing the sleeve from jumping out of mesh.

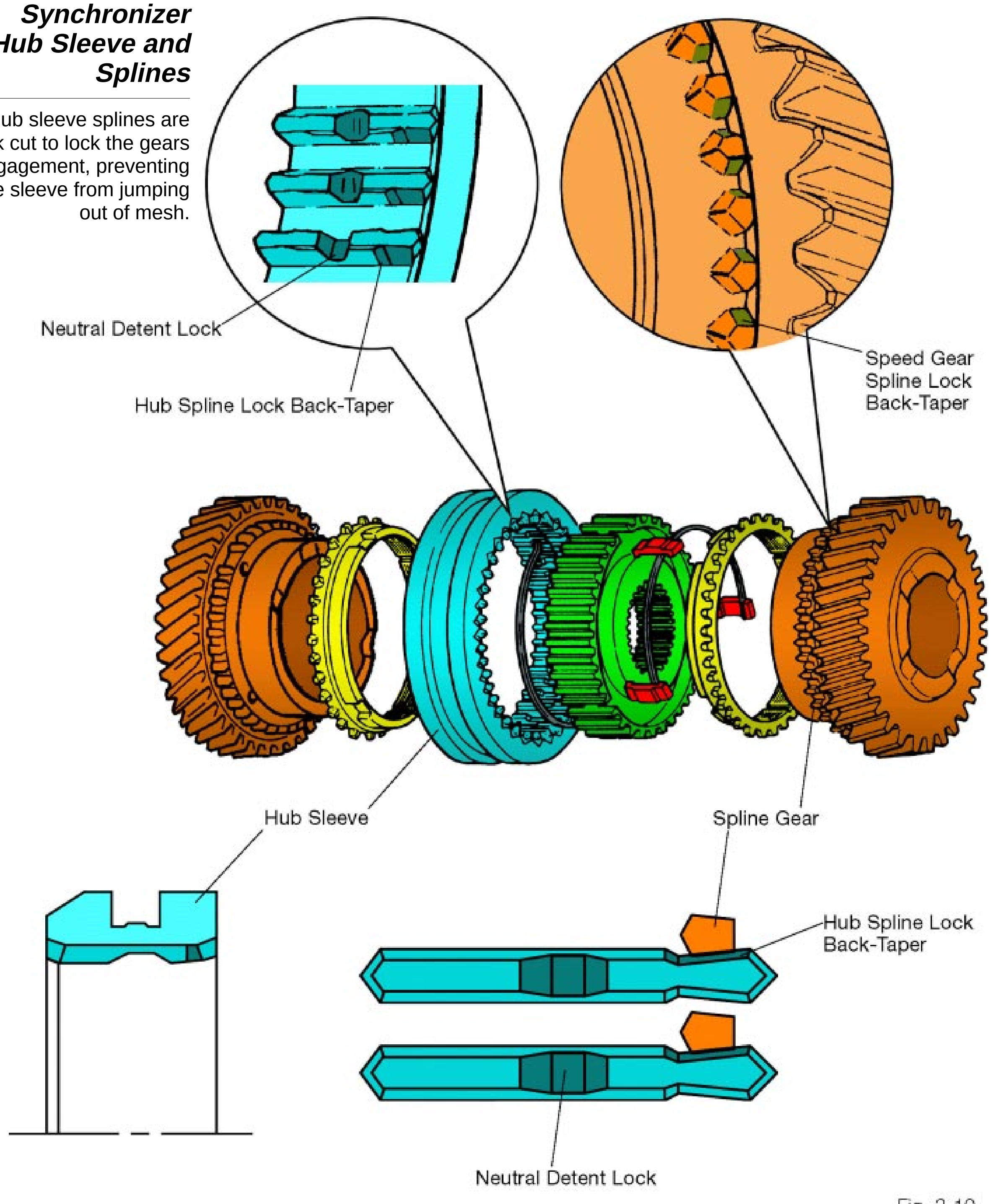


Fig. 3-10
T302f310

Inertia Lock

Splines of different thickness have been used where the gears fit into the hub sleeve to increase the meshing pressure (surface pressure) of the hub and gears, and to prevent the sleeve from jumping out of engagement.

As a result, when driving torque is transmitted from a gear to the hub sleeve, all of the splines of the gear mesh with the hub sleeve, but during engine braking (driving torque transmitted from the hub sleeve to the gears), the number of gear splines meshing with the hub sleeve decreases. This causes the meshing pressure of the hub sleeve and the gear to increase, thus preventing the sleeve from jumping out of engagement.

Inertia Lock

During engine braking, the number of hub splines in contact with the gear splines is reduced causing more pressure to be exerted on the splines still in contact.

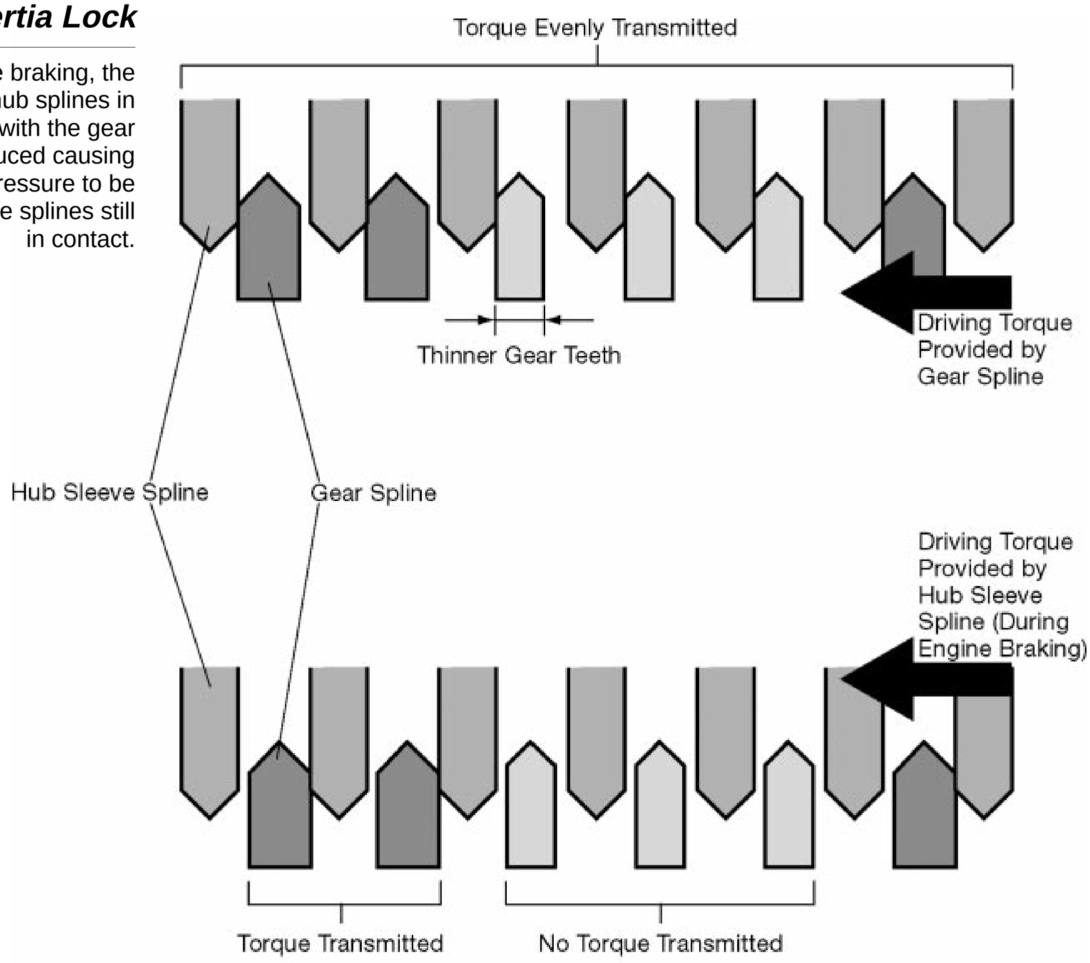


Fig. 3-11
T302f311

Multi-Cone Synchronizer

Some transmissions use two or three cone synchronizer units. Multiple cone synchronizers have more surface area available to provide low shift effort for the lower gear ranges.

Two-Cone Synchronizer

The two cone synchronizer is so named from the two cone shaped surfaces which make up the assembly. The middle ring provides two cone surfaces and almost twice the surface area to slow the gear to the speed of the output shaft.

In a two-cone synchronizer, the inner and outer rings are indexed together and turn with the transmission output shaft. The middle ring is indexed to the gear and they turn together driven by the input shaft.

During shifting, the hub sleeve pushes the synchronizer keys against the outer ring. The inside surface of the outer ring mates with the outside surface of the middle ring creating one friction surface. The inside surface of the middle ring mates with the outside surface of the inner ring providing the second friction surface.

Two-Cone Synchronizer

In a two-cone synchronizer, the inner and outer rings turn with the transmission output shaft. The middle ring and gear turn together driven by the input shaft.

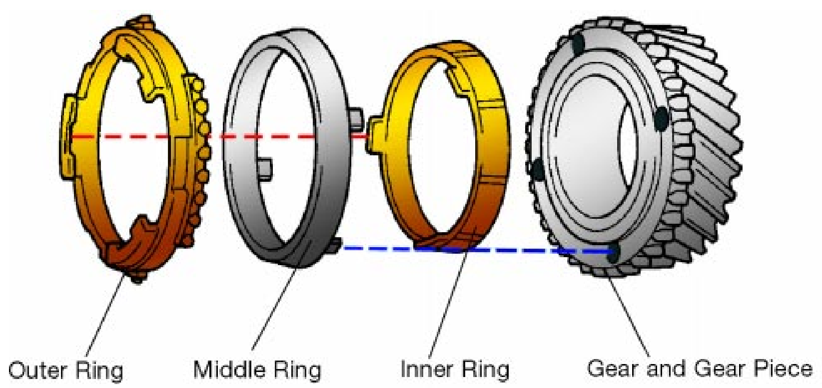


Fig. 3-12
T302f312

Three-Cone Synchronizer

The three cone synchronizer is so named from the three cone shaped surfaces which make up the assembly. In addition to the middle ring providing two cone surfaces, the speed gear has a third cone surface providing three surface areas to slow the gear to the speed of the output shaft.

In a three-cone synchronizer, the inner and outer rings turn with the transmission output shaft. The middle ring is indexed to the gear and they turn together driven by the input shaft.

During shifting, the hub sleeve pushes the synchronizer keys against the outer ring. The inside surface of the outer ring mates with the outside surface of the middle ring creating one friction surface. The inside surface of the middle ring mates with the outside surface of the inner ring providing the second friction surface. The inside surface of the inner ring mates with the cone surface of the speed gear providing the third friction surface.

Three-Cone Synchronizer

In a three-cone synchronizer, the inner and outer rings turn with the transmission output shaft. The middle ring is indexed to the gear and they turn together driven by the input shaft.

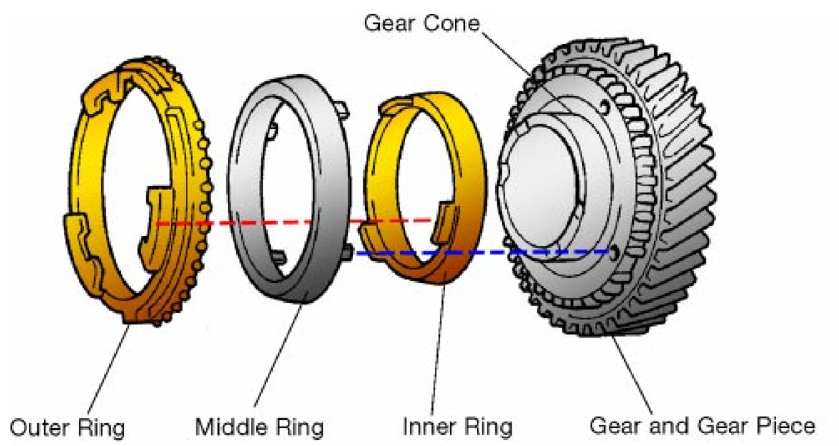


Fig. 3-13
T302f313

Transmission Powerflow

Understanding the powerflow through a transmission helps the technician in diagnosing complaints and determining the proper repairs to be done. The following illustrations show the typical powerflow through a five-speed transmission.

For example, in first gear, power flows from the input shaft and main drive gear to the counter shaft. First gear, on the counter shaft, drives first gear on the output shaft. The first gear is locked to the synchronizer clutch hub transmitting power to the output shaft.

On the following three pages, in figures 3-14 through figure 3-19, the powerflow for 1st, 2nd, 3rd, 4th, 5th, and Reverse are highlighted and traced through a transmission.

1st Gear

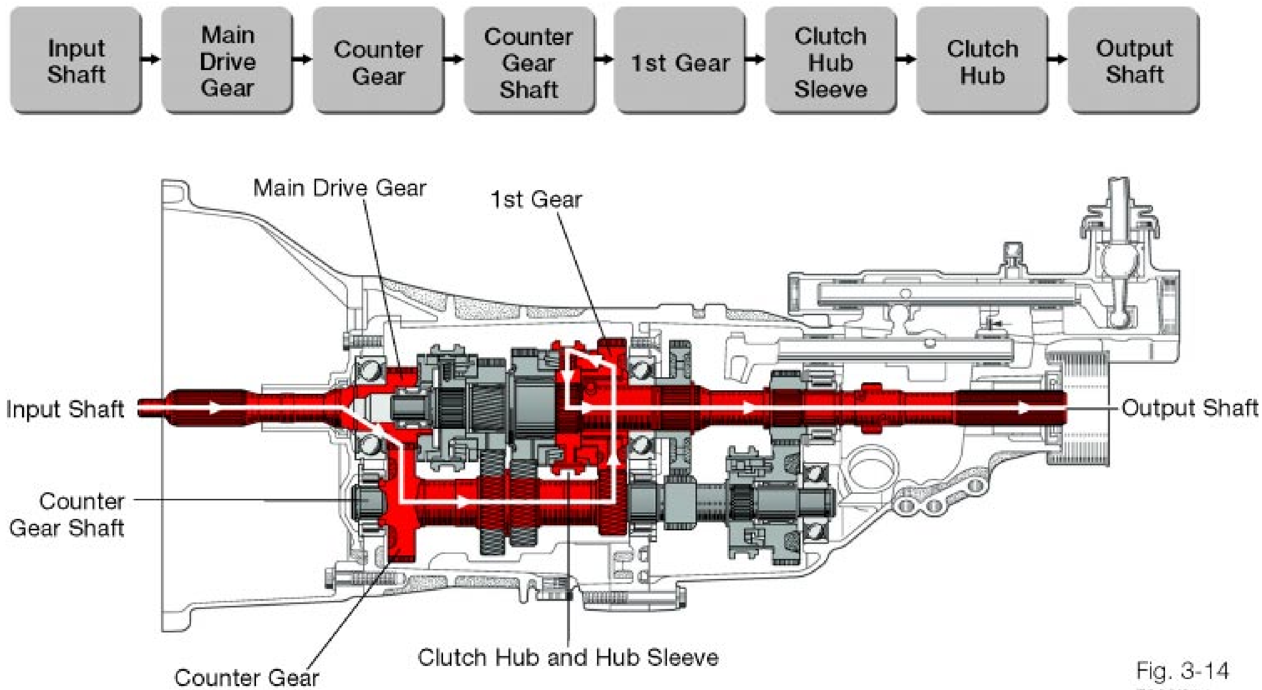


Fig. 3-14
T302f314

2nd Gear

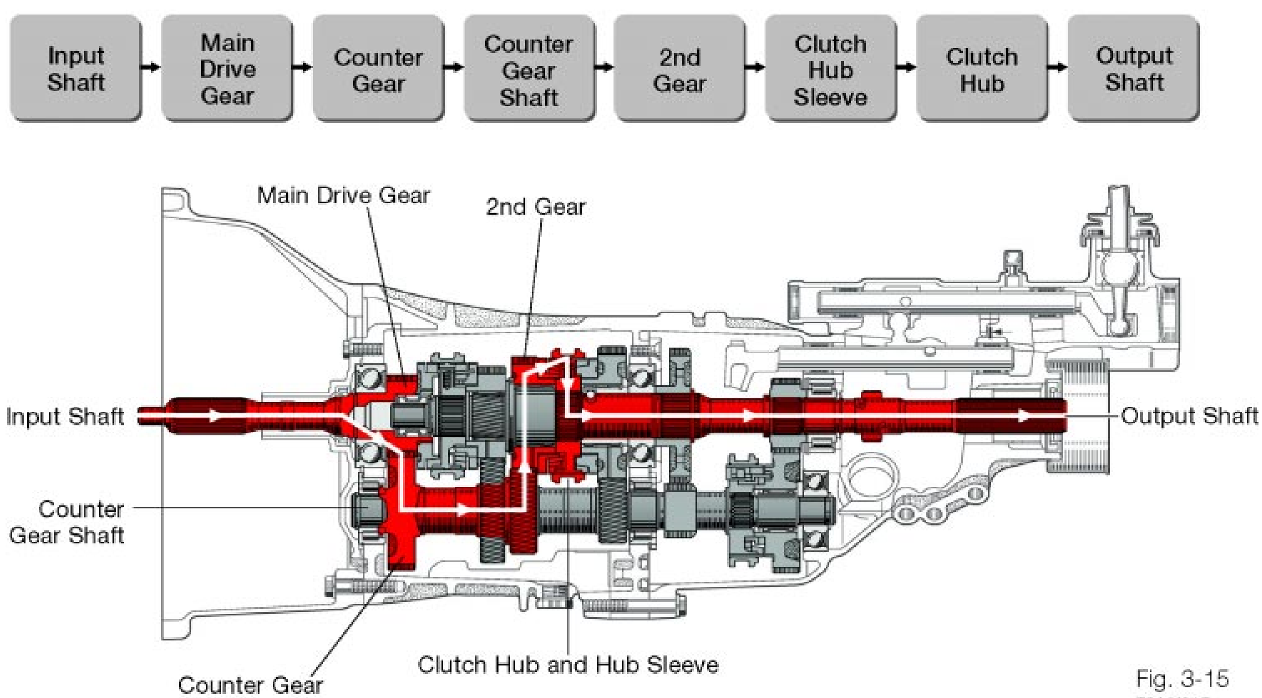


Fig. 3-15
T302f315

3rd Gear

Input Shaft → Main Drive Gear → Counter Gear → Counter Gear Shaft → 3rd Gear → Clutch Hub Sleeve → Clutch Hub → Output Shaft

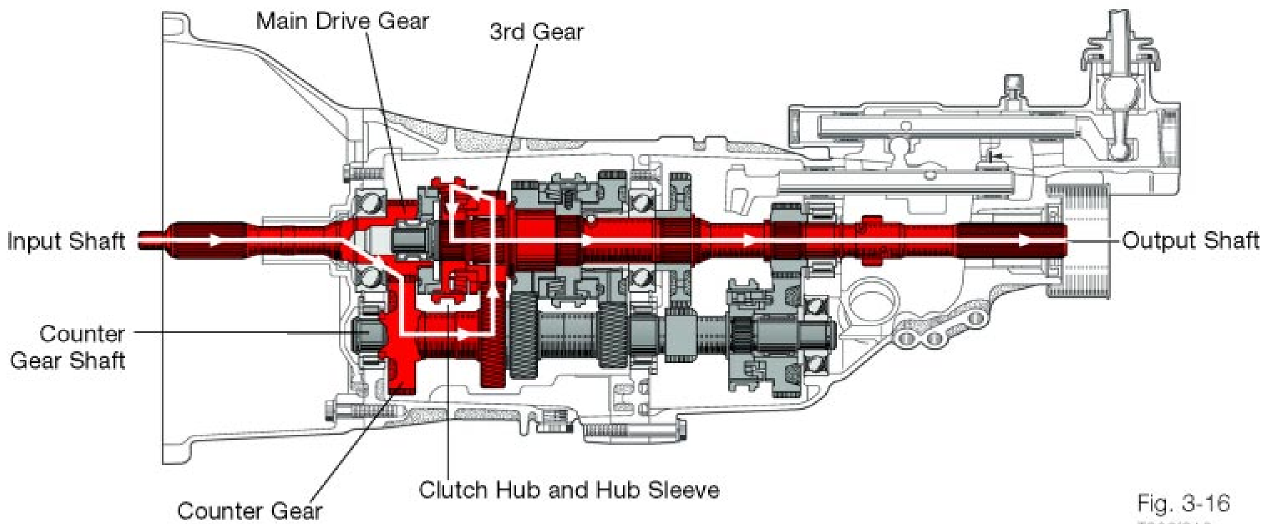


Fig. 3-16
T302f316

4th Gear

Input Shaft → Main Drive Gear (4th) → Clutch Hub Sleeve → Clutch Hub → Output Shaft

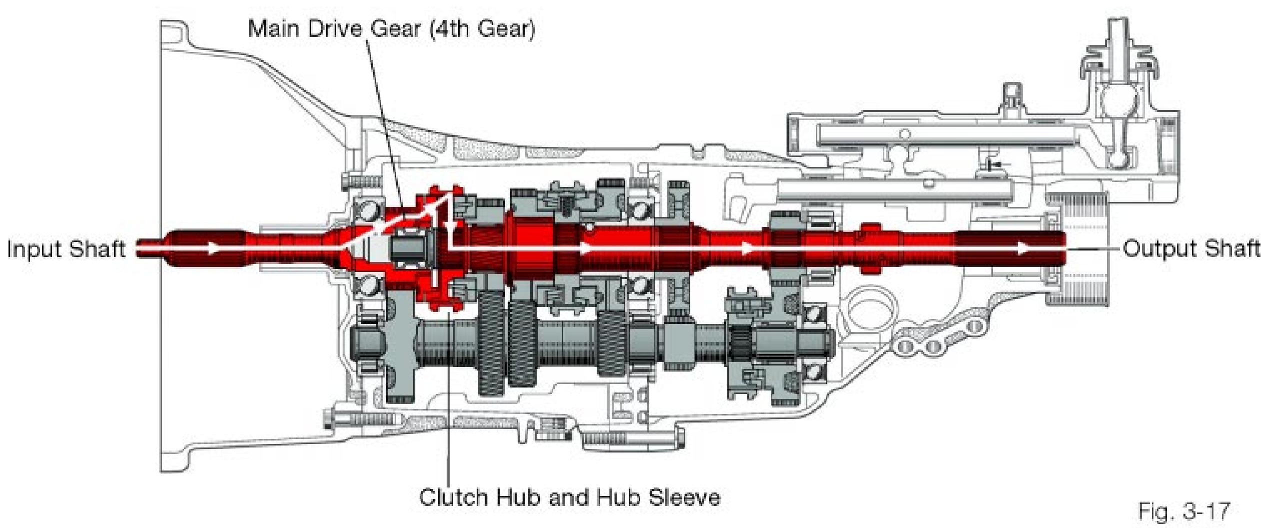


Fig. 3-17
T302f317

5th Gear

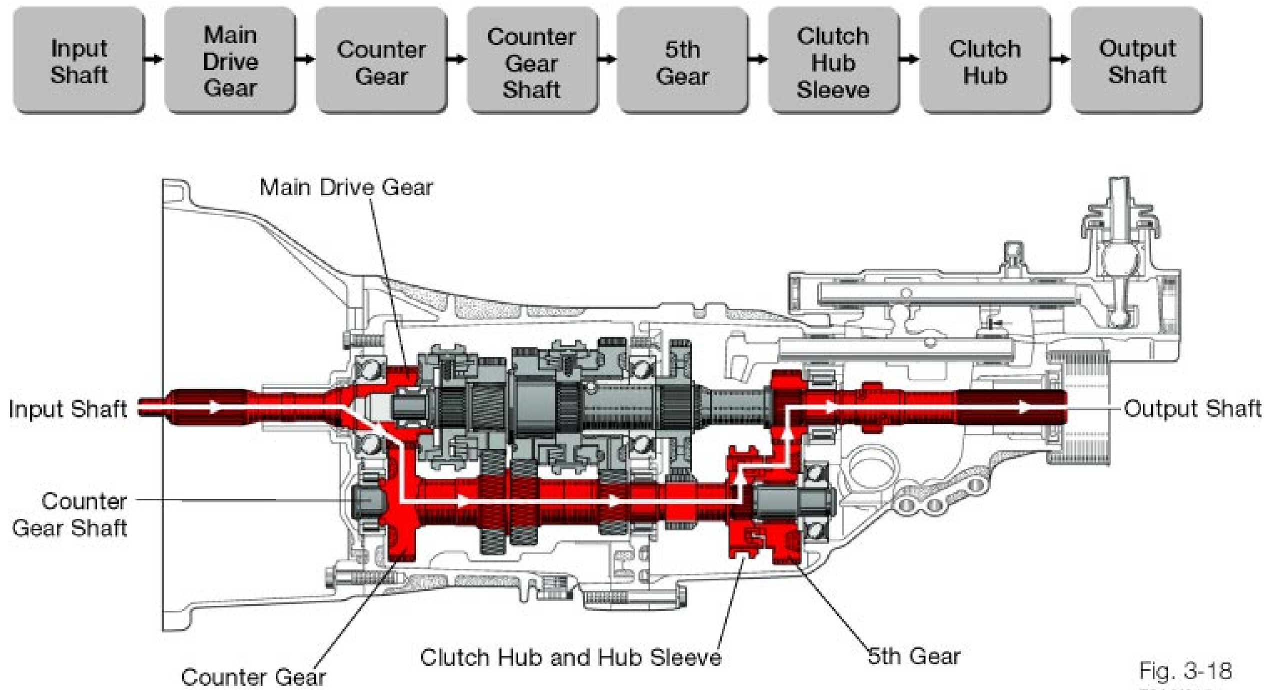


Fig. 3-18
T302f318

Reverse Gear

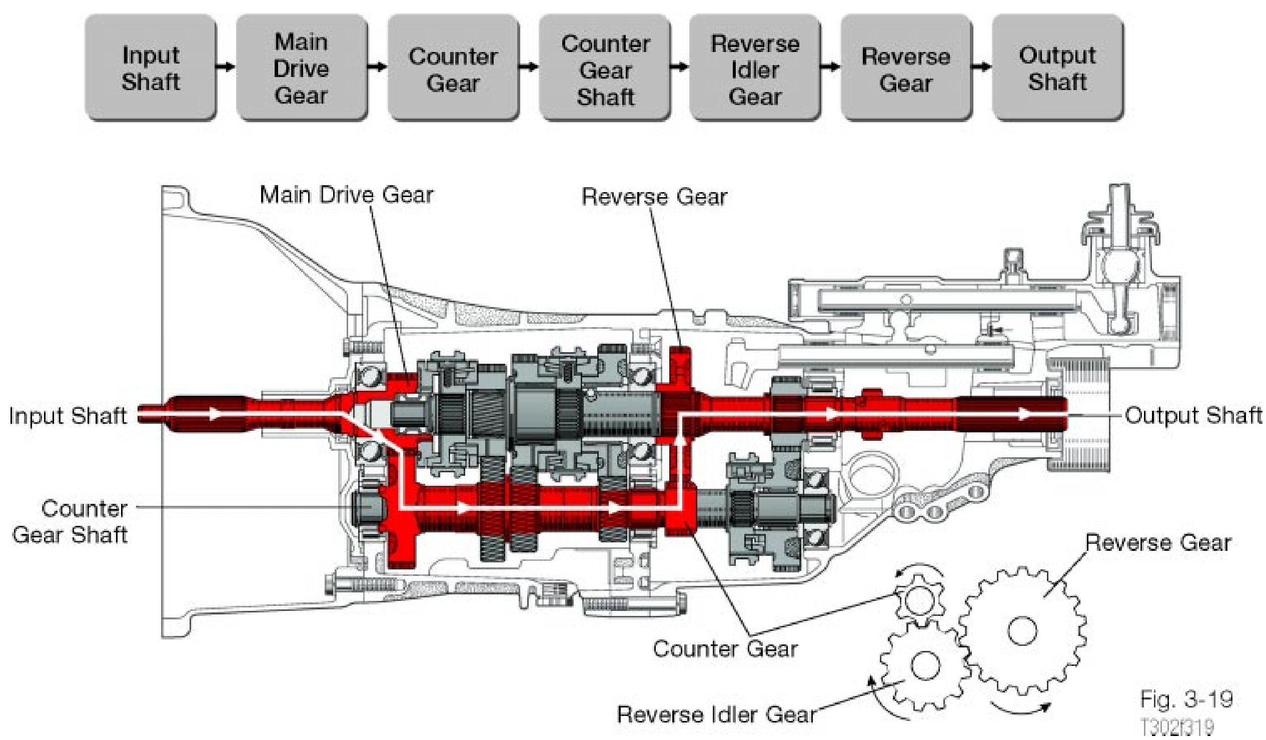


Fig. 3-19
T302f319

Gear Shift Mechanism

The gear shift lever and internal linkage allow the transmission to be shifted through the gears.

The **shift lever** is mounted in the transmission extension housing and pivots on a **ball socket**. The **shift fork shaft** connects the shift lever to the shift forks. A detent ball and spring prevent the forks from moving on their own. The **shift forks** are used to lock and unlock the synchronizer hub sleeve and are mounted on the shafts either by bolts or roll pins. The shift forks ride in the grooves of the synchronizer hub sleeves.

Shift forks contact the spinning synchronizer sleeve and apply pressure to engage the gear. To reduce wear, the steel or aluminum forks can have contact surfaces of hardened steel, bronze, low-friction plastic, or a nylon pad attached to the fork.

After the sleeve has been positioned, there should be very little contact between the fork and sleeve. The fork is properly positioned by the detent. The back taper of the hub sleeve splines and spline gear, and gear inertia lock mechanism, keep it in mesh during different driving conditions.

Holding a gear into mesh with the fork results in rapid wear of the fork and hub sleeve groove. Wear at the shift lever ball socket, shift fork shaft bushings, and shift fork contact surfaces may cause the synchronizer sleeve to be improperly positioned, causing the sleeve to jump out of gear.

Gear Shift Mechanism

The gear shift mechanism includes the shift lever, shift fork shafts, shift forks, and shift detents.

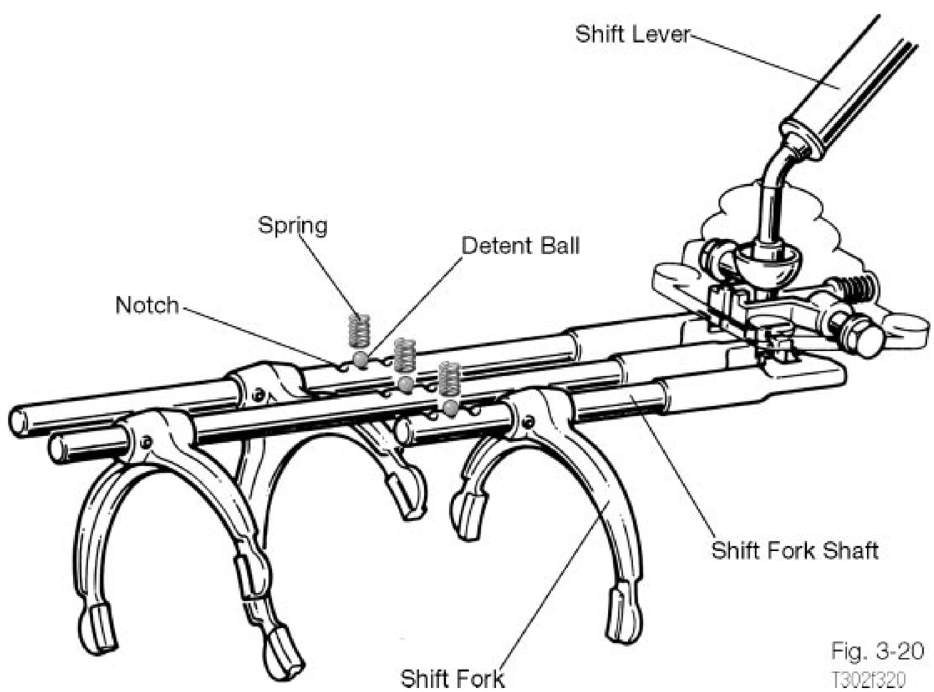


Fig. 3-20

Other mechanisms that make up gear shift control are the:

- Shift detent mechanism
- Shift interlock mechanism
- Mis-shift prevention
- Reverse mis-shift prevention
- Reverse pre-balk mechanism
- Shift detent mechanism
- Reverse one-way mechanism

Shift Detent Mechanism

Detents locate the internal shift forks in one of their three positions. The detent ball rides in one of three notches cut into the shift fork shaft. The center detent position is neutral. Moving the shift shaft to a detent on either side of center engages a speed gear. When the shaft is moved either forward or backward, the ball rides on the shaft and is forced into a notch by the spring. The spring holds the ball secure in the notch and will not let the shaft move unless the shift lever applies enough force to overcome the spring tension.

Shift Detent Mechanism

The detent ball rides in one of three notches cut into the shift fork shaft.

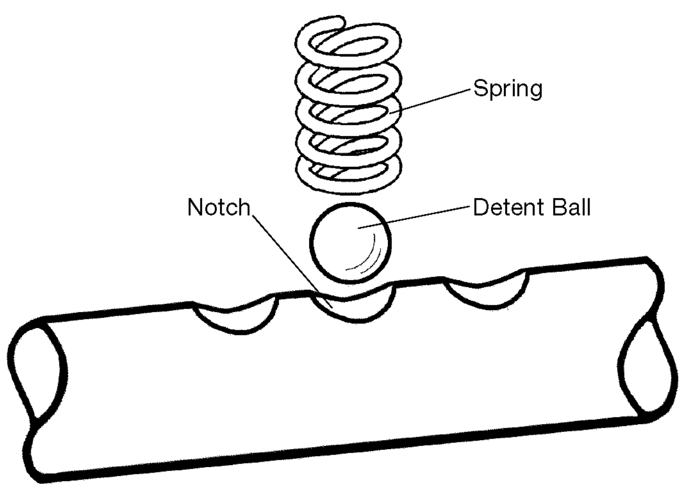


Fig. 3-21
T302f321

Shift Interlock Mechanism

The shift interlock prevents engaging more than one gear at a time. A set of pins hold the other shift fork shafts in place when one of the shafts has been moved by the shift lever. This operation insures that the transmission will not be shifted into two gears at the same time.

Shift Interlock Mechanism

A set of interlock pins hold the other shift fork shafts in place when the shift lever moves one of the shafts.

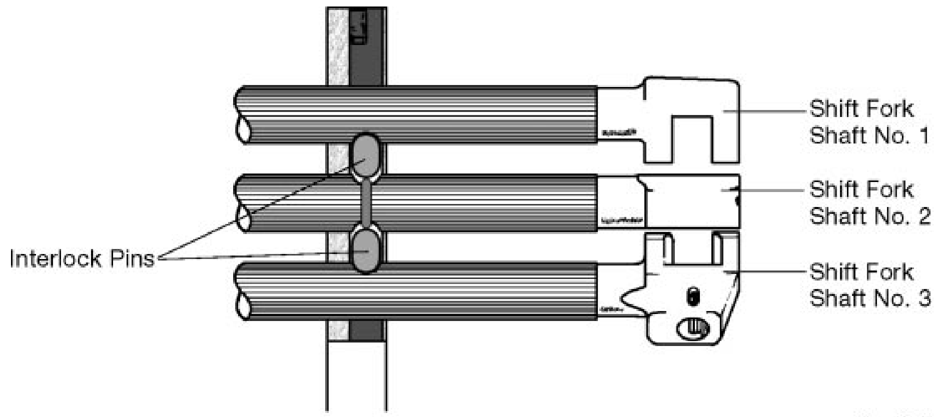


Fig. 3-22
T302f322

Shaft Locking

When **shift fork shaft No. 1** is moved to the left, the **two interlock pins** are pushed out by the shaft and into the slots on the other shafts. As a result, shafts two and three are locked in position.

When **shift fork shaft No. 2** is moved to the left, the **two interlock pins** are pushed out by the shaft and into the slots on the other shafts. As a result, shafts one and three are locked in position.

When **shift fork shaft No. 3** is moved to the left, the **two interlock pins** are pushed out by the shaft and into the slots on the other shafts. As a result, shafts one and two are locked in position.

Shift Fork Shafts and Interlock Pins

When a shift fork shaft is moved to the left, the two interlock pins are pushed out, locking the other two shafts in position.

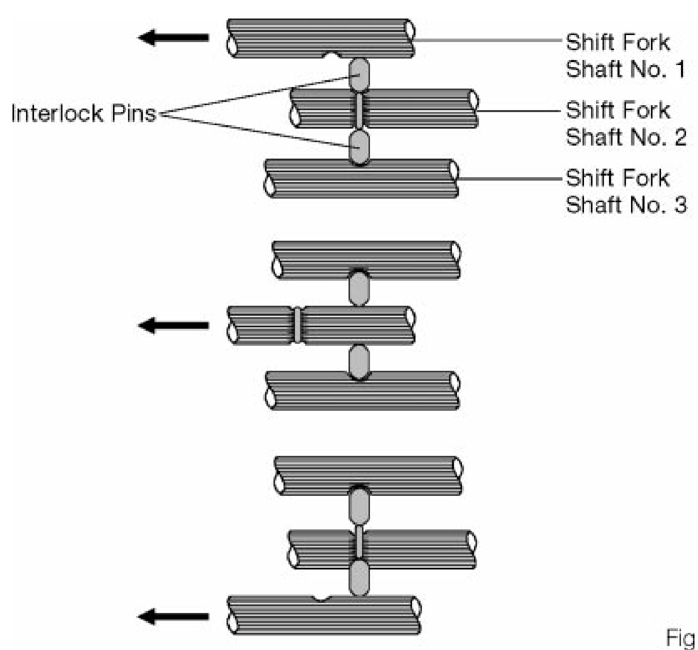


Fig. 3-23
T302f323

Mis-Shift Prevention

The mis-shift prevention mechanism is located in the transmission extension housing. The shift lever is spring loaded to provide the driver with a sense of the shift lever position during shifting,

Mis-Shift Prevention Upshift

Shift restrict pins are installed on opposite sides of the extension housing adjacent to the shift lever. The pins contain **springs** of different tension and are color coded for that reason. The restrict pins ensure that the shift lever is always pushed toward the 3rd and 4th gear select position. When shifting from 2nd to 3rd gear, the pins will help the driver engage 3rd gear and not 1st.

Mis-Shift Prevention Upshift

Shift restrict pins have different tension and push the shift lever toward the third and fourth gear select position.

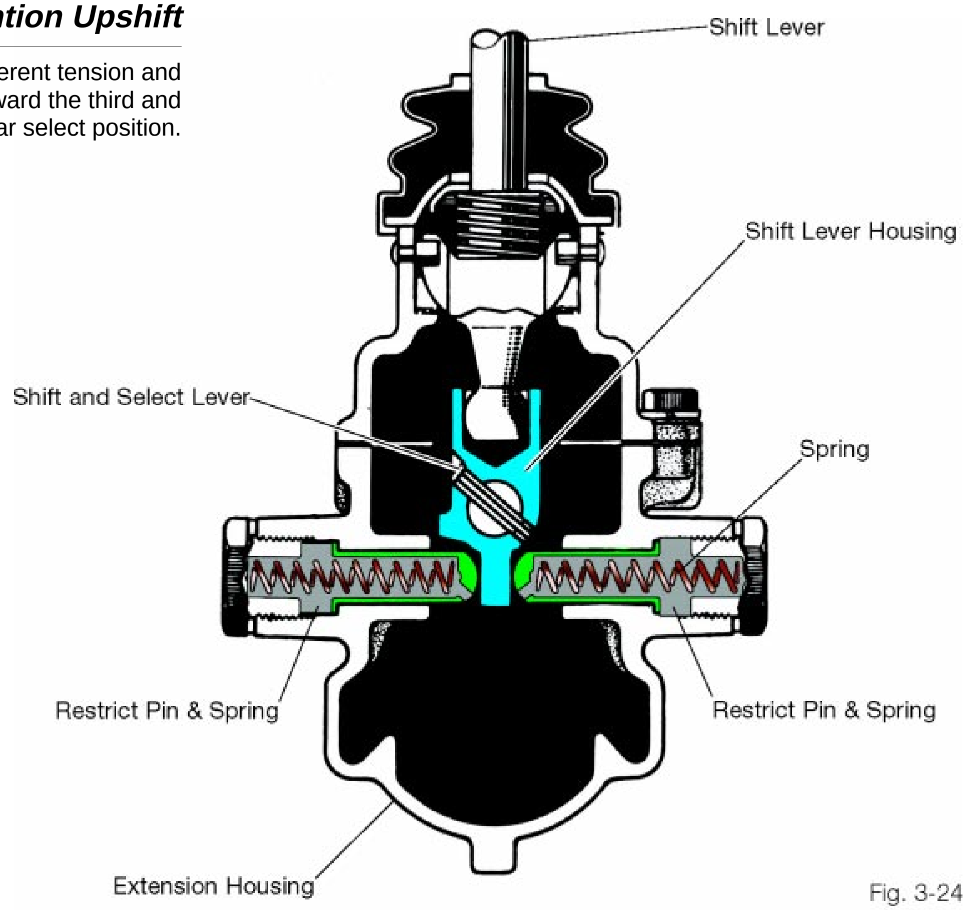


Fig. 3-24
T302f324

Reverse Mis-Shift Prevention

The reverse restrict pin is located in the extension housing and prevents the driver from down shifting from 5th gear into reverse by stopping the travel of the **shift and select lever**. When the transmission is shifted into 5th gear, the shift and select lever passes by the **reverse restrict pin**.

When shifting out of fifth gear the lever will contact the protrusion on the restrict pin, compress the spring on the shaft and force the pin against the stop. The shift and select lever is not allowed past the neutral position and into reverse gear.

Shifting into Reverse

When shifting into reverse, the shift and select lever contacts the restrict pin protrusion, rotates the pin on the shaft and causes the spring to coil tighter. The lever can now move the required parts to engage reverse gear. The spring tension is relieved when the lever is moved to the neutral position and the restrict pin returns to original position.

Reverse Mis-Shift Prevention

The reverse restrict pin prevents the driver from down shifting from 5th gear into reverse by stopping the travel of the shift and select lever.

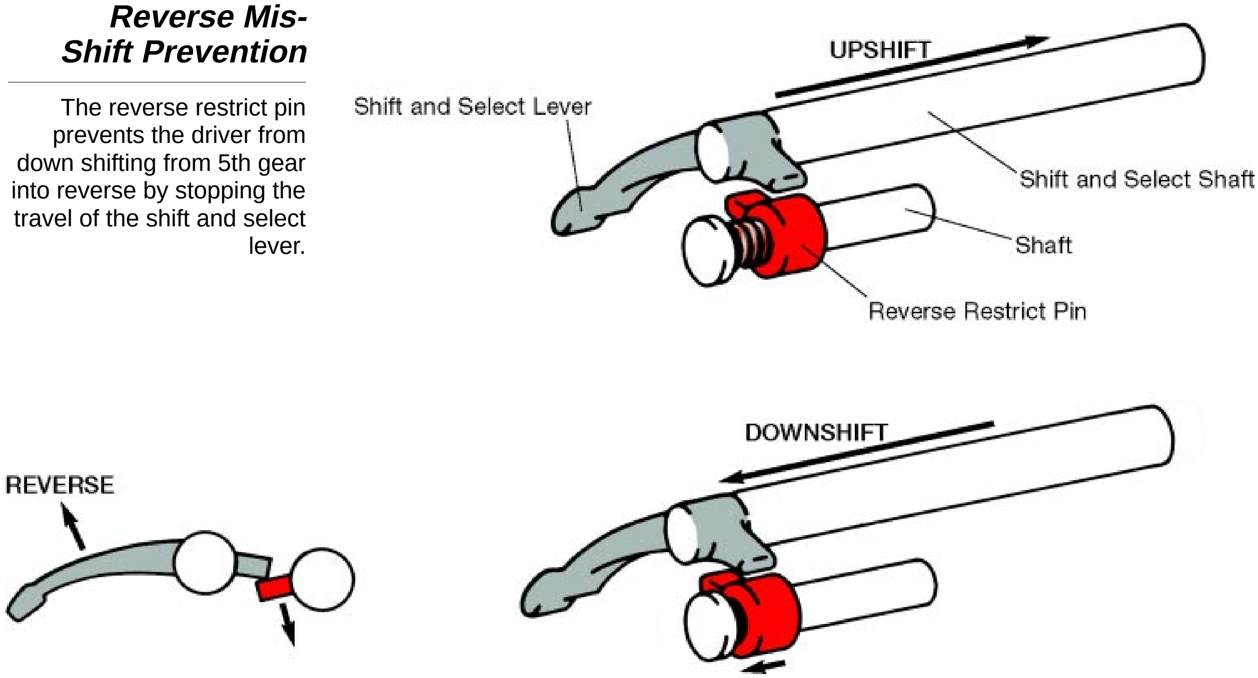


Fig. 3-25
T302f325

Reverse Pre-Balk Mechanism

The reverse pre-balk mechanism utilizes the fifth gear synchronizer assembly on the countershaft to reduce gear clash when shifting into reverse. By engaging the fifth synchronizer ring the input shaft, counter gear shaft and speed gears are slowed allowing the reverse idler gear and the reverse gears to engage with a minimum gear clash.

The synchronizer assembly components include the following:

- Reverse synchronizer ring
- 5th synchronizer hub sleeve (hub sleeve No. 3)
- 5th synchronizer ring
- Synchronizer cone ring
- Reverse synchronizer pull ring
- Gear spline piece No. 5

The **synchronizer cone ring** is indexed to the **gear spline piece** that is pressed to the counter gear shaft. It is the cone that the **5th synchronizer ring** contacts when shifting into 5th gear or reverse.

Reverse Pre-Balk Mechanism

The fifth gear synchronizer assembly on the countershaft is used to reduce gear clash when shifting into reverse.

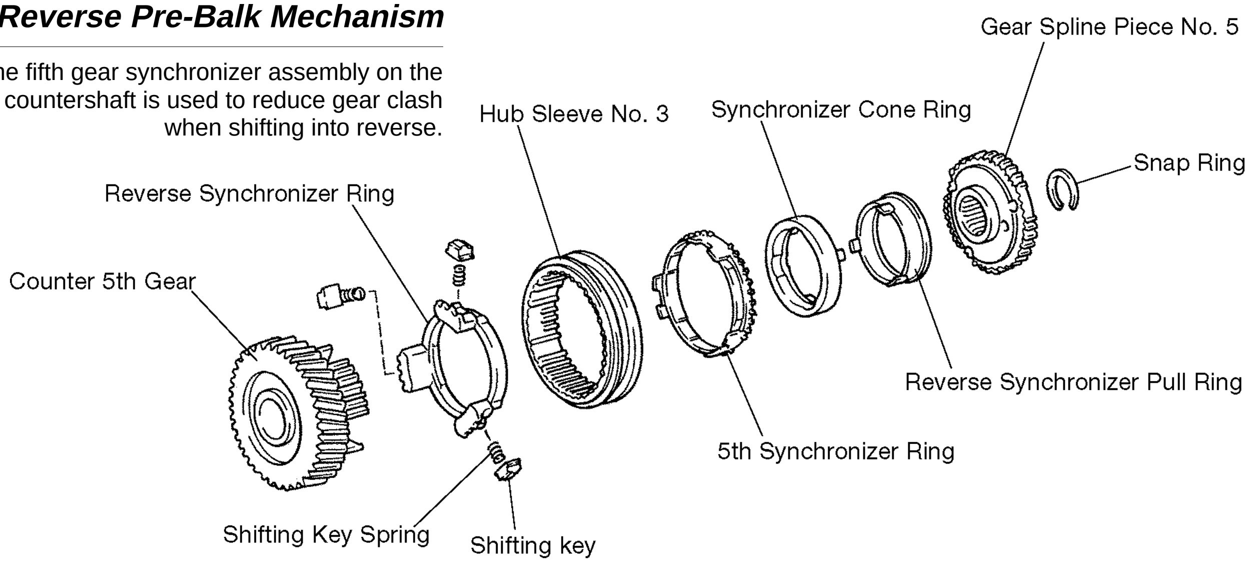


Fig. 3-26
T302f326

The synchronizer assembly is held together with the **reverse synchronizer pull ring** tabs locked to the **reverse synchronizer ring**. The **synchronizer cone ring** and 5th synchronizer ring are located between these two parts and cause the braking action to slow the counter gear shaft and speed gears.

When shifting into reverse the **5th synchronizer hub sleeve** is moved to the left and moves the reverse synchronizer ring and shifting keys. As with the key type synchronizer covered earlier, the reverse synchronizer ring rotates slightly causing the misalignment of the synchronizer spline teeth and the hub sleeve splines. As the taper on the front of the reverse synchronizer ring and hub sleeve splines make contact, greater force is applied to the reverse synchronizer ring and reverse synchronizer pull ring. The pull ring pulls the synchronizer cone ring into engagement with the 5th synchronizer ring, slowing the counter gear shaft and speed gears on the output shaft.

Synchronizer Rings

The synchronizer assembly is held together with the reverse synchronizer pull ring tabs locked to the reverse synchronizer ring.

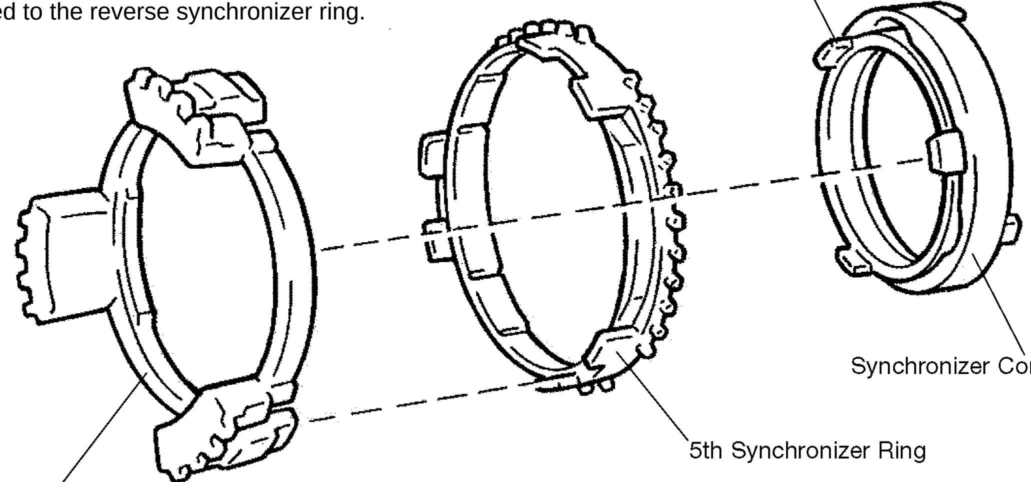


Fig. 3-27
T302f327

Reverse One-Way Mechanism

The reverse one-way mechanism on the R and W series transmissions allows 5th gear and reverse to be selected using the same shift fork shaft. The reverse one-way mechanism prevents the movement of the reverse shift fork while shifting in or out of 5th gear. This is accomplished with the use of a snap ring and an interlock ball or pin. The interlock ball/pin is located in the reverse shift fork between shift fork shaft No. 3 and shift fork shaft No. 4. The snap ring is installed on shift fork shaft No. 3, between the intermediate plate and the reverse shift fork. Shift fork shaft No. 4 is a stationary shaft that is locked to the transmissions intermediate plate.

Reverse One-Way Mechanism

The interlock pin is located in the reverse shift fork between the two shift fork shafts.

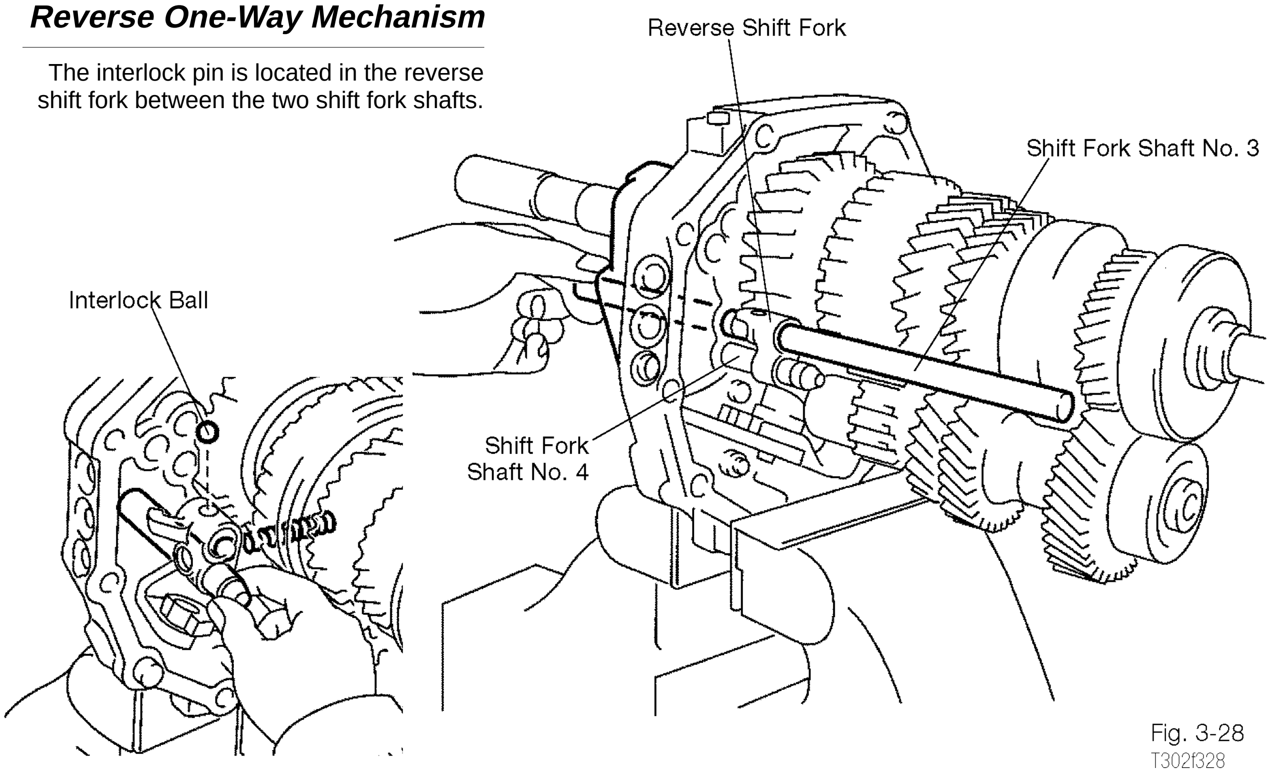


Fig. 3-28
T302f328

Operation

When 5th gear is selected, shift fork shaft No. 3 is moved to the right. The interlock ball is pushed into the notch in shift fork shaft No. 4, locking the reverse shift fork to the shaft.

The reverse shift fork can only move into reverse when shift fork shaft No. 3 is in the neutral position. When shifting into reverse, shift fork shaft No. 3 moves to the left causing the snap ring to move the reverse shift fork. As the shift fork moves over shift fork shaft No. 4, the interlock ball moves into the notch of shift fork shaft No. 3, locking the shift fork to shaft No. 3.

When shifting out of reverse, shift fork shaft No.3 moves to the right and the reverse shift fork also moves to the right. If the interlock ball were not installed during reassembly, the transmission would remain in reverse with no way to disengage reverse gear as it is held in position by its detent ball and spring. Selecting a forward gear and engaging the clutch will cause the engine to stall because two gears are engaged at the same time.

Reverse One-Way Mechanism Operation

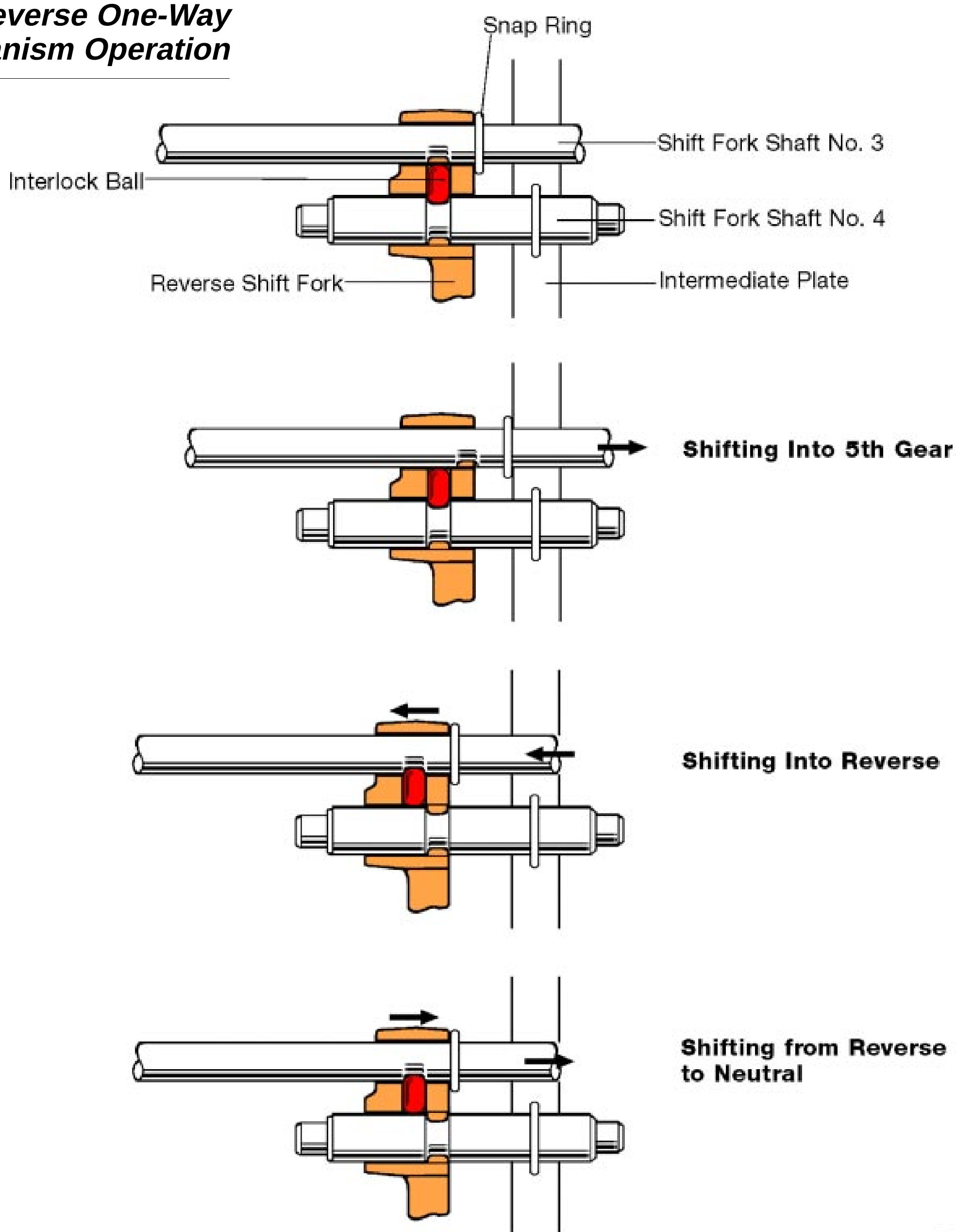


Fig. 3-29
T302f329

Transmission Lubrication

To prevent overheating, the lower transmission gears run in a bath of lubricant. As they spin, their motion spreads the lubricant throughout the case.

Floating gears on the mainshaft or counter shaft of R series transmissions have oil passages drilled to get lubricant into critical areas. Some transmissions use scoops, troughs, or oiling funnels as lubrication paths. Each transmission includes a vent at the top, to relieve internal pressure (heat) during operation.

Gear Lubrication

The transmission gears are lubricated to:

- Reduce friction
- Transfer heat away from gears and bearings
- Reduce corrosion and rust
- Remove dirt and wear particles from moving parts

The Society of Automotive Engineers (SAE) and the American Petroleum Institute (API) Service Classification provide rating systems for selection of proper lubricants for particular uses.

Viscosity is a measurement of fluid thickness and is determined by how fast a fluid runs through a precisely sized orifice at a particular temperature.

The following are API gear oil classifications:

- GL-1: Straight mineral oil; used in non-synchromesh transmissions; use additives; not suitable for modern automobile transmissions
- GL-2: A designation for worn gear drives used in mostly industrial applications
- GL-3: Contains mild EP additives; used in manual transmissions and transaxles with spiral bevel final drives
- GL-4: Used in manual transmissions and transaxles with hypoid final drives; contains half the additives found in GL-5
- GL-5: Contains enough EP additive to lubricate hypoid gears in drive axles

An additional classification, GLS (Gear Lubricant Special), is sometimes used to indicate a proprietary set of specifications determined by the vehicle or gearbox manufacturer.

Gear Lubrication Types

Toyota manual transmissions use the following gear lubrication types:

- 75W-90 GL4/GL5
- 80W-90 GL4/GL5
- TOYOTA V160 (Supra 6-Speed V160MT)

Consult the vehicle repair manual for specific lubrication information.

Case Sealants

Toyota transmission cases use **Formed-In-Place Gaskets (FIPG)**. FIPG gaskets are usually **Room-Temperature Vulcanizing (RTV)** or **anaerobic sealants**. RTV sealant is made from silicone and is one of the most widely used gasket compounds. It is extremely thick, and sets up to a rubber-like material very quickly when exposed to air.

Anaerobic sealant is similar in function to RTV. It can be used either to seal gaskets or to form gaskets by itself. Unlike RTV, anaerobic sealant cures only in the absence of air. This means that an anaerobic sealant cures only after the assembly of parts, sealing them together.

Notes

WORKSHEET 3-1

Rear-Drive Transmission—Case Removal and Component Identification

Vehicle:	Year/Prod. Date:	Engine	Transmission:

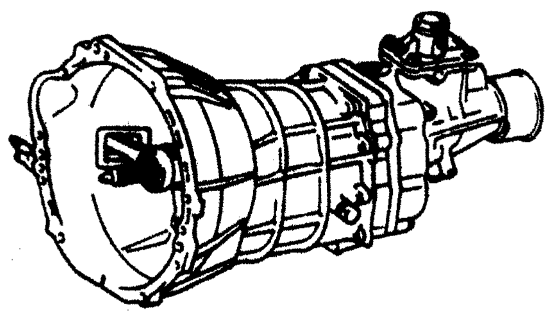
Worksheet Objectives

With this worksheet, you will follow the disassembly of a rear-drive transmission using the required special tools, make measurements where appropriate, retrieve and apply the needed service information, retrieve and interpret service specification information from the repair manual.

Tools and Equipment

- Vehicle Repair Manual
- Hand Tool Set
- Owner's Manual or Access to TIS

Section 1: Case Removal



1. Remove speed sensor and back-up light switch to prevent damage.
2. Remove the front bearing retainer and the rear extension housing from the intermediate plate.
3. What part/s must be removed from the front bearings before the transmission case is separated from the intermediate plate?

   ____

4. What part/s should be removed before the extension housing can be separated from the intermediate housing?

   ____

5. Remove the clutch housing/transmission case from the intermediate plate.

Section 2: Intermediate Plate and Gear Shaft Mounting

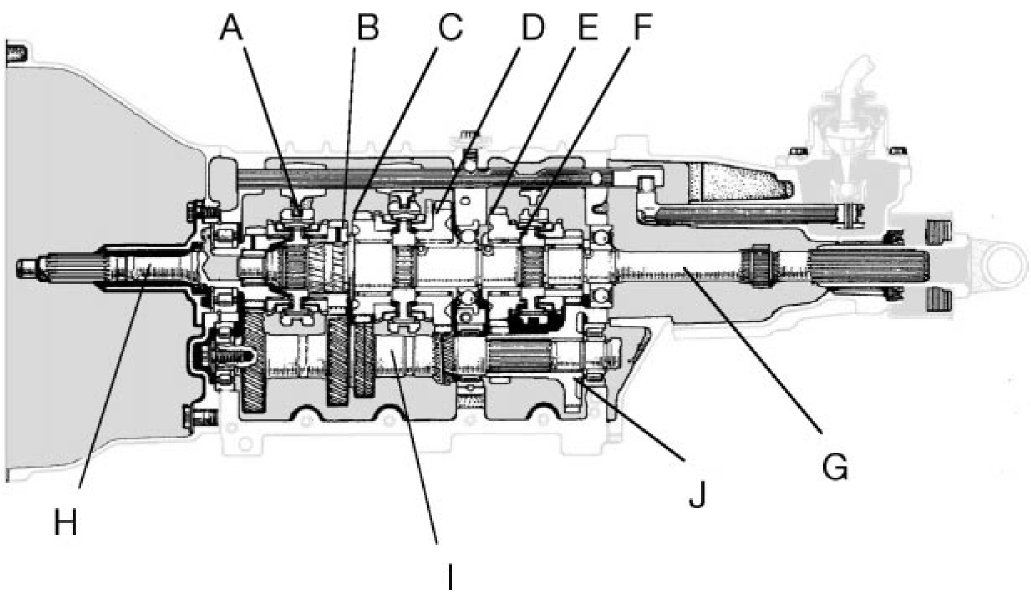
1. To prevent damage to the intermediate plate's sealing surface, use two clutch housing bolts, plate washers and nuts. Install the bolts into the holes of the intermediate plate, and clamp the bolts in a bench vice.

2. What precaution does the repair manual recommend regarding the bolt threaded end prior to clamping them.

    ____

Section 3: Component Identification

Identify each lettered component in the space provided below the transmission illustration by placing the letter of the component in front of the component name.



______ 1. Input shaft

______ 2. Counter gear

______ 3. Output shaft

______ 4. 1st gear

______ 5. 2nd gear

______ 6. 3rd gear

______ 7. 5th gear

______ 8. Reverse gear

______ 9. 5th/Reverse Synchronizer

______ 10. 3rd/4th Synchronizer

Section 4: Powerflow

1. With the transmission in neutral; rotate the input shaft. What are the speed gears on the output shaft doing?

   ____

2. How are the speed gears engaged to the output shaft?

   ____

3. With the transmission in neutral; hold the input shaft and rotate the output shaft. What are the speed gears on the output shaft doing?

   ____

4. How are the speed gears on the output shaft lubricated when the vehicle is being towed with the rear wheels on the ground? (Dingy tow)

   ____

5. What does the owner's manual recommend about dingy towing a rear wheel drive vehicle with manual transmission?

   ____

Trace the power flow from the input shaft through the transmissions to the output shaft. Be prepared to demonstrate powerflow to your instructor.

Instructor's Initials: _______________

6. How is 4th gear power flow different than the power flow in other forward gears.

   ____

   ____

7. Describe how the output shaft's direction of rotation changes from the input shaft's rotation in reverse gear.

   ____

   ____

Instructor's Initials: _______________

Notes

Rear-Drive Transmission—
Case Removal & Component Identification

Name: ____ Date: ____________________

Review this sheet as you are doing the Rear-Drive Transmission—Case Removal & Component Identification worksheet. Check each category after viewing the instructor's presentation and completing the worksheet. Ask the instructor if you have questions regarding the topics provided below. Additional space is provided under Topic for you to list any other concerns that you would like your instructor to address. The comments section is provided for your personal comments, information, questions, etc.

Topic	I have questions	I know I can	Comment
Locate the model specific disassembly procedure in the repair manual.			
Mount the intermediate plate to prevent damage to sealing surfaces.			
Identify all gears in the transmission.			
Identify all synchronizers in the transmission.			
Explain how speed gears are connected to the output shaft.			
Trace powerflow through all gears.			
Describe transmission lubrication when the vehicle is dingy towed.			
Can find the towing recommendation in the owner's manual.			

Notes

WORKSHEET 3-2
Rear-Drive Transmission—Shift Mechanism and Shaft Removal

Vehicle:	Year/Prod. Date:	Engine	Transmission:

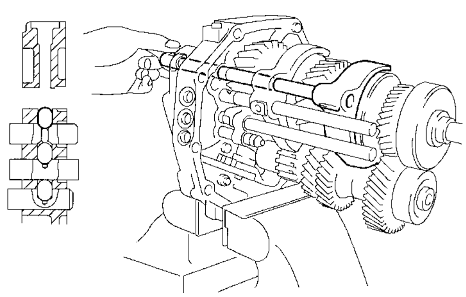
Worksheet Objectives

With this worksheet and a repair manual, you will follow the disassembly of the shift mechanism and shaft removal from a rear-drive transmission using the required special tools. You will make measurements where appropriate, retrieve and apply the needed service information, retrieve and interpret service specification information from the repair manual.

Tools and Equipment

- Vehicle Repair Manual
- 5th Gear Puller SST (P/N 00002-00907-01)
- Hand Tool Set
- Dial Indicator and Stand
- Micrometer, 0-1 in., 1-2 in.
- Feeler Gauge Set
- Magnet

Section 1: Remove Shift Mechanism



1. Remove the shift rail snap rings, screw plugs, locking balls and springs.
2. What function do the locking balls and springs serve in the shift mechanism?

___

3. Remove the shift fork shafts and interlock pins from the intermediate plate.
4. What function do the interlock pins serve?

___

5. What function does the reverse shift fork detent ball and spring serve?

____

6. What function does the reverse shift fork interlock ball have and where is it located?

____

____

Section 2: Measure thrust clearance and remove the rear bearing and 5th gear from the countershaft.

1. Inspect the thrust clearance of counter 5th gear.

   Measurement: ____________ Specification: ____________

2. Measure the thickness of the countershaft snap ring and identify the "Mark" designation from the repair manual chart.

   Measurement: ____________ Specification: ____________

3. What is the SST number/s used to remove the 5th gear?

____

____

4. **R150** – After pulling the 5th gear spline piece, countershaft 5th gear can be removed from the shaft by pushing out the split roller bearings so the gear clears the output shaft rear bearing.

5. **W59** – When removing the 5th gear from the countershaft be careful not to catch the output shaft rear bearing rollers with the teeth of 5th gear

Section 3: Remove output shaft rear bearing and 5th gear.

1. **R150** – The output shaft can be removed without removing the rear bearing and 5th gear. Removing these components can be done in a hydraulic press but may not be required by your instructor.

2. **W59** – What SST number/s should be used to remove 5th gear and reverse gear? (See SST Bulletin on page C-1 in the Tech Handbook Appendix.)

____

____

3. Remove the bearing retainer, center bearing snap ring and then remove the gear shafts.

Section 4: Thrust Clearance

Inspect the following thrust clearances:

1. Output shaft 1st gear:

   Measurement: ____________ Specification: ____________

2. Output shaft 2nd gear:

   Measurement: ____________ Specification: ____________

3. Output shaft 3rd gear:

   Measurement: ____________ Specification: ____________

4. If 2nd or 3rd gear thrust clearance is excessive, what additional measurement must be made to determine the cause?

   ____

   ____

Notes

Rear-Drive Transmission—
Shift Mechanism & Shaft Removal

Name: ____ Date: ______________________

Review this sheet as you are doing the Rear-Drive Transmission—Shift Mechanism & Shaft Removal worksheet. Check each category after viewing the instructor's presentation and completing the worksheet. Ask the instructor if you have questions regarding the topics provided below. Additional space is provided under Topic for you to list any other concerns that you would like your instructor to address. The comments section is provided for your personal comments, information, questions, etc.

Topic	I have questions	I know I can	Comment
Explain the function of the locking ball and spring on the shift fork shafts.			
Explain the function of the interlock pins on the shift fork shafts.			
Explain the function of the reverse shift fork (shift head) detent ball and spring and interlock ball/pin.			
Use the proper SSTs to remove 5th gear.			
Measure thrust clearances.			
Determine the snap ring "Mark" designation using the repair manual and micrometer.			

Notes

WORKSHEET 3-3
Rear-Drive Transmission—Output Shaft Disassembly

Vehicle:	Year/Prod. Date:	Engine	Transmission:

Worksheet Objectives

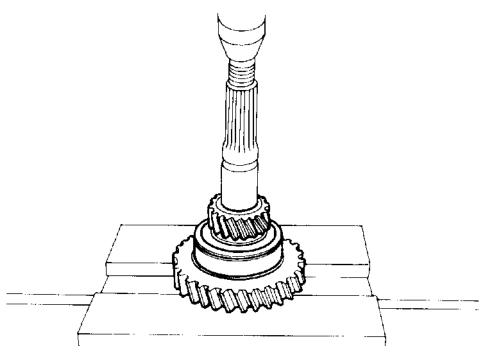
With this worksheet, you will follow the disassembly of output shaft on a rear-drive transmission using the required special tools, make measurements where appropriate, retrieve and apply the needed service information, retrieve and interpret service specification information from the repair manual.

Tools and Equipment

- Vehicle Repair Manual
- Hand Tool Set
- V-Blocks
- Dial Indicator and Stand
- Micrometer, 0-1 in.
- Feeler Gauge Set
- Hydraulic Press
- Bearing Separators (Output Flange Remover)
- Bearing Replacer Set SST (P/N 09316-60011)

Section 1: Output Shaft Disassembly

(This portion of the worksheet is optional – consult your instructor)



1. Measure gear radial clearance using a dial indicator for 1st, 2nd, and 3rd gear:

    1st Gear Measurement: ____________ Specification: ____________

    2nd Gear Measurement: ____________ Specification: ____________

    3rd Gear Measurement: ____________ Specification: ____________

2. If the radial clearance is greater than the maximum, how is it repaired?

____

____

3. Use a hydraulic press to remove 5th gear, center bearing, thrust washer and 1st gear assembly.

4. What component prevents the thrust washer from rotating on the shaft?

____

5. Use a hydraulic press to remove the reverse gear assembly and 2nd gear assembly.

6. Use a hydraulic press to remove the hub sleeve assembly and 3rd gear assembly.

7. Record the measurements of the output shaft:

Flange Thickness: ____________ Specification: ____________

1st Gear Journal: ____________ Specification: ____________

2nd Gear Journal: ____________ Specification: ____________

3rd Gear Journal: ____________ Specification: ____________

Output Shaft Runout: ____________ Specification: ____________

Section 2: Inspect Synchronizer Ring

1. The synchronizer assembly engages the speed gear and the output shaft during shifting of the transmission. Since the output shaft and speed gear turn at different speeds, the synchronizer assembly brings them to the same speed so the synchronizer sleeve can engage the gear. While the clutch is disengaged the synchronizer sleeve forces the synchronizer ring to engage the gear cone and bring the two to the same speed.

2. Check the braking effect of the synchronizing ring by placing it over the gear cone. While applying pressure toward the cone, turn the ring and it should lock.

3. Using a feeler gauge, measure the clearance between the synchronizer ring and the gear:

1st Gear Measurement: ____________ Specification: ____________

2nd Gear Measurement: ____________ Specification: ____________

3rd Gear Measurement: ____________ Specification: ____________

4th Gear Measurement: ____________ Specification: ____________

4. What is the most likely symptom of a synchronizer ring to gear clearance that is below specification?

____

____

5. Inspect the synchronizer sleeve splines and the speed gear spline teeth.

6. What unique shape does the spline tooth have when viewed from the top?

____

____

7. How does the spline tooth design prevent the synchronizer sleeve from disengaging from the speed gear?

____

____

Instructor's Initials: _________________

Notes

Rear-Drive Transmission—
Output Shaft Disassembly

Name: ____ Date: ______________________

Review this sheet as you are doing the Rear-Drive Transmission—Output Shaft Disassembly worksheet. Check each category after viewing the instructor's presentation and completing the worksheet. Ask the instructor if you have questions regarding the topics provided below. Additional space is provided under Topic for you to list any other concerns that you would like your instructor to address. The comments section is provided for your personal comments, information, questions, etc.

Topic	I have questions	I know I can	Comment
Measure gear radial clearance using a dial indicator.			
Placement of the bearing separators over the press ways.			
Measure the 5th gear journal diameter and compare to specifications.			
Measure the synchronizer ring to gear clearance using a feeler gauge.			
Describe the symptoms of a worn synchronizer ring.			
Describe the spline tooth design that prevents the synchronizer sleeve from popping out of mesh with the speed gear.			

Notes

WORKSHEET 3-4
Rear-Drive Transmission—Reassembly

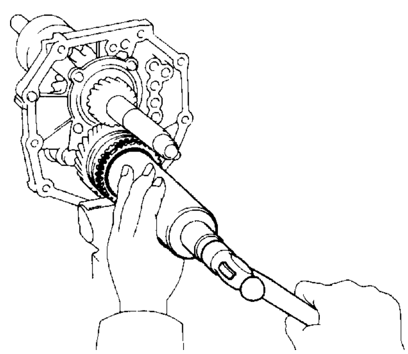
Vehicle:	Year/Prod. Date:	Engine	Transmission:

Worksheet Objectives

With this worksheet and the repair manual, you will follow the reassembly of a rear-drive transmission using the required special tools, make measurements where appropriate, retrieve and apply the needed service information, retrieve and interpret service specification information from the repair manual.

Tools and Equipment

- Vehicle Repair Manual
- 5th Gear Puller Set SST (P/N 00002-00907-01)
- Bearing Replacer Set SST (P/N 09316-60011)
- Hand Tool Set
- Dial indicator and stand
- Micrometer, 0-1 in.
- Feeler Gauge set
- Magnet



Section 1: Reassemble Output Shaft

1. Install 3rd gear and the 3-4 synchronizer (No. 2 hub and sleeve) on the output shaft.

2. What feature of the 3-4 synchronizer would face the front of the transmission?

____

____

____

3. What is the 3rd gear thrust clearance measurement and maximum clearance specification?

   Measurement: ____________ Specification: ____________

4. Install 2nd gear and 1-2 synchronizer assembly/reverse gear on the output shaft

5. What do you have to align when installing second gear and 1-2 synchronizer assembly/reverse gear?

   ____

   ____

6. Install first gear and the output shaft center bearing on the output shaft.

7. Does the center bearing have to be installed in a particular direction?

   ____

8. What is the 2nd gear thrust clearance measurement and maximum clearance specification?

   Measurement: ____________ Specification: ____________

9. What is the 1st gear thrust clearance measurement and maximum clearance specification?

   Measurement: ____________ Specification: ____________

10. R150 - Install the output shaft center bearing and 5th gear.

Section 2: Assemble countershaft and output shaft into the intermediate plate

1. Install the input shaft over the pocket bearing of the output shaft and hold the countershaft against the output shaft and install them into the intermediate plate. (The countershaft can be installed after the output shaft is mounted by placing the rear bearing in the shaft after the countershaft is positioned in the intermediate plate)

2. Install snap rings.

3. Install the bearing retainer.

4. Rotate shafts and check for binding.

5. Install the 5th gear and 5th gear synchronizer assembly (no.5 hub and sleeve) onto the countershaft.

6. W59 - Install reverse gear, and 5th gear onto the output shaft.

Section 3: Install shift assembly

1. Install the shift forks, shift shafts and interlock pins.
2. Install the detent balls and screw plugs.
3. Rotate shafts and check for binding.
4. What is used to seal the threads of the screw plugs?

   ____

5. Engage each of the gears and ensure that only one gear can be engaged at one time.
6. Using the shift shaft head, engage and disengage reverse gear.
7. What part on shift fork shaft No. 3 (5th & reverse) causes the reverse shift fork to engage reverse gear?

   ____

8. What part in the reverse shift fork causes it to disengage reverse gear?

   ____

   ____

Section 4: Install extension housing and clutch housing/transmission case

1. Check that 4th gear synchronizer ring is indexed to synchronizer keys as transmission case and front bearing retainer are installed.
2. Referring to the repair manual, how is the FIPG applied to the mating surfaces of the transmission case, front bearing retainer and extension housing and why?

   ____

   ____

3. What is used to seal the threads of the front bearing retainer bolts?

   ____

4. Install the Clutch Housing
5. Rotate shafts and check for binding.
6. Using gearshift lever, shift the transmission through each gear.

Instructor Initials ____________

Notes

Rear-Drive Transmission—Reassembly

Name: ____ Date: ____________________

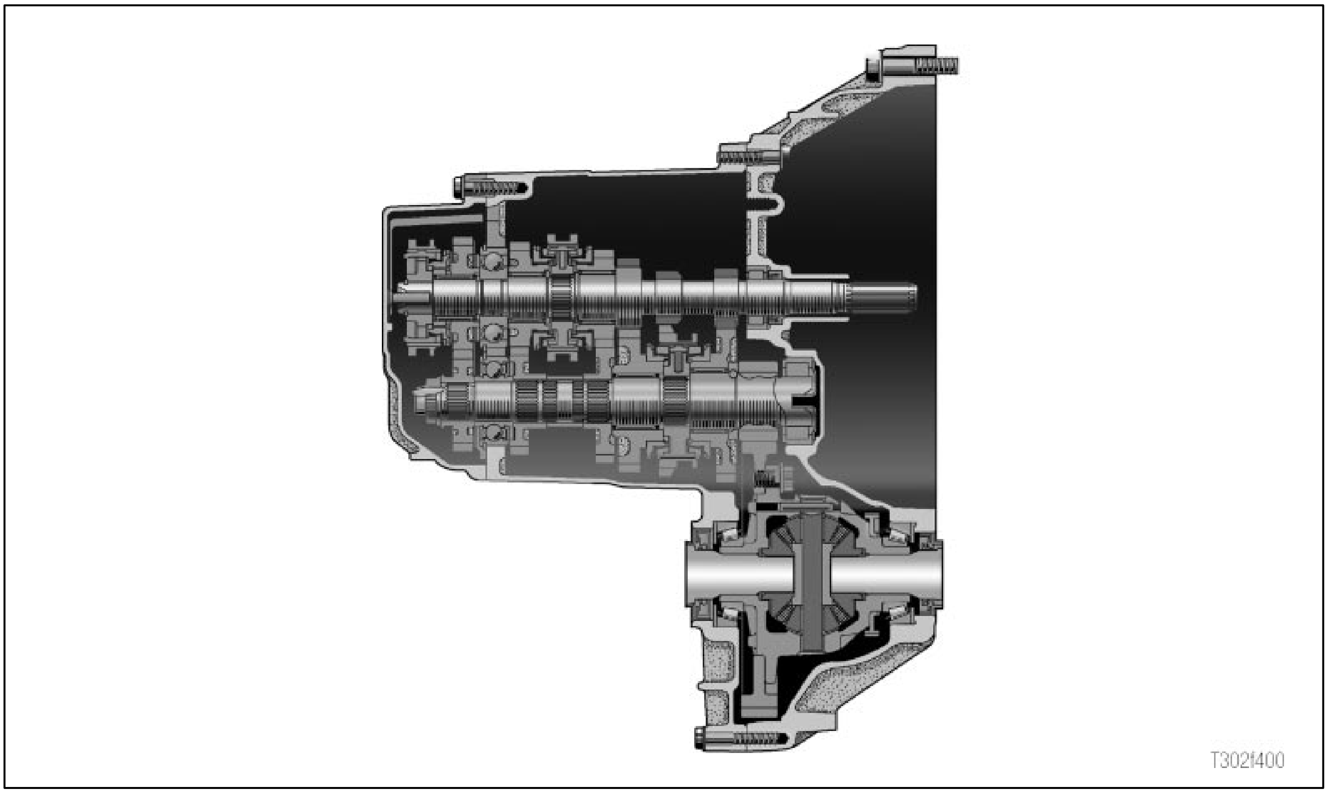
Review this sheet as you are doing the Rear-Drive Transmission—Reassembly worksheet. Check each category after viewing the instructor's presentation and completing the worksheet. Ask the instructor if you have questions regarding the topics provided below. Additional space is provided under Topic for you to list any other concerns that you would like your instructor to address. The comments section is provided for your personal comments, information, questions, etc.

Topic	I have questions	I know I can	Comment
Describe the features that determine how a component is placed on the output shaft.			
Explain the importance of output shaft gear thrust clearance check.			
Explain the importance of shaft rotation when installed in the intermediate plate.			
Install the locking balls, detent pins shift forks and the shift shafts.			
Explain the application of FIPG sealants.			
Explain the importance of shifting through all the gears when the transmission case is assembled.			

Notes

Section 4

Manual Transaxles



Learning Objectives:

1. Identify the purpose and function of the transaxle
2. Describe transaxle construction
3. Identify and describe the operation of the following transaxle components:
   a. Input shaft
   b. Output shaft
   c. Differential
   d. Shift mechanism
   e. Bearings
   f. Oil pump
   g. Remote control mechanism
   h. Reverse detent mechanism
   i. Reverse one-way mechanism
4. Describe transaxle powerflow
5. Describe transaxle lubrication

Section 1
Manual Transaxles

Introduction

A front-wheel drive vehicle utilizes a transaxle to transfer power from the engine to the drive wheels. The transmission portion of the transaxle shares many common features with the transmission. Differences in design include: number of shafts, powerflow, and the addition of final drive gears.

A complete description of components shared with transmissions is found in Section 3: Manual Transmissions.

Understanding manual transaxle design features increases your knowledge of transaxle operation, and provides for more accurate problem diagnosis.

Construction

Toyota transaxles are constructed with two parallel shafts, a differential, four to six forward gears and a reverse gear.

Transaxle Construction

The transmission portion of the transaxle shares many common features with the transmission. (This example is the C50 series transaxle)

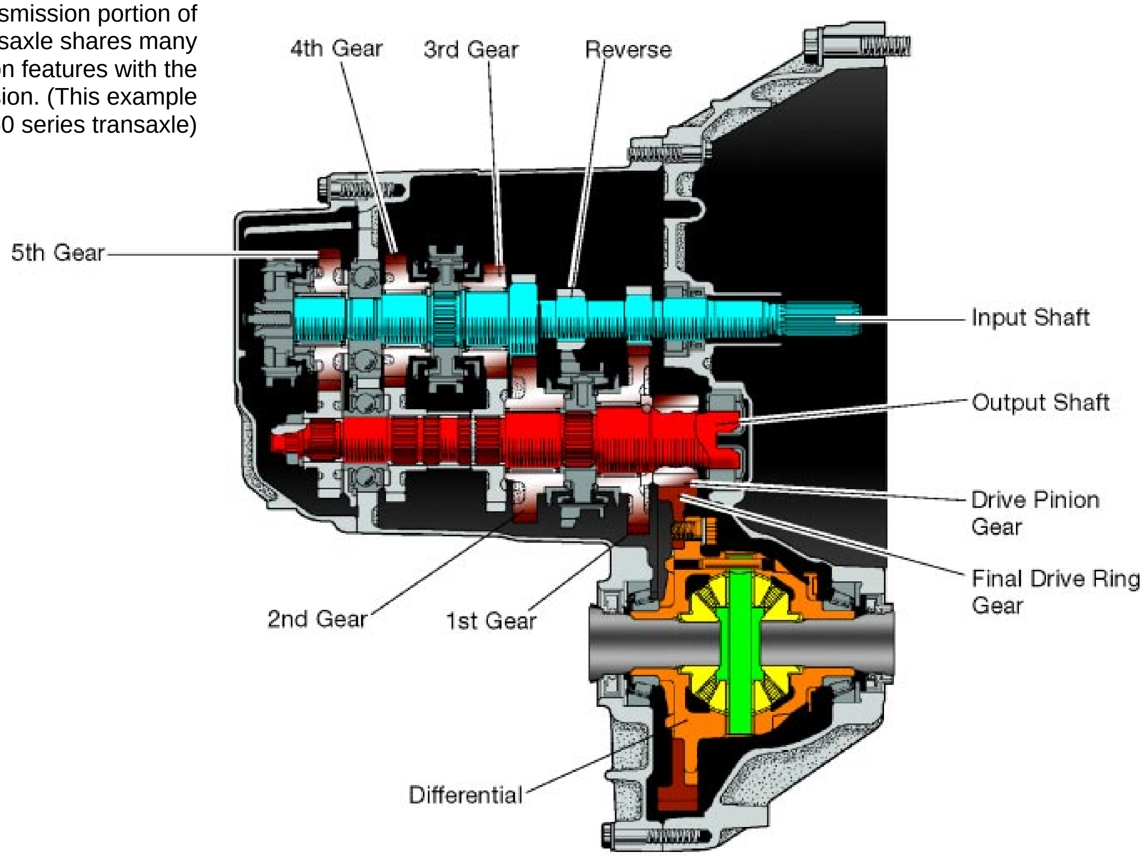


Fig. 4-1
T302f401

Input Shaft

The **input shaft** connects to and is driven by the clutch disc. The drive gears are located on the input shaft, one for each forward speed and reverse. The input shaft is supported by bearings at the front and rear of the transaxle case. No pilot bearing is needed.

Output Shaft

The **output shaft** includes a driven gear for each forward speed. The output shaft also includes the drive pinion, which drives the **final drive ring gear** on the differential. The output shaft is supported by bearings at the front and rear of the transaxle case.

Differential

The **differential**– also also known as a final drive– divides powerflow between the half shafts connected to the front drive wheels.

Power exits the output shaft through the drive pinion gear driving the final drive ring gear on the differential case.

The ring gear and drive pinion gear are helical gears, and have a gear ratio similar to that in a rear axle. This gear set operates quietly and doesn't require critical adjustments as in the rear axle hypoid gear set.

Open Differential

The simplest type of differential is called an open differential. It is constructed of a **final drive ring gear**, **side gears**, **pinion shaft** and **pinion gears**. The ring gear is attached to the **differential case**. The pinion gears mount to the pinion shaft attached to the differential case. The side gears mesh with the pinion gears and transfer the rotation of the differential case to the side gears, which turn the drive axles.

When a vehicle is going straight, the pinion gears do not rotate, and both wheels spin at the same speed. During a turn, the inside wheel turns slower than the outside wheel and the pinion gears start to turn, allowing the wheels to move at different speeds.

Open Differential

The simplest type of differential is called an open differential. It is constructed of a ring gear, side gears, pinion shaft, pinion gears, and differential case.

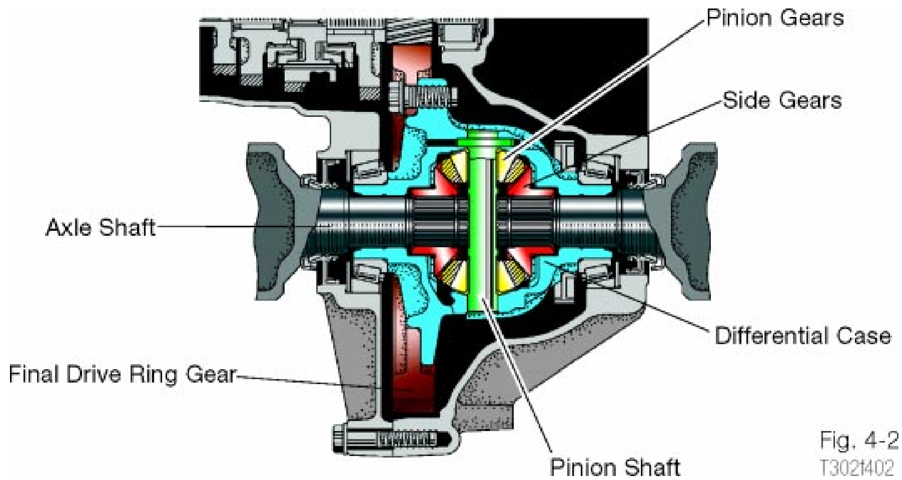


Fig. 4-2
T302f402

Viscous Coupling Limited Slip Differential

With an open differential, if one tire loses traction, the differential will transfer power to the slipping wheel, leaving the wheel with traction without torque. A viscous coupling Limited Slip Differential (LSD) uses a viscous fluid coupling differential to increase torque to the drive wheel with traction. If one wheel is slipping, some of the power is transferred to the other wheel. This also allows the wheels to rotate at different speeds when turning on dry pavement.

Viscous Coupling Limited Slip Differential

A viscous coupling Limited Slip Differential (LSD) uses a viscous fluid coupling differential to increase torque to the drive wheel with traction.

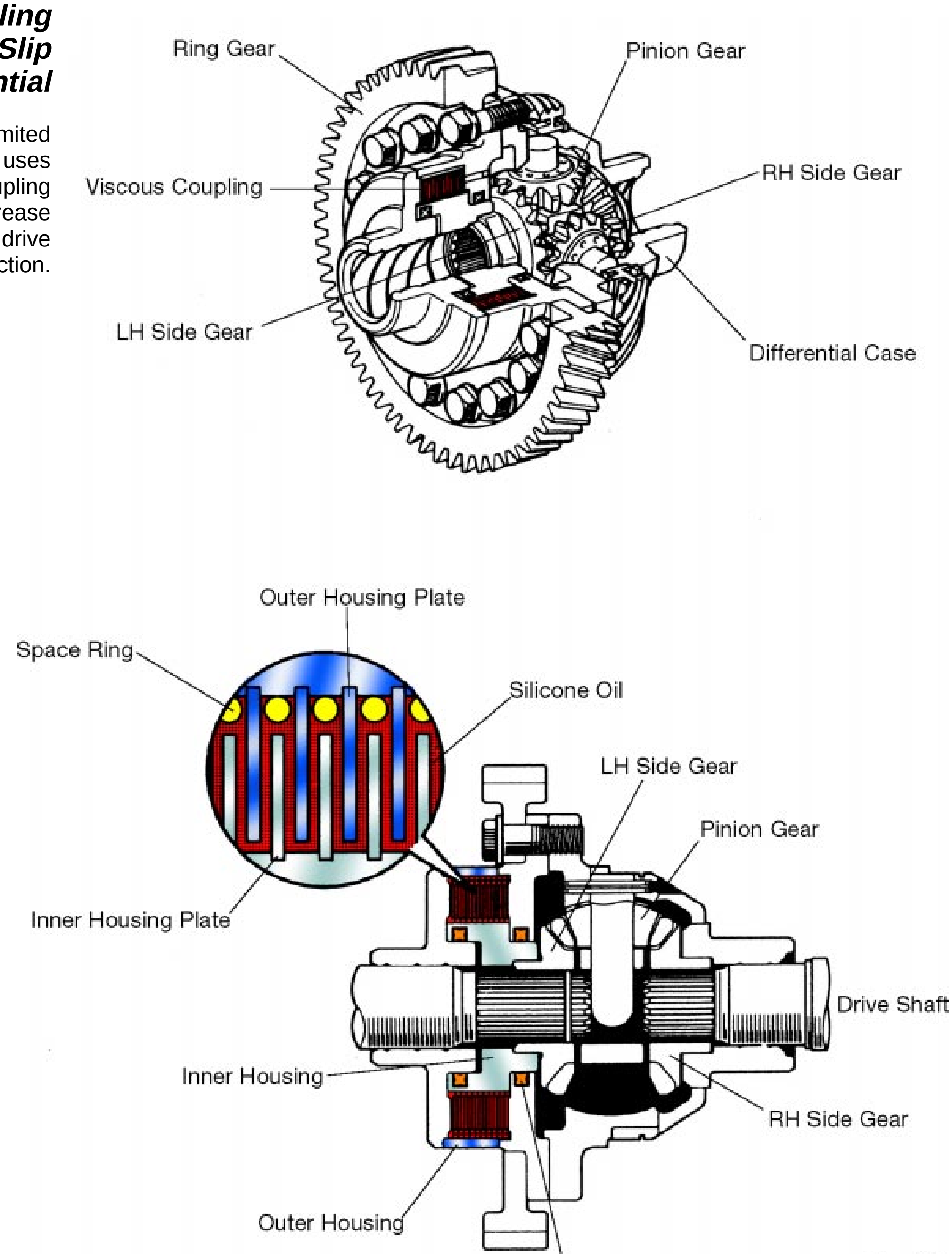


Fig. 4-3
T302f403

C140 & C150 Series Construction

The C-Series transaxle has been used in four-speed (C140 series), five-speed (C50 series, C150 series) and six-speed (C60 series) configurations. The operation of the C140 and C150 series transaxles is the same as the C50 series transaxle. The C140 and C150 series transaxles are smaller and lighter. End covers are pressed steel instead of cast aluminum. The C140 series transaxle has a shallower end cover, as there is no 5th gear, leading to a shorter input shaft.

C140 and C150 Series Transaxle Construction

The C140 series transaxle has a shallower end cover, as there is no 5th gear, leading to a shorter input shaft.

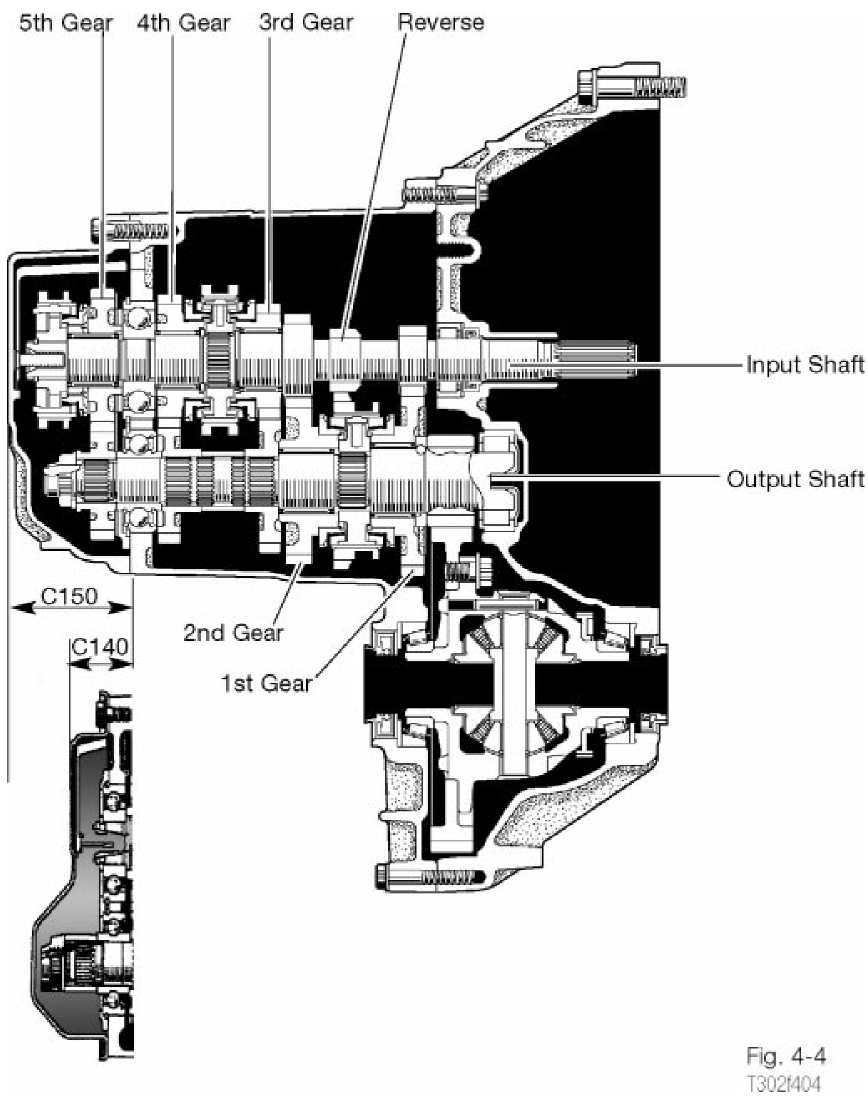


Fig. 4-4

C60 Series Six-Speed Transaxle Construction

The C60 six-speed transaxle adds an additional gear to the output shaft and an additional speed gear to the input shaft. The 6th gear is connected to the input shaft through the 5th gear/6th gear synchronizer.

C60 Series Six-Speed Transaxle Construction

A six-speed transaxle adds an additional gear to the output shaft and an additional speed gear to the input shaft of a five-speed version.

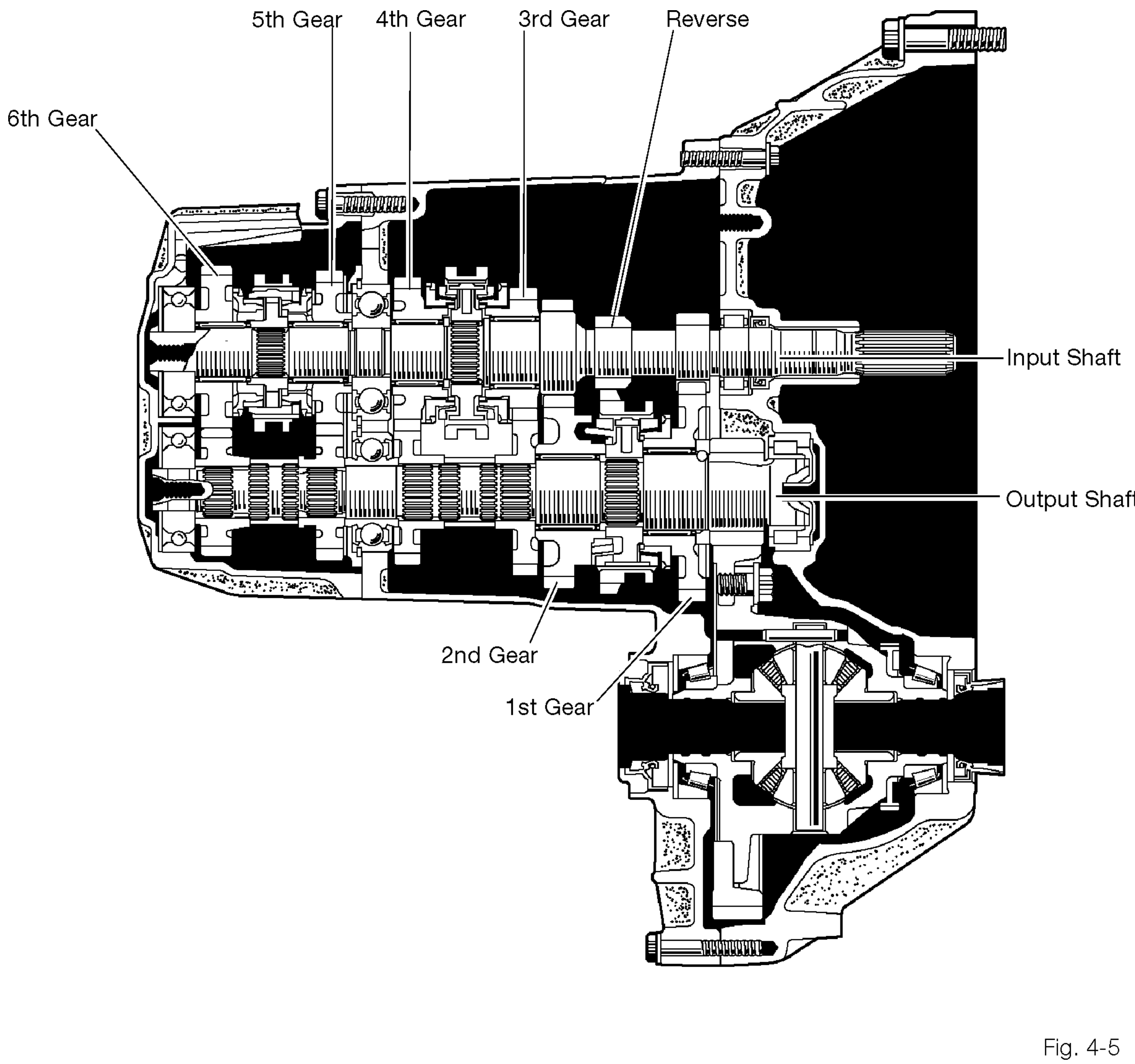


Fig. 4-5
T302f405

E Series Transaxles

The E series was developed to be used with a larger displacement engine. This transaxle is also used with the manual All Wheel Drive (AWD) models.

The transaxle construction is based on the C50 series, but the main parts of the transaxle are much larger and heavier than the C50 series.

An oil pump is also incorporated in the lubrication system of the unit. The oil pump is driven by the ring gear. The oil pump is explained in more detail in the lubrication section.

E Series Transaxle Construction

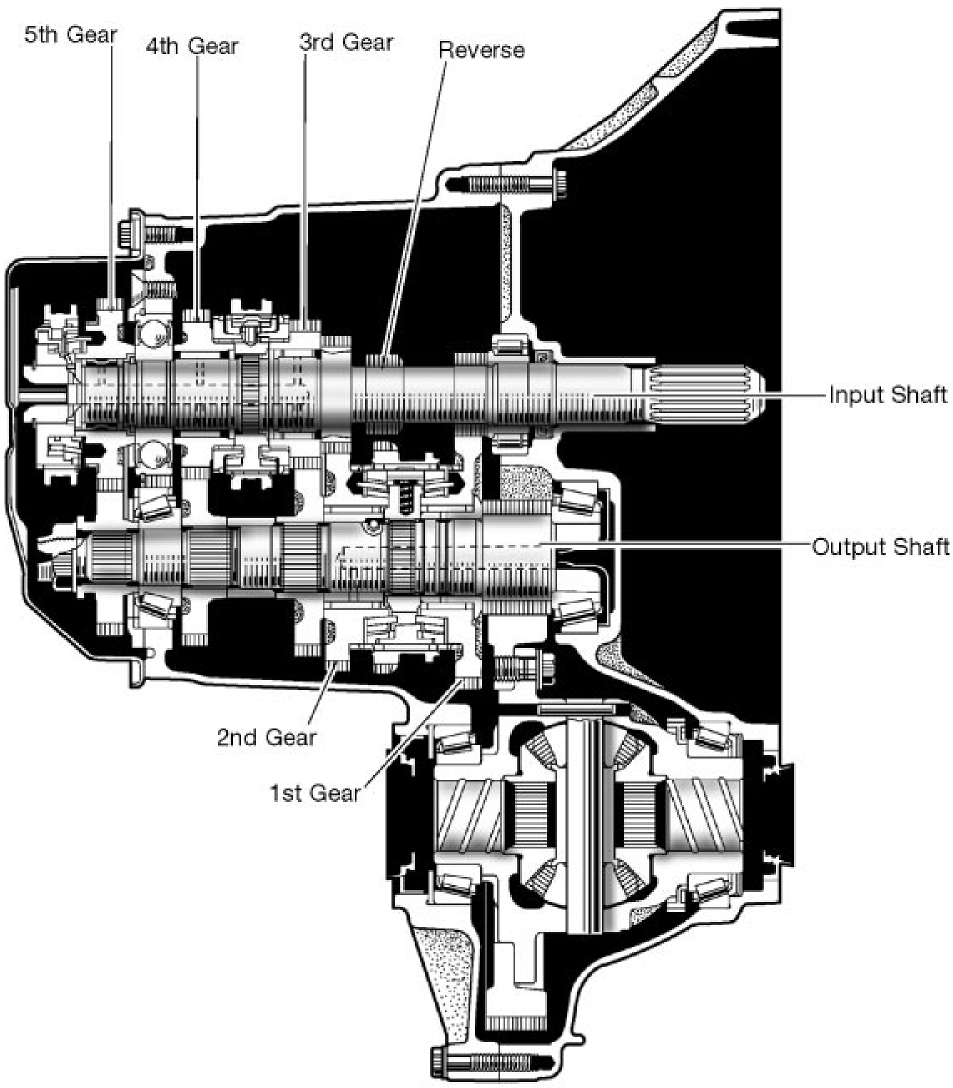


Fig. 4-6
T302f406

Gears

Gears transfer engine power from the input shaft, through the output shaft, to the differential. There are five forward gears and one reverse gear.

Forward Gears

All forward motion gears are helical gears and are in constant mesh. In each pair of gears, one gear is secured to the shaft and one gear floats on the shaft next to the synchronizer assembly.

Reverse Gears

Reverse requires an additional gear in the gear train. A reverse idler gear is used to change the direction of the output shaft for reverse. The reverse gear is a straight cut spur gear and does not have a synchronizer.

Reverse Idler Gear

The reverse gears are not in constant mesh, an idler gear is used to engage reverse.

Fig. 4-7
T302f407

Bearings

Bearings are used to support the shafts, gears and the differential in the transaxle: gears use needle bearings; shafts use roller, ball, and tapered roller bearings.

Transaxle Bearings

Types of bearings used in transaxles include, needle bearings, roller bearings, ball bearings and tapered roller bearings.

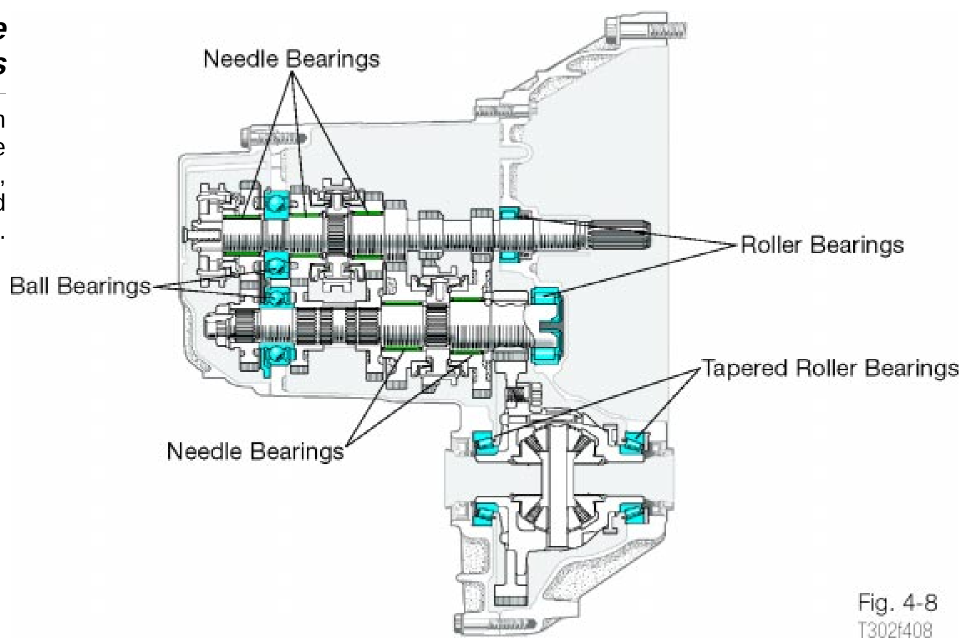


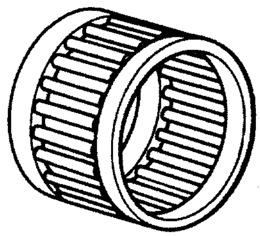
Fig. 4-8
T302f408

Gear Bearings

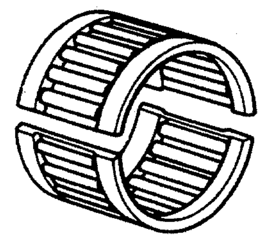
Needle bearings are used in all gear applications to insure durability. Split needle bearings provide even load distribution. They also resist fretting better than the one piece bearing. Fretting is the surface damage that occurs on the bearing from vibration existing in the contact surfaces.

Gear Bearings

Needle bearings are used in all gear applications to insure durability. Split needle bearings provide even load distribution.



One-Piece Needle Bearing



Split Needle Bearing

Fig. 4-9
T302f409

Transaxle Gear Bearing Application

Transaxle Gear	S Series	C Series	E Series
1st	One-Piece Needle Bearing		Split Needle Bearing
2nd	One-Piece Needle Bearing		One-Piece Needle Bearing
3rd	Split Needle Bearing		Split Needle Bearing
4th	Split Needle Bearing		Split Needle Bearing
5th	Split Needle Bearing		Split Needle Bearing

Shaft Bearings

Transaxle shafts use **roller bearings**, **ball bearings**, and **tapered roller bearings**. Each bearing type offers unique application characteristics.

Shaft Bearings

Roller bearings, tapered roller bearings, and ball bearings are used for shaft bearing applications.

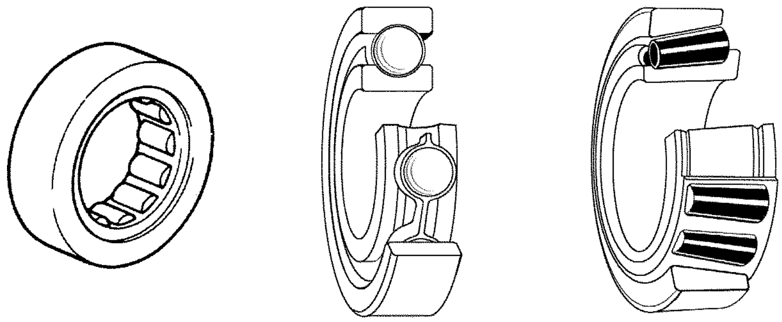


Fig. 4-11
T302f411

Roller Bearings Roller bearings can handle large side loads, but provide no thrust support. They are located on the engine side of the input and output shafts.

Ball Bearings Ball bearings are used as support bearings **opposite the roller bearing** on the input and output shafts because they can handle a moderate to high thrust load as well as side load.

Tapered Roller Bearings Tapered roller bearings handle large side and thrust loads and are used in pairs with the cones and cups facing in opposite directions on the ends of the same shaft. Some method of preload adjustment is typically provided for this type of bearing. The differential on all transaxles and the output shaft on the E series transaxles are supported by tapered roller bearings. Preload is adjusted by placement of the correct size shim at the bearing outer race. Consult the proper repair manual for the procedure, SSTs and specifications.

Transaxle Gear Bearing Application

Shaft \ Transaxle		S Series	C Series	E Series
Input	Engine Side	Roller Bearing	Roller Bearing	Roller Bearing
	Rear Side	Ball Bearing	Ball Bearing	Ball Bearing
Output	Engine Side	Roller Bearing	Roller Bearing	Tapered Roller Bearing
	Rear Side	Ball Bearing	Ball Bearing	Tapered Roller Bearing

Pilot Bearing

There is no pilot bearing used on the transaxles. There is no need for a pilot bearing, because of the length of the input shaft and where the transaxle bearings are mounted.

Synchronizer Assemblies

Synchronizer assemblies are used to make all forward shifts and to assist reverse gear engagement. The role of the synchronizer is to allow smooth gear engagement. It acts as a clutch, bringing the gears and shaft to the same speed before engagement occurs. Synchronizer components help make the speeds equal while synchronizing the shift.

Gears on the input shaft are in mesh (contact) with gears on the output shaft at all times. Consequently, when the input shaft turns, the gears on the output shaft rotate. When shifting gears, the synchronizer ring supplies the friction force, which causes the speed of the gear that is being engaged to match the speed of the hub sleeve. This allows the gear shift to occur without the gear and hub sleeve splines clashing or grinding.

Key Type Synchronizer

The key type synchronizer and multi-cone synchronizer used in manual transaxles are similar to the type used in manual transmissions. Refer to the synchronizer section in Section 3: Manual Transmissions.

Key-less Type Synchronizer

Some Toyota transaxles use a **key-less type synchronizer**. For example, in E series transaxles, a key-less type synchronizer is used on fifth gear to improve shift feel and reduce size and weight.

The difference in key-less type synchronizers is the circular key spring, which combines the role of the shift keys and key springs. The key spring has three claws that center the hub sleeve. There are also one to two projections that locate the spring to the clutch hub to keep it from spinning.

The key-less synchronizer hub sleeve pushes the key spring to force the synchronizer ring against the gear cone.

Key-less Type Synchronizer Components

Some Toyota transaxles use a key-less type synchronizer to improve shift feel and reduce size and weight.

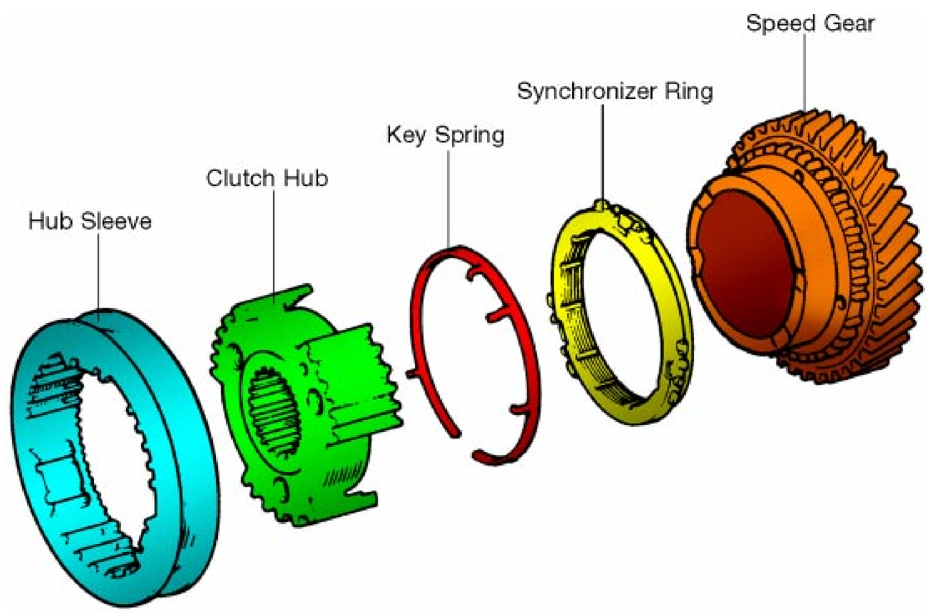


Fig. 4-13
T302f413

Key-less Type Operation

The operation of the mechanism can be best described in three stages:

1st Stage - Initial Synchronization

When shifting into gear, the projections in the hub sleeve contact the claws of the key spring and push it against the **synchronizer ring**. The ring is forced against the conical surface of the gear. This action causes the synchronizer ring to grab the gear. The ring rotates the distance represented by Gap A (in figure 4-14). The hub sleeve splines now contact the splines of the synchronizer ring.

1st Stage – Initial Synchronization (Index Position)

The projections in the hub sleeve contact the claws of the key spring and push it against the synchronizer ring, forcing it against the conical surface of the gear.

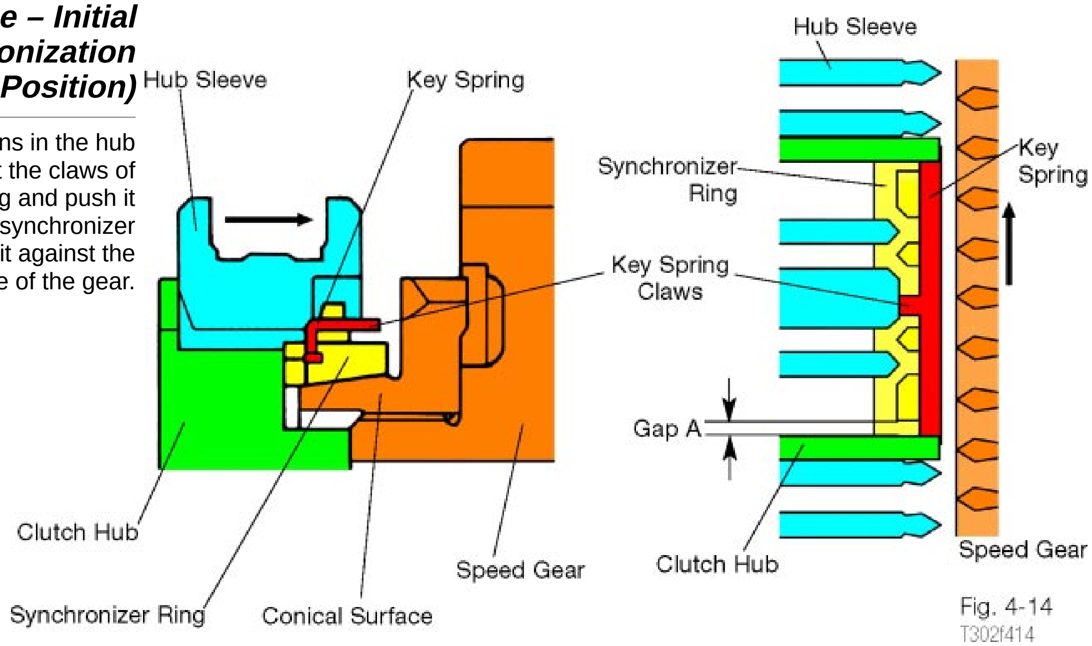


Fig. 4-14
T302f414

2nd Stage - Synchronizing

As the hub sleeve moves further from the index position, more force is applied to the contact between the conical surface of the gear and synchronizer ring. The speeds of the hub sleeve and gear are now synchronized (matched). At the same time, the projections in the hub sleeve compress the key spring and the sleeve moves over the claws of the spring.

2nd Stage Synchronizing

As the hub sleeve moves further from the index position, more force is applied to the contact between the conical surface of the gear and synchronizer ring, synchronizing them.

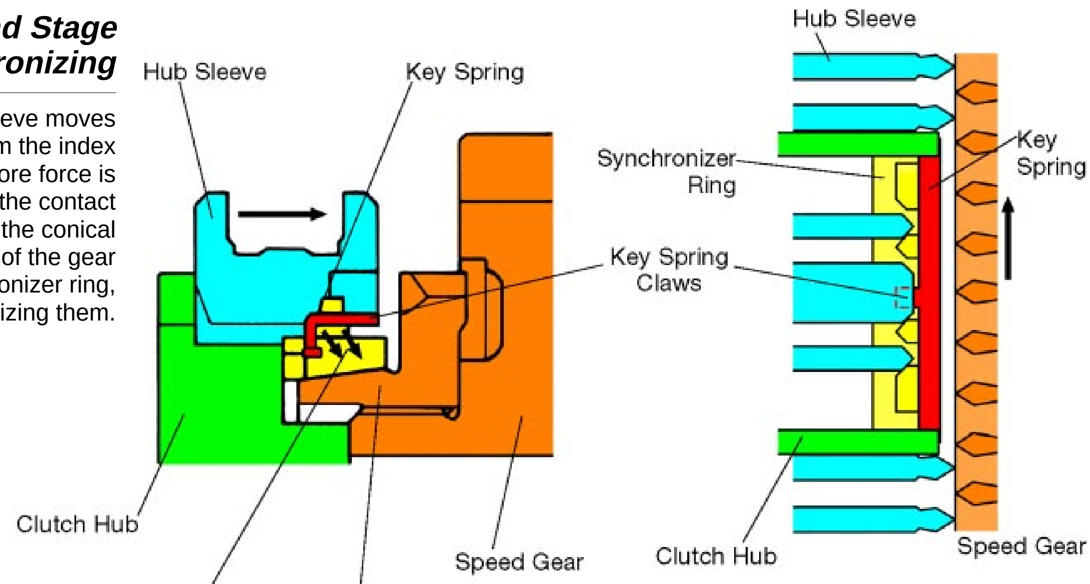


Fig. 4-15
T302f415

3rd Stage - Synchronized Mesh

As the hub sleeve and gear rotate at the same speed, the hub sleeve moves further. The splines of the sleeve and gear now contact each other and engage. This completes shifting into gear.

3rd Stage – Synchronized Mesh

As the hub sleeve and gear rotate at the same speed, the hub sleeve continues to move, fully engaging the sleeve and gear.

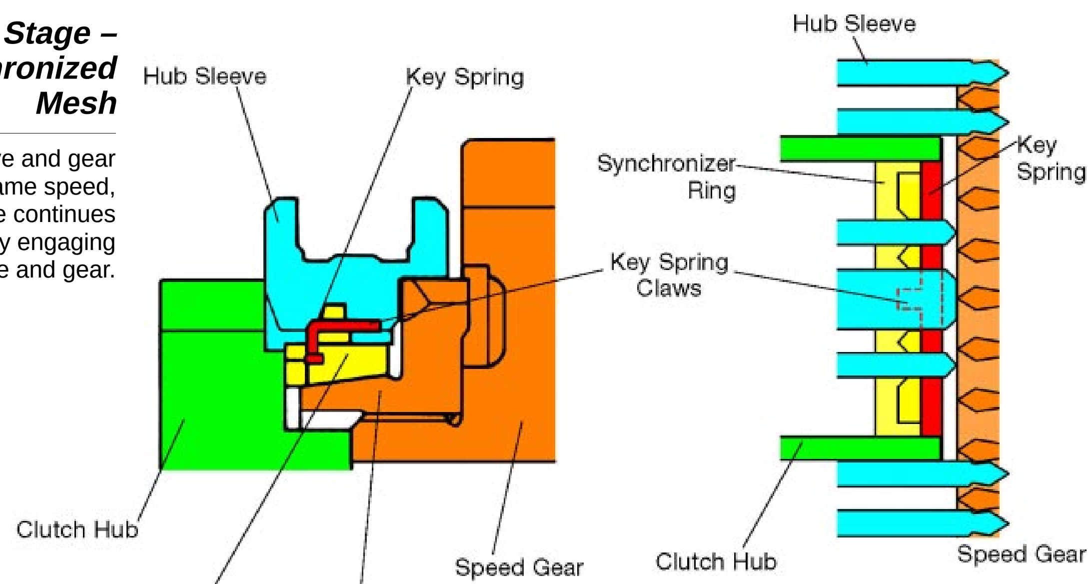


Fig. 4-16
T302f416

Powerflow

Understanding powerflow through a transaxle helps in diagnosing complaints and determining the proper repairs. Power passes from the drive gear on the input shaft to the driven gear on the output shaft and through the synchronizer assemblies to the output shaft. For first gear, the smallest gear on the input shaft drives the largest gear on the output shaft, and for top gear, the largest gear on the input shaft drives the smallest gear on the output shaft.

Powerflow for reverse gear is similar to powerflow in a transmission. The reverse idler gear is shifted to mesh with the reverse gear on the input shaft and the sleeve of the 1-2 synchronizer assembly on the output shaft. The spur gear teeth for reverse are on the outer diameter of the synchronizer hub sleeve.

On the following three pages, figures 4-17 through 4-22 show the typical power flow through a five-speed transaxle.

1st Gear

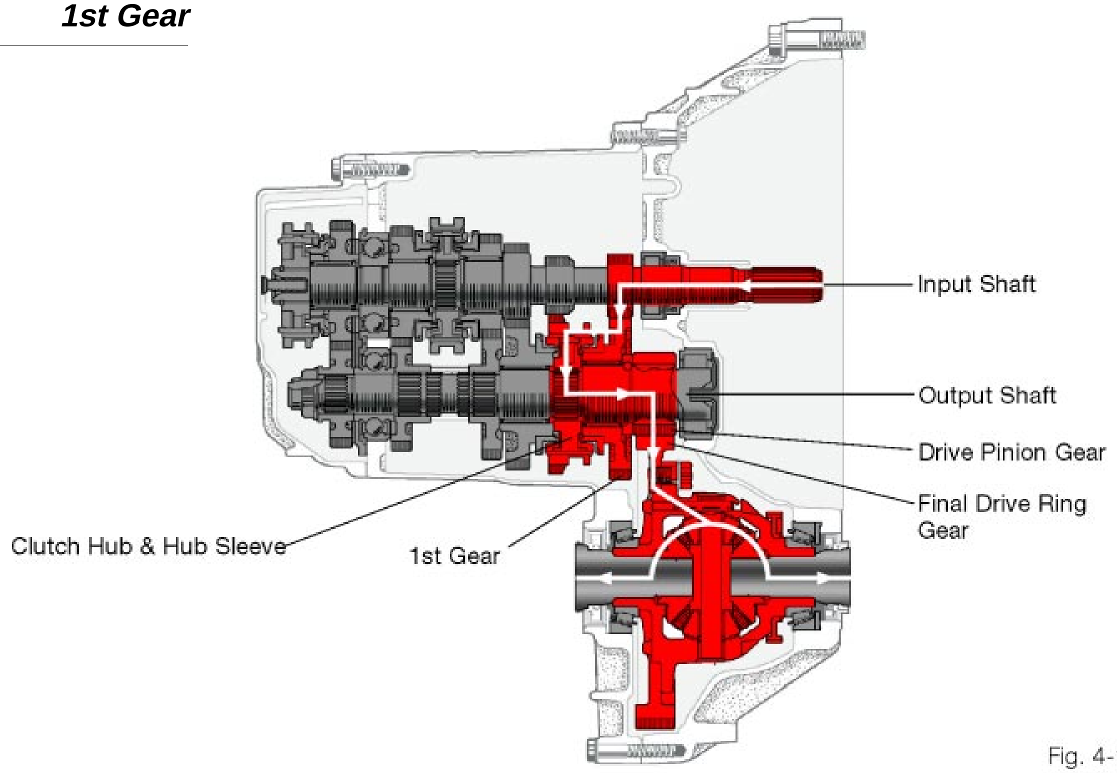


Fig. 4-17
T302f417

2nd Gear

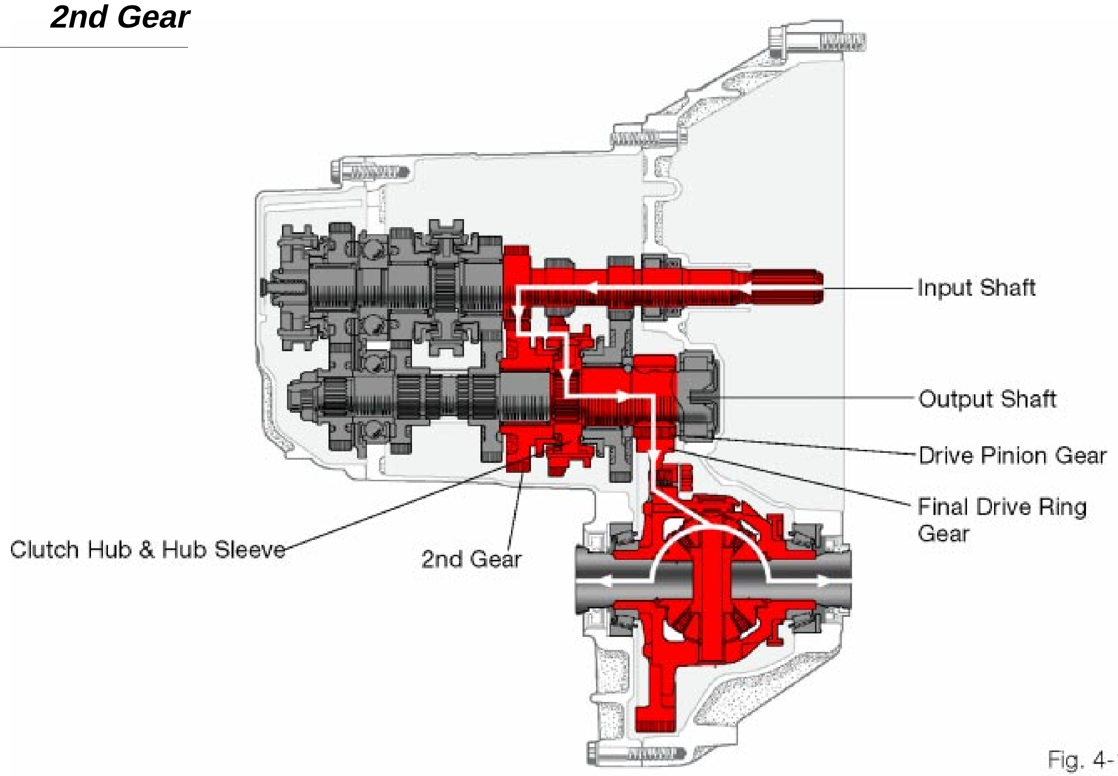


Fig. 4-18
T302f418

3rd Gear

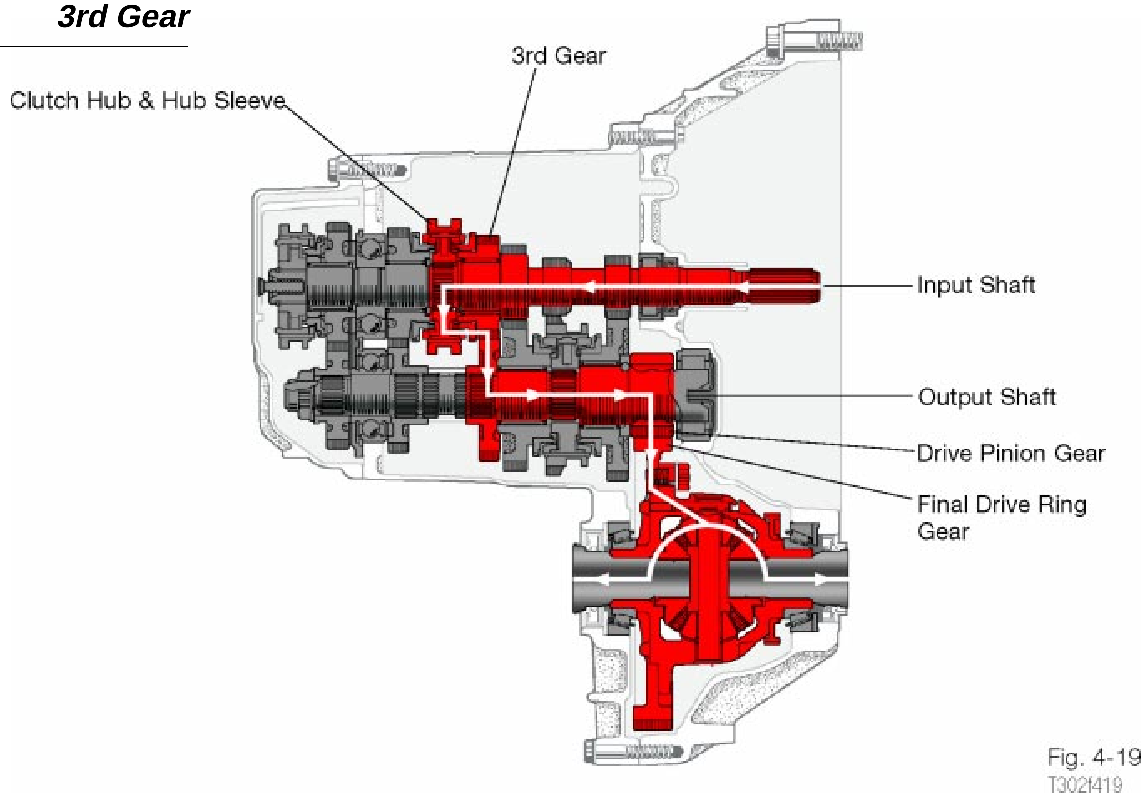


Fig. 4-19
T302f419

4th Gear

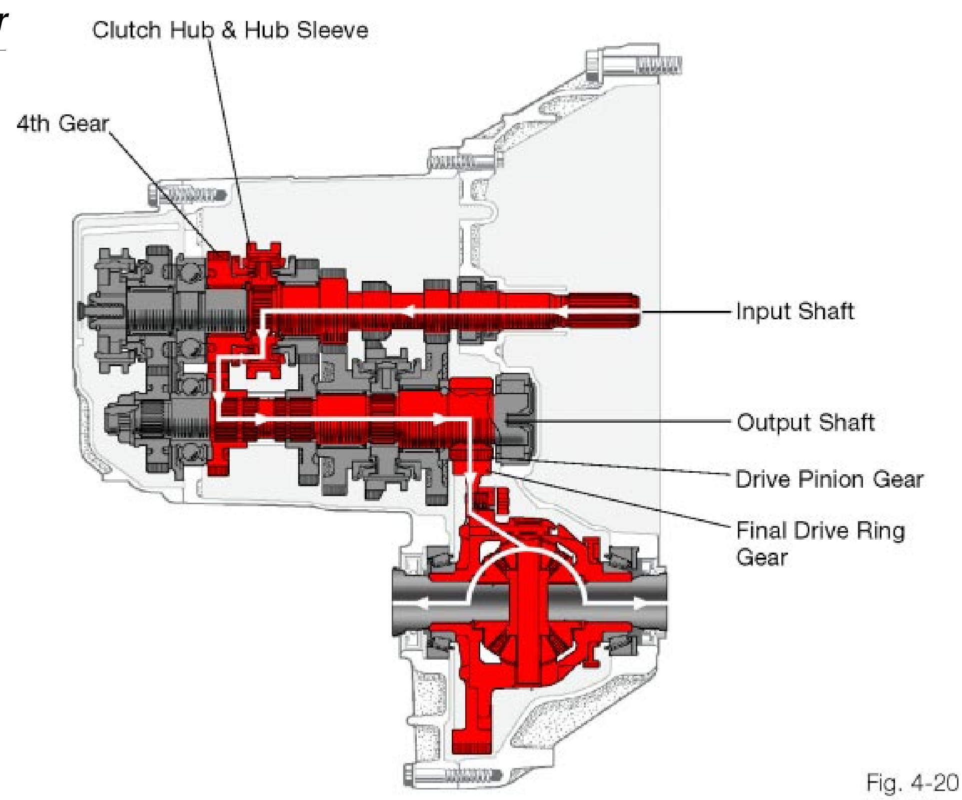


Fig. 4-20
T302f420

5th Gear

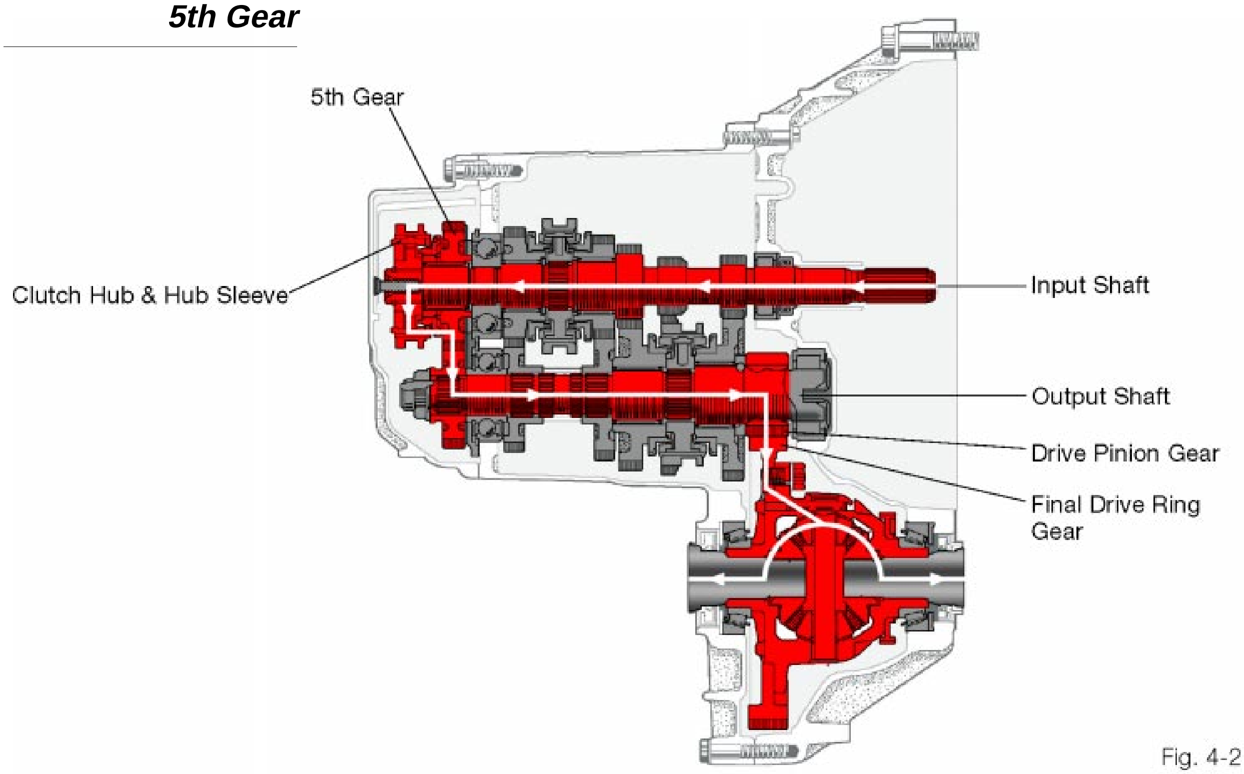


Fig. 4-21
T302f421

Reverse Gear

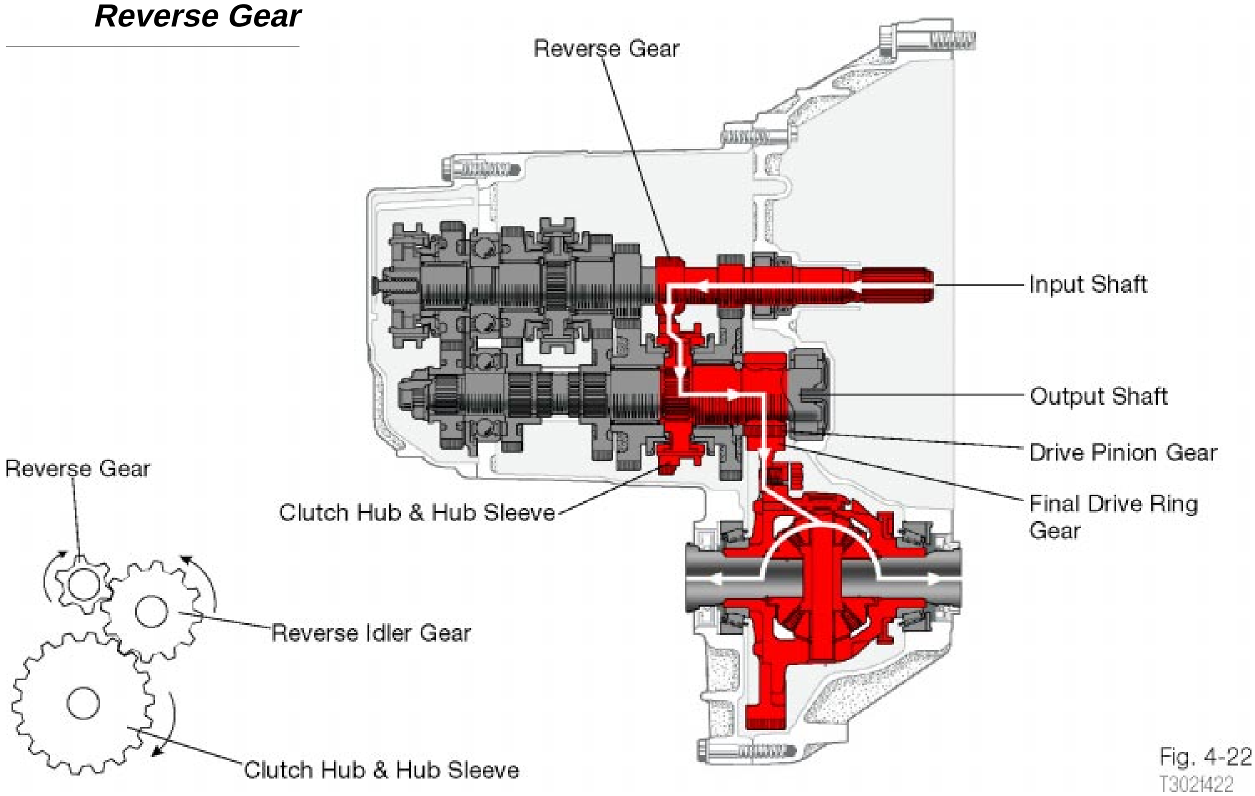


Fig. 4-22
T302f422

Gear Shift Controls

The gear shift lever and cables allow the transaxle to be shifted through all the gears. The cables' flexibility allows easy alignment, and absorption of engine vibrations and rocking motions.

In the push pull mechanism the shift lever movement is transmitted to the transaxle shift and select assembly by two rigid cables. Both cables are connected to the shift lever. Selecting a gear involves two operations. The shift control cable rotates the shift and select shaft to move the shift forks. The select control cable moves the shift and select shaft back and forth to select the proper shift fork head.

Gear Shift Controls

On the push pull type mechanism, shift lever movement is transmitted to the transaxle levers by two rigid cables connected to the shift lever.

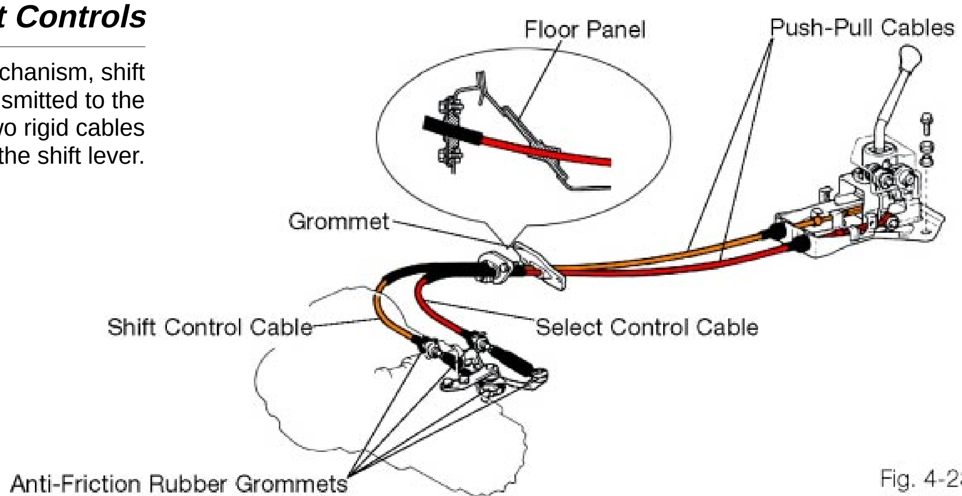


Fig. 4-23
T302f423

Shift and Select Assembly

The **shift and select assembly** (as shown in figure 4-24) transfers motion from the shift cables to the shift fork head, to the shift shafts and forks allowing the transaxle to be shifted through the gears.

The internal shift linkage includes shift forks, which move the synchronizer sleeves or reverse idler gear, detents, which properly position the shift forks, and interlocks, which prevent the movement of more than one fork at a time.

The **shift fork shaft** connects the shift and select assembly to the shift forks. A detent ball and spring prevent the forks from moving on their own. The shift forks ride in the grooves of the synchronizer hub sleeves. The **shift forks** are used to lock and unlock the synchronizer hub sleeve and are mounted on the shafts either by bolts or roll pins.

Shift and Select Assembly

The shift and select assembly is held in place by a retaining cover, which is either bolted or threaded to the transaxle case.

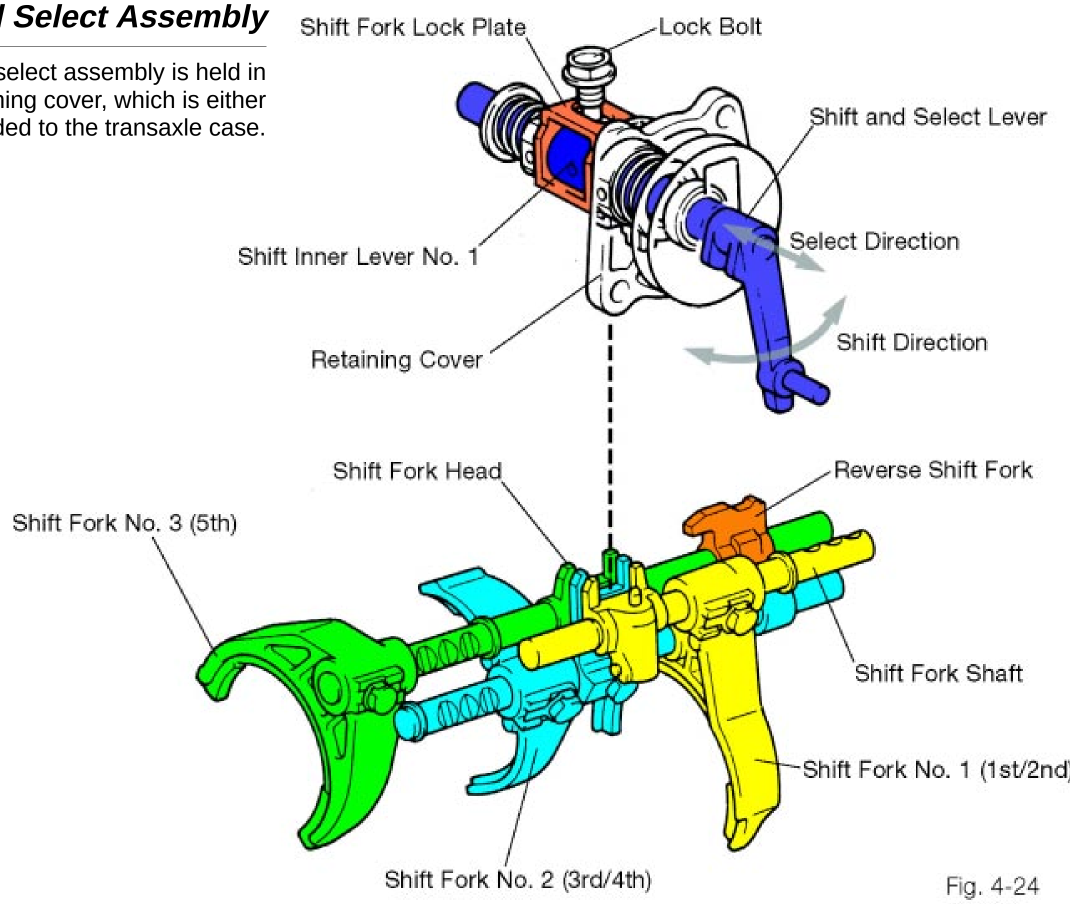


Fig. 4-24

Shift forks contact the spinning synchronizer hub sleeve and apply pressure to engage the gear. To reduce wear, the steel or aluminum forks can have contact surfaces of hardened steel, bronze, low-friction plastic, or a nylon pad attached to the fork.

After the sleeve has been positioned, there should be very little contact between the fork and sleeve. The fork is properly positioned by the detent. The back taper of the hub sleeve splines and spline gear, or gear inertia lock mechanism, keep it in mesh during different driving conditions.

Holding a gear into mesh with the fork, while driving, results in rapid wear of the fork and fork groove.

S Series Shift Fork Construction

Key features of the S series transaxle shift and select assembly:

- Uses one fork shaft, which has four shift forks mounted on it.
- Contains an adjustable lock ball used in place of the detent balls and springs.
- 1st through 4th gear shift forks slide on the fork shaft to engage the gears.
- 5th gear shift fork is bolted to the shaft.
- The 1st through 4th gear shift forks are made of either steel or of cast iron and are nylon capped.
- 5th gear shift fork is made of die cast aluminum.
- The shift and select assembly is held in place by a retainer cover that threads into the transaxle case.

S Series Transaxle Shift Fork Construction

The S series transaxle uses A single fork shaft with four shift forks mounted on it.

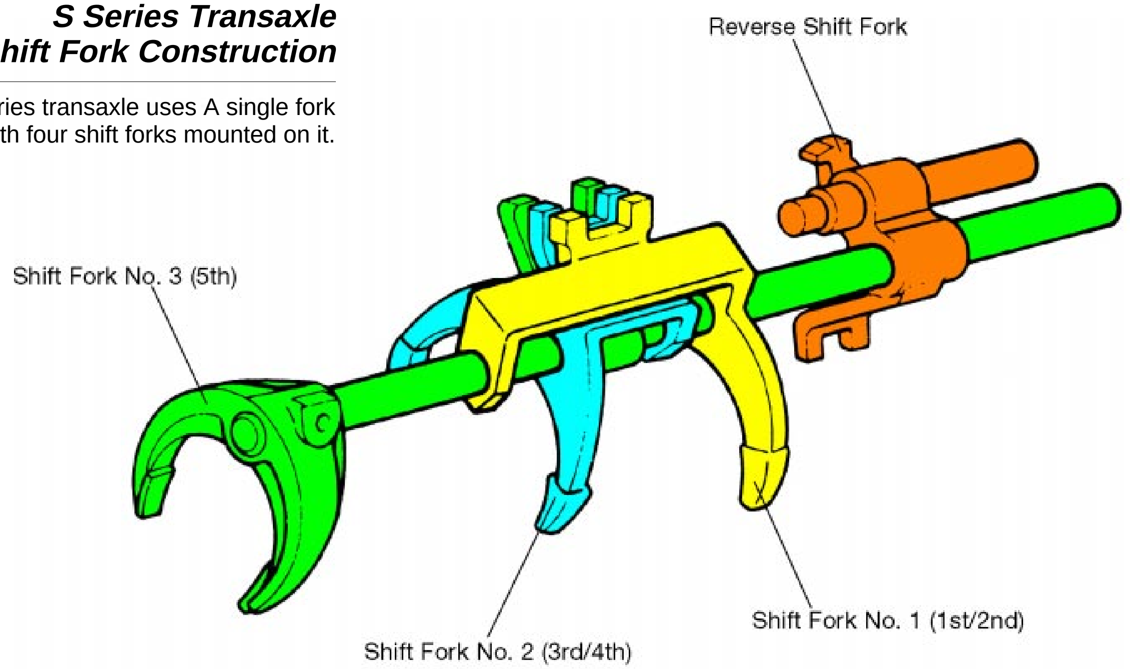


Fig. 4-25
T302f425

C & E Series Shift Fork Construction

Three fork shafts allow shifting into gears one through five and reverse. A shift head and shift fork is attached to each fork shaft. Shift forks are typically made from die-cast aluminum and are attached to the shaft with a bolt.

C & E Series Construction

Three fork shafts allow shifting into gears one through five and reverse.

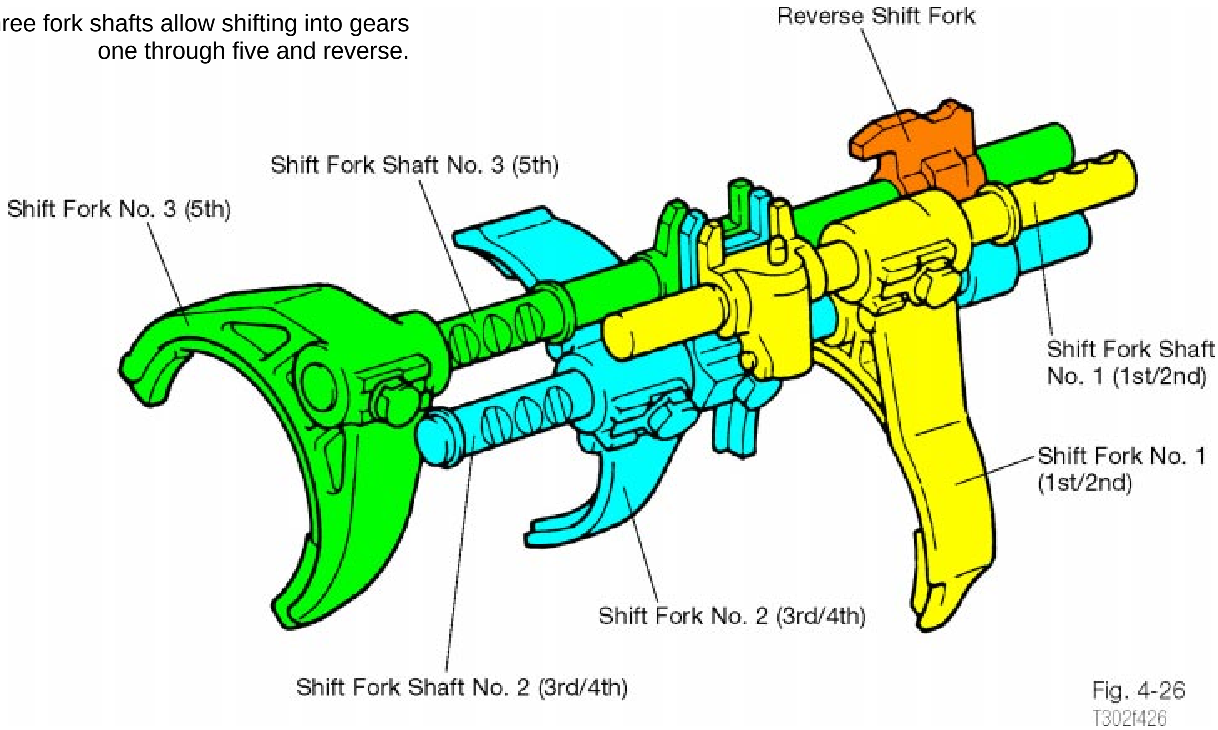


Fig. 4-26

Shift Mechanisms

There are six mechanisms that make up the shift and select assembly:

- Shift detent mechanism
- Double meshing prevention
- Reverse detent
- Reverse one way
- Reverse mis-shift prevention
- Reverse pre balk

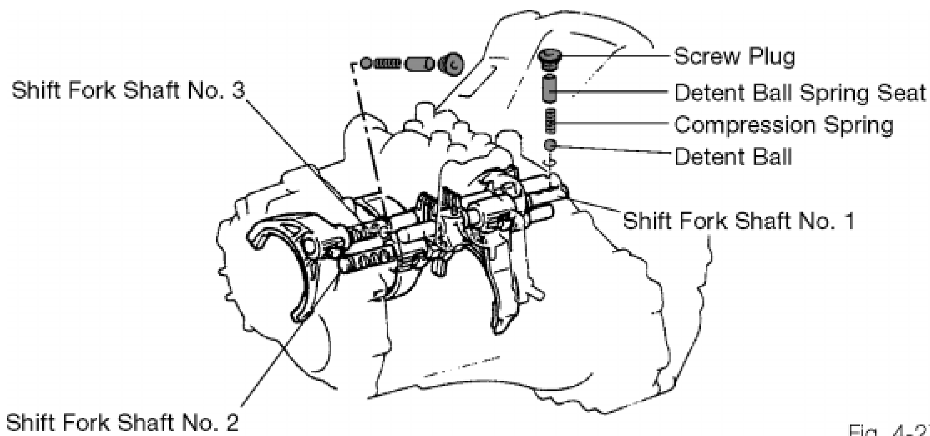
Shift Detent Mechanisms

The shift detent mechanism provides for proper sleeve/fork position and shift feel. The mechanism also tells the driver whether or not the gears have fully engaged.

Each fork shaft has three grooves cut into it. A detent ball is pushed by a spring into the groove when the transaxle is shifted into a gear. The 1st and 2nd gear detent ball is located in the front of the transaxle case. The 3rd, 4th, 5th and reverse gear detent balls are located in the rear of the transaxle case.

Shift Detents

Each fork shaft has three grooves cut into it. A detent ball is pushed by a spring into the groove when the transaxle is shifted into a gear. This provides proper sleeve/fork position and shift feel.



C Series

Fig. 4-27
T302f427

Double Meshing Prevention

The shift fork lock plate allows the selection of one shift shaft at a time. It fits into two of the shift fork head slots at all times, locking them, while the other is being used. For example, when the shift lever is put into 1st or 2nd gear, the shift fork lock plate and shift inner lever No. 1 move to the right (as shown in figure 4-28) and the transmission is able to shift into 1st or 2nd gear. The shift fork lock plate is now in the slots of the 3rd/4th and 5th/reverse shift fork heads, preventing those heads from moving into gear.

Double Meshing Prevention

The shift plate fits into two of the shift fork head slots at all times and locks all shift forks, except for the one in use.

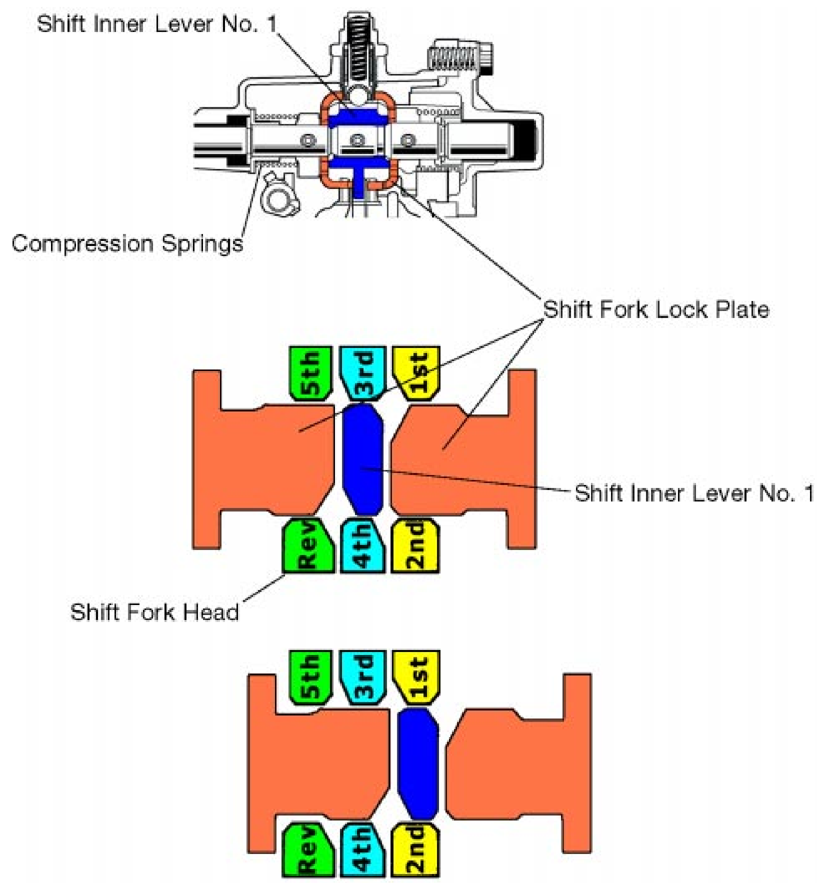


Fig. 4-28
T302f428

Mis-Shift Prevention

Springs are mounted over the shift and select shaft on both sides of the shift fork lock plate to position the shift inner lever in the 3-4 shift head. This requires the operator to move the gear selector to the left or the right of the center position to select first or second gear or fifth or reverse gear. It also provides feedback to the operator to determine what gear position is being selected. The C60 series six-speed transmissions employs an additional spring called the reverse select spring that requires additional effort to shift from the first and second shift position into reverse.

Mis-Shift Prevention

Springs are mounted over the shift and select shaft on both sides of the shift fork lock plate to position the shift inner lever in the 3-4 shift head.

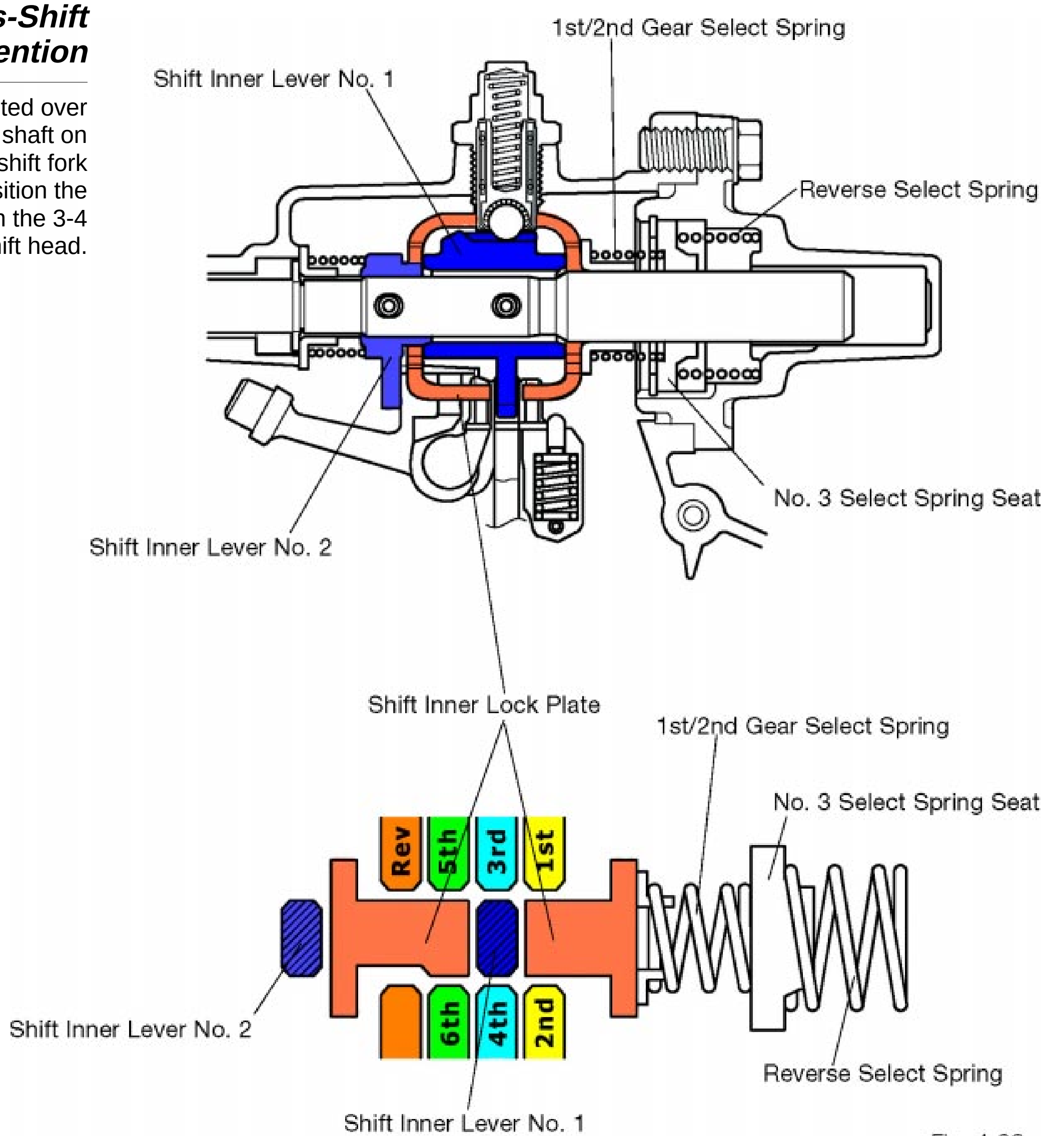


Fig. 4-29
T302f429

C Series Reverse Shift Detent Mechanism

There is a groove on the upper surface of the reverse shift fork. A lock ball is pushed into the groove by spring tension. This prevents the reverse idler gear from moving when the transaxle is not shifted into reverse. The mechanism also tells the driver whether or not the reverse gears have fully engaged.

C Series Reverse Shift Detent Mechanism

This mechanism also tells the driver whether or not the reverse gears have fully engaged.

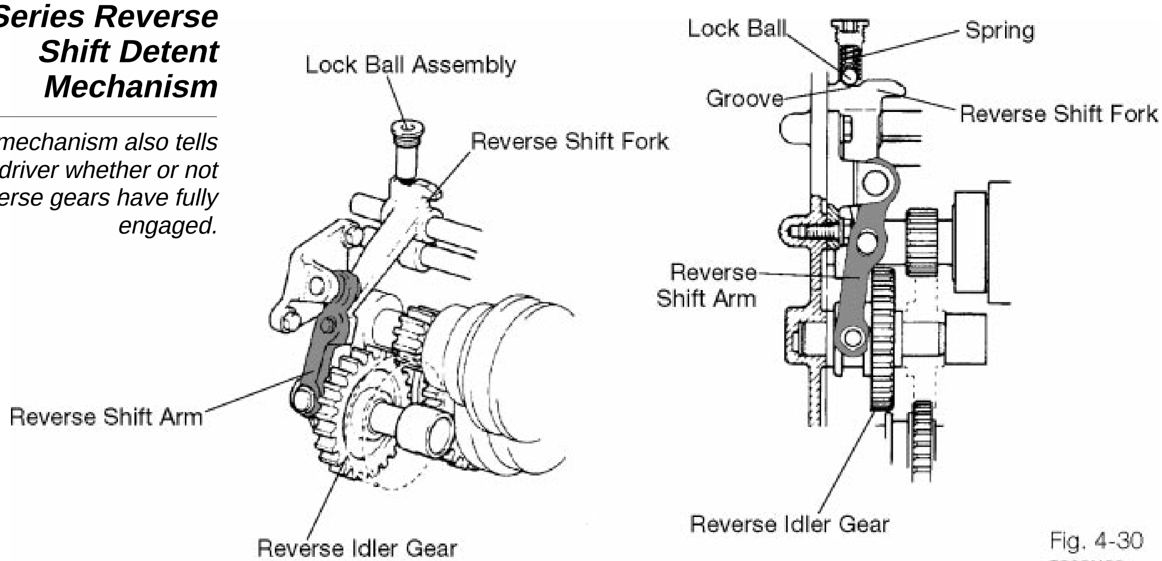


Fig. 4-30
T302f430

S & E Series Reverse Shift Detent Mechanism

Two grooves are cut in the reverse shift arm for engaging and disengaging reverse gear. The roller (lock ball in the E series) and spring supply the needed force to hold the arm in either of the grooves.

S & E Series Reverse Shift Detent Mechanism

This mechanism also tells the driver whether or not the reverse gears have fully engaged.

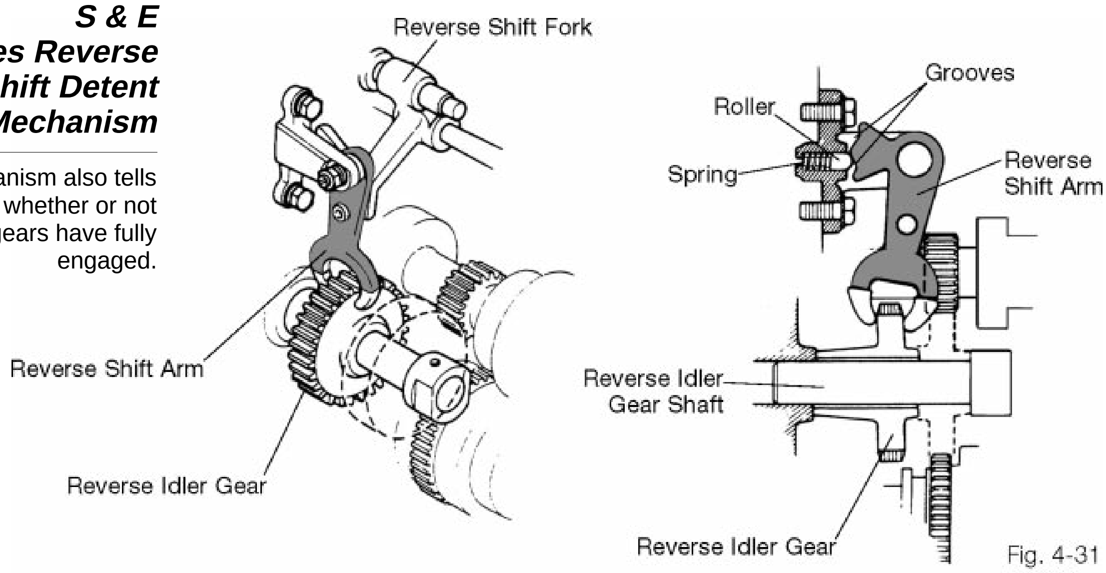


Fig. 4-31
T302f431

C & E Series Reverse One-Way Mechanism

The reverse one-way mechanism prevents the movement of the reverse shift fork while shifting out of 5th gear. Shift fork No. 3, which selects 5th gear and the reverse shift fork are both controlled by the same shift fork shaft. This is accomplished with the use of snap rings and interlock balls or pins. The interlock balls are located in the reverse shift fork between shift fork shafts No. 2 and No. 3. The reverse shift fork can only move into reverse when both shift fork shafts are in the neutral position. The C and E series reverse one-way mechanism is similar in design and operation.

C & E Series Shift & Select Assembly

By using this mechanism, the overall length of the transaxle can be shortened. Only one shift fork shaft is needed to operate 5th and reverse gears.

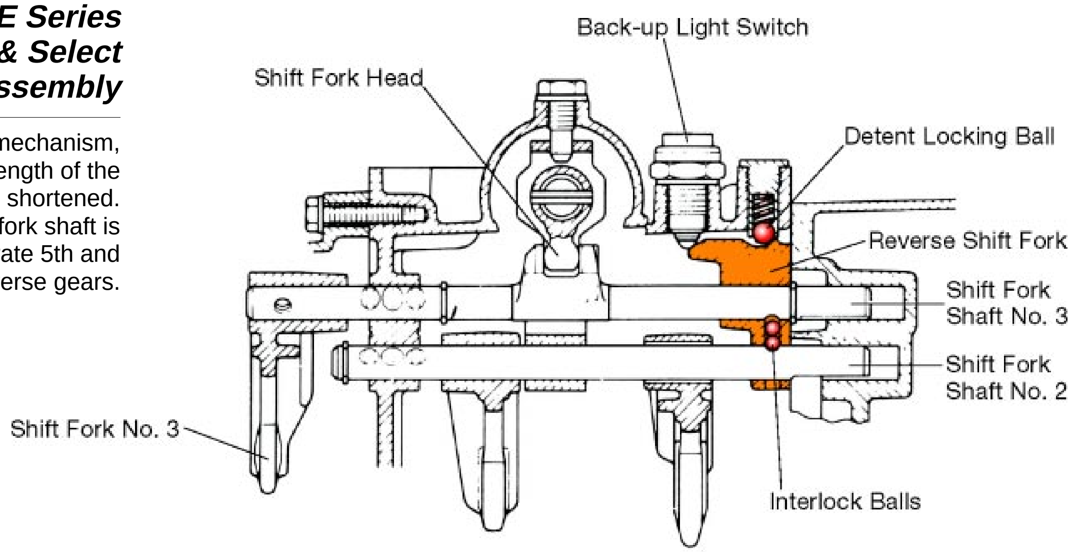


Fig. 4-32
T302f432

If the interlock balls or pin were not installed during reassembly, the transmission remains in reverse with no way to disengage reverse gear as it is held in position by the detent locking ball. Selecting a forward gear and engaging the clutch will cause the engine to stall.

Operation

The operation of the C and E Series mechanism can be broken down into three steps.

1. When the transaxle is shifted into 5th gear, shift fork shaft No. 3 is moved to the right. The balls are pushed into the groove in shift fork shaft No. 2. This prevents the reverse shift fork from moving.
2. When the transaxle is shifted into reverse, the reverse shift fork is moved to the left by the snap ring that is mounted on shift fork shaft No. 3. The balls are pushed into the groove in shift fork shaft No. 3 when shifted from neutral to reverse locking the shift fork shaft.
3. When shifting from reverse into neutral, shift fork shaft No. 3, the balls, and the reverse shift fork are all moved together to the right.

C & E Series Reverse One-Way Mechanism Operation

The balls lock the reverse shift fork to shift fork shaft No. 2, preventing a shift to reverse when shift fork shaft No. 3 moves out of 5th gear.

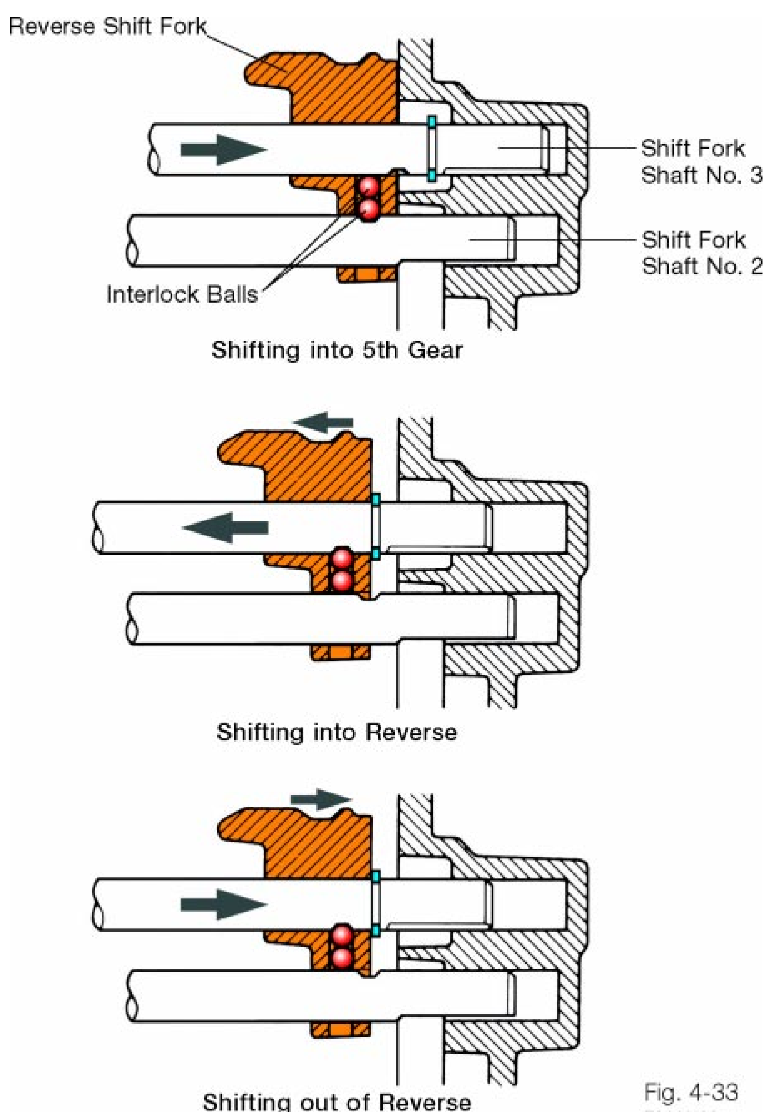


Fig. 4-33
T302f433

S Series Reverse One-Way Mechanism

The S series shift and select assembly uses only one full-length shift fork shaft. The stamped steel or cast iron shift forks slide on the shaft, but are not fixed to it. The 5th gear shift fork is attached to the shaft on one end and the reverse shift fork slides on the opposite end.

S Series Shift & Select Assembly

By using this mechanism, the overall length of the transaxle can be shortened. Only one shift fork shaft is needed to operate 5th and reverse gears.

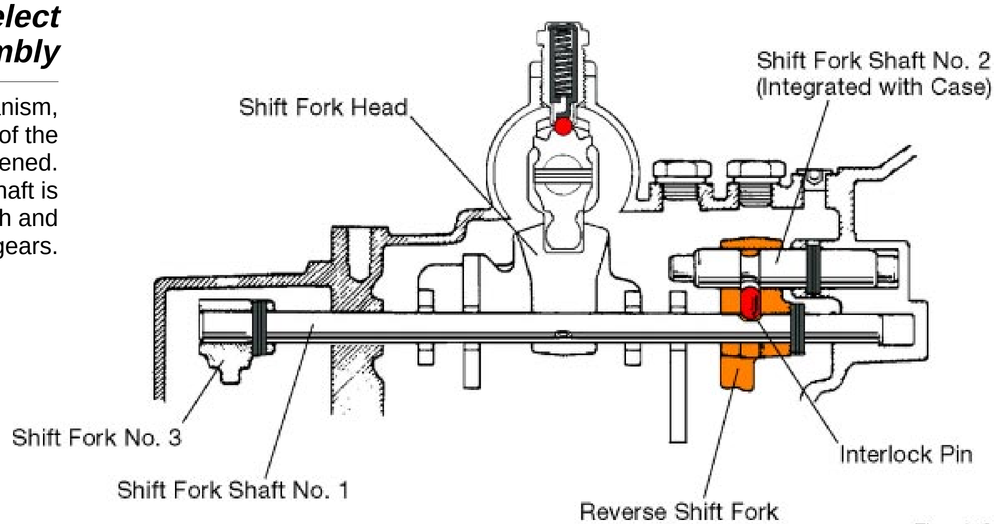


Fig. 4-34
T302f434

Operation The operation of this mechanism for 5th and Reverse can be broken down into three steps.

1. The shift fork shaft No. 1 moves to the right, forcing the pin into the groove of the shift fork shaft No. 2. This prevents the reverse fork from moving.
2. When shifting into reverse, the reverse fork is moved to the left by the slotted spring pin in shift fork shaft No. 1. The detent pin drops into the groove of the shift fork shaft No. 1 and is locked to the shaft by the interlock pin.
3. When shifting from Reverse to neutral, shift fork shaft No. 1, the pin, and reverse shift fork move to the right as a unit.

S Series Shift & Select Assembly Operation

The reverse fork is moved to the left by the slotted spring pin in shift fork shaft No. 1. The interlock pin drops into the groove of shift fork shaft No. 1 and the reverse shift fork is lock to the shaft.

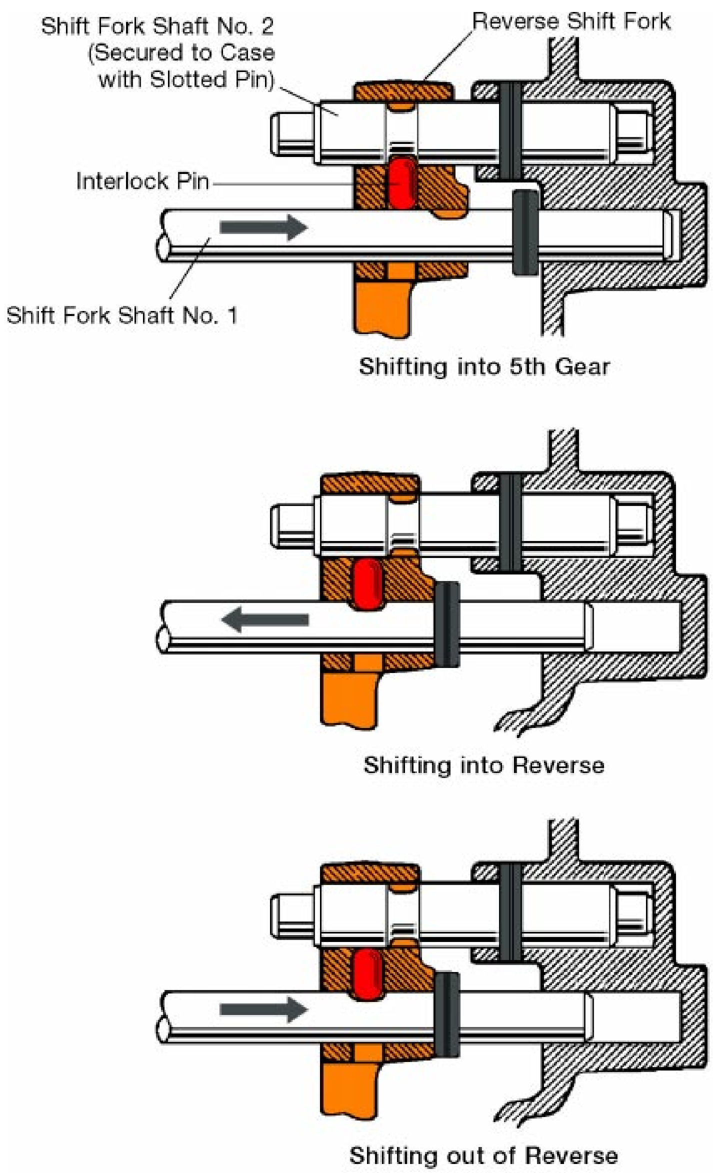


Fig. 4-35
T302f435

Reverse Mis-Shift Prevention

This mechanism prevents accidental shifting from 5th gear into reverse while the vehicle is in motion. It does this by requiring the shift lever to be put in neutral before the transaxle can be shifted into reverse.

Construction of the mechanism is very similar in the C, S, and E series transaxles.

Reverse Mis-Shift Prevention

When shifting from 5th gear to reverse, shift inner lever No. 2 hits the reverse restrict pin and prevents a shift to reverse.

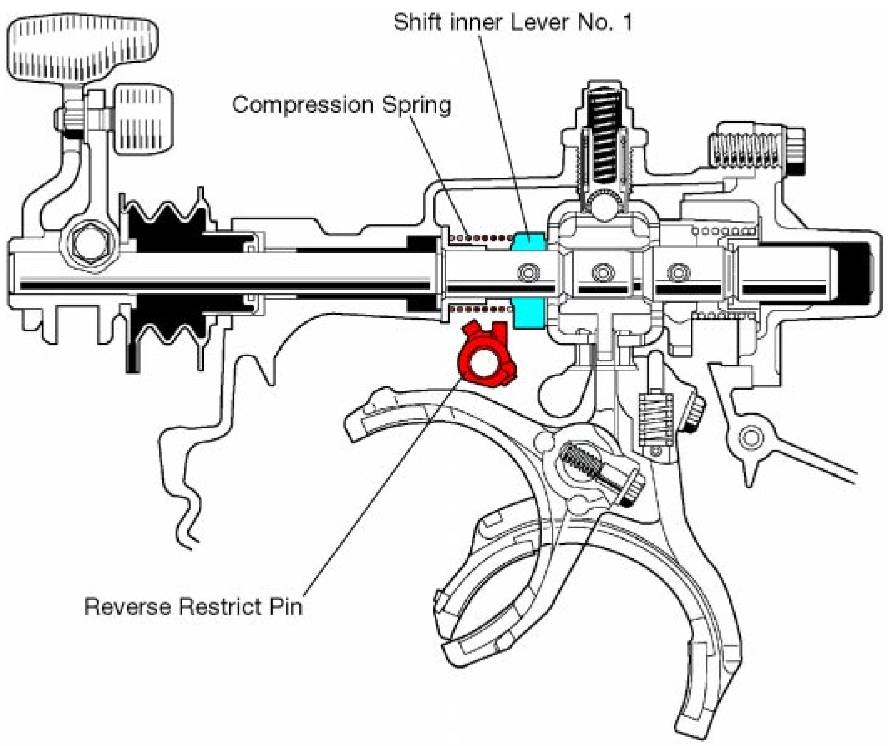


Fig. 4-36
T302f436

Operation

The operation of the mechanism can be broken down into the following four steps (as shown in figure 4-37):

1. Shifting from neutral to 5th or reverse - If the transaxle is shifted from neutral into 5th gear or reverse, shift inner lever No. 2 pushes the reverse restrict pin and causes the pin to turn in the direction of the arrow.
2. Shifting into 5th gear - If the transaxle is shifted into 5th gear, shift inner lever No. 2 moves away from the reverse restrict pin. The pin is therefore moved in the direction of the arrow by a spring.
3. Shifting from 5th into reverse - If an attempt is made to shift from 5th gear into reverse, shift inner lever No. 2 hits the reverse restrict pin and pushes it. The pin hits the stopper on the support shaft. The shift inner lever is stopped midway between 5th gear and reverse, therefore it cannot rotate any further and shifting into reverse is prevented.
4. Shifting into reverse - When the gear shift lever is moved to neutral from the position midway between 5th gear and reverse (explained in the previous step), the reverse restrict pin moves away from the shift inner lever No. 2. The spring pushes the lever back to the neutral position. At this time, reverse gear can be engaged.

Reverse Mis-Shift Prevention Mechanism Operation

When selecting 5th gear, the reverse restrict pin moves into position to prevent the shift inner lever from selecting reverse.

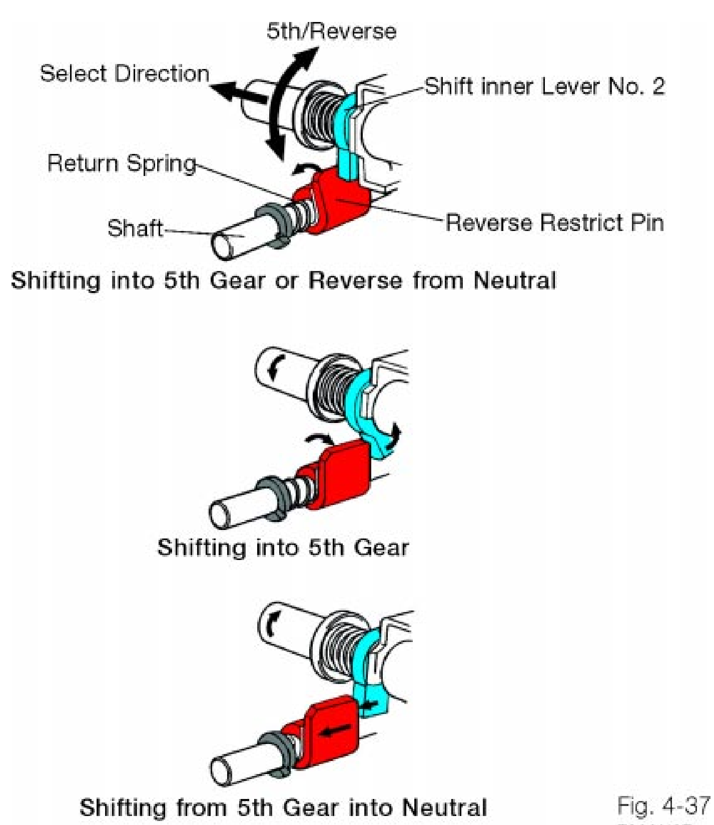


Fig. 4-37
T302f437

Reverse Pre-Balk Mechanism

The reverse pre-balk mechanism is used to eliminate gear clash when shifting into reverse. The shift and select assembly applies one of the synchronizer mechanisms to slow the speed of the input shaft. By slowing the speed of the input shaft, the reverse idler gear can engage smoothly with the input shaft reverse gear. The C series transaxles apply the 2nd gear synchronizer mechanism to slow the input shaft down. The S series transaxle applies the 4th gear synchronizer mechanism to accomplish the same results.

C Series Operation

When shifting into reverse, shift inner lever No. 1 moves shift fork shaft No. 3 in the reverse direction. At the same time, shift inner lever No. 3 contacts the pin on shift fork shaft No. 1, moving it in the 2nd gear direction. The distance is denoted by “A” in figure 4-38. This causes the synchronizer ring to push lightly on the conical surface of the 2nd gear, lowering the speed of the input shaft. As the shift inner lever No. 3 moves away from the pin of the shift fork shaft No. 1, the process of shifting into reverse is complete.

C Series Reverse Pre-Balk Mechanism

This mechanism is used to eliminate gear clash when shifting into reverse.

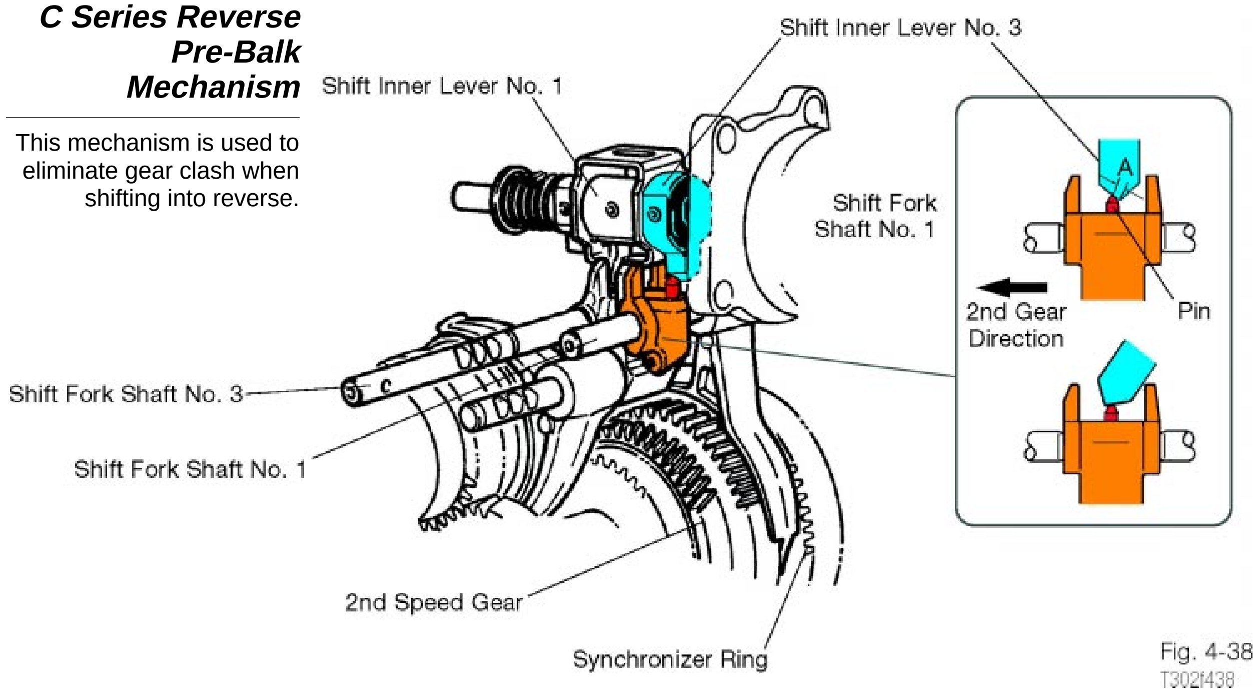


Fig. 4-38
T302f438

S Series Operation

The shift and select assembly applies the fourth gear synchronizer mechanisms to slow the speed of the input shaft. By slowing the speed of the input shaft, the reverse idler gear can engage smoothly with the input shaft reverse gear:

1. When the transaxle is shifted into reverse, shift inner lever No. 1 turns in the opposite direction of the 5th/reverse shift head. At the same time, the reverse restrict pin holder, which is splined to the shift and select lever shaft, turns in the same direction.
2. The reverse restrict pin holder turns the shift fork lock plate in the same direction. This is done with the use of a steel ball and pin.
3. Since the shift fork lock plate moves the 3rd/4th shift fork head lightly in the direction of the fourth gear, the 4th gear synchronizer ring applies pressure to the conical surface of the gear and the input shaft speed is reduced.
4. When the steel ball of the reverse pin holder enters securely into the pin of the shift fork lock plate, shifting into reverse is completed.

S Series Operation

The shift and select assembly applies one of the synchronizer mechanisms to slow the speed of the input shaft.

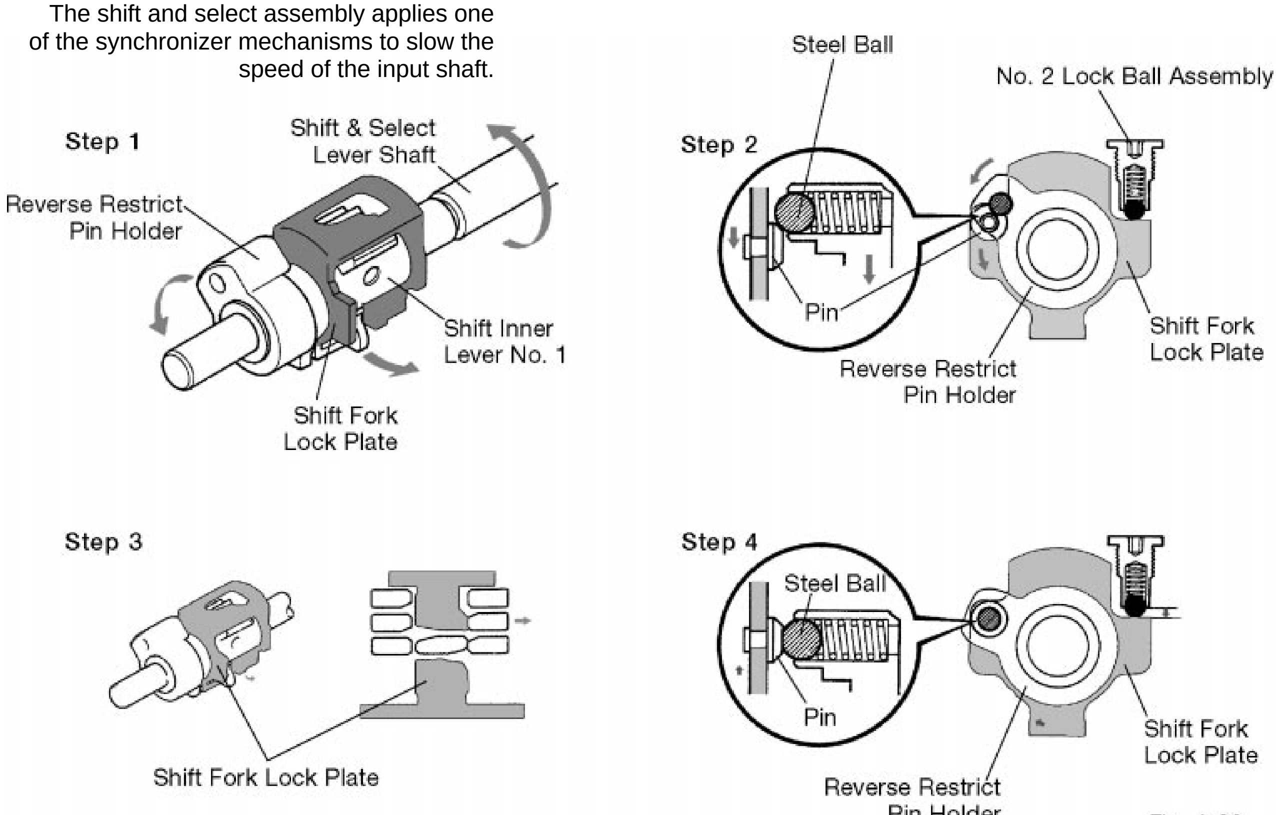


Fig. 4-39
T302f439

Reverse Synchromesh Mechanism

E-series transaxles have replaced the pre-balk mechanism with the reverse synchromesh mechanism; the reverse synchromesh mechanism allows for smoother shifting into reverse. It uses the multi-cone synchronizer assembly for 5th gear to stop the input shaft so the reverse idler can engage with the reverse gears on the input and output shaft. When shifting into reverse the hub sleeve is moved to the left exerting pressure on the key spring that pulls the pull ring to the left. As with a key type synchronizer, the pull ring rotates slightly causing a misalignment of the pull ring teeth and the hub sleeve splines. As the taper on the front of the pull ring teeth and hub sleeve splines make contact, greater force is applied to the pull ring. The inner ring is connected to the pull ring with a snap ring. The outer ring and middle ring are located between the inner ring and pull ring so, when the pull ring moves to the left it causes the inner ring to pull the middle ring and outer ring together slowing the input shaft.

Reverse Synchromesh Mechanism

The 5th gear synchronizer ring is pulled toward the reverse gear, synchronizing the input or counter shaft.

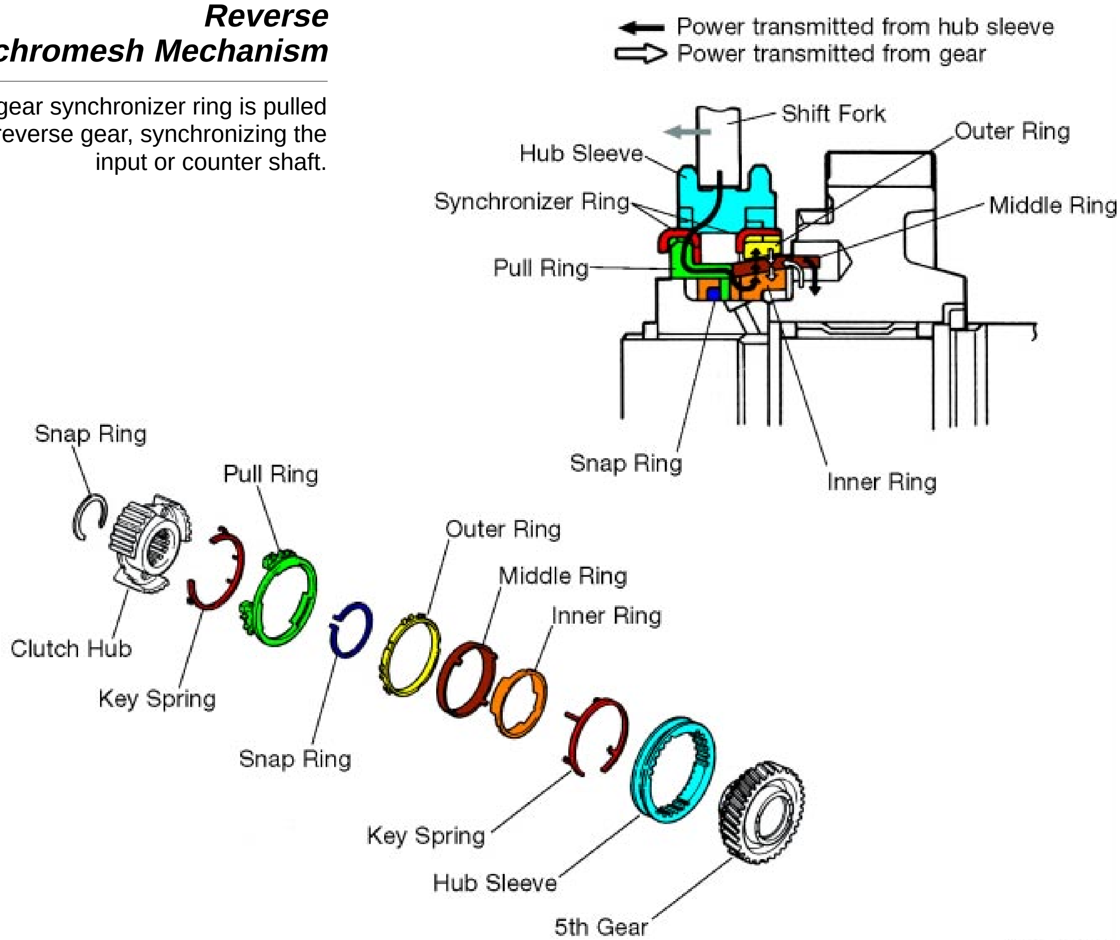


Fig. 4-40
T302f440

Lubrication

To prevent overheating, the transaxle gears run in a bath of lubricant. Oil is circulated by the motion of the gears, and directed to critical areas by design features like troughs and oiling funnels. The fluid level is usually checked at a fill level plug.

S & C Series Lubrication

Lubrication of input and output shaft gears and needle bearings is accomplished by recovering oil splashed up from the input shaft gears to the oil receiver. The oil drains to the input shaft and out to each gear through the oil holes.

Lubrication of Input & Output Shaft Gears & Needle Bearings

The oil receiver recovers oil splashed up from the input shaft gears.

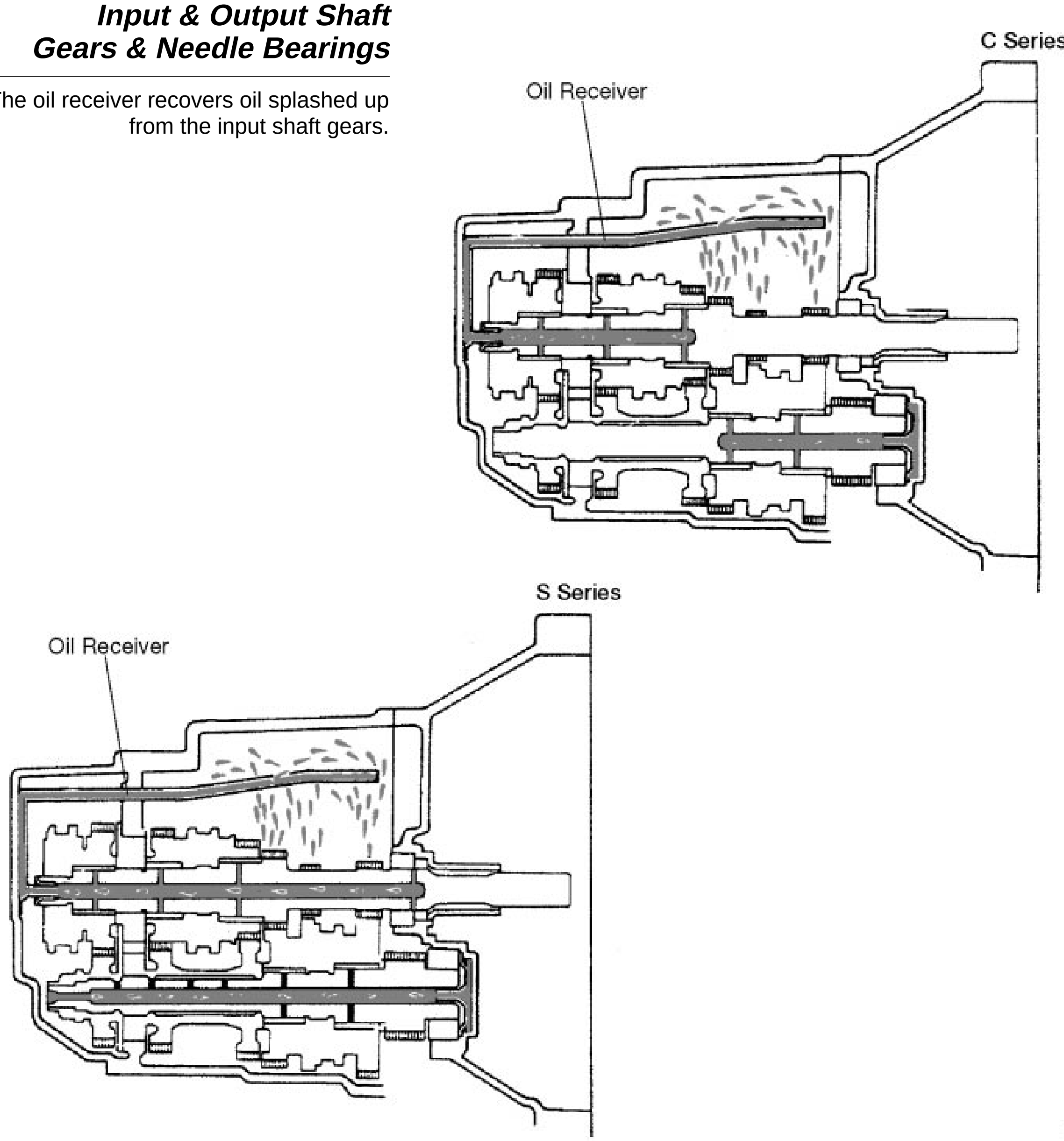


Fig. 4-41
T3021441

Lubrication of Input & Output Shaft Gears Roller Bearings

Oil splashed up from the differential ring gear accumulates in the oil pocket and is then fed to each bearing through the oil holes in the transaxle case.

Lubrication of Input & Output Shaft Gears Roller Bearings

Oil splashed up from the differential ring gear accumulates in the oil pocket.

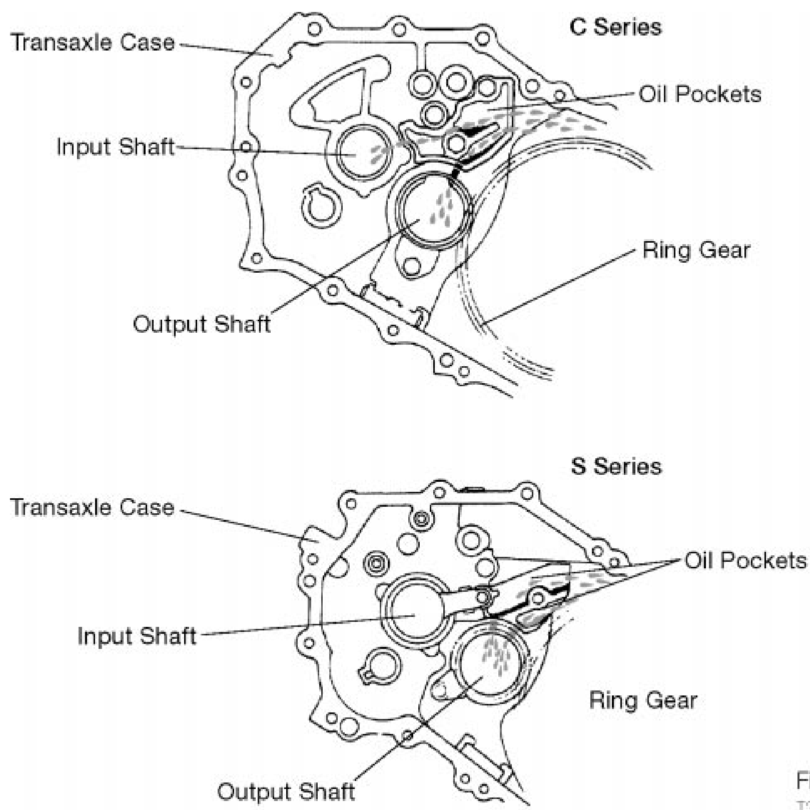


Fig. 4-42
T3021442

Oil Pump

The E Series lubrication system uses a trochoid type oil pump driven by the ring gear of the differential and located in the bottom of the transaxle case.

E Series Lubrication

A trochoid type oil pump is driven by the ring gear of the differential.

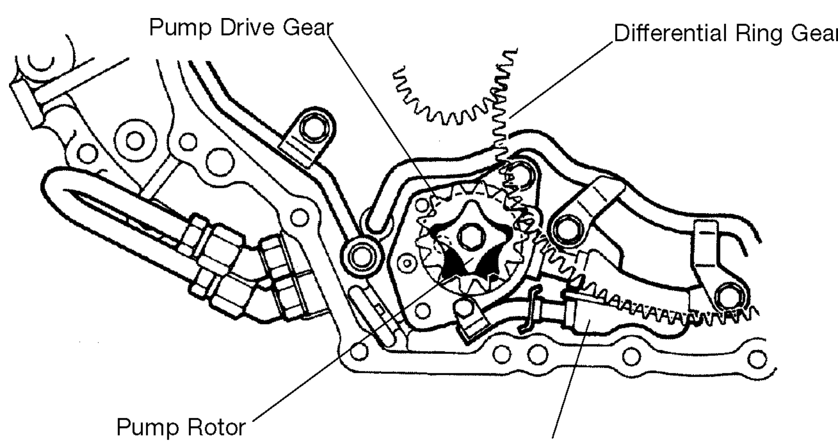


Fig. 4-43
T302f443

Lubrication by the Oil Pump

The oil pump supplies oil to these areas of the transaxle:

- Seals and bearings in both sides of the differential
- Through the drive shaft to the inside of the differential
- To the oil receiver for the 3rd and 4th gear synchronizers
- Through the transaxle case cover to the 5th gear and synchronizer

Lubricating Paths

The oil pump supplies oil to the differential side bearings, gears, and oil receiver to lubricate the input shaft gears.

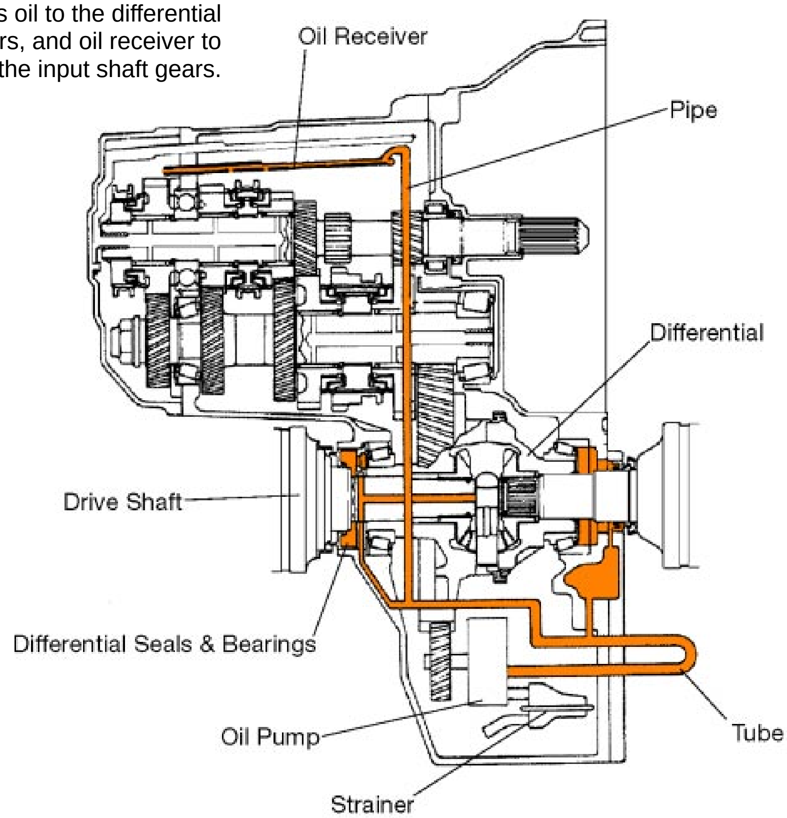


Fig. 4-44
T302f444

Case Sealants

Toyota transmission cases use **Formed-In-Place Gaskets (FIPG)**. FIPG gaskets are usually **Room-Temperature Vulcanizing (RTV)** or **anaerobic sealants**. RTV sealant is made from silicone and is one of the most widely used gasket compounds. It is extremely thick, and sets up to a rubber-like material very quickly when exposed to air.

Anaerobic sealant is similar in function to RTV. It can be used either to seal gaskets or to form gaskets by itself. Unlike RTV, anaerobic sealant cures only in the absence of air. This means that an anaerobic sealant cures only after the assembly of parts, sealing them together.

WORKSHEET 4-1
Transaxle—Case Removal and Component Identification

Vehicle:	Year/Prod. Date:	Engine	Transmission:

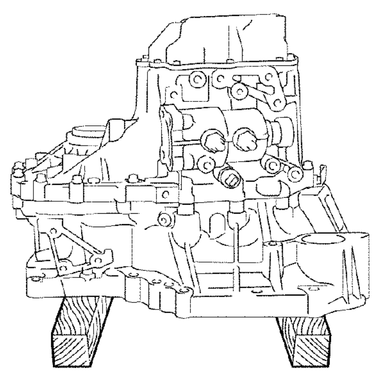
Worksheet Objectives

With this worksheet, you will follow the disassembly of a front-drive transmission to remove the case using the required special tools, make measurements where appropriate, retrieve and apply the needed service information, identify components using the technician handbook and repair manual.

Tools and Equipment

- 5th Gear Puller SST (P/N 09310-17010)
- 5th Gear Replacer SST (P/N 09309-12020-01)
- Hand Tool Set
- Dial Indicator and Stand
- Micrometer, 0-1 in.
- Corolla RM (C Series Transaxle)
- Camry RM (E Series Transaxle)

Section 1: Case Removal



1. Remove the shift and select lever assembly.
2. Remove the lock nut from the output shaft
3. What procedure prevents the output shaft from turning while removing the lock nut?

4. Measure 5th gear thrust clearance and radial clearance:

   Thrust Clearance: ____________ Specification: ____________

   Radial Clearance: ____________ Specification: ____________

5. Remove 5th gear from the output shaft

6. What SSTs are used to remove 5th gear from the output shaft?

   ____

   ____

7. Remove the fifth gear synchronizer hub and 5th gear from the input shaft.

8. What SSTs are used to remove 5th gear and the synchronizer hub from the input shaft?

   ____

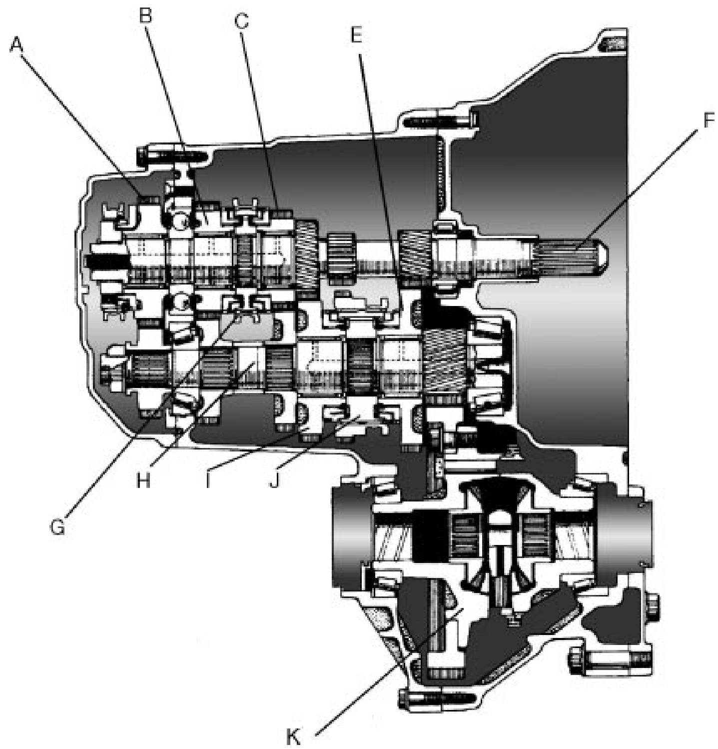
   ____

9. Remove the three snap rings from the shift shafts and remove the spring and detent balls.

10. Remove transaxle case

Section 2: Component Identification

Match the component names listed below with the parts in the illustration. Place the letter that identifies the part on the line in front of the component name.



______ 1. 1st gear

______ 2. 2nd gear

______ 3. 3rd gear

______ 4. 4th gear

______ 5. 5th gear

______ 6. Input shaft

______ 7. Output shaft

______ 8. Differential

______ 9. 1-2 Synchronizer & reverse

______ 10. 3-4 Synchronizer

Section 3: Powerflow

1. With the transmission in neutral, tip the transmission up to rotate the input shaft while holding the differential from rotating. What are the speed gears on the output shaft doing?

   ____

2. How are the speed gears engaged to the output shaft?

   ____

3. With the transmission in neutral, hold the input shaft and rotate the differential. What are the speed gears on the input and output shaft doing?

   ____

   ____

4. How are the speed gears lubricated when the vehicle is being towed with the front wheels on the ground? (Dingy tow)

   ____

   ____

5. What does the owners manual recommend about dingy towing a front wheel drive vehicle with manual transmission?

   ____

6. Trace the power flow from the input shaft through the transmissions to the output shaft. Be prepared to demonstrate power flow to your instructor.

7. The rear wheel drive transmission has a direct drive in 4th gear. Does the transaxle have a direct drive?

   ____

8. Describe how the output shaft's direction of rotation changes from the input shaft's rotation in reverse gear.

   ____

Instructor's Initials: ___________

Transaxle—Case Removal & Component Identification

Name: ____ Date: ____________________

Review this sheet as you are doing the Transaxle—Case Removal & Component Identification worksheet. Check each category after viewing the instructor's presentation and completing the worksheet. Ask the instructor if you have questions regarding the topics provided below. Additional space is provided under Topic for you to list any other concerns that you would like your instructor to address. The comments section is provided for your personal comments, information, questions, etc.

Topic	I have questions	I know I can	Comment
Locate the model specific disassembly procedure in the repair manual.			
Use appropriate SSTs to remove 5th gear.			
Identify all gears in the transaxle.			
Identify all synchronizers in the transaxle.			
Explain how speed gears are connected to the output shaft.			
Trace powerflow through all gears.			
Describe transaxle lubrication when the vehicle is dingy towed.			
Can find the towing recommendation in the owner's manual.			

Notes

WORKSHEET 4-2
Transaxle—Shaft Removal and Inspection

Vehicle:	Year/Prod. Date:	Engine	Transmission:

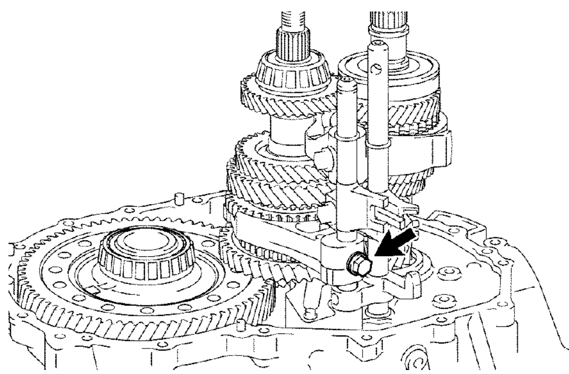
Worksheet Objectives

With this worksheet, you will follow the disassembly of a front-drive transmission shift mechanism and shafts using the required special tools, make measurements where appropriate, retrieve and apply the needed service information, retrieve and interpret service specification information from the repair manual.

Tools and Equipment

- Hand Tool Set
- Dial Indicator and Stand
- Micrometer, 0-1 in.
- Feeler Gauge
- Corolla RM (C Series Transaxle)
- Camry RM (E Series Transaxle)

Section 1: Remove Shift Mechanism



1. Remove the shift rail snap rings, screw plugs, locking balls and springs.

2. What function do the locking balls and springs serve in the shift mechanism?

   ____

3. Remove the shift shafts from the shift fork and slide the shift forks out of the synchronizer sleeves.

4. Remove the input and output shafts and differential assembly.

Section 2: Input Shaft Inspection

1. Inspect and measure the following thrust clearances:

   Input Shaft 3rd Gear Measurement: ____________ Specification: ____________

   Input Shaft 4th Gear Measurement: ____________ Specification: ____________

2. Inspect and measure the following radial (oil) clearances:

   Input Shaft 3rd Gear Measurement: ____________ Specification: ____________

   Input Shaft 4th Gear Measurement: ____________ Specification: ____________

3. If the radial (oil) clearance is greater than the maximum, how is it repaired?

   ____

   ____

Section 3: Output Shaft Inspection

4. Measure gear radial (oil) clearance using a dial indicator:

   1st Gear Measurement: ____________ Specification: ____________

   2nd Gear Measurement: ____________ Specification: ____________

5. Inspect and measure the following thrust clearances:

   Output Shaft 1st Gear Measurement: ____________ Specification: ____________

   Output Shaft 2nd Gear Measurement: ____________ Specification: ____________

Section 4: Clutch Fork Inspection

1. Measure shift fork to hub sleeve clearance:

   1st/2nd Shift Fork: ____________ Specification: ____________

   3rd/4th Shift Fork: ____________ Specification: ____________

   5th Shift Fork: ____________ Specification: ____________

Transaxle—Shaft Removal and Inspection

Name: ____ Date: _____________________

Review this sheet as you are doing the Transaxle—Shaft Removal and Inspection worksheet. Check each category after viewing the instructor's presentation and completing the worksheet. Ask the instructor if you have questions regarding the topics provided below. Additional space is provided under Topic for you to list any other concerns that you would like your instructor to address. The comments section is provided for your personal comments, information, questions, etc.

Topic	I have questions	I know I can	Comment
Explain the function of the detent balls and springs on the shift fork shafts.			
Explain the function of the interlock pins on the shift fork shafts.			
Measure thrust clearances.			
Measure radial (oil) clearances.			
Explain the diagnosis process if radial clearance is excessive.			
Measure hub sleeve to shift fork clearances.			

Notes

WORKSHEET 4-3
Transaxle—Preload Check and Reassembly

Vehicle:	Year/Prod. Date:	Engine	Transmission:

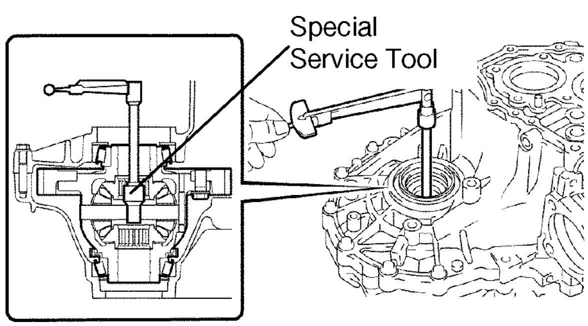
Worksheet Objectives

With this worksheet, you will follow the reassembly of a front-drive transmission using the required special tools, make measurements where appropriate, retrieve and apply the needed service information, retrieve and interpret service specification information from the repair manual.

Tools and Equipment

- Hand Tool Set
- Dial Indicator Torque Wrench
- Preload Adapter SST (P/N 09564-32011)
- 5th Gear Replacer SST (P/N 09309-12020-01)
- 5th Gear Remover & Replacer SST (P/N 09310-17010-01)
- Corolla RM (C Series Transaxle)
- Camry RM (E Series Transaxle)

Section 1: E Series Transaxle Differential Preload Check and Adjustment



1. Install the output shaft alone into the lower case and install the upper case half.

2. Install the bearing race, adjusting shim and bearing retainer.

3. Secure the case bolts and retainer bolts, and record their torque specifications below.

    a. Transmission case bolt torque:

    ____

    b. Bearing retainer bolt torque:

    ____

4. Using an inch pound torque (in-lbf) wrench with sweeping dial, measure the starting torque.

   a. Starting torque:

   ____

   b. Starting torque for used bearings specification:

   ____

5. Remove the bearing retainer and measure the shim thickness and determine the Mark designation from the repair manual chart.

   Shim Thickness: ____________ Mark Designation: ____________

6. According to the chart in the repair manual, if starting torque required and additional 8 in-lbf of torque, what shim mark designation would be required?

   ____

7. Install the differential, output shaft and bearing retainer and torque the case and bearing retainer.

8. Using the same inch pound torque wrench used above, measure the starting preload of both the output shaft and differential.

9. If the starting torque of the output shaft was 8 in-lbf, in what torque range should the differential and output shaft fall in for new differential bearings?

   ____

Section 2: C Series Transaxle Differential Preload Check and Adjustment

1. Install the differential into the lower case.

2. Install the top case and torque the case bolts

3. Using an inch pound (in-lbf) torque wrench with sweeping dial, measure the starting torque.

   c. Starting torque:

   ____

   d. Starting torque for used bearings specification:

   ____

4. What special service tool is used to turn the differential?

   ____

5. Remove the outer side bearing race from the transmission case.

6. What special service tool is used to remove the bearing race?

   ____

7. Measure the preload shim thickness and determine the size designation using the repair manual chart. Shim thickness:

    ____

Section 3: Transaxle Reassembly

1. Install the input and output shafts together.
2. Install the shift forks and shift shafts and detent balls.
3. Install transaxle case half.
4. What type of sealant does the repair manual recommend?

    ____

5. Turn the shafts and check for binding.
6. Install 5th driven gear using 5th gear replacer. What is the SST number?

    ____

7. Install 5th drive gear and 5th synchronizer hub and shift fork.
8. What precaution is required when installing this assembly?

    ____

9. Using a dial indicator measure the 5th gear thrust clearance:

    Measurement: ____________ Specification: ____________

10. Install the rear case cover.
11. Be sure that the shift shaft heads are aligned in neutral and install the shift and select assembly into the case
12. Shift the transaxle into all the gear positions while rotating the input shaft and feeling the differential

rotation to ensure that all gear positions work and don’t bind.

Instructor’s Initials: __________________

Notes

Transaxle—Preload Check and Reassembly

Name: ____ Date: ______________________

Review this sheet as you are doing the Transaxle—Preload Check and Reassembly worksheet. Check each category after viewing the instructor's presentation and completing the worksheet. Ask the instructor if you have questions regarding the topics provided below. Additional space is provided under Topic for you to list any other concerns that you would like your instructor to address. The comments section is provided for your personal comments, information, questions, etc.

Topic	I have questions	I know I can	Comment
Measure differential preload check and adjustment.			
Explain where the differential preload adjustment is made.			
Use the charts and specifications in the repair manual to determine shim thickness for preload adjustment.			
Properly install synchronizer key springs.			
Explain the importance of shaft rotation when installed in the case.			
Install the locking balls, detent pins shift forks and the shift shafts.			
Explain the application of FIPG sealants.			
Explain the importance of shifting through all the gears when the transmission case is assembled.			

Notes

WORKSHEET 4-3
Transaxle—Preload Check and Reassembly

Vehicle:	Year/Prod. Date:	Engine	Transmission:

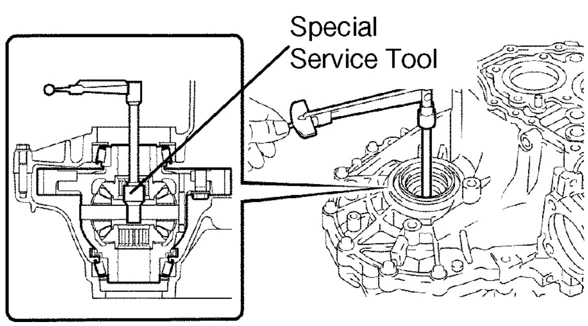
Worksheet Objectives

With this worksheet, you will follow the reassembly of a front-drive transmission using the required special tools, make measurements where appropriate, retrieve and apply the needed service information, retrieve and interpret service specification information from the repair manual.

Tools and Equipment

- Hand Tool Set
- Dial Indicator Torque Wrench
- Preload Adapter SST (P/N 09564-32011)
- 5th Gear Replacer SST (P/N 09309-12020-01)
- 5th Gear Remover & Replacer SST (P/N 09310-17010-01)
- Corolla RM (C Series Transaxle)
- Camry RM (E Series Transaxle)

Section 1: E Series Transaxle Differential Preload Check and Adjustment



1. Install the output shaft alone into the lower case and install the upper case half.
2. Install the bearing race, adjusting shim and bearing retainer.
3. Secure the case bolts and retainer bolts, and record their torque specifications below.
   a. Transmission case bolt torque:

   ____

   b. Bearing retainer bolt torque:

   ____

4. Using an inch pound torque (in-lbf) wrench with sweeping dial, measure the starting torque.
   a. Starting torque:

   ____

   b. Starting torque for used bearings specification:

   ____

5. Remove the bearing retainer and measure the shim thickness and determine the Mark designation from the repair manual chart.

   Shim Thickness: ____________ Mark Designation: ____________

6. According to the chart in the repair manual, if starting torque required and additional 8 in-lbf of torque, what shim mark designation would be required?

   ____

7. Install the differential, output shaft and bearing retainer and torque the case and bearing retainer.
8. Using the same inch pound torque wrench used above, measure the starting preload of both the output shaft and differential.
9. If the starting torque of the output shaft was 8 in-lbf, in what torque range should the differential and output shaft fall in for new differential bearings?

   ____

Section 2: C Series Transaxle Differential Preload Check and Adjustment

1. Install the differential into the lower case.
2. Install the top case and torque the case bolts
3. Using an inch pound (in-lbf) torque wrench with sweeping dial, measure the starting torque.
   c. Starting torque:

   ____

   d. Starting torque for used bearings specification:

   ____

4. What special service tool is used to turn the differential?

   ____

5. Remove the outer side bearing race from the transmission case.
6. What special service tool is used to remove the bearing race?

   ____

7. Measure the preload shim thickness and determine the size designation using the repair manual chart. Shim thickness:

    ____

Section 3: Transaxle Reassembly

1. Install the input and output shafts together.
2. Install the shift forks and shift shafts and detent balls.
3. Install transaxle case half.
4. What type of sealant does the repair manual recommend?

    ____

5. Turn the shafts and check for binding.
6. Install 5th driven gear using 5th gear replacer. What is the SST number?

    ____

7. Install 5th drive gear and 5th synchronizer hub and shift fork.
8. What precaution is required when installing this assembly?

    ____

9. Using a dial indicator measure the 5th gear thrust clearance:

    Measurement: ____________ Specification: ____________

10. Install the rear case cover.
11. Be sure that the shift shaft heads are aligned in neutral and install the shift and select assembly into the case
12. Shift the transaxle into all the gear positions while rotating the input shaft and feeling the differential

rotation to ensure that all gear positions work and don't bind.

Instructor's Initials: _________________

Notes

Transaxle—Preload Check and Reassembly

Name: ____ Date: _____________________

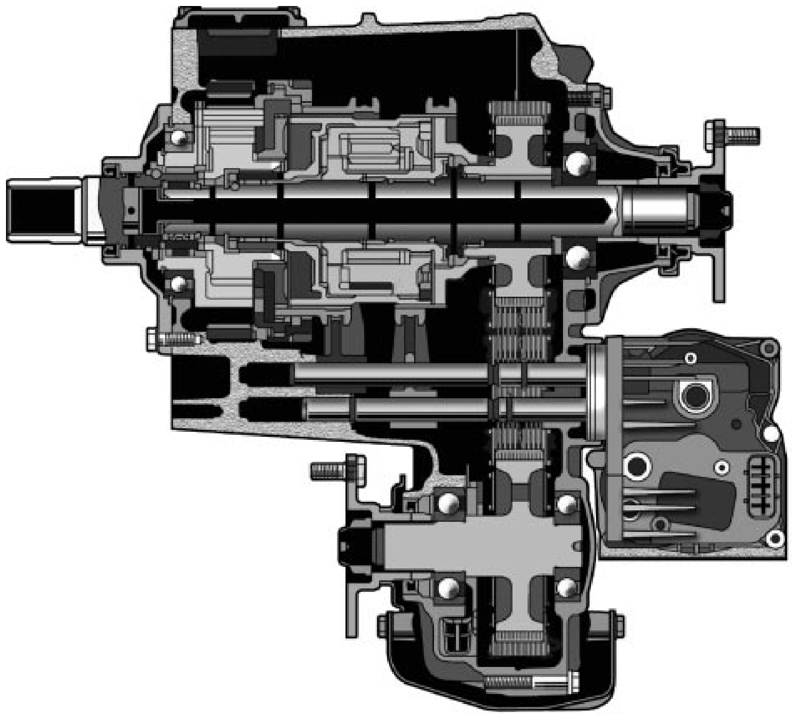
Review this sheet as you are doing the Transaxle—Preload Check and Reassembly worksheet. Check each category after viewing the instructor's presentation and completing the worksheet. Ask the instructor if you have questions regarding the topics provided below. Additional space is provided under Topic for you to list any other concerns that you would like your instructor to address. The comments section is provided for your personal comments, information, questions, etc.

Topic	I have questions	I know I can	Comment
Measure differential preload check and adjustment.			
Explain where the differential preload adjustment is made.			
Use the charts and specifications in the repair manual to determine shim thickness for preload adjustment.			
Properly install synchronizer key springs.			
Explain the importance of shaft rotation when installed in the case.			
Install the locking balls, detent pins shift forks and the shift shafts.			
Explain the application of FIPG sealants.			
Explain the importance of shifting through all the gears when the transmission case is assembled.			

Notes

Section 5

Transfer Case



Learning Objectives:

1. Identify the purpose and function of the transfer case.
2. Describe 4WD operation.
3. Describe AWD operation.
4. Describe transfer case operation
   a. Gear drive transfer case
   b. Chain drive transfer case
   c. Planetary gear type
5. Identify and describe the operation of the following transfer case and transaxle components:
   a. Planetary gear unit
   b. Center differential
   c. Shift mechanism
   d. Wait mechanism
6. Identify and describe the operation of the differential lock
7. Identify and describe the operation of the Automatic Disconnecting Differential (A.D.D.)
8. Identify transfer case lubrication
   a. Describe the trochoid pump used on some transfer cases

Section 5
Transfer Case

Introduction

A four-wheel drive (4WD) vehicle has more pulling power and traction since it drives all four wheels. To drive all four wheels, the powertrain requires a drive axle at each end of the vehicle, a second propeller shaft and a transfer case. The transfer case is mounted to the rear of the transmission and its purpose is to drive the additional shaft and provide a gear reduction mode in four-wheel drive only.

When torque is equally distributed to the front and rear axles and the vehicle is driven in a straight line, all wheels turn at the same speed, as do the two drive shafts. When the vehicle is driven in a turn however, all four wheels rotate at different speeds because each of the wheels has a different turning radius around the center of the turn. The outer front wheel turns the fastest, followed by the outer rear, the inner front and the inner rear wheels.

Since the front axle is turning faster than the rear axle, the drive shafts also turn at different speeds. This does not present a problem when the vehicle is driven on loose surfaces such as sand or snow because the tires will slip on the loose surface. However, when driven on pavement, the difference in speeds causes tire scuffing and bind up of the powertrain. At low speeds the bind up may cause the engine to stall. Some transfer case designs use a center differential to provide proportional distribution of torque to the axles eliminating the bind up effect in the powertrain.

All-Wheel Drive (AWD)

Full-time 4WD or all-wheel drive (AWD) transfer cases include a center differential between the front and rear drive shafts and maintain constant power to both the front and rear axles.

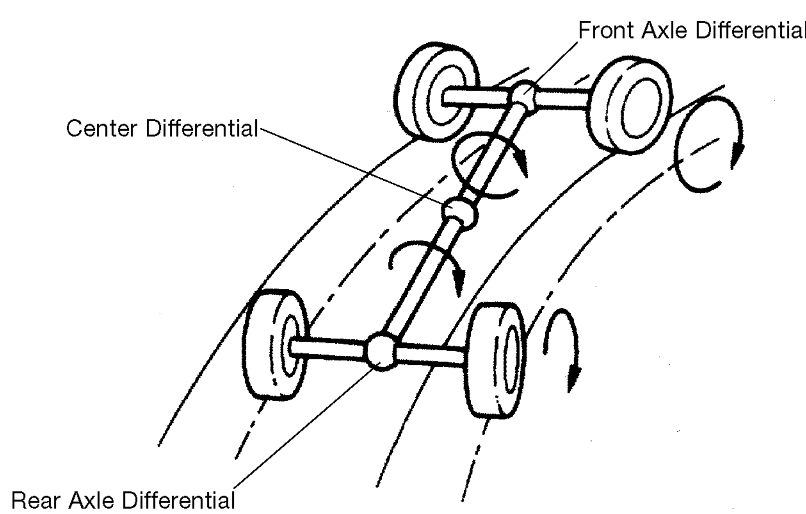


Fig. 5-1
T302f501

Understanding transfer case design features increases your knowledge of transfer case operation and provides for more accurate problem diagnosis.

Transfer Case Types

There are three types of transfer case operating systems: part-time, full-time and multi-mode. In each of these systems high and low gear can be selected.

A **part-time four-wheel drive system** allows two wheel or four-wheel drive. When four-wheel drive is selected, torque is evenly distributed to the front and rear axles. Because the wheels turn at different speeds as described earlier, part-time four-wheel drive vehicles should operate in two-wheel drive on pavement.

To further contrast the three types of transfer case designs it is important to understand the operating characteristics in 4WD when traction is lost. In the part-time system when one wheel loses traction, all the torque for that axle goes to the wheel with the least traction. However since the transfer case distributes equal torque to each axle, the opposite axle has torque delivered to the wheels.

In a **full time four-wheel drive system** or a **multi-mode four-wheel drive system**, if one wheel loses traction all torque goes to the wheel and axle with the least traction. This is when you would lock the center differential causing the torque to be equally distributed to the front and rear axle similar to part-time operation.

In the event one wheel on each axles lost traction, the torque would still go to the wheel with the least traction. What is needed at this point is a locking differential that causes both wheels at the rear axle to be driven together.

Transfer Case Construction

The transfer case is attached to the rear of the transmission. It has a single input shaft driven by the transmission output shaft and two output shafts, one for the front drive axle and one for the rear drive axle. There are two designs that have been used in various Toyota models. The first was a gear design used in pickup models and 4Runners that were used until 1995. The Land Cruiser has used an exclusive gear design that is used in the current model. The second design with several variations is the silent chain model used in all rear wheel drive model pickups and SUVs.

Gear Drive Transfer Case

The Land Cruiser gear drive transfer case has three major components: the input shaft assembly, the idler gear assembly and the center differential assembly. The input shaft assembly is driven by the transmission output shaft and has a single drive gear. The idler gear assembly is driven by the input drive gear and provides for high and low gear. The low speed idler gear is mounted to the idler gear assembly and rotates on a set of needle roller bearings. The high & low clutch sleeve engages the low speed idler gear and the high speed idler gear for low gear.

The center differential assembly is driven either by the high speed idler gear or the low speed idler gear on the idler gear assembly. The high speed output gear rotates on the center differential front case and is driven by the high speed idler gear. It is coupled to the center differential by the No. 1 high & low clutch sleeve. The low speed output gear is attached to the center differential case and is driven by the low speed idler gear. The front drive clutch sleeve locks the center differential by locking the front output shaft to the center differential front case. An oil pump, driven by the idler gear assembly, provides lubrication.

Land Cruiser Gear Drive Transfer Case

The Land Cruiser uses a gear drive transfer case; the power flows in through the input shaft and is transferred through gears to both the front and rear drive shafts.

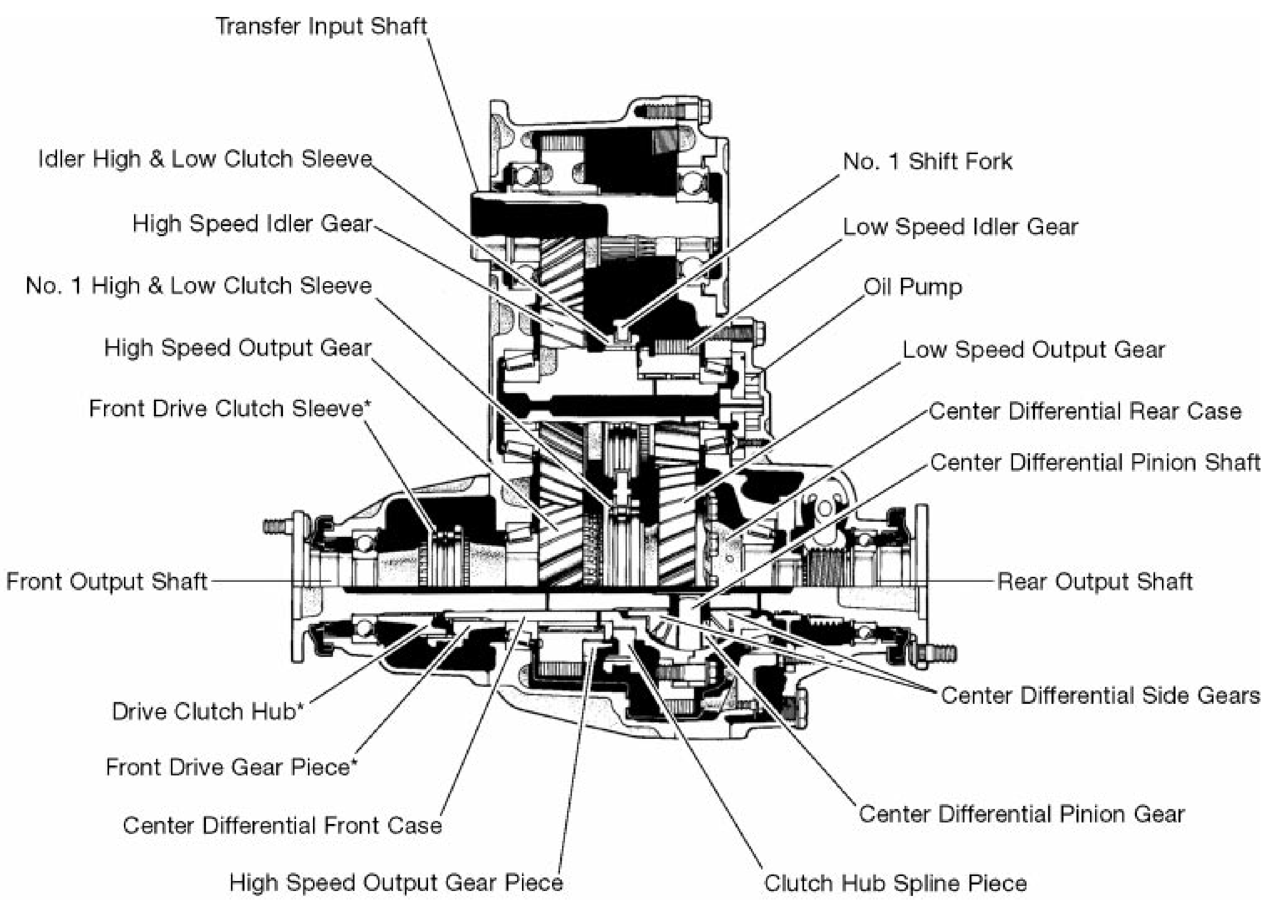


Fig. 5-2
T302f502

*for Center Differential Lock Mechanism

Shifting between high speed and low speed is done with a floor mounted shift selector while the vehicle is stopped. When the shift selector is moved, the high & low clutch sleeve on the idler gear assembly and the No. 1 high & low clutch sleeve on the center differential assembly move to the right at the same time. When low speed is selected, the low speed idler gear is engaged with the high speed idler gear and the high speed output gear is disengaged from the center differential case. The high gear ratio (2.48:1) between the smaller low speed idler gear and the larger low speed output gear provides low gear.

When high speed is selected, the high speed idler gear is disengaged with the low speed idler gear and the high speed output gear is engaged with the center differential case. The gear ratio in high is 1:1 as the input drive gear and high speed output gear have the same number of teeth. When the center differential case is driven, the pinion shaft transfers torque through the pinion gears to the side gears, driving the front and rear output shafts.

Gear Drive Transfer Case Operation

When low speed is selected, the low speed idler gear is engaged with the high speed idler gear and the high speed output gear is disengaged from the center differential case.

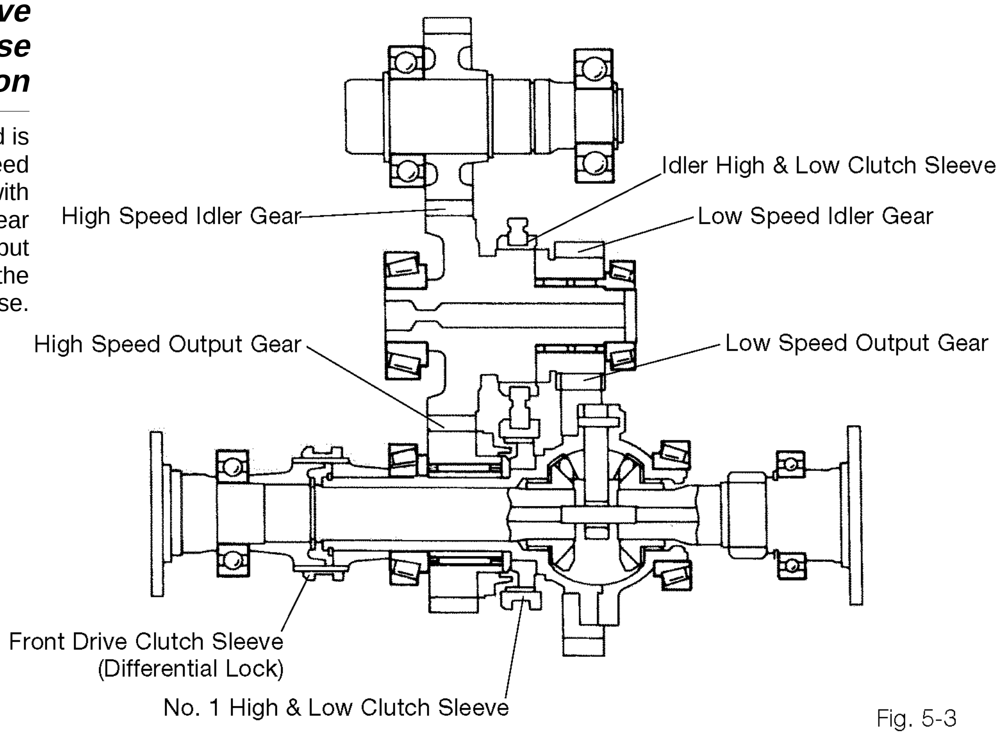


Fig. 5-3
T302f503

An electric shift actuator motor (discussed later in this section) causes the front drive clutch sleeve to lock the front output shaft to the center differential front case, completing the center differential lock function. The actuator is controlled by a center differential lock switch located on the instrument panel and a 4WD control relay.

Chain Drive Transfer Case

The chain drive transfer case has a similar function to the gear drive transfer case. This type of transfer case uses a planetary gear set instead of a countershaft to provide low range gear reduction. It also uses a large silent chain instead of an idler gear to transfer power to the front output shaft. A synchronizer assembly allows changing ranges from L4 to H4 without stopping. In 4WD, the front drive clutch sleeve connects the output shaft to the chain sprocket and chain, which drives the front output shaft. This transfer case has its own oil pump to ensure proper lubrication.

Chain Drive Transfer Case

A chain drive transfer case uses a large silent chain to transfer power from the rear output shaft to the lower front output shaft.

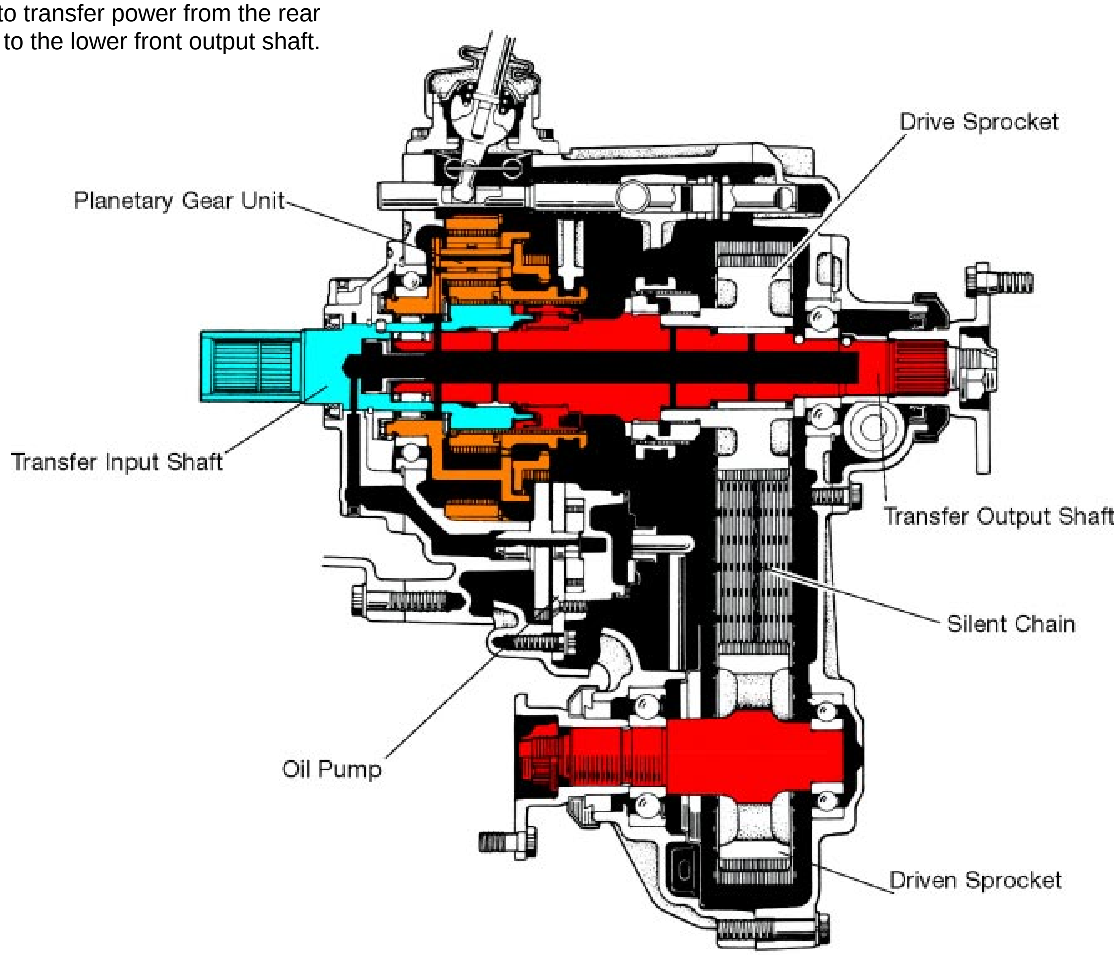


Fig. 5-4
T302f504

Planetary Gear Unit

The **planetary gear unit** is constructed in the following manner:

- The transfer input shaft is splined to the planetary sun gear.
- Four planetary pinion gears are fitted to the planetary carrier.
- A planetary spline piece is fitted to the rear of the carrier and internal gear teeth of the spline piece can be engaged with the external teeth of the high and low clutch sleeve.
- The planetary ring gear is fixed to the transfer case and the internal teeth are meshed with the planetary pinion gears.
- The high and low clutch sleeve can be engaged with the splines located on the rear portion of the transfer input shaft.

Planetary Gear Unit Construction

This view identifies the key components. A helical type planetary gear provides gear reduction for low-range operation.

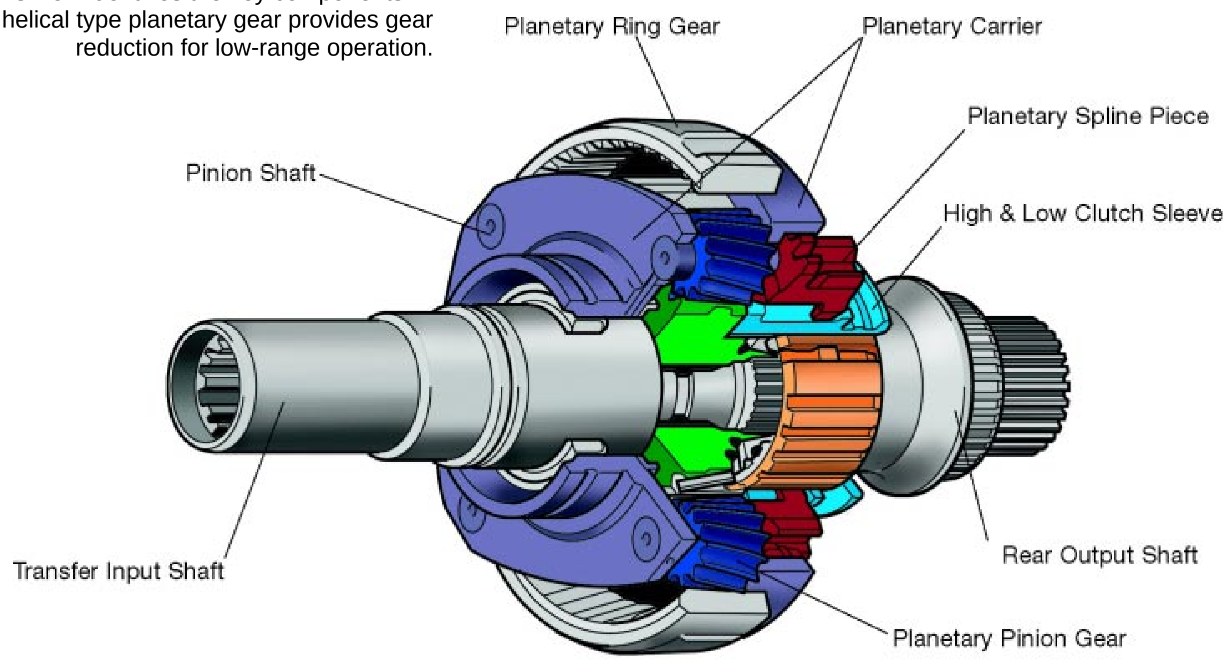


Fig. 5-5
T302f505

Planetary Gear Operation

In transfer case high-range operation, the input shaft drives the high and low clutch sleeve (in high position), which in turn, drives the output shaft.

Planetary Gear Operation

In transfer case low-range operation, the input shaft drives the sun gear, the ring gear is fixed to the case, and the planetary carrier drives the rear output shaft.

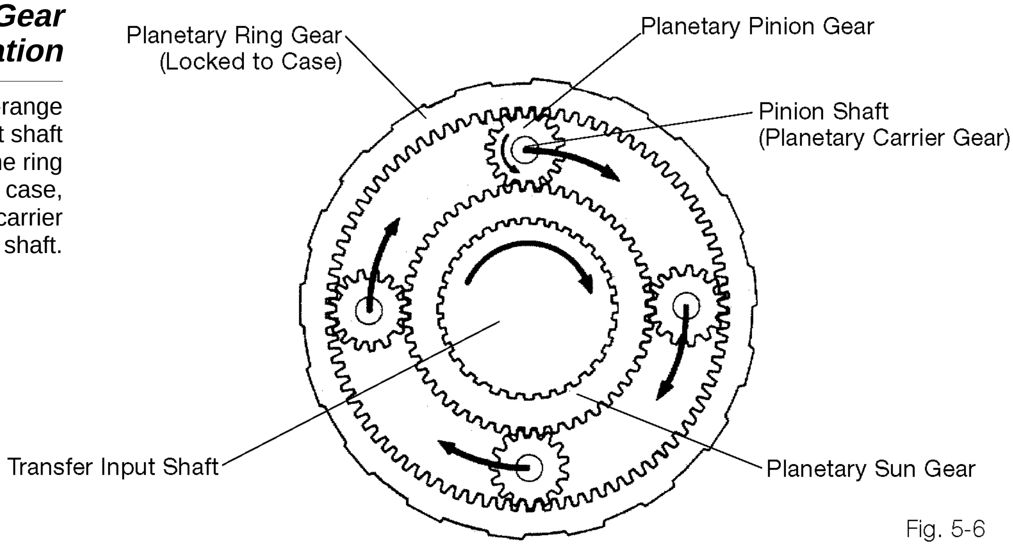


Fig. 5-6
T302f506

In transfer case low-range operation, the input shaft drives the sun gear, which with the planetary ring gear locked to the transfer case, drives the planetary pinion gears and planetary carrier gear. The planetary carrier gear then drives the output shaft.

Gear reduction is attained when power flows from the input shaft, turning the sun gear; the sun gear drives the planetary pinion gears, which rotate in the opposite direction around the ring gear. As the pinion gears "walk" around the ring gear, they rotate the planetary carrier at a slower speed than the input shaft, providing gear reduction. Gear reduction (as demonstrated in figure 5-7) is achieved when the pinion gears rotate the carrier 1/3 revolution for each revolution of the sun gear.

Gear Reduction

One rotation of the input shaft moves the planetary carrier about one-third revolution, resulting in gear reduction.

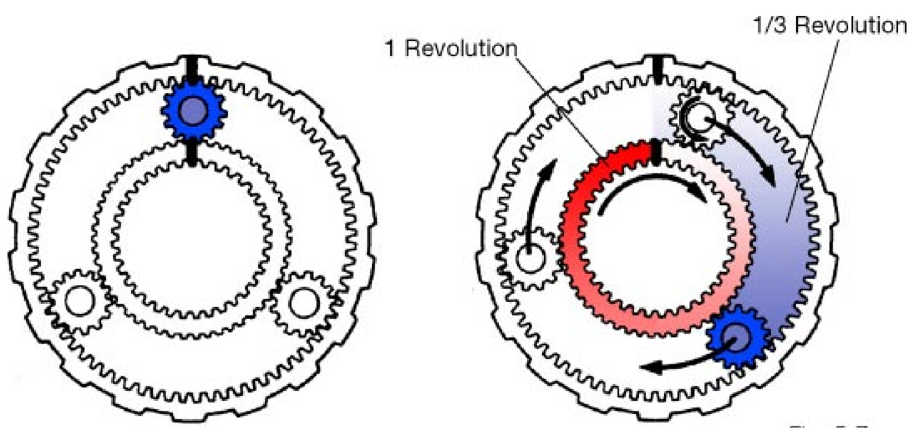


Fig. 5-7
T302f507

Planetary Gear Unit Powerflow

The high and low clutch sleeve is used to engage the planetary gear set to provide gear reduction for low speed, and to connect the input shaft to the output shaft for high speed operation.

H2 and H4 Position

In the high position (H2 or H4), the clutch sleeve locks the input shaft to the rear output shaft. The high and low clutch sleeve slides over the splines of the high and low clutch hub. As it moves to the left its internal splines engage the input shaft splines and locks the input shaft to the output shaft.

H2 and H4 Position

In the high position, the engine power is transmitted directly from the transfer input shaft to the rear output shaft.

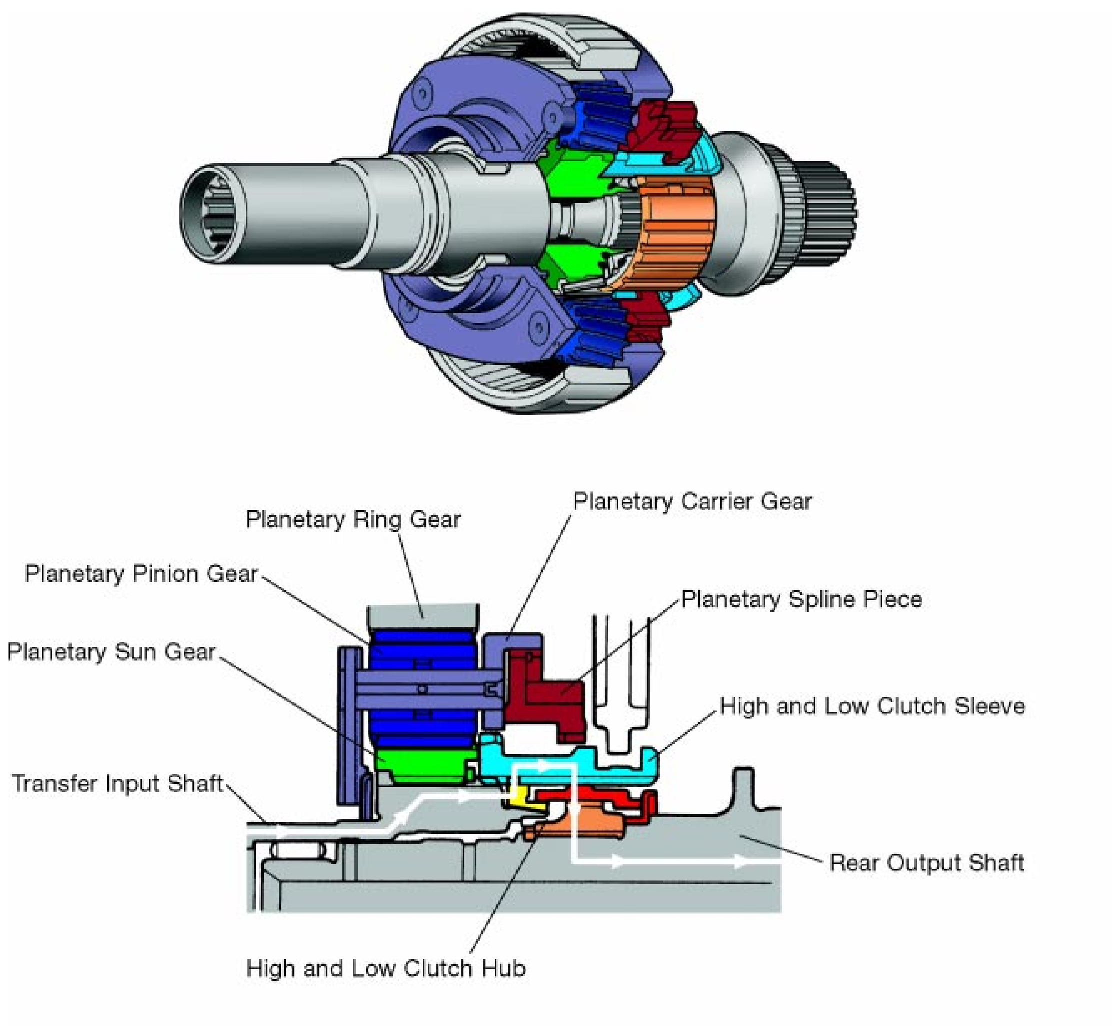


Fig. 5-8
T302f508

L4 Position In the L4 position, the engine power is transmitted from the input shaft to the output shaft through the planetary gear unit. The high and low clutch sleeve moves to the right and is now engaged with the planetary spline piece and the planetary carrier. The sun gear drives the pinion gears and causes the carrier to rotate at a slower speed. Gear reduction occurs at this time, causing the output shaft to rotate at a slower speed than the input shaft.

L4 Position

In this position, the engine power is transmitted from the input shaft to the output shaft, through the planetary gear unit.

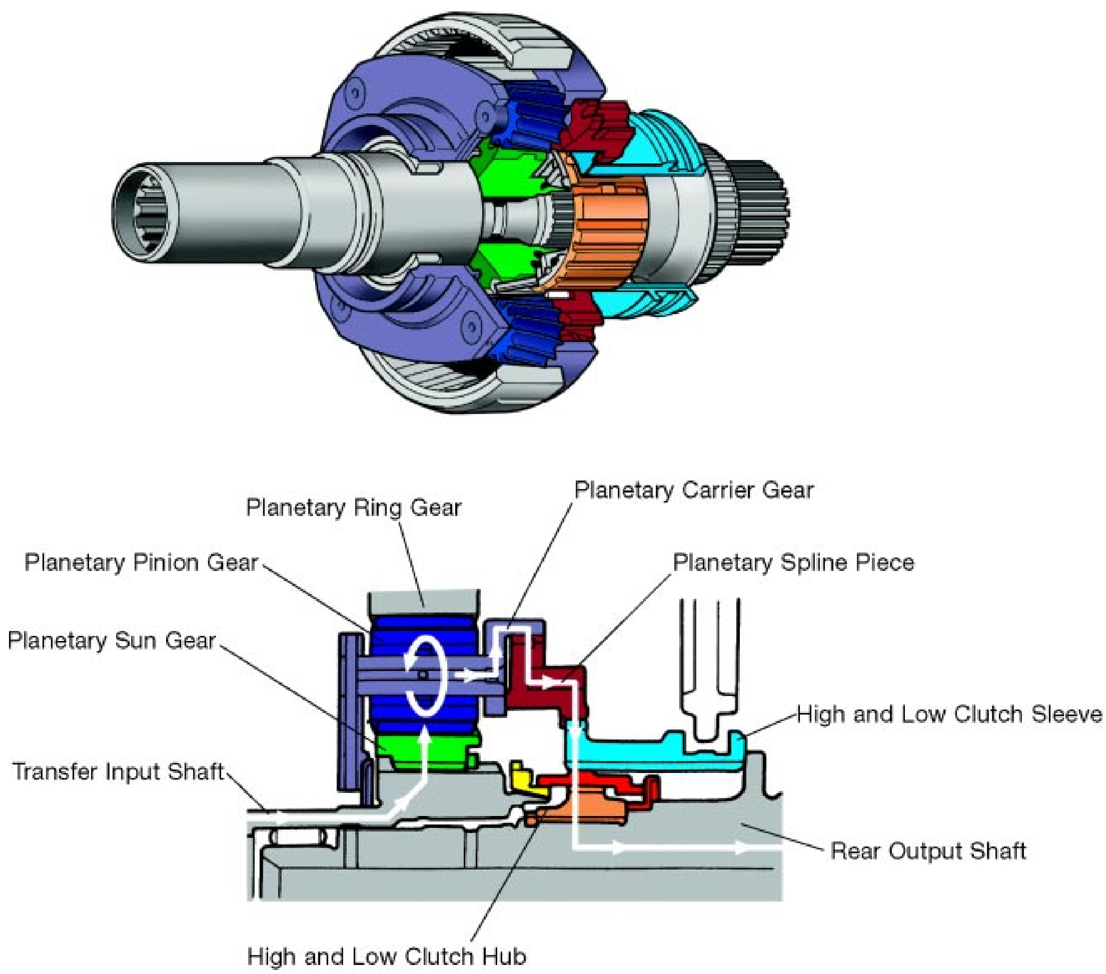


Fig. 5-9
T302f509

Synchro Mechanism

The **synchro mechanism** permits smooth shifting from L4 to H4 even while the vehicle is moving. The clutch pedal must be depressed when shifting the lever from L4 to the H4 position.

Synchro Mechanism

The synchro mechanism permits smooth shifting from L4 to H4 even while the vehicle is moving.

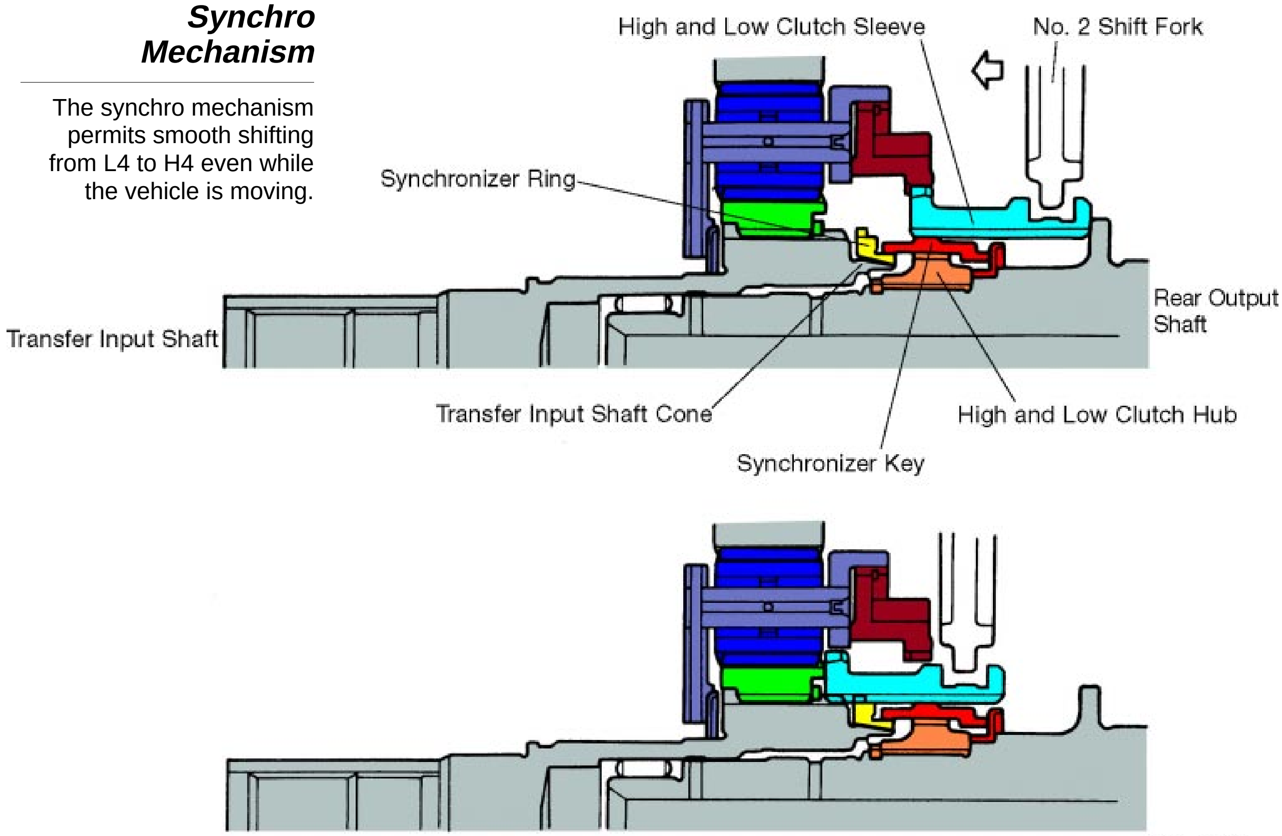


Fig. 5-10
T302f510

Operation

When the transfer shift lever is shifted from the L4 to the H4 position, the No. 2 shift fork moves to the left. The high and low clutch sleeve also moves to the left, causing the key to push the synchronizer ring against the cone at the rear of the transfer input shaft, causing synchronization.

While moving in L4, the speed of the input shaft is faster than the output shaft due to the action of the planetary gear unit. When the transfer is shifted to the H4 position, the synchro mechanism slows the input shaft and both shafts rotate at the same speed. The high and low clutch sleeve moves to engage the input shaft.

Since no synchro mechanism is provided for shifting from H4 into L4, the vehicle must be stopped for this shift to occur without gear noise. Even when the vehicle speed is 5 mph (8 km/h) or lower, gear noise will be generated when shifting to L4, so it is advised that the vehicle is stopped before making the shift.

Center Differential

All-wheel-drive (AWD) vehicles incorporate a differential between the front and the rear drive axles, because the front wheels travel a different distance through a turn than the rear wheels.

Center Differential

All-wheel-drive vehicles need a differential between the front and rear axles, as well as one on each axle between each of the wheels.

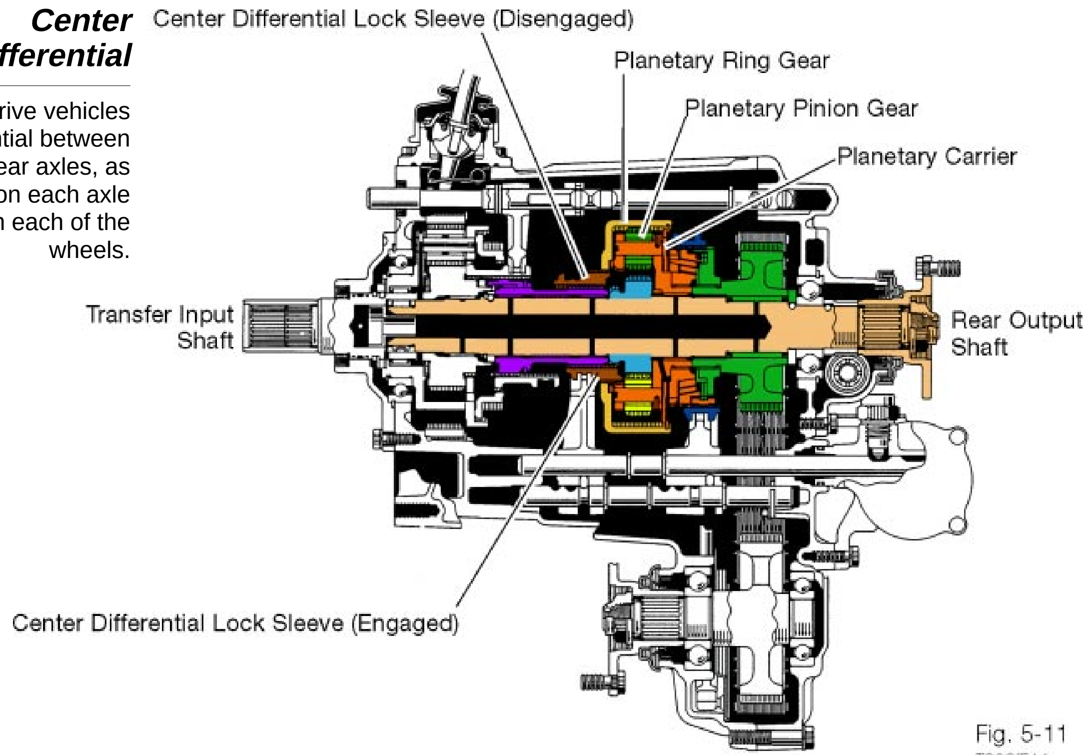


Fig. 5-11
T302f511

Center Differential Construction

The double pinion planetary gear type center differential consists of a planetary ring gear, a planetary sun gear, a planetary carrier and three pairs of planetary pinion gears.

Center Differential Construction

The double pinion planetary gear type center differential consists of a planetary ring gear, a planetary sun gear, a planetary carrier and six planetary pinion gears.

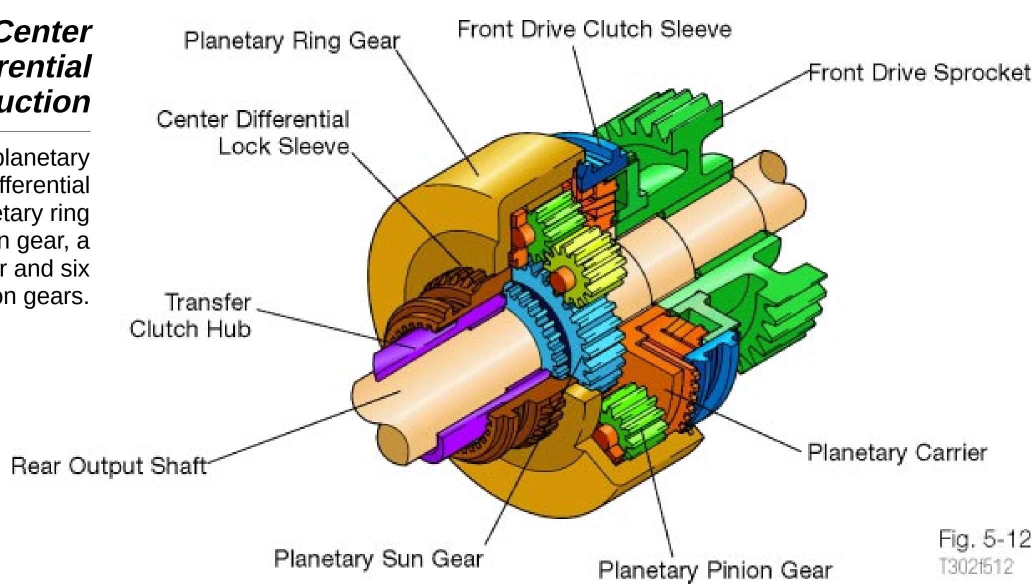


Fig. 5-12
T302f512

Three sets of planetary pinion gears, which are meshed in pairs are enclosed in the planetary carrier. The outer planetary pinion gear is meshed with the planetary ring gear and the inner gear is meshed with the planetary sun gear of the rear output shaft.

The drive force from the transfer clutch hub is transmitted to the planetary ring gear via the center differential lock sleeve. The planetary carrier transmits the drive force to the front wheels and the planetary sun gear transmits the drive force to the rear wheels.

Additionally, a center differential lock mechanism is provided in the front of the center differential.

Center Differential Operation

The **center differential** uses planetary gears to distribute power between the front and rear axles.

Free Mode - Vehicle Travelling in a Straight Line

When the vehicle is moving in a straight line, there is practically no speed difference between the front and rear wheels. In this case, the transfer clutch hub, front drive sprocket and rear output shaft rotate at the same speed with the center differential. The driving force from the transfer clutch hub is transmitted to the front and rear wheels through the planetary ring gear to the planetary pinion carrier and planetary sun gear.

Free Mode - Vehicle Traveling in Straight Line

The driving force from the transfer clutch hub is transmitted to the front and rear wheels from the planetary pinion carrier and planetary sun gear.

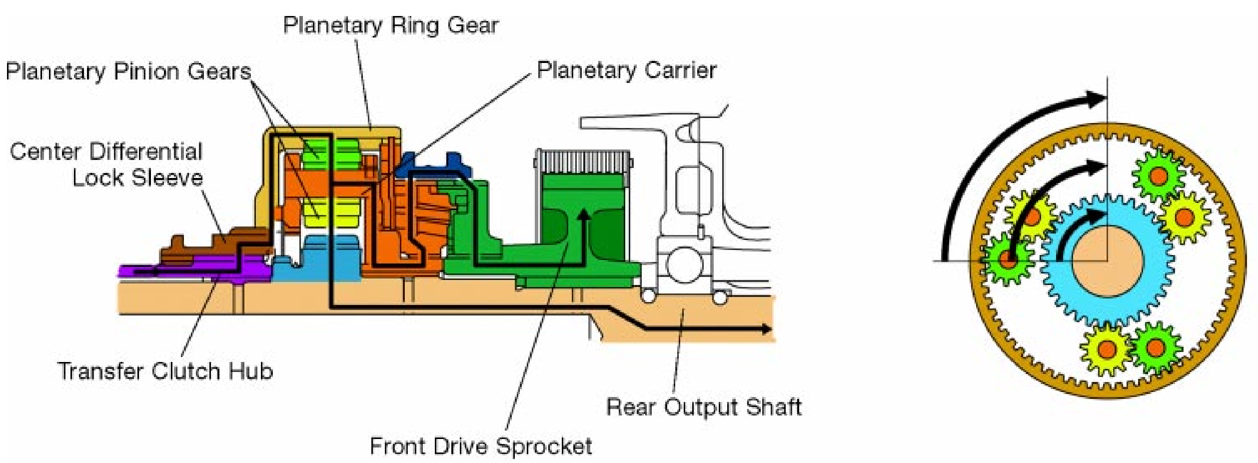


Fig. 5-13
T302f513

Free Mode - Vehicle Turning

If a speed difference is generated between the front and rear wheels because of a turn, the planetary pinion gears of the center differential rotate and absorb the speed difference. As a result, the planetary carrier rotates faster, but in the same direction as the planetary ring gear. This causes the outer pinion gear to rotate in the opposite direction while revolving around the ring gear in the same direction. The inner pinion gear rotates in the same direction as the ring gear and the rotation of the rear output shaft becomes slower than the drive sprocket by the amount of the rotating pinion gear.

Free Mode - Vehicle Turning

If a speed difference is generated between the front and rear wheels because of a turn, the planetary pinion of the center differential rotates and absorbs the speed difference.

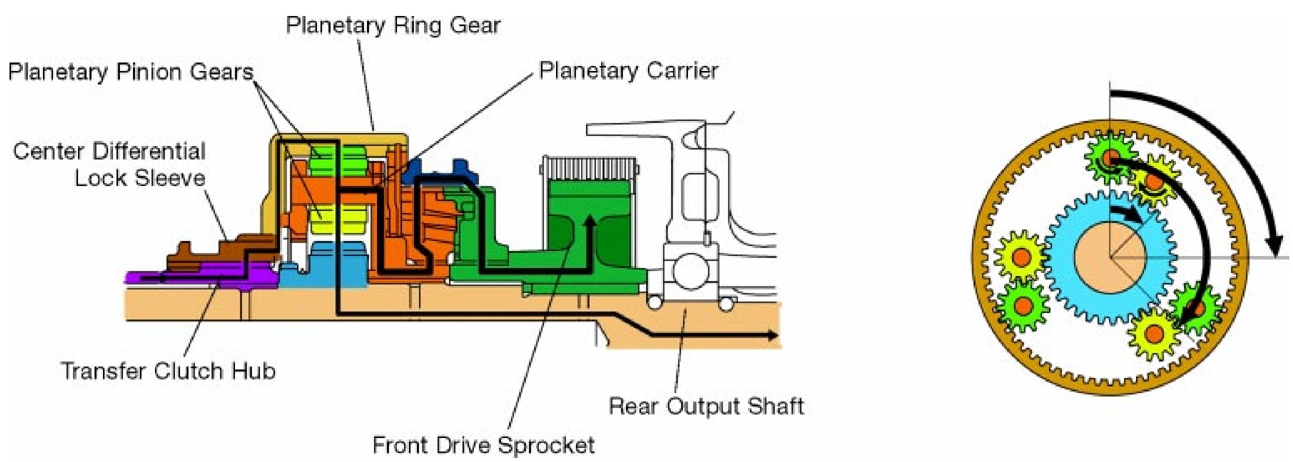


Fig. 5-14
T302f514

Lock Mode

The center differential, much like the front and rear differentials in the axles, is an open differential distributing torque to the axle with the least traction. When in four-wheel drive mode, if one wheel is suspended or lost it's traction, all the torque is sent to axle of the wheel with the least traction and the vehicle is stuck. By locking the center differential, torque is distributed to each propeller shaft equally, just like a part time or conventional transfer case, and the wheels on the opposite axle will move the vehicle.

The center differential lock sleeve moves to the right, enabling the inner teeth of the center differential lock sleeve to mesh with the rear output shaft. As a result, the center differential stops operating and is locked.

Lock Mode

The center differential lock sleeve locks the ring gear to the sun gear driving the front and rear axles equally.

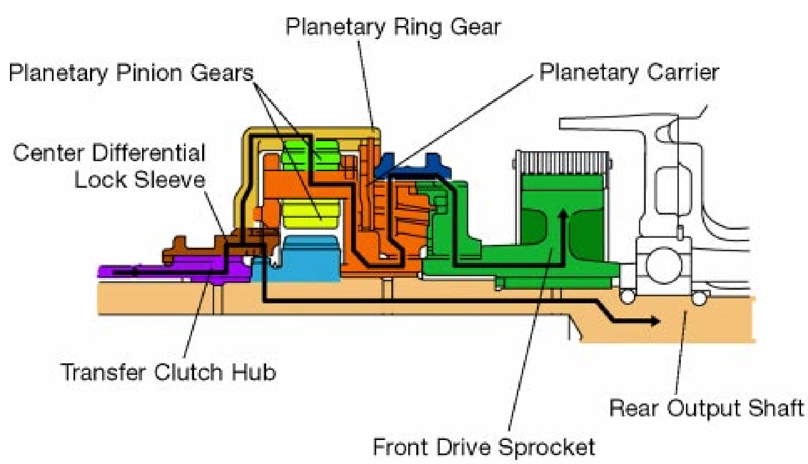


Fig. 5-15
T302f515

NOTE AWD vehicles should have four equal diameter tires, since unequal diameters create dissimilar axle speeds. Dissimilar axle speeds cause increased wear at the drive axle and/or center differential.

Torsen Limited Slip Differential

The Torsen Limited Slip Center Differential (LSD) is installed in the full-time and multi-mode electric shift transfer case found in the 2003 and later 4Runner. The Torsen LSD cannot be disassembled and is replaced as an assembly. As with the multi-mode center differential, it has a planetary gear set constructed of a sun gear, a ring gear and planetary gears connected to a planetary carrier. Additional components include four clutch plates that assist the distribution of torque to the wheels with traction. The unit instantly applies the clutches to distribute torque and compensate for differences in front wheel speed to rear wheel speed.

Torsen Limited Slip Differential

The Torsen LSD has a planetary gear set made up of a sun gear, ring gear, planetary gears and a planetary carrier.

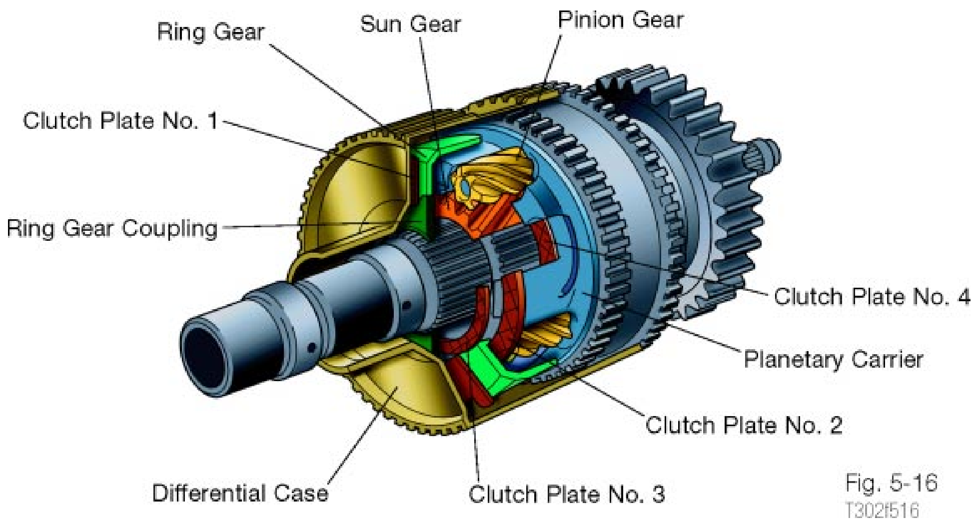


Fig. 5-16
T302f516

The differential case is driven by the high and low clutch sleeve that engages the planetary gear set. Depending on the high/low clutch sleeve, it will drive the differential case in high gear or low gear. The differential case drives the planetary carrier and eight pinion gears. These pinion gears are helically cut and drive the ring gear and sun gear that are connected to the two drive shafts. The sun gear is connected to the front output shaft and the ring gear is connected to the rear output shaft. When the vehicle is driven in a straight line the pinions do not rotate within the carrier and torque is transmitted equally to each drive shaft.

Operation

The differential case drives the planetary carrier and eight pinion gears that drive the ring gear and sun gear

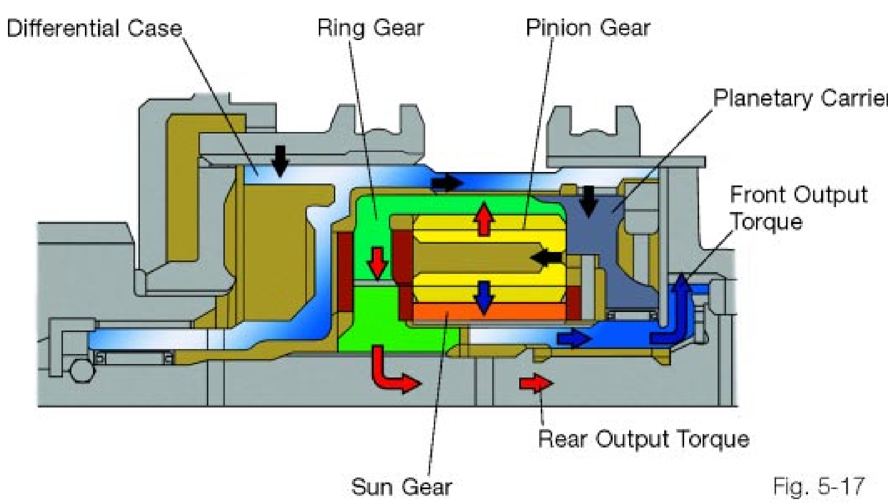


Fig. 5-17
T302f517

When turning corners without wheel slippage, the pinion gears rotate to distribute the torque proportionately according to the speed of the drive shafts. When the front drive shaft exceeds the speed of the rear drive shaft, beyond the normal difference that would be experienced while cornering, the sun gear rotates faster than the ring gear. The helical cut of the gears causes the sun gear to be thrust toward clutch plate No. 4 that transfers torque to the planetary carrier and differential case. The pinion gears exert a smaller amount of thrust to the ring gear pushing against clutch plate No. 1 and the differential case. Additional torque is exerted through clutch plate No. 1 to the ring gear and to the rear drive shaft.

Front Wheel Slippage

When the front drive shaft spins faster than the Rear drive shaft, the sun gear and ring gear create thrust that transfers torque to the axle with traction.

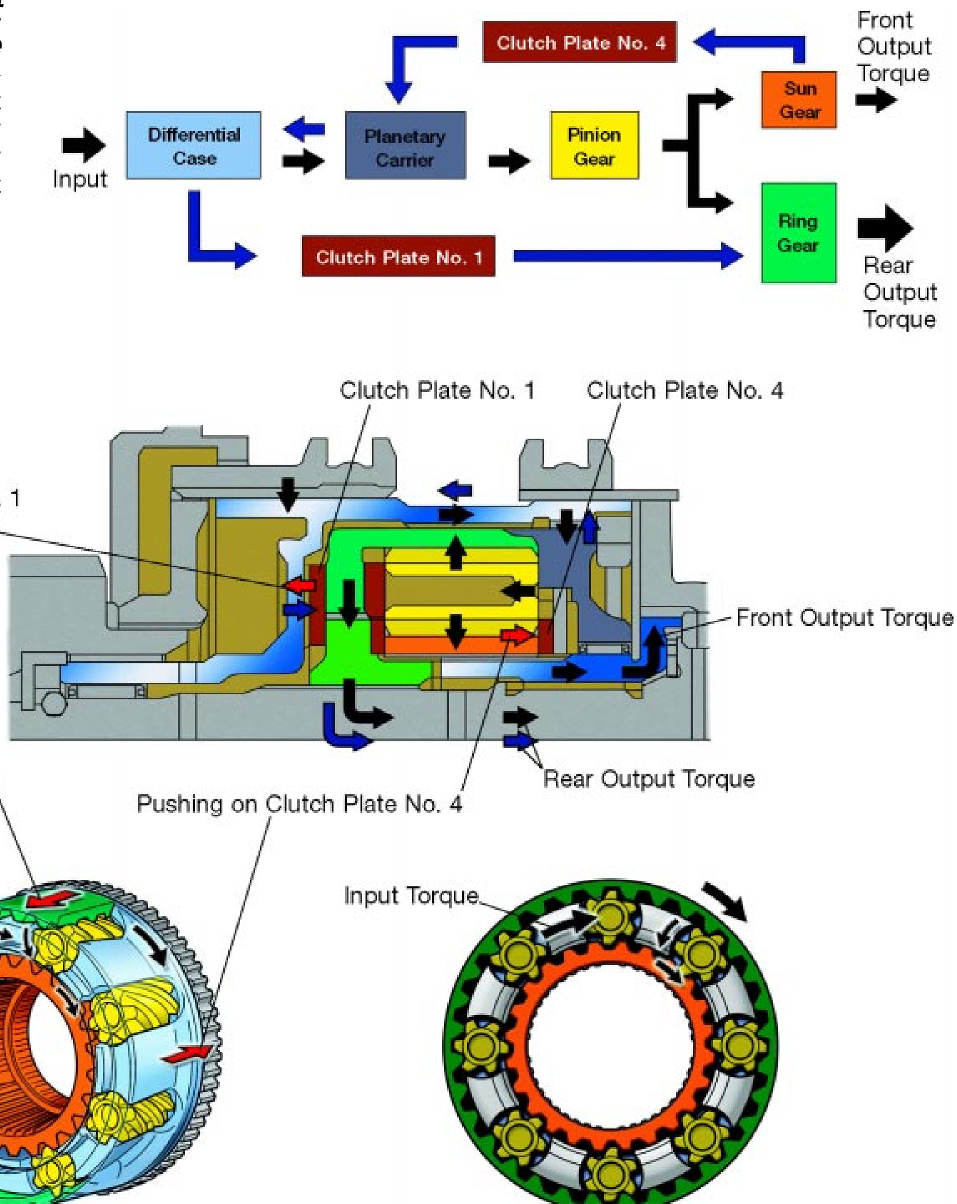


Fig. 5-18
T302f518

Similarly, when the rear drive shaft speed exceeds the speed of the front shaft, the ring gear creates the larger amount of thrust against clutch plate No.1 and the differential case and carrier drive the sun gear through clutch plate No.4 and provides added torque to the front drive shaft.

Shift Mechanism

The **shift mechanism** is used to provide a smooth engagement for shifting from H2 to H4 and L4 ranges. It features:

- A direct control type transfer shift lever that controls two shift fork shafts.
- A shift shaft interlock mechanism used to ensure that low range is only selected when in four-wheel drive.
- Detents are used to provide shift feel.
- A wait mechanism is used for shifting from H4 to H2.

Shift Mechanism

The shift mechanism provides for a smooth engagement for shifting from H2 to L4 and H4 ranges.

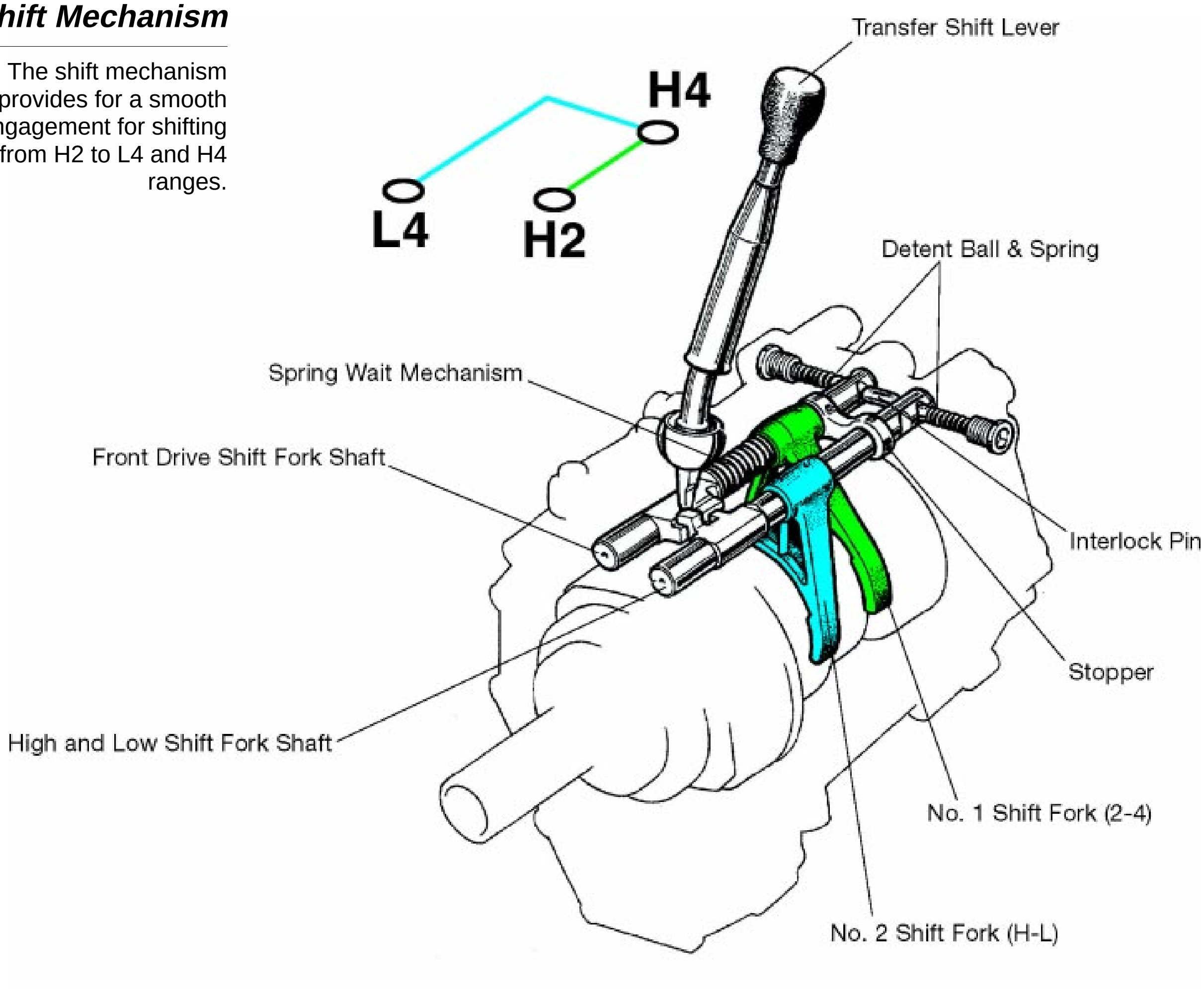


Fig. 5-19
T302f519

Shifting from H2 into H4 Position

In the H2 position, low gear is locked out by the interlock pin between the high and low shift fork shaft and the front drive shift fork shaft. When shifting from H2 to H4, the front drive clutch sleeve moves to the left to couple the output shaft to the drive sprocket and silent chain that drives the front propeller shaft.

Shifting from H2 into H4 Position

When shifting from H2 to H4, the front drive clutch sleeve moves to the left to couple the output shaft to the drive sprocket for the silent chain that drives the front propeller shaft.

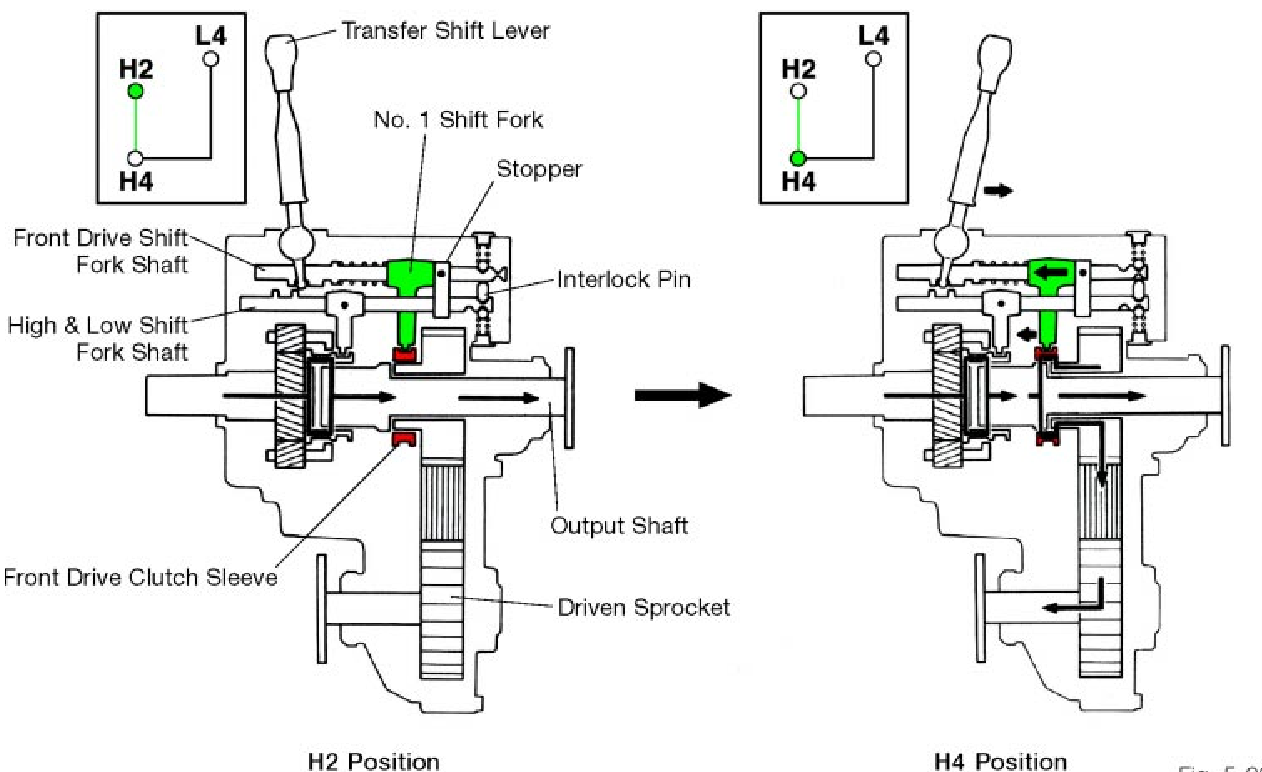


Fig. 5-20
T302f520

Shifting from H4 into L4 Position

In the H4 position, the interlock pin allows the high and low shift fork shaft to move from the high position to the low position. When the high and low shift fork shaft is moved to the right, the interlock pin moves up into the groove of the high and low shift fork shaft, engaging L4.

Shifting from H4 into L4 Position

In the H4 position, the interlock pin allows the high and low shift fork shaft to move from the high position to the low position.

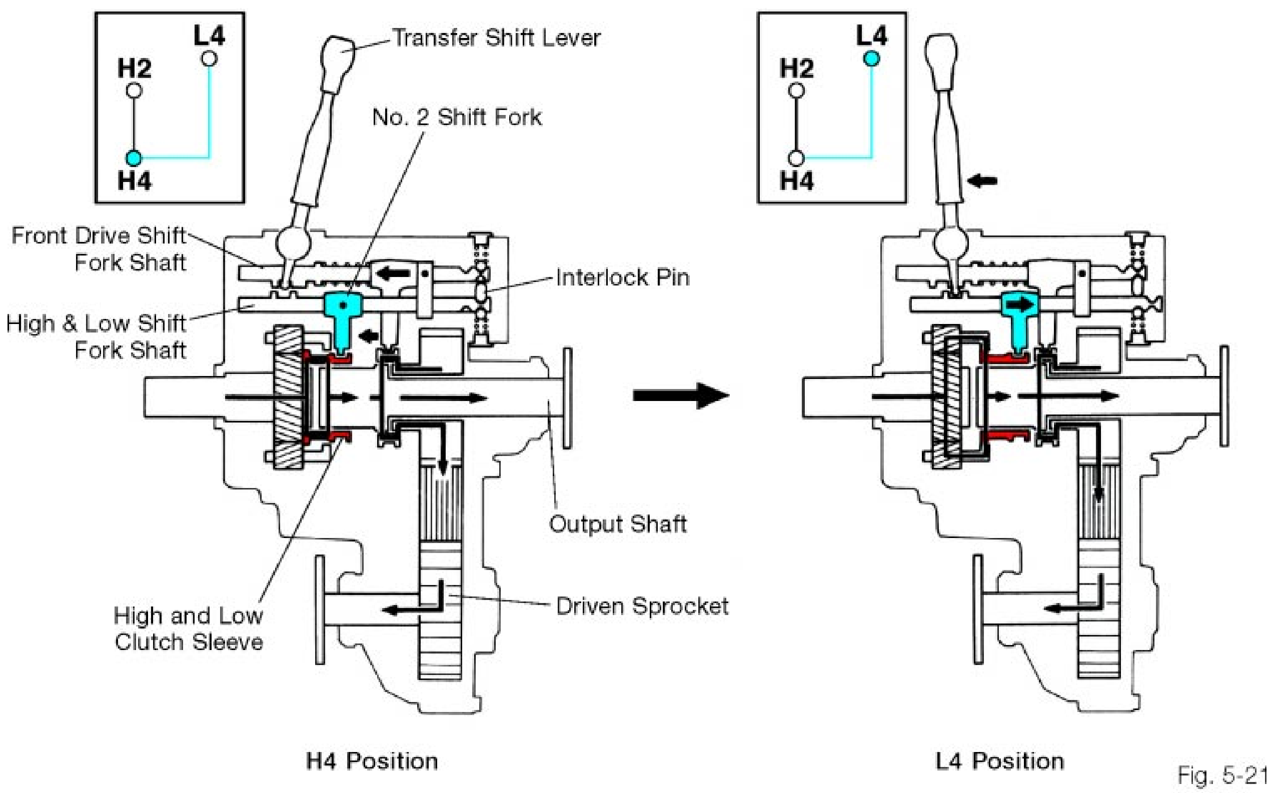


Fig. 5-21
T302f521

Wait Mechanism

The **wait mechanism** is used for shifting from H4 into H2 position. When the front drive shift fork shaft moves to the right, the front drive shift fork will not move until the torque is removed from the front drive clutch sleeve. The compression spring pushes against the front drive shift fork No. 1. When torque is removed, front drive shift fork No. 1 and sleeve are pushed to the right by the spring force. The transfer case is now in H2 position.

Shifting from H4 into H2 Position

The wait mechanism is used for shifting from H4 into H2 position.

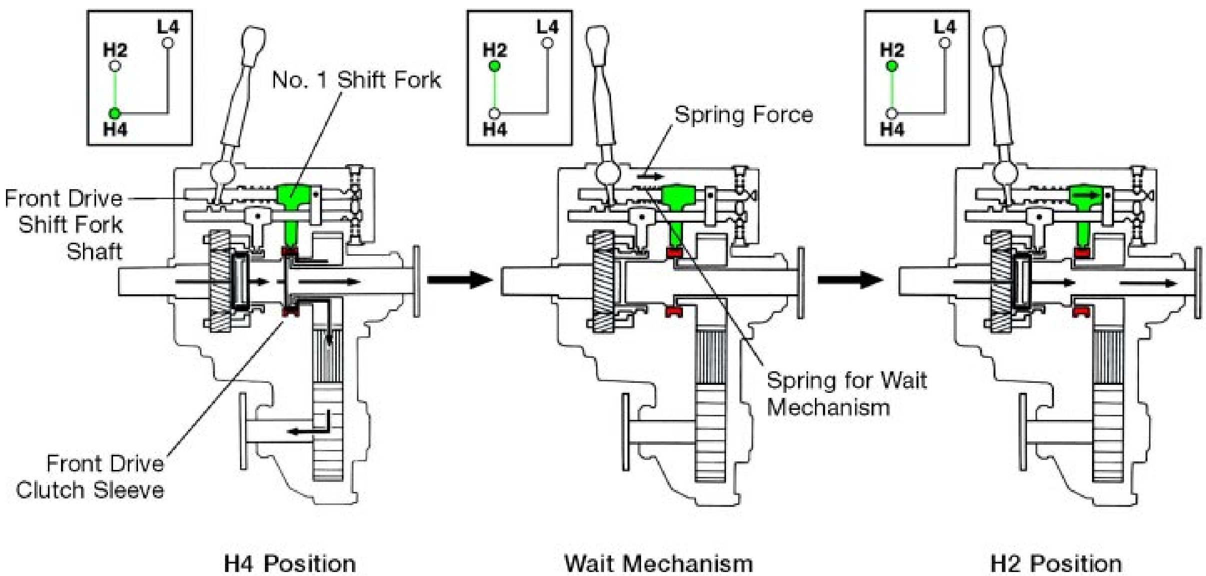


Fig. 5-22
T302f522

Electric Shift Control

Electrical control of the transfer case functions is accomplished by means of a transfer shift actuator controlled by the 4WD control ECU. The ECU relies on input from the driver operated 2-4 switch and high-low switch or in some cases the differential lock switch. The ECU receives input from sensors– the 4WD and L4 position switches– that monitor transfer case shift shaft position to determine engagement. The ECU then engages the A.D.D (This topic is handled separately later in this section). actuator to lock the front differential. In addition, the ECU controls indicator lights mounted in the combination meter to indicate when H4 or L4 are engaged or, depending on the vehicle, when the locking differential is engaged. The indicator light on the switch will flash while this electric shift control is happening. This sequence of events is shown in figure 5-20.

Electric Shift ECU Control

Electric ECU control of the 4WD system follows a specific sequence of events from the time the switch is activated to the time the indicator light illuminates.

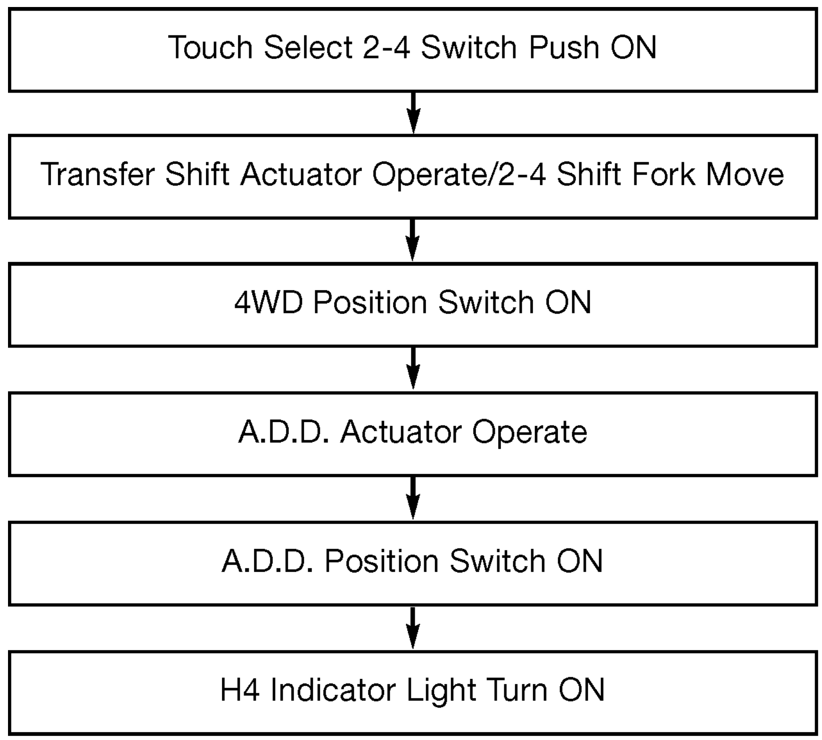


Fig. 5-23

Electric Shift Control

Electrical control of the transfer case functions is accomplished by means of a Transfer Shift Actuator controlled by the 4WD Control ECU.

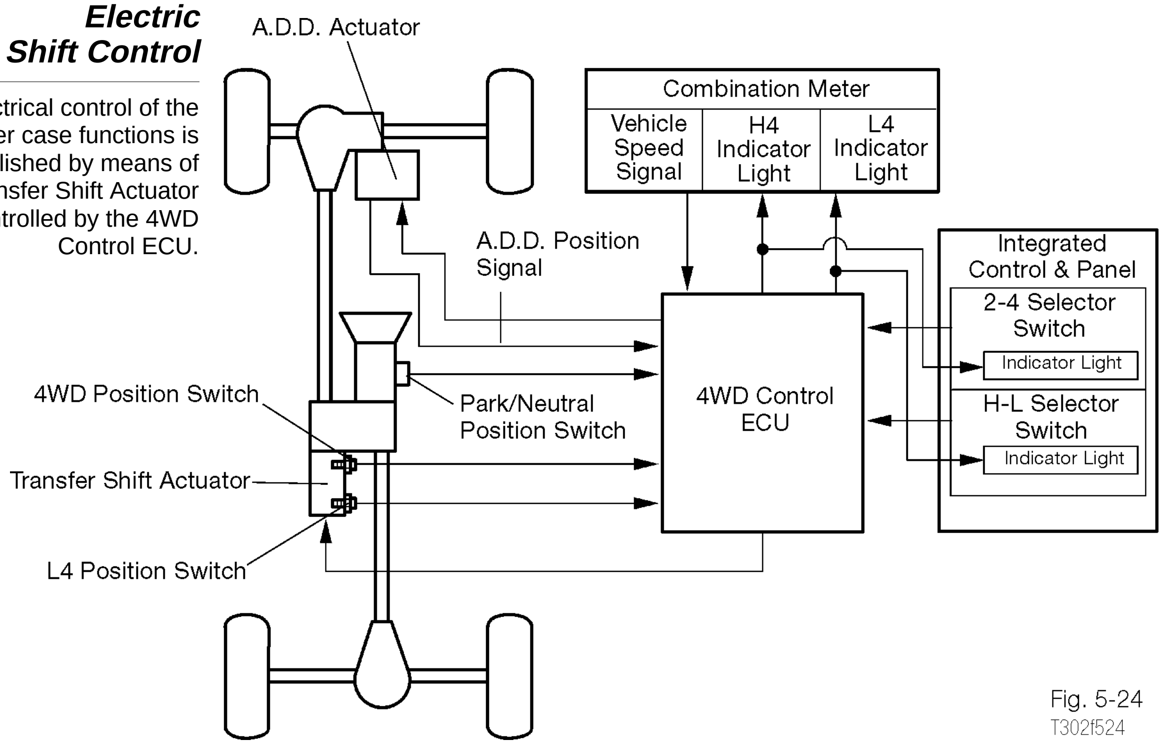


Fig. 5-24
T302f524

Transfer Shift Actuator

The **transfer shift actuator** consists of an electrical motor driven screw gear that turns the driven gear and contact plate. The limit switches maintain contact with the contact plate, providing a position signal to ECU. Open gaps in the plate cause the motor circuit to open at precisely the right time in the driven gear's rotation to stop shift shaft movement. For this reason the actuator should never be removed without the shift shaft as the entire assembly is timed to the contact plate.

The driven gear turns the shaft and final gear that causes the transfer shift shaft and shift fork to move back and forth in the transfer case. A spring loaded wait mechanism separates the driven gear from the final gear so that during a shift from 4WD to 2WD, when tension at the 2WD/4WD clutch sleeve is released, it can move the clutch sleeve and release the front drive shaft.

Transfer Shift Actuator

The transfer shift actuator consists of an electrical motor driven screw gear that turns the driven gear and contact plate.

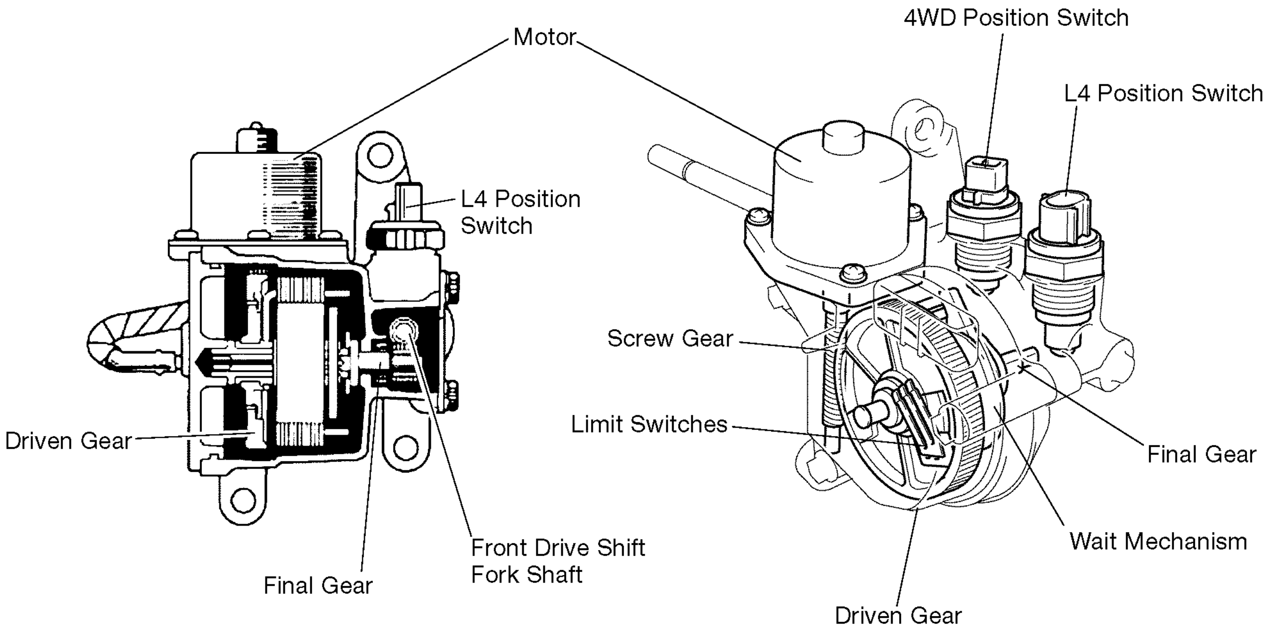


Fig. 5-25
T302f525

Motor Control Circuit

The ECU controls the motor and monitors its position with the limit switches. When selecting H4 from H2 or L4 from H4, the 4WD Control ECU switches current to flow to actuator terminal 1 through the motor to terminal 2.

The monitoring path to ground in a H4 from H2 shift is through ECU terminal TL3 to actuator terminal 5 and the H2 contact plate through the sliding limit switch to terminal 4 and ground. When the sliding contact reaches the open gap at the H4 position shown in the illustration, the ground circuit is opened and the ECU shuts down the motor.

The monitoring path to ground in a L4 from H4 shift is through ECU terminal TL2 to actuator terminal 6 and the H4 contact plate through the sliding limit switch to terminal 4 and ground. When the sliding contact reaches the open gap at the L4 position shown in the illustration, the ground circuit is opened and the ECU shuts down the motor.

When selecting H4 from L4 or H2 from H4, the 4WD Control ECU switches current to flow to actuator terminal 2 through the motor to terminal 1 causing the motor to turn in the opposite direction which causes the shift shaft to move in the opposite direction also.

The monitoring path to ground in a H4 from L4 shift is through ECU terminal TL1 to actuator terminal 3 and the L4 contact plate through the sliding limit switch to terminal 4 and ground. When the sliding contact reaches the open gap at the H4 position shown in the illustration, the ground circuit is opened and the ECU shuts down the motor.

Transfer Shift Actuator Electric Motor Circuit

The ECU controls the motor and monitors its position with the limit switches.

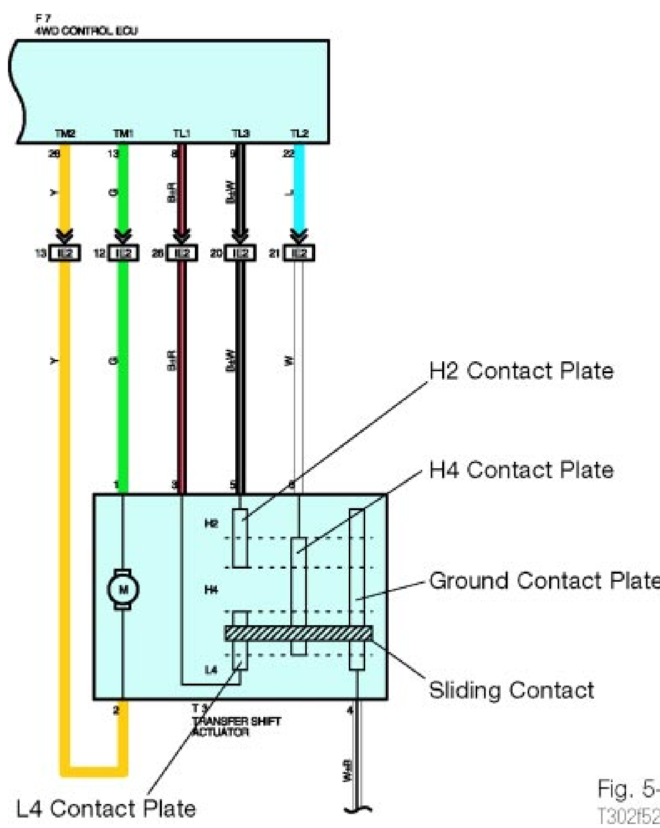


Fig. 5-26
T302f526

Position Switches

The 4WD and L4 position switches monitor the shift shaft position and can be mounted to the transfer case or to the actuator body. These switches are normally open and when the shift shaft passes by the switch the plunger rises to close the switch, notifying the ECU of the transfer shift position. The ECU uses this input to activate the A.D.D. actuator on the front differential.

Position Switches

The 4WD and L4 Position switches monitor the shift shaft position and can be mounted to the transfer case or to the actuator body.

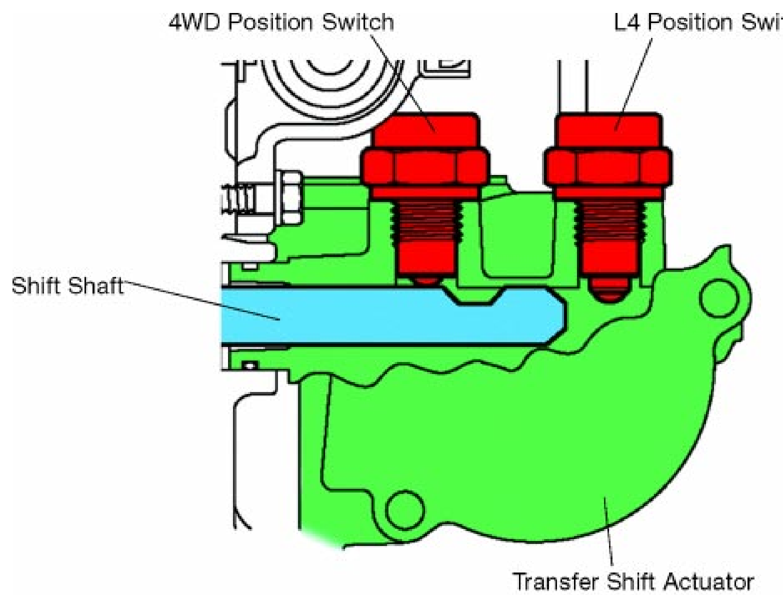


Fig. 5-27
T302f527

Electric Shift Control Types

The transfer case actuator is mounted to the rear of the transfer case. Electric control of the transfer case functions is accomplished in different ways for different types of four wheel drive systems:

- There are two types of electrical control in **part-time** transfer cases:
  - In the first type the high and low synchronizer assembly is engaged and disengaged using a floor mounted shift lever and the 2WD/4WD synchronizer assembly is engaged by a single electrical motor transfer shift actuator.
  - In the second type– fully electric control transfer cases– the high/low shift and 2WD/4WD shift is accomplished by a single electrical motor transfer shift actuator.
- In **full-time** transfer cases, there are two electrical motors to control the transfer case; the high and low synchronizer assembly and another dedicated to the center differential lock function.
- In **multi-mode** transfer cases the high and low synchronizer assembly is engaged and disengaged using a floor mounted shift lever and 2WD/4WD and center differential lock are controlled by the transfer shift actuator.

Part Time Electric Shift Operation

The electrical shift control moves a single shift fork shaft to accomplish 2WD/4WD as well as high/low range. It accomplishes this through the use of snap rings and interlock pins that function with a stationary transfer shift fork shaft. When selecting low range 4WD, the transfer has to select 4WD first and then low range is selected similar to manual shift mechanism.

Part-Time Electric Shift Transfer Case

The electrical shift control moves a single shift fork shaft to accomplish 2WD/4WD as well as high/low range.

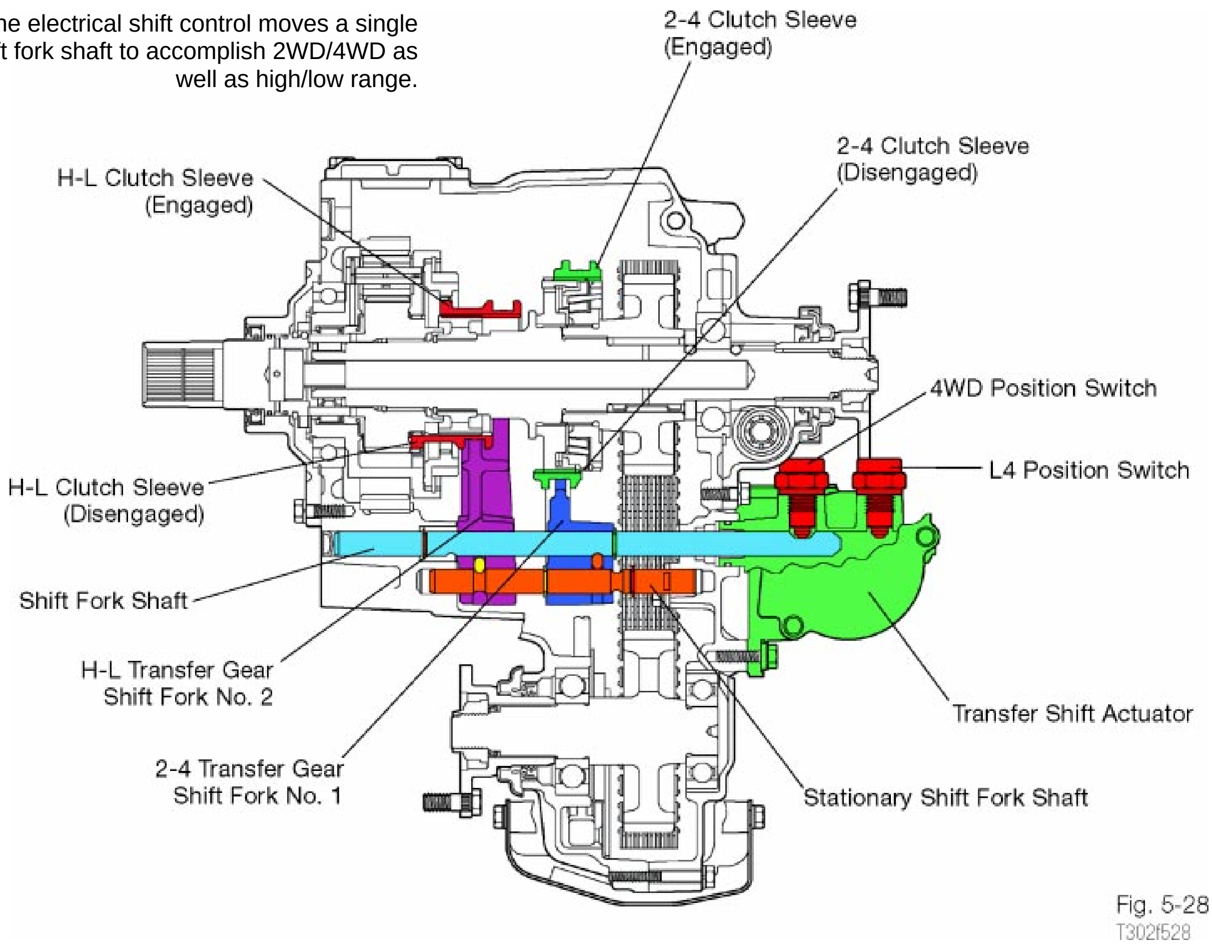


Fig. 5-28

Shifting from H2 to H4

When shifting from H2 to H4, interlock pin A (as shown in figure 5-24) locks the 2-4 shift fork to the shift fork shaft so that when the actuator moves the shift fork shaft to the right, the shift fork moves the synchronizer sleeve to engage 4WD. The shift fork stops when it contacts snap ring C (as shown in figure 5-24) on the stationary shift shaft and the interlock pin drops into the shafts groove.

Shifting from H2 to H4

Interlock pin A locks the 2-4 shift fork to the shift fork shaft so when the actuator moves the shift fork shaft to the right, the shift fork moves the synchronizer sleeve to engage 4WD.

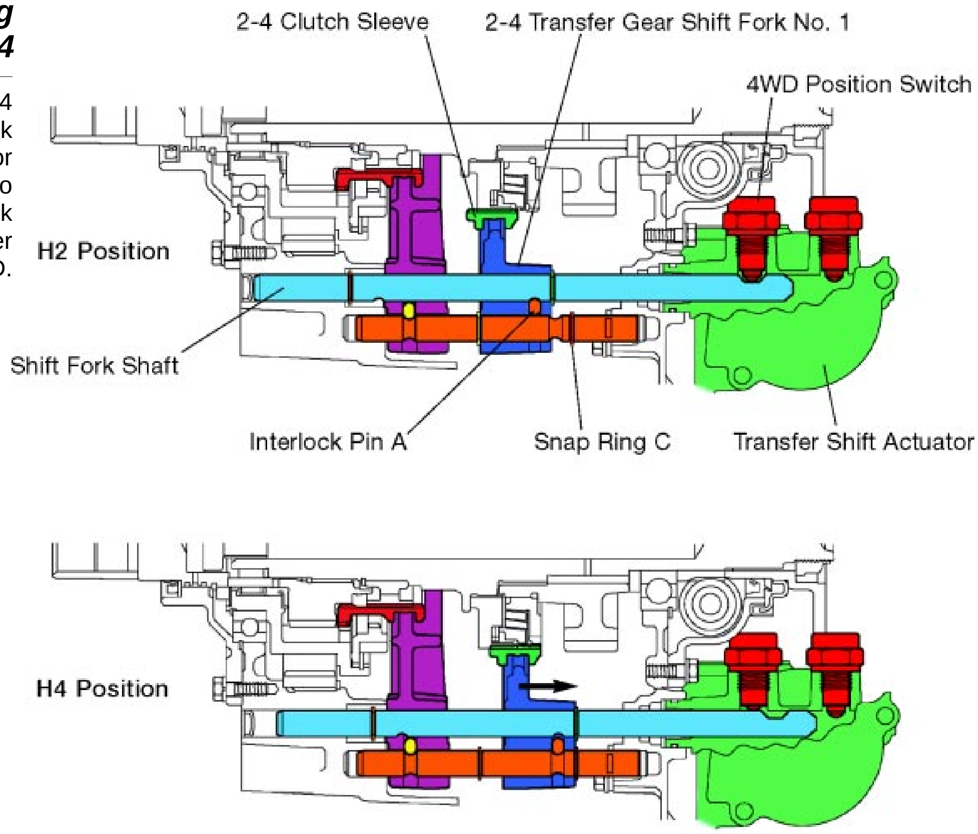


Fig. 5-29
T302f529

Shifting from H4 to L4

When shifting from H4 to L4, the actuator continues to move the shift shaft to the right, and snap ring E pushes the high/low shift fork, forcing interlock pin B into the groove in the shift shaft. (As shown in figure 5-25) The high/low shift sleeve is engaged. Snap ring D on the stationary shift fork shaft limits the high/low shift fork travel.

Shifting from H4 to L4

The actuator continues to move the shift shaft to the right, until the groove in the shift shaft picks up the high/low interlock pin B and moves the high low shift fork to engage the high/low shift sleeve.

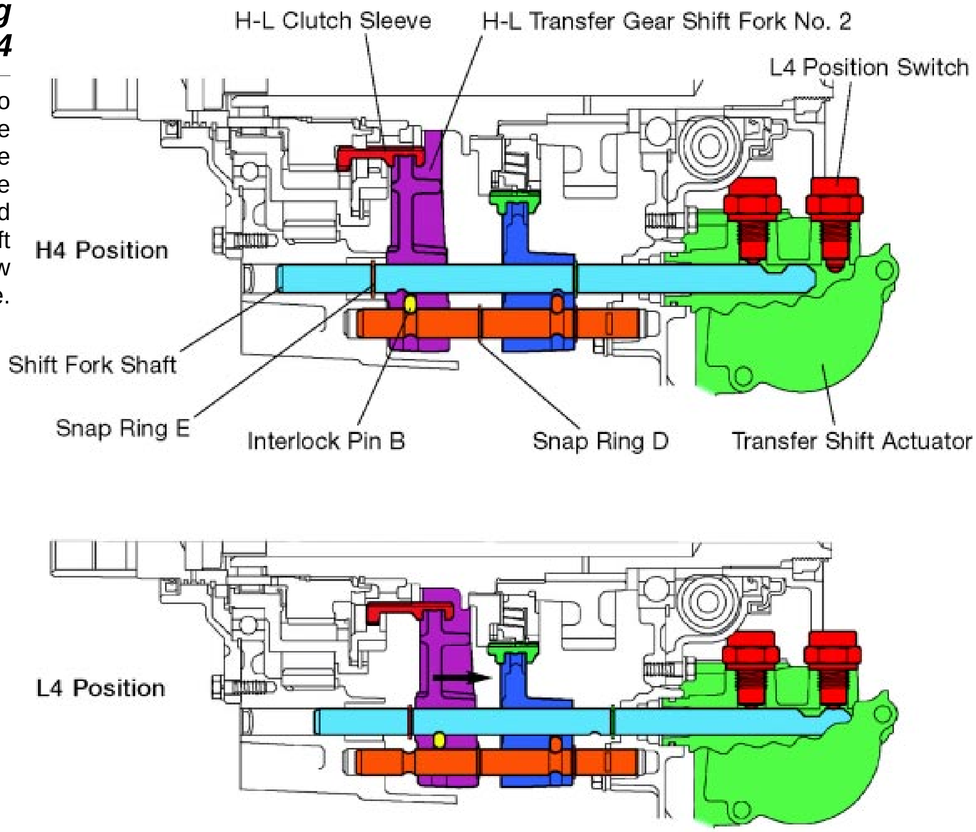


Fig. 5-30
T3021530

Full-Time Electrical Shift Operation

The full time transfer case electrical shift control is accomplished with one transfer shift actuator, housing two separate electrical motors and shift shafts. The motors are controlled by the 4WD control ECU based on the operation of the 4WD Control Switch and the center differential lock switch. The high/low shift motor controls the high/low shift shaft and shift fork. The center differential lock motor controls the center differential lock shift shaft and shift fork. Contact point switches in the actuator limit the travel of the shift forks. The transfer shift actuator is not serviceable and is replaced if found to be faulty.

Full-Time Electrical Shift Transfer Case

The full time transfer case electrical shift control is accomplished with one transfer shift actuator, housing two separate electrical motors and shift shafts.

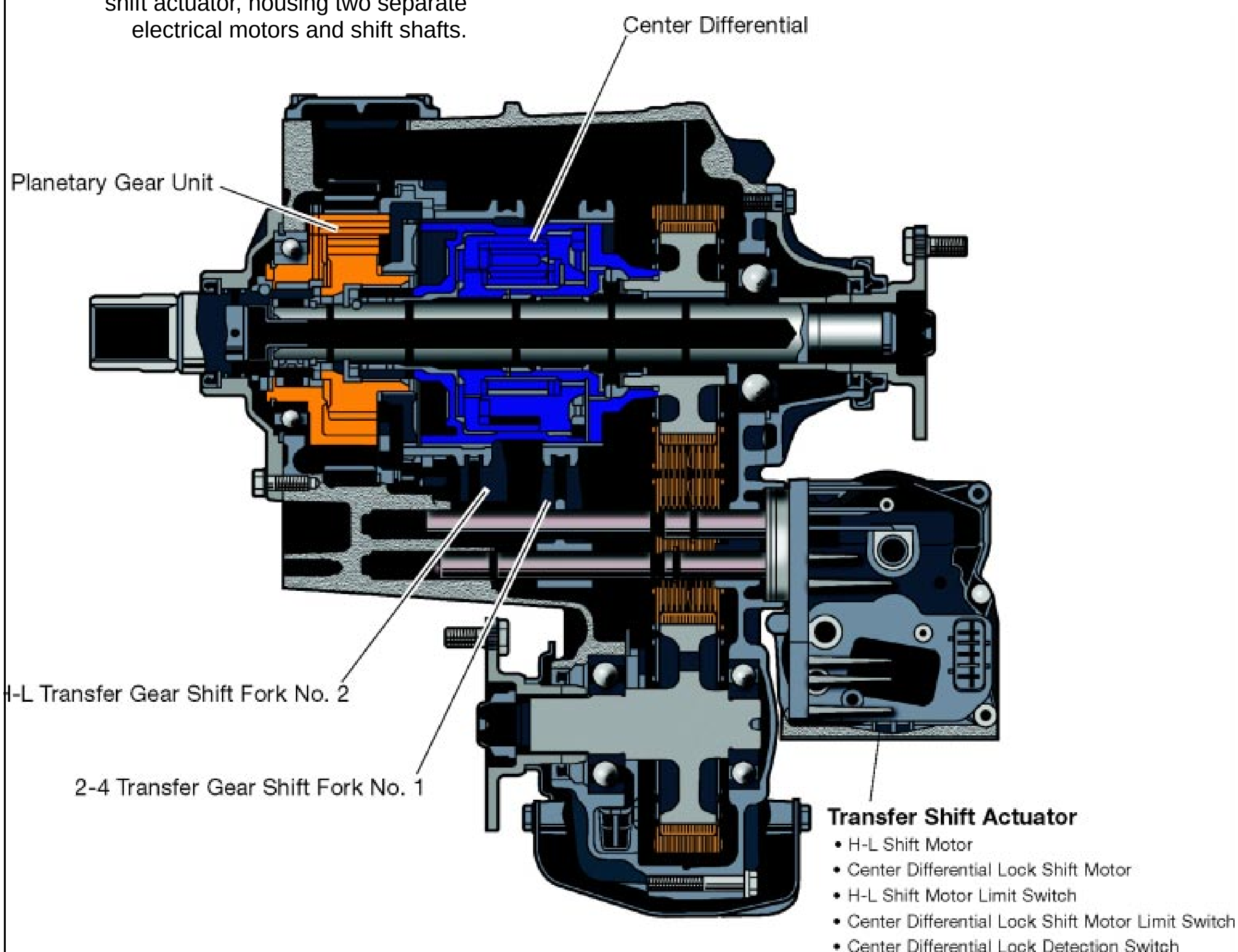


Fig. 5-31
T302f531

Multi-Mode Electrical Shift Operation

In multi-mode shift operation, the function of the actuator, the single shift rail and the interlock pins are the same as the Part-Time system described earlier. But instead of high/low control, the forward shift fork controls the center differential lock.

Multi-Mode Electric Shift Transfer Case

In multi-mode shift operation the forward shift fork controls center the differential lock.

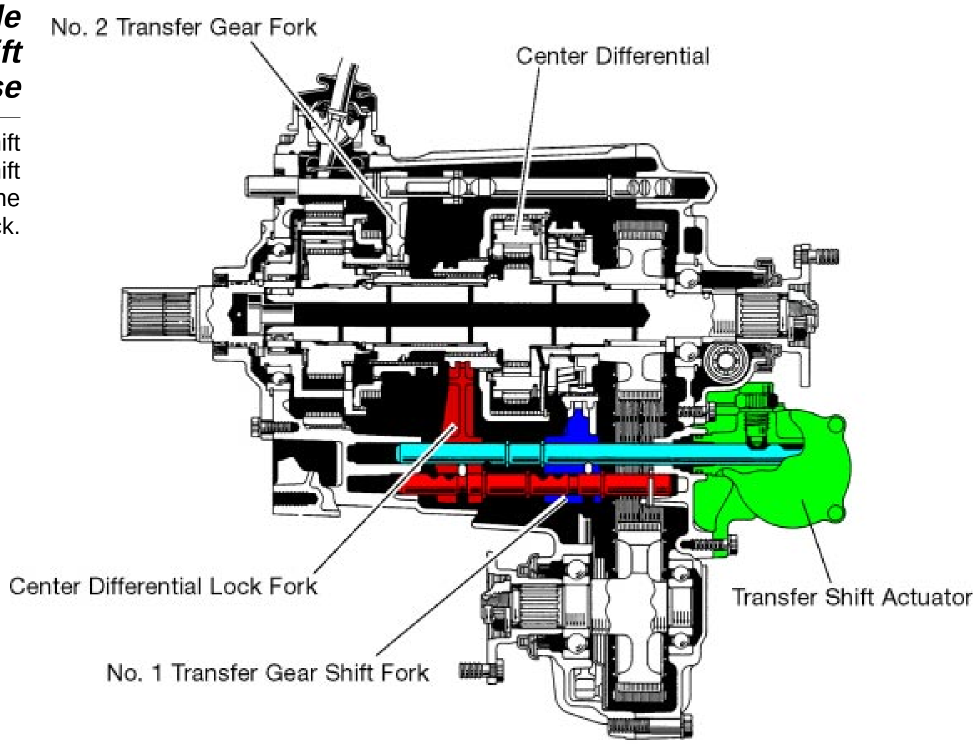


Fig. 5-32
T302f532

Automatic Disconnecting Differential (A.D.D.)

The purpose of Automatic Disconnecting Differential (A.D.D.) is to allow 4WD to be selected while the vehicle is moving because the front axle is locked following the shift to 4WD. The A.D.D. disengages the wheels from the powertrain in 2WD so the wheels do not drive the differential, the front propeller shaft and the silent chain components in the transfer case. In early 4WD systems, both front wheel hubs were locked to the front axles either manually or automatically when the vehicle was placed in 4WD. The A.D.D. system replaces the need for locking hubs.

The front drive axle is an open differential, which means if one wheel loses traction, all torque would go to the wheel with the least traction. This operation does not change when A.D.D. is activated.

The right axle in figure 5-28 below is connected to the differential side gear and intermediate shaft through a movable clutch sleeve. When the side gear is disconnected from the axle, the left drive axle still turns the left side gear but like a wheel with no traction, the pinion gears just rotate the right side gear. With proper lubrication and no load, wear to the differential components are negligible.

The A.D.D. locks the front drive axle to the differential side gear when four-wheel drive is selected. By coupling the side gear to the drive axle the front differential delivers torque to each front wheel.

Electric A.D.D. Actuator

The actuator moves the clutch sleeve to engage the axle to the intermediate shaft and side gear. The actuator can be either vacuum or electric operated. The electric actuator uses a spring loaded wait mechanism to allow the splines of the intermediate shaft and clutch sleeve to match before the sleeve and shaft engage.

Electrical A.D.D. Actuator

The actuator moves the clutch sleeve to engage the axle to the intermediate shaft and side gear.

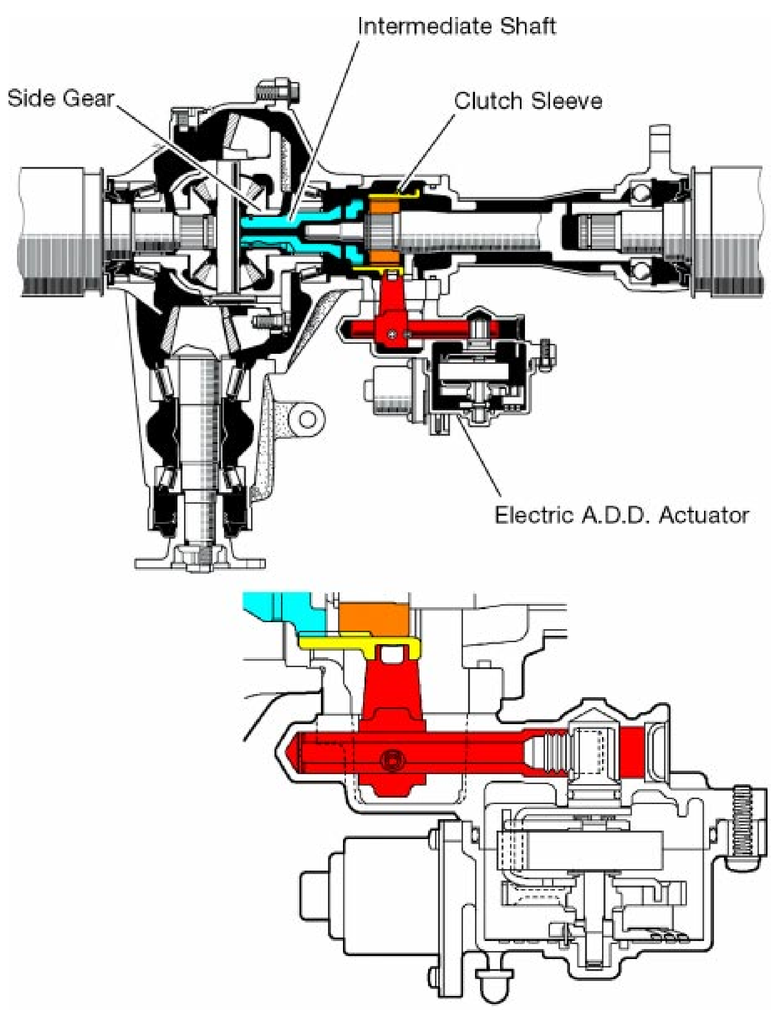


Fig. 5-33
T302f533

A.D.D. Electric Control Operation

The 4WD control ECU controls the A.D.D. actuator and indicator lights in the combination meter. The actuator is activated whenever the transfer case is shifted into four-wheel drive. When the operator selects 4WD, the ECU waits for the 4WD position switch signal to activate the A.D.D. actuator. When the clutch sleeve engages the differential side gear, the A.D.D. position switch at the actuator closes to inform the ECU that the axle is engaged and the 4WD indicator light illuminates.

Electric A.D.D. Control

The 4WD control ECU controls the A.D.D. actuator and indicator lights in the combination meter. The actuator is activated whenever the transfer case is shifted into four-wheel drive.

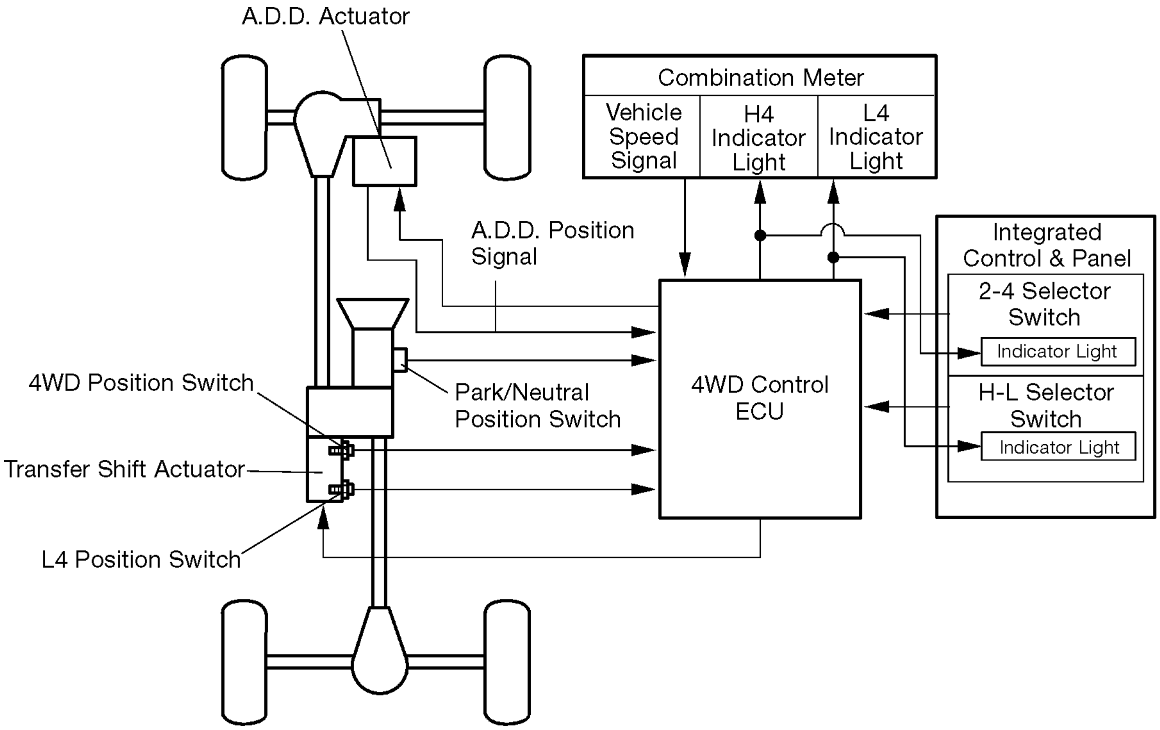


Fig. 5-34
T302f534

Vacuum A.D.D. Actuator

The vacuum actuator performs the same function as the electric actuator in that it moves the clutch sleeve to engage the side gear and drive axle. If the splines of the sleeve do not align for engagement the vacuum actuator has a built in wait function when vacuum is applied to the diaphragm and as the side gear begins to rotate, the clutch sleeve moves as the splines align. The shift fork and shaft are positioned by the detent ball and spring.

Vacuum A.D.D. Actuator

If engagement is delayed the electric actuator has a spring loaded wait mechanism and the vacuum actuator relies on vacuum to hold tension on the clutch sleeve.

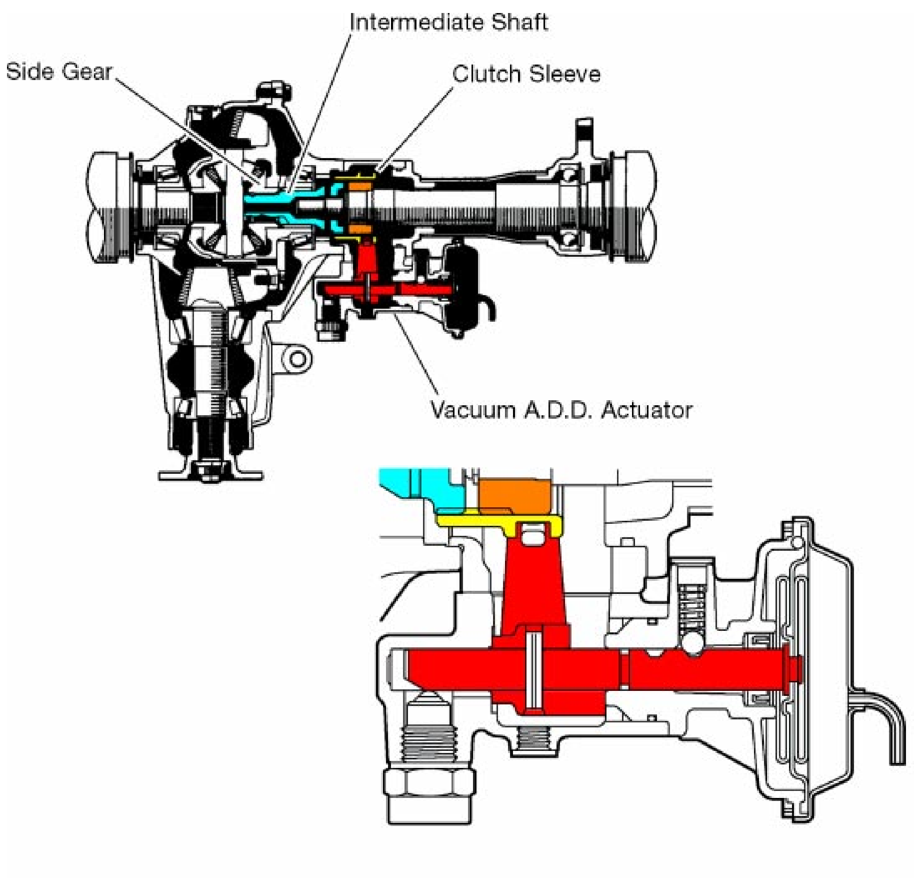


Fig. 5-35
T302f535

Vacuum Control Operation

The A.D.D. vacuum actuator has two chambers, one on each side of the diaphragm. The diaphragm is connected to the shift fork shaft. In the diagram in figure 5-36, Vacuum Switching Valve (VSV) No. 1 controls vacuum to the apply chamber (left side) of the actuator. When vacuum is open to the apply chamber, the shift shaft and fork is moved to the left, engaging the drive axle and the differential side gear. VSV No. 2 controls vacuum to the release side (right side) of the chamber and when vacuum is applied, the shift rail moves to the right and disengages the drive axle from the differential side gear.

The VSV's operation is identical, when energized they block atmospheric pressure and are open to the vacuum source. When not energized they are open to atmospheric pressure and block the vacuum source.

The VSVs are controlled by the two-position A.D.D. relay operated by the 4WD control ECU. When the relay is energized the current flows to VSV No. 1 opening the apply chamber to the vacuum tank. Since VSV No. 2 is not energized it is open to atmospheric pressure and the release chamber. The opposite happens when the relay is not energized, VSV No. 1 opens to atmospheric pressure and VSV No. 2 opens the release chamber to the vacuum tank and the shift fork moves to the right.

Vacuum Control Differential System Diagram

The VSVs are controlled by the two-position A.D.D. relay operated by the 4WD control ECU.

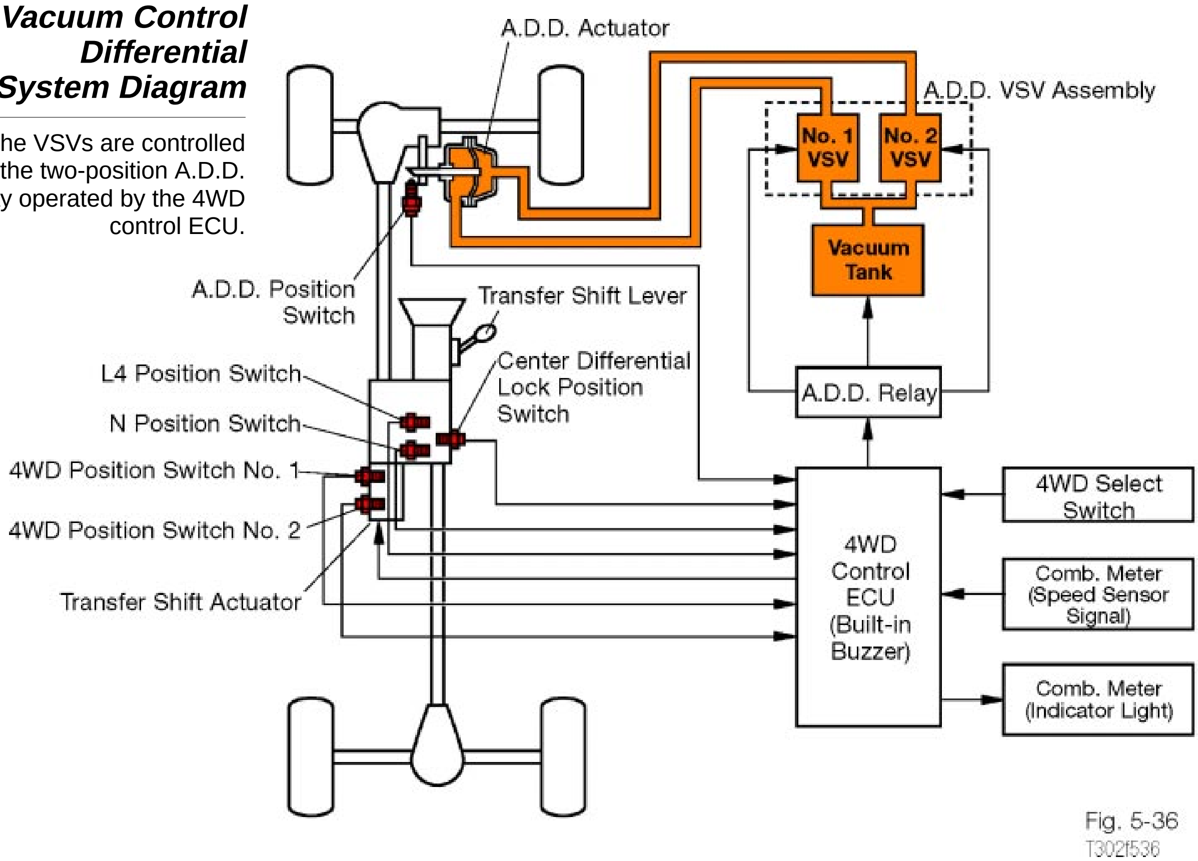


Fig. 5-36

A.D.D. 4WD Control ECU

The ECU controls the motor and monitors its position with the limit switch. When the transfer case is shifted to H4 or L4 the ECU received a signal from the transfer case 4WD detect switch and switches current to flow to terminal 5 of the ADD Actuator to the motor, to terminal 1 and back to the ECU through terminal DM2. The monitoring path to ground is through ECU terminal DL2 to terminal 2 of the actuator, through the limit switch to terminal 4 and ground. When the limit switch opens, the ECU shuts down the motor.

When the transfer case is shifted to H2 from H4 or L4 the ECU received a signal from the transfer case 4WD detect switch and switches current to flow to terminal 1 of the ADD Actuator to the motor to terminal 5 and back to the ECU through terminal DM1. The monitoring path to ground is through ECU terminal DL1 to terminal 6 of the actuator, through the limit switch to terminal 4 and ground. When the limit switch opens, the ECU shuts down the motor.

4WD Control ECU

The 4WD control ECU monitors the A.D.D. actuator operation through the limit switch.

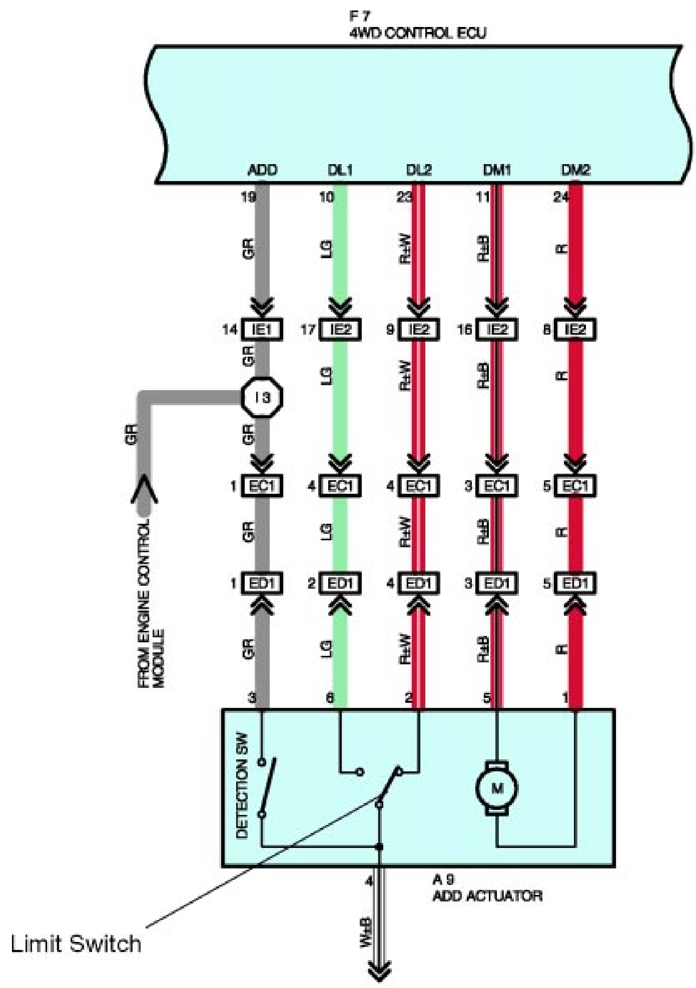


Fig. 5-37
T302f537

Rear Locking Differential

The rear locking differential is a selectable option that locks the differential to provide equal turning torque to each rear wheel regardless of turning radius. The differential operates as an open differential until the operator selects this function. The rear locking differential is available as an option with A.D.D. or separately on some 2WD models.

Under certain circumstances when one of the front wheels and one of the rear wheels lose traction at the same time, the vehicle will be unable to move. The ability to lock the rear differential will provide equal turning torque to each rear wheel. The vehicle should be stopped before selecting.

Rear Locking Differential

The rear differential locking system locks the differential to provide equal turning torque to each rear wheel.

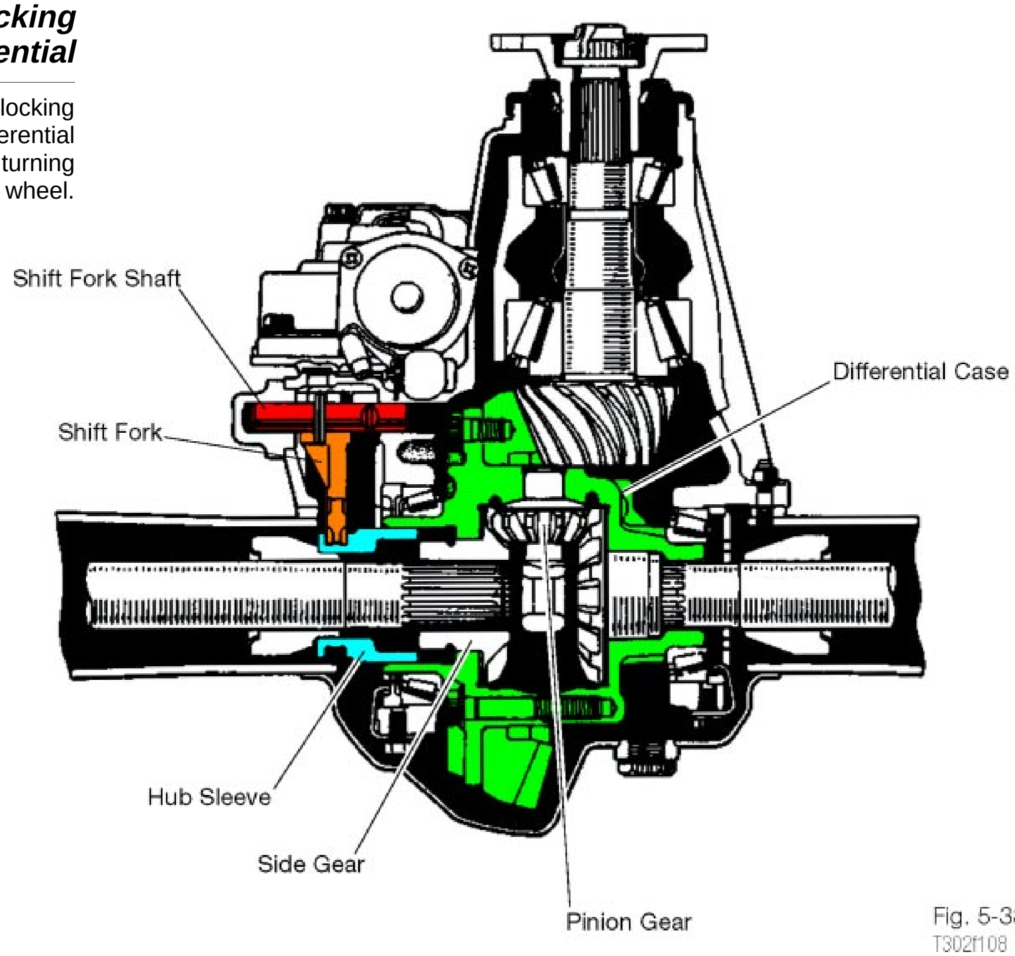


Fig. 5-38

Rear Locking Differential Control Operation

The 4WD Control ECU controls the rear differential lock actuator. The transfer case must be in 4WD Low Range when the operator presses the rear differential lock switch. The ECU monitors the L4 position switch and then causes the lock actuator to engage the lock sleeve and the lock position switch causes the ECU to illuminate the indicator light. As with the A.D.D. actuator, the ECU monitors actuator operation through the limit switch to control the motor.

Rear Locking Differential Control Diagram

The ECU monitors the L4 position switch and then causes the lock actuator to engage the lock sleeve.

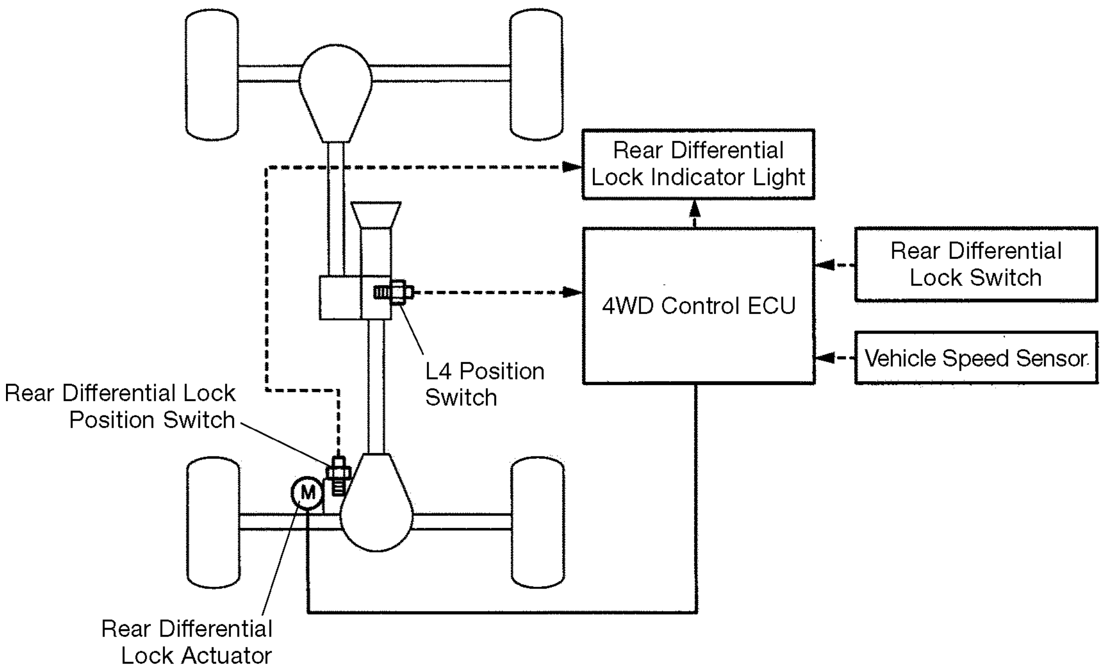


Fig. 5-39
T302f539

Rear Locking Differential Powerflow

The sleeve has splines on both the inner and outer diameter. When the differential is engaged the sleeve locks the left side gear to the differential case. With the side gear locked, the pinion gears are unable to turn on the pinion shaft and therefore the differential drives both wheels equally.

Rear Locking Differential Powerflow

With the side gear locked, the pinion gears are unable to turn on the pinion shaft and therefore the differential drives both wheels equally.

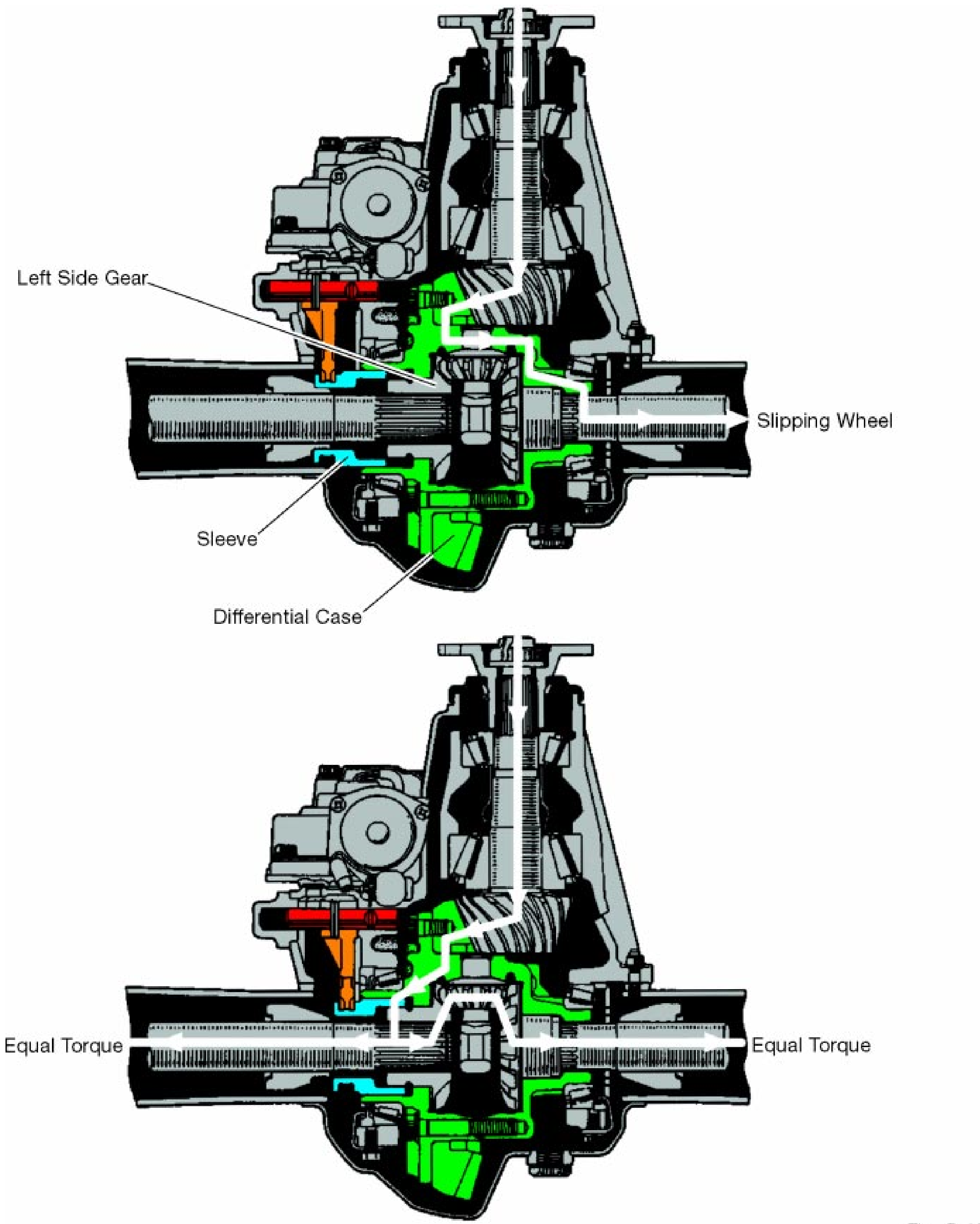


Fig. 5-40
T302f540

Lubrication System

Lubrication for gears and bearings in the transfer case is provided by an internal trochoid type oil pump.

Trochoid Pump Construction

A trochoid pump is used in the chain drive transfer case. Oil flows through the transfer input shaft and rear output shaft to the planetary gear assembly, bearings and other parts.

Trochoid Pump

A trochoid pump is used in the chain drive transfer case.

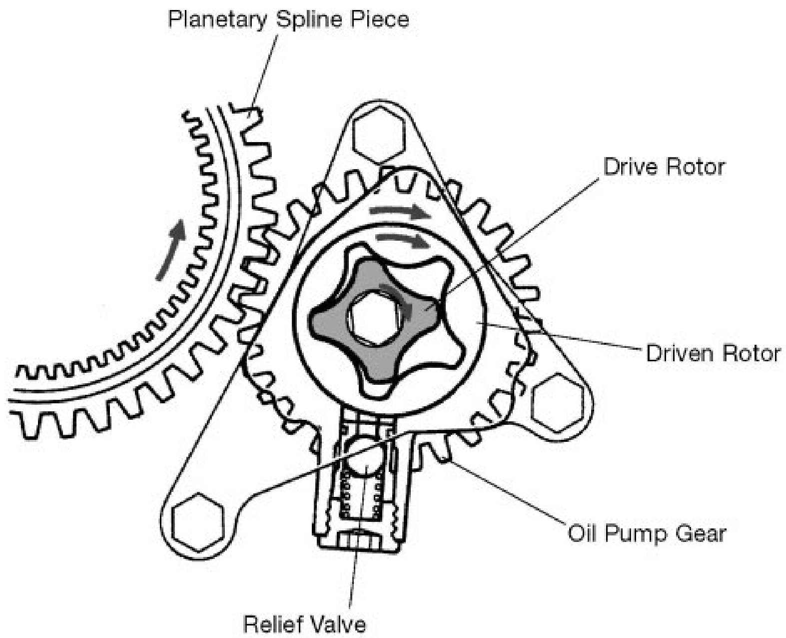


Fig. 5-41
T302f5341

Trochoid Pump Operation

The transfer case oil pump is driven by the outer gear on the planetary spline piece. It circulates oil onto the gears and friction areas through various channels and paths provided for this purpose. A relief valve regulates the oil pressure.

Trochoid Pump Operation

The oil pump is driven by the outer gear on the planetary spline piece.

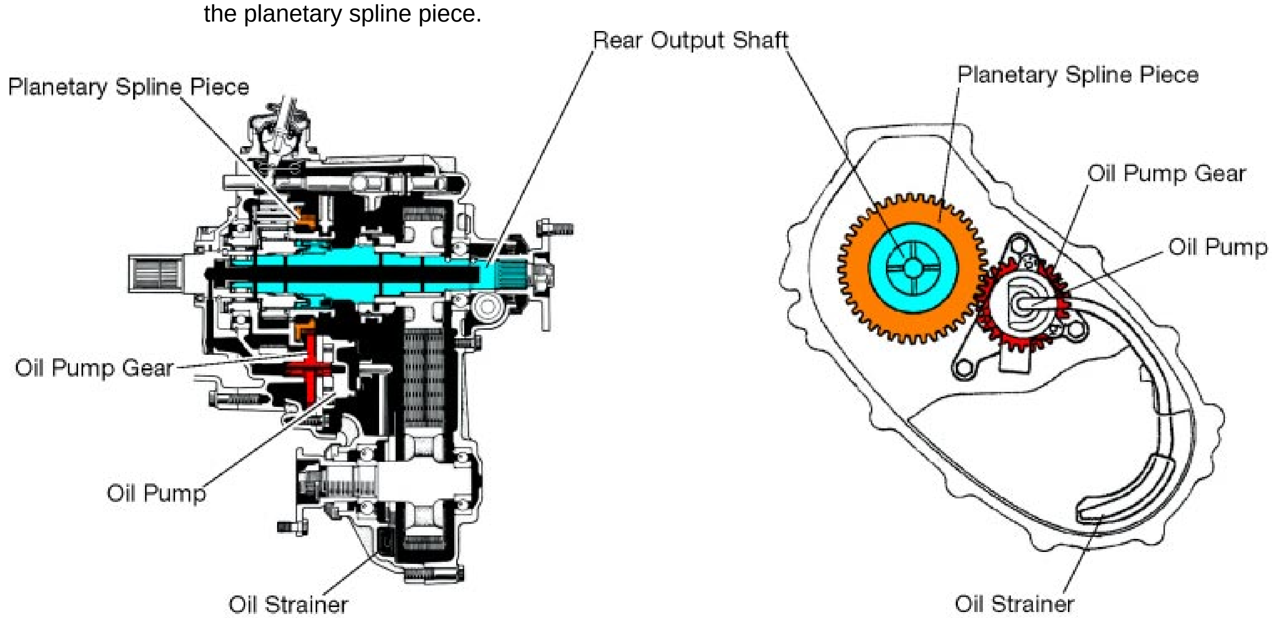


Fig. 5-42
T30215342

Notes

WORKSHEET 5-1
Transfer Case—Disassembly and Component Identification

Vehicle:	Year/Prod. Date:	Engine	Transmission:

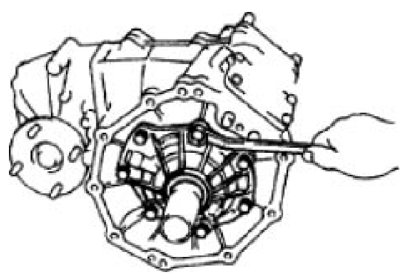
Worksheet Objectives

With this worksheet, you will follow the disassembly of a four wheel drive transfer case using the required special tools, make measurements where appropriate, retrieve and apply the needed service information, retrieve and interpret service specification information from the repair manual.

Tools and Equipment

- Vehicle Repair Manual
- Hand Tool Set
- Dial Indicator and Stand
- Micrometer, 0-1 in.
- Feeler Gauge

Section 1: Case Disassembly



1. Remove the front bearing retainer and front and rear companion flanges.
   a. What Special Service Tool is used to remove the companion flange?

   ____

   b. Is this Special Service Tool an essential tool or available tool?

   ____

2. Remove extension housing and speedometer drive gear. (Caution: Don’t loose the steel ball)
3. Remove the detent plugs, springs and balls.
4. Separate the case halves and remove the front case.
5. What shaft turns to drive the oil pump?

   ____

   ____

6. Is the vehicle dinghy tow able?

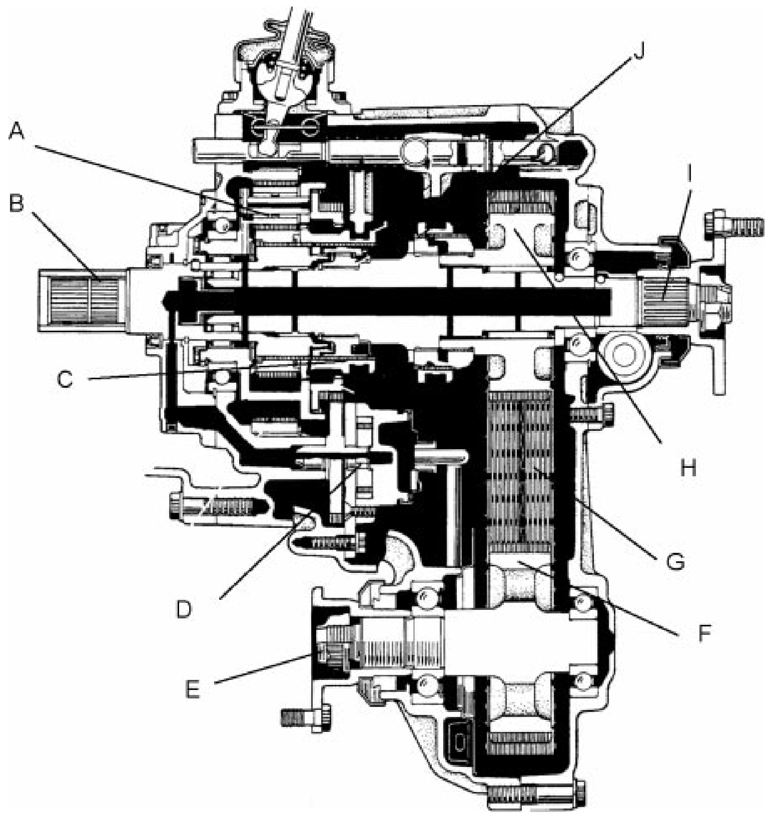
____

____

____

Section 2: Component Identification

Match the component names listed below with the parts in the illustration. Place the letter that identifies the part on the line in front of the component name.



______ 1. Transfer input shaft

______ 2. Planetary gear set

______ 3. Rear output shaft

______ 4. Silent chain

______ 5. Front output shaft

______ 6. Drive sprocket

______ 7. Driven sprocket

______ 8. Front drive clutch sleeve

______ 9. High low clutch sleeve

______ 10. Oil pump

Section 3: Gears, Shafts and Shift Linkage Removal

1. **STOP** proceed only as directed by your instructor.
2. Remove the shift forks and shift fork shafts. Shift forks are secured to the shaft with a roll pin or in some cases with a double roll pin. The position of the roll pin slit is essential to preventing the pin from being compressed and working its way from the shift shaft. Explain how the roll pin should be placed into position.

   ____

   ____

3. Remove the output shaft, chain and front drive sprocket.
4. Remove the oil pump and planetary gear assembly with input shaft.

Section 4: Clearance Measurement

1. Measure the rear output shaft drive sprocket thrust clearance:

   Measurement: ____________ Specification: ____________

(If the clearance exceeds the maximum, the sprocket should be replaced.)

2. Measure the input shaft and planetary gear thrust bearing axial play:

   Measurement: ____________ Specification: ____________

Notes

Transfer Case—Disassembly & Component Identification

Name: ____ Date: _____________________

Review this sheet as you are doing the Transfer Case—Disassembly & Component Identification worksheet. Check each category after viewing the instructor's presentation and completing the worksheet. Ask the instructor if you have questions regarding the topics provided below. Additional space is provided under Topic for you to list any other concerns that you would like your instructor to address. The comments section is provided for your personal comments, information, questions, etc.

Topic	I have questions	I know I can	Comment
Identify all gears in the transfer case.			
Identify all synchronizers in the transfer case.			
Explain how 2WD and 4WD is engaged.			
Explain how 4 low and 4 high is engaged.			
Measure output shaft drive sprocket thrust clearances.			
Measure input shaft and planetary gear thrust bearing axial play.			

Notes

WORKSHEET 5-2
Transfer Case—Reassembly

Vehicle:	Year/Prod. Date:	Engine	Transmission:

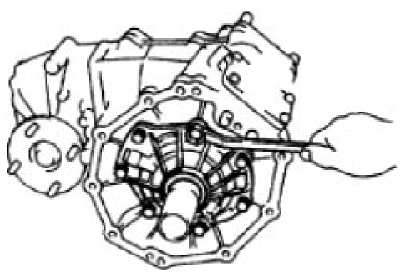
Worksheet Objectives

With this worksheet, you will follow the assembly of a four wheel drive transfer case using the required special tools, make measurements where appropriate, retrieve and apply the needed service information, retrieve and interpret service specification information from the repair manual.

Tools and Equipment

- Vehicle Repair Manual
- Hand Tool Set
- Dial Indicator and Stand
- Micrometer, 0-1 in.
- Feeler Gauge

Section 1: Case Reassembly



1. Assemble planetary gear assembly.

2. Using a dial indicator, measure the input shaft axial play:

   Measurement: ____________ Specification: ____________

3. If the snap ring has a mark designation of H and the axial play is 0.009 in., what is the mark designation of the shim that will bring the axial play within specification?

   ____

4. What component holds the planetary ring gear from rotating?

   ____

5. Assemble rear output shaft

6. Remeasure the rear output shaft drive sprocket thrust clearance following assembly:

   Measurement: ____________ Specification: ____________

7. Install the planetary gear assembly, oil pump, rear output shaft, chain and driven sprocket.

8. Install the shift forks, shift shafts, rear case and extension housing.

Transfer Case—Reassembly

Name: ____ Date: _____________________

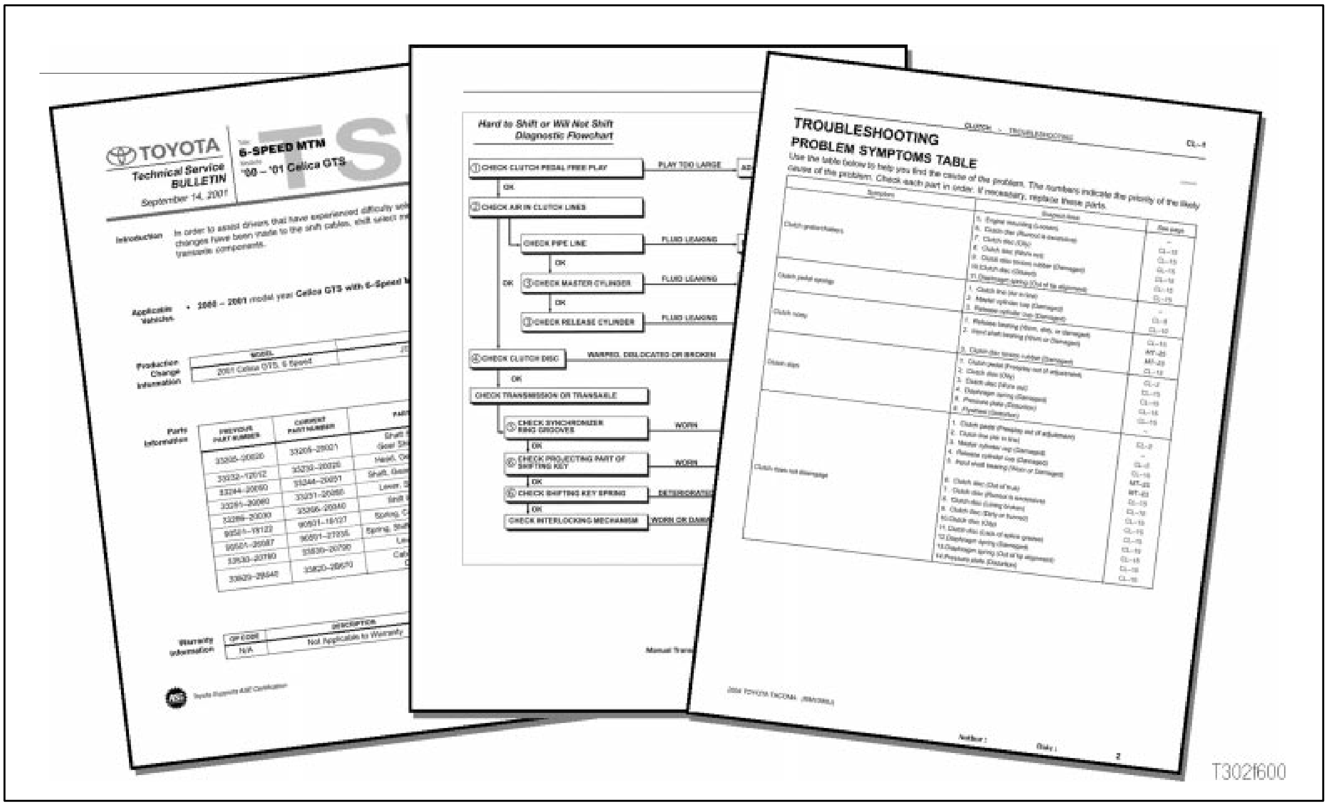
Review this sheet as you are doing the Transfer Case—Reassembly worksheet. Check each category after viewing the instructor's presentation and completing the worksheet. Ask the instructor if you have questions regarding the topics provided below. Additional space is provided under topic for you to list any other concerns that you would like your instructor to address. The comments section is provided for your personal comments, information, questions, etc.

Topic	I have questions	I know I can	Comment
Determine shim mark designation from the repair manual shim chart.			
Use a dial indicator to measure input shaft axial play.			
Explain the application of FIPG to the transfer case sealing surfaces.			

Notes

Section 6

Diagnostic Procedures



Learning Objectives:

1. Describe manual transmission, transaxle and transfer case component inspection and diagnostic procedures
2. Identify clutch component inspection procedures:
   a. Flywheel runout
   b. Minimum thickness
   c. Hotspots
3. Measure transmission components for wear, runout and preload:
   a. Synchronizers
   b. Gear end play
4. Describe manual transmission, transaxle, transfer case and clutch assembly and disassembly procedures
5. Describe synchronizer measurement procedures

Section 6

Diagnostic Procedures

Introduction

Proper diagnosis is the key to repairing the customer's vehicle the ***first time***. By applying the basic knowledge of all the components that make up the manual transmission system, diagnosis can become an easy and rewarding part of automotive repair. The technician who can effectively diagnose and correct a problem will instill customer confidence in his ability and reflects positively on the dealership. A positive service experience helps to ensure the likelihood that the customer will return to your dealer for subsequent service needs.

Diagnosis verifies the customer complaint and identifies the symptoms that pinpoint the cause *before* the transmission is removed from the vehicle. Once the unit is removed, time spent in diagnosis will pay off by focusing your inspection on specific components and systems.

During diagnosis, observe other potential problems to ensure the customer is aware of any additional service needs. This awareness reduces the likelihood the customer will have to return later or that they might feel the repair was not done properly the first time.

Experienced technicians are able to determine the cause and select appropriate repairs using specific tests and diagnostic procedures. Visual inspections reveal potential causes for further testing. Listening for noises can give clues, performing shift tests and test drives help identify customer concerns and verify the repair.

Toyota technicians utilize a six-step diagnostic procedure to verify and resolve customer concerns.

Six-Step Diagnostic Procedure

To perform a complete diagnostic check, these six steps should be followed:

1. Verify the customer complaint
2. Identify the symptoms
3. Isolate the cause
4. List recommended repairs and possible related repairs
5. Repair the cause
6. Verify proper operation

Verify the Customer Complaint

Verifying the customer complaint is the single most important step in diagnosis. Check to see that all the information you need to begin is on the work order. If more information is needed, contact the service writer or customer to clarify the complaint and acquire the needed information to begin the diagnostic procedure. If you are unable to verify the customer complaint, it may be necessary to test-drive the vehicle with the customer or the service writer. It is impossible to repair a complaint that cannot be verified or is a normal characteristic of a specific vehicle.

Identify the Symptoms

During the test drive and inspection of the vehicle, identify the symptoms. Flow charts are provided to deal with specific problem areas. They provide a logical sequence to follow in completing this step and the following step   isolate the cause.

Note any abnormal operating conditions that may cause related or future problems for the customer. This not only helps to create a good professional image but also eliminates the chance of the customer coming back with a similar problem and believing the problem was not repaired the first time.

Isolate the Cause

Check to see what components and/or parts are causing the main complaint. Determine what it will take to make the proper repairs. Look for any related components that could cause a similar complaint or future complaints. For example, a slipping clutch complaint may be caused by an oil soaked clutch disc. The oil leak must be repaired to eliminate the same problem occurring again.

List Recommended Repairs

Following the inspection and test drive, you should have all the information you need to discuss the complaint and repairs with the service writer. Be sure to bring up any related repairs you feel may cause similar or future problems. If the customer does not want to do all the repairs at this time, note them on the work order for future reference.

Repair

The technician can now proceed with the necessary repairs. The repair may be as simple as a clutch adjustment or hydraulic component replacement and bleeding, or may require transmission removal and disassembly. Whatever the repair, consult the Toyota Information System (TIS) to access:

- **Repair Manuals** for procedures, specifications and adjustments.
- **Technical Service Bulletins (TSBs)** for providing the most current repair information on a component.
- **Special Service Tools (SSTs)** for performing the repair manual procedures correctly.

Verify Operation

When repairs are completed, the technician should verify that the complaint has been corrected. This is accomplished by test driving the vehicle and verifying the operation of the component that has been repaired.

Common Tests

To aid in the diagnostic process, there are some common tests used to pinpoint the cause of clutch, transmission and transaxle complaints:

- Visual Check
- Engine Off Shift Test
- Engine Running Shift Test
- Road Test

Visual Check

During a visual check, look under the hood and under the vehicle for abnormal conditions.

Under hood checks:

- Clutch master cylinder fluid level and mechanical linkage
- Broken engine motor mounts
- Transaxle/transmission and bell housing bolt tightness

Under vehicle checks:

- Damage to transaxle/transmission case, mounts and support
- Worn, bent, or loose shift linkage
- Loose or missing transaxle/transmission or clutch housing mounting bolts
- Fluid leaks from the clutch master cylinder, release cylinder or transaxle/transmission
- Half shaft condition: bent or torn boots

NOTE

When diagnosing fluid leaks, remember that gravity pulls fluid downward and wind under the vehicle pushes the fluid rearward. To locate the source of the leak, look forward and above the location of the fluid drips.

Engine Off Shift Test

The engine off shift test measures the effort it takes to move the synchronizer sleeve or gear, fork, and shift rail past the neutral detent and into mesh with the gear detent position.

The amount of force required to move the shift lever may vary between models. To determine an abnormal condition, compare the gear shift effort on a similar transaxle/transmission. When performing this test, be sure to listen for any unusual noises.

To perform this test:

- Disengage the clutch by depressing the clutch pedal.
- Shift the transmission/transaxle into gear and then shift back to neutral.
- Shift back to the originally selected gear. Note the amount of effort required.
- Repeat the check on all remaining gears. Note any shift requiring increased effort.

Engine Running Shift Test

A similar test to the engine-off test is the engine running shift test. This test also checks for clutch drag.

To perform this shift test:

- Set the parking brake and start the engine.
- Idle the engine in neutral. Note any unusual noises.
- Disengage the clutch and shift into first gear. Note the amount of effort required to complete the shift and compare it to the engine-off test. Note any unusual noises. If the effort required to complete the shift is higher than the engine off shift test, it could indicate a clutch that is not fully disengaged. Release the parking brake, engage the clutch to move the vehicle slightly and check for any unusual noises or movement.
- Repeat this process for each gear position.

Road Test

Once an initial check and visual inspection have been performed, and the customer's concern has not been identified, perform a road test. During the road test, check the shifts between gears, and listen for any unusual noises during acceleration and deceleration in each gear. Normal operation should be compared to that of a similar vehicle.

NOTE During a road test, an output bearing noise can be isolated from other noises by disengaging the clutch, shifting to neutral and coasting. The only thing turning will be the output shaft in the transmission; or or in a transaxle, the differential, final drive gear, and output shaft.

A typical road test procedure includes:

- Check the transmission oil level.
- Warm up the transmission before the road test.
- With the vehicle stationary in neutral, and the engine idling:
  - Disengage the clutch
  - Engage the clutch and listen for noise, depress the pedal again noting any noises.
  - Repeat the steps above and wait three seconds, shift into reverse, first gear, and back to reverse. Wait twenty seconds and repeat this procedure. Note any differences in noise, shifting ability, pedal movement, and position at which the clutch engages.
  - Shift into reverse, release the pedal, and back up the vehicle while increasing engine speed to 2,500 rpm. Note any noises. Remember that reverse gear is a spur cut gear and will be noisier than forward gears.

CAUTION When road testing a vehicle, particularly in reverse, be sure to exercise extreme caution. Be aware of vehicles, traffic and pedestrians in the area.

Drive the vehicle on the road:

- Start in first gear, accelerate, and upshift at 4,000 rpm through all the gears. Note shift quality and any noises.
- Decelerate using engine braking. Downshift in each gear and note any noises.
- On the highway, drive in fourth gear at 60 mph, accelerate and shift into fifth gear. Note any problems.

NOTE During a shift, the synchronizer ring cuts through the lubricant and contacts the speed gear cone. If the lubricant is too thick or the synchronizer rings are worn, hard shifts will occur.

NOTE Downshifts are normally harder to make than upshifts, since the synchronizer must speed up the gears during a downshift, requiring additional effort.

Common Transmission/ Transaxle Problems

Some common problems and specific concerns with transmissions and transaxles include:

- **Oil leakage** – fluid escaping from the transaxle/transmission
- **Hard to shift** – a high force required to shift into gear
- **Will not shift** – can not shift into one or more gears
- **Locked into gear** – will not shift out of a gear
- **Jumps out of gear** – Pops out of gear into neutral during acceleration/deceleration
- **Gear clash/grinding during shift** – grinding noise and vibration while shifting
- **Noisy in neutral** – a grinding or growling noise
- **Noisy in one gear** – a grinding or growling bearing or gear noise in one gear
- **Noisy in all gears** – a grinding or growling bearing or gear noise in all gears

Experienced technicians encounter many of these problems, and utilize appropriate test and diagnostic procedures to identify and resolve the problem quickly and efficiently.

Symptom Diagnosis Chart

Technicians often consult diagnosis charts to help determine the possible cause of a transaxle/transmission fault. Toyota repair manuals provide trouble shooting symptom tables to deal with clutch, transmission and transaxle problem areas. These charts provide possible causes for each symptom.

Symptom Diagnosis Chart

Symptom	Possible Cause
Oil Leakage	• Oil level too high • Wrong lubricant • Faulty seal • Faulty gasket sealant
Hard To Shift	• Dragging clutch • Faulty control cable (FF) • Faulty synchronizer assembly • Damaged shift rail, detent, or interlock • Improper lubricant
Will Not Shift	• Damaged shift linkage • Damaged synchronizer • Restricted travel of shift fork
Locked Into Gear	• Damaged shift linkage • Damaged synchronizer • Worn or damaged internal shift linkage
Jumps Out of Gear	• Worn or damaged shift linkage • Interference with shift linkage movement • Broken or loose engine/transmission mounts • Worn pilot or input shaft bearing • Worn shift fork • Worn synchronizer • Worn spline teeth gears
Clash During Shift	• Clutch drag • Worn or damaged shift fork • Worn synchronizer ring
Noisy in Neutral	• Low oil level • Worn or damaged input shaft bearings • Worn countershaft bearings
Noisy in One Gear	• Damaged teeth on that gear set
Noisy in All Gears	• Low oil level • Contact between transmission and vehicle body or exhaust • Loose mounting bolts • Worn or damaged gear teeth

Fig. 6-1

Diagnostic Flowcharts

The following conditions represent some common transmission and transaxle concerns. Each concern is supported by inspection procedures for related components.

Hard to Shift or Will Not Shift

A Diagnostic Flowchart helps determine the specific cause of a problem by eliminating possible causes. For a hard to shift or will not shift complaint, there are six steps to determine if a common problem is to blame (Each step below is also represented in the flowchart in figure 6-2):

1. If the pedal play is too large, the clutch cannot disengage when the pedal is fully depressed. For vehicles equipped with adjustable release cylinders, the play of the pedal and release fork is checked separately.
2. Depress the clutch pedal several times. If the lever can be shifted smoothly, air may be mixed in the pipeline.
3. Fluid leakage at the release and/or master cylinder dust boots can be caused by damage or wear to the piston cup or cylinder bore.
4. Shifting may be sluggish or impossible as a result of problems in the clutch assembly or transmission/transaxle. If the clutch functions normally, then the transmission or transaxle is the next component to be inspected.
5. The synchronizer ring is an essential part of the synchromesh mechanism. Narrow grooves are provided on the inner surface of the synchronizer ring. The grooves help to increase the applied pressure on the conical surface of the gear and cut the oil film to increase the friction force needed for smooth synchronization. When the synchronizer ring grooves become worn, the ring and gear tend to slip and hard shifting results. To check the synchronizer ring, push it against the conical surface of the gear and check the clearance. As the ring grooves wear, the clearance decreases.
6. The synchronizer key is made with a raised portion in the middle. The hub sleeve is in contact with the raised portion. More force can be applied to the synchronizer ring to hold the gear. When the raised portion of the key wears, less force is applied to the synchronizer ring and hard shifting can occur.

Hard to Shift or Will Not Shift Diagnostic Flowchart

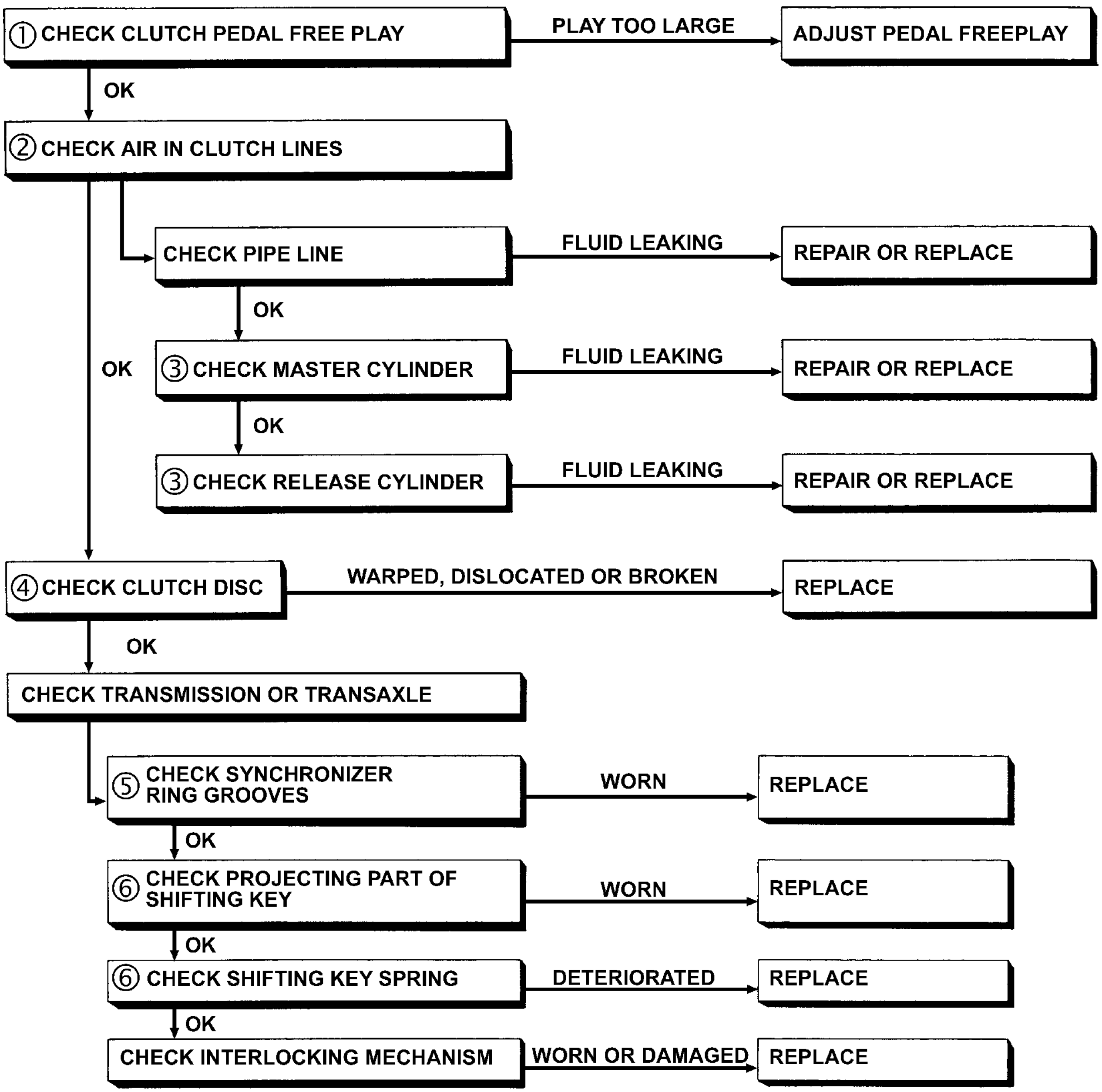


Fig. 6-2
T302f602

Gear Slip-Out When the thrust clearance for a gear becomes too large, the hub sleeve may not engage the gear splines completely. If the gear is not totally engaged, gear slip-out will occur.

Gear Thrust clearance Check thrust clearance for each gear, detent ball compression spring, hub sleeve and gear splines. Use a feeler gauge to check for proper gear thrust clearance.

Gear Slip-Out

Check thrust clearance for each gear, detent ball compression spring, hub sleeve and gear splines.

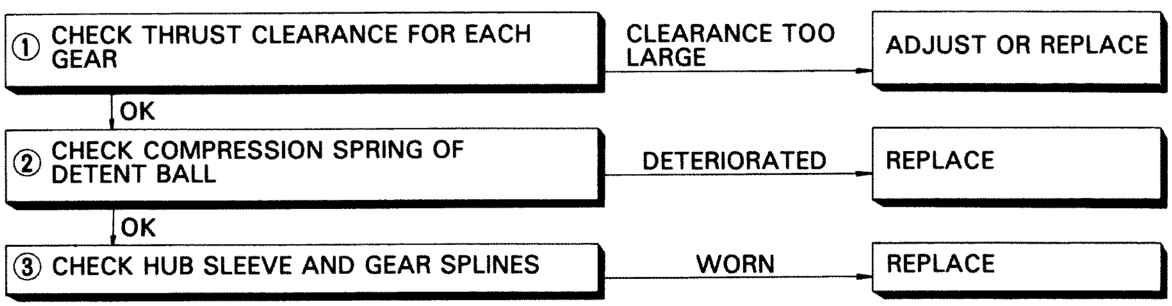


Fig. 6-3
T302f603

Gear Thrust Clearance Checks

Use a feeler gauge to check for proper gear thrust clearance.

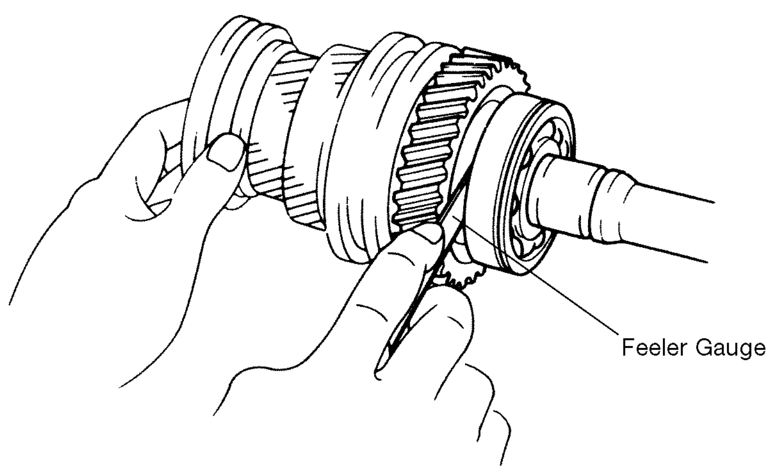


Fig. 6-4
T302f604

Shift Fork Component Wear

Positive shift feedback in shifting is created by the detent ball being pushed into the slots on the shift fork by a spring. Wear to these parts can aide in allowing gear slip out as the shift fork does not fully engage the spline teeth of the speed gear and hub sleeve.

Shift Fork Component Wear

Wear to these parts can aide in allowing gear slip out as the shift fork does not fully engage the spline teeth of the speed gear and hub sleeve.

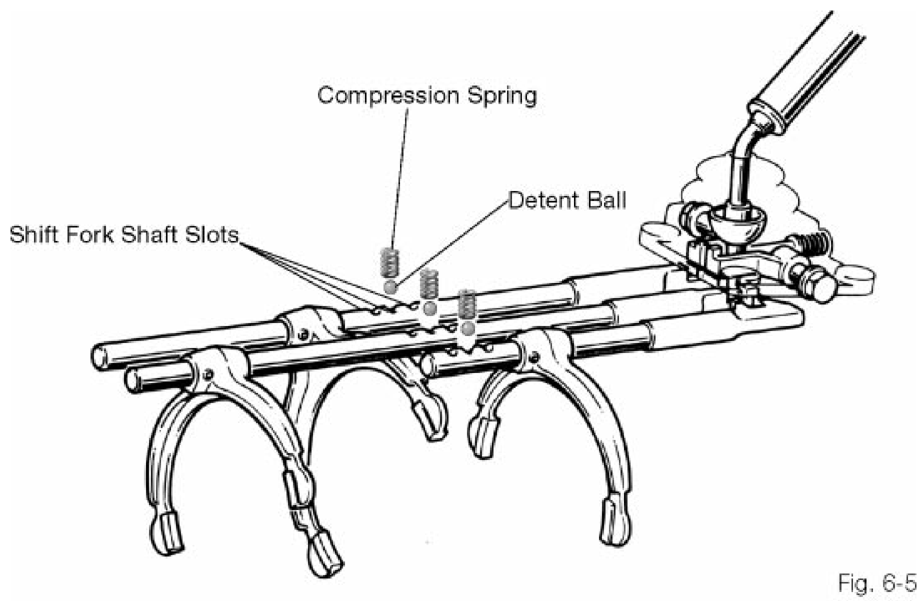


Fig. 6-5
T302f605

Worn Gear Splines

Tapered chamfers are provided where the hub sleeve and gear splines engage to prevent the gear from slipping out. When the parts are rotating, the gear and hub sleeve splines are forced together to create a positive engagement. Gear slip-out can occur when the splines become worn.

Worn Gear Splines

Gear slip out can occur when the splines become worn.

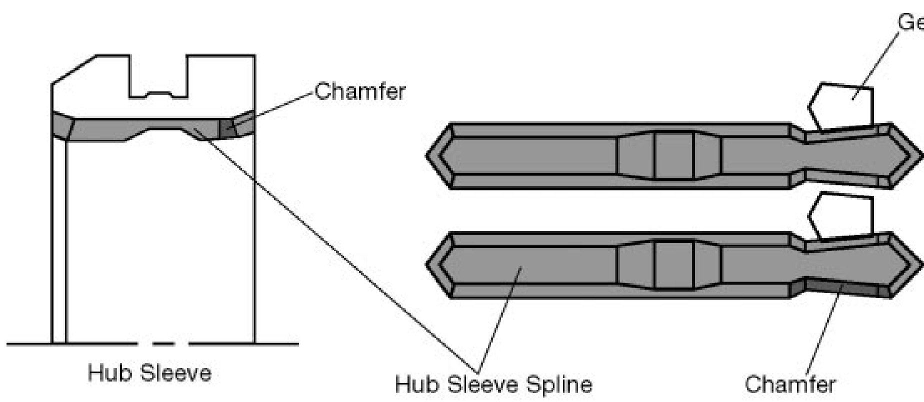
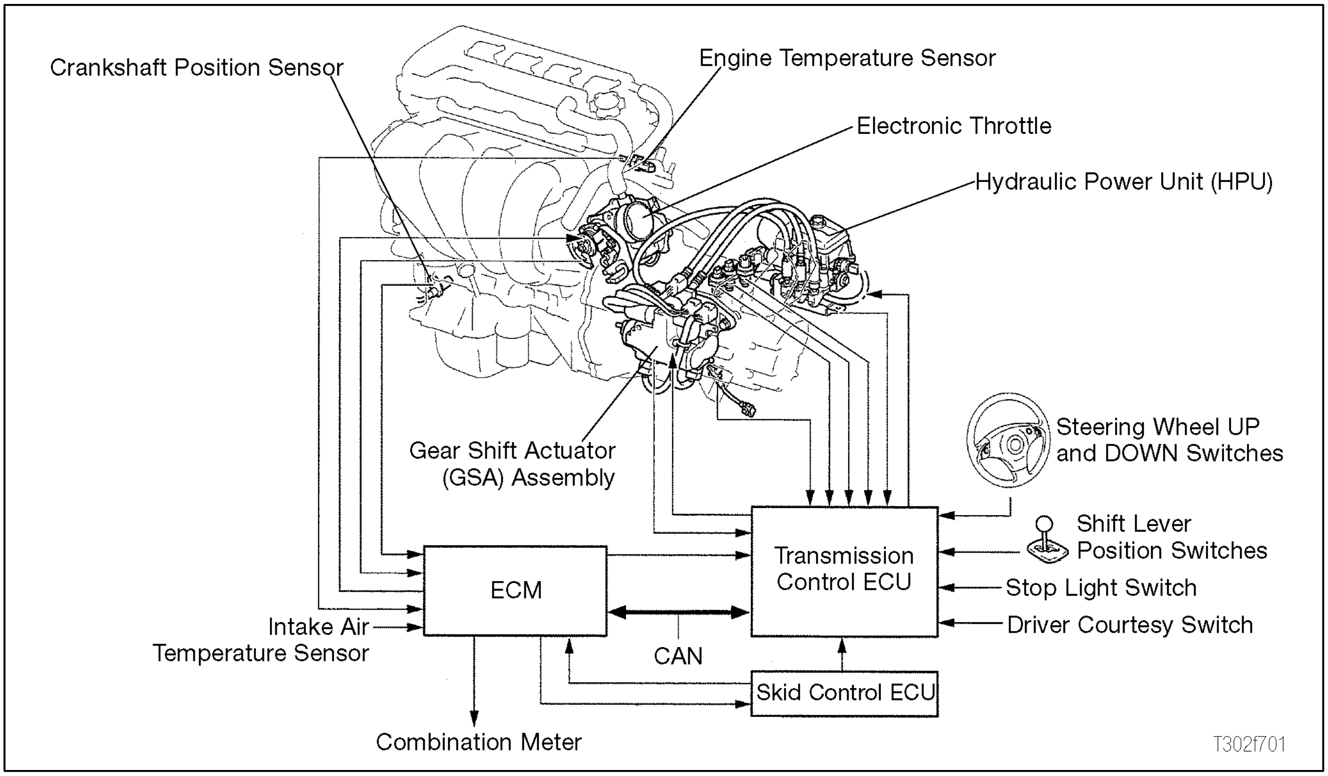


Fig. 6-6
T302f606

Notes

Section 7

Sequential Manual Transmission



Learning Objectives:

1. Identify the purpose and function of the sequential manual transmission
2. Identify and describe the operation of the following sequential manual transmission components:
   a. Hydraulic Power Unit
   b. Gear Shift Actuator
   c. Shift lever
   d. Shift Lever Switches
   e. Transmission Control ECU
   f. ECM
   g. System Warning Light
   h. Gear Position Indicator
   i. Stop Light Switch
   j. Shift Lock Solenoid
3. Revolution Sensor
4. Describe normal system operation
   a. Starting the system
   b. Start
5. Describe diagnostic equipment and tests for sequential manual transmissions, including:
   a. Diagnostic Tester
   b. Pinpoint Tests
   c. ECU Relearning

Sequential Manual Transmission

Introduction

The sequential manual transmission is based on the C Series five-speed manual transaxle, and was introduced on the 2002 MR2 Spyder. The clutch pedal and master cylinder have been replaced with an actuator that is electronically controlled. When the driver presses shift switches on the steering wheel or moves the shift lever forward or rearward to shift gears, the engine speed is electronically controlled, the actuator operates the clutch and shifts gears.

When the vehicle comes to a stop, the transaxle automatically shifts to 1st gear so it can start off again without having to operate the shift lever or shift buttons. On the six speed transaxle introduced in 2003, the automatic downshift occurs to 2nd gear below 18 mph and 1st gear below 5 mph.

Components

The sequential manual transmission contains a Hydraulic Power Unit (HPU) assembly, Gear Shift Actuator (GSA), electronic throttle, dedicated shift lever, transmission control ECU and sensors, in addition to the conventional transaxle.

Sequential Manual Transmission System Components

The sequential manual transmission contains a hydraulic actuator, electronic throttle, dedicated shift lever, transmission control ECU, and sensors.

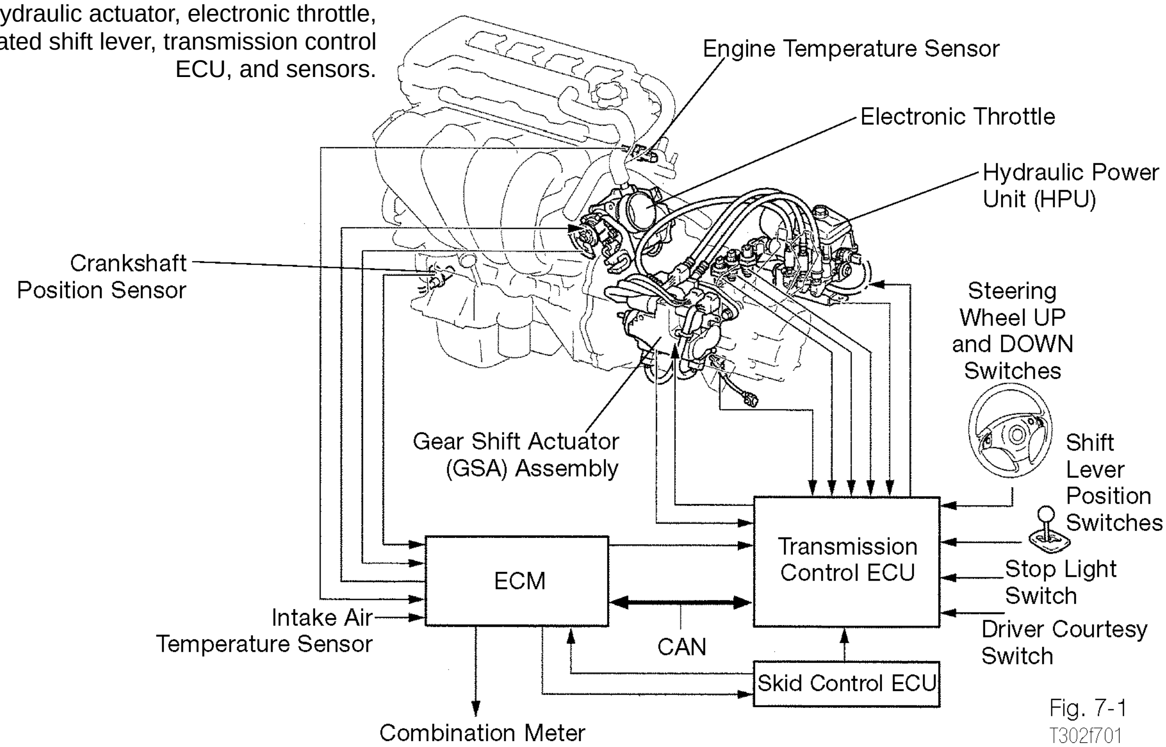


Fig. 7-1
T302f701

Transmission Control Unit

The Transmission Control ECU controls the hydraulic power unit and the gear shift actuator assembly to engage or disengage the clutch and shift the gears based on signals from the ECM, sensors, and switches. Additionally, the Transmission Control ECU requests the ECM to control the ETCS-i throttle control motor during gear changes.

Transmission Control ECU

The transmission control ECU controls the pump assembly and the actuator assembly to engage or disengage the clutch and shift the gears.

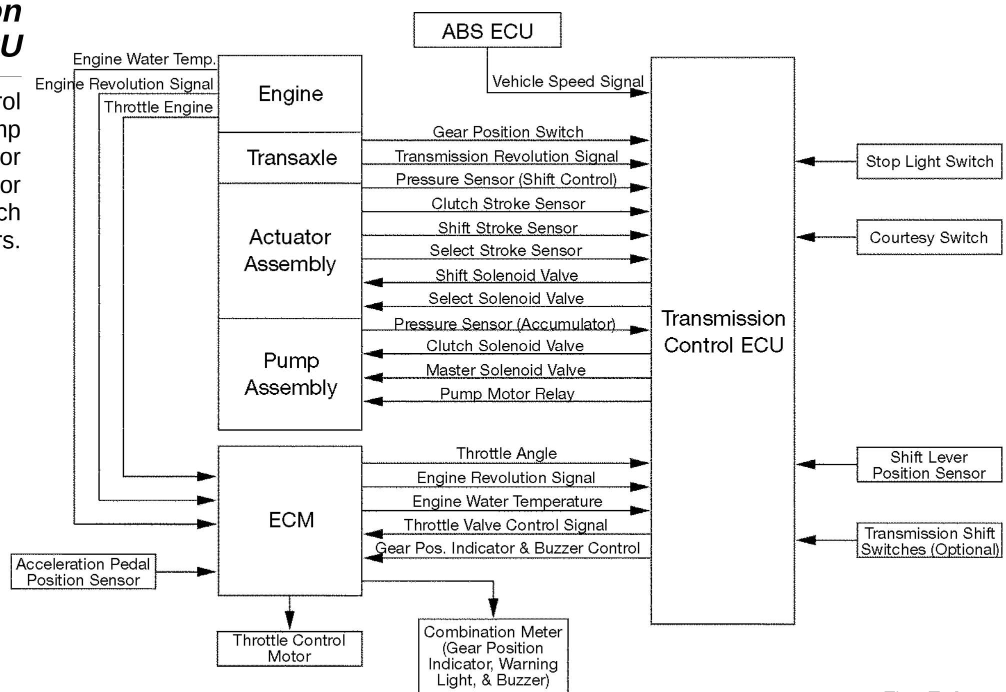


Fig. 7-2
T302f702

Hydraulic Power Unit (HPU)

The Hydraulic Power Unit (HPU) assembly generates hydraulic pressure for the shift operating system and the clutch release cylinder. It is located in the engine compartment and mounted to the vehicle body. The pump draws the sequential M/T fluid from the reservoir tank and provides high pressure to the accumulator. The pressure sensor monitors accumulator pressure and provides input to the transmission control ECU. The hydraulic power unit is connected to the gear shift actuator through three high-pressure hoses.

Hydraulic Power Unit (HPU)

The Hydraulic Power Unit assembly generates hydraulic pressure for the shift operating system and the clutch release cylinder.

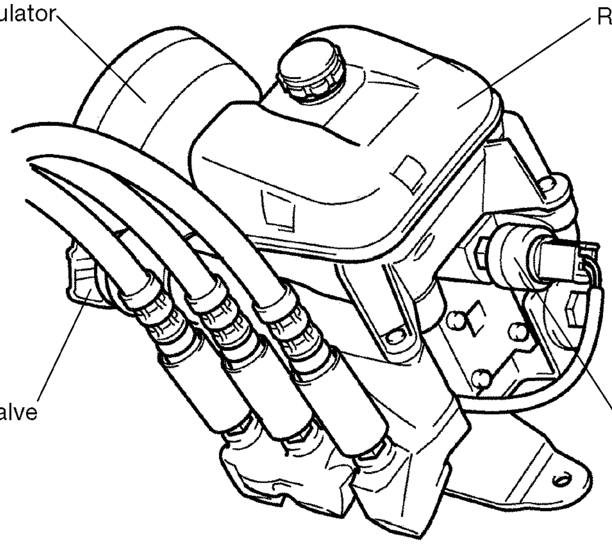


Fig. 7-3
T302f703

Gear Shift Actuator (GSA)

The Gear Shift Actuator (GSA) assembly engages or disengages the clutch and selects gears based on signals from the transmission control ECU. It is mounted to the side of the transaxle case, and attaches to the shift and select lever shaft. The actuator clutch cable attaches to the transaxles clutch release fork.

The select solenoid valve provides hydraulic pressure to move the select shaft. The select shaft positions the shift inner lever and shift fork lock over the shift fork heads of the transaxle shift and select assembly. The shift solenoid valve provides hydraulic pressure to rotate the select shaft that moves the shift inner lever to engage the desired gear. The clutch solenoid valve provides hydraulic pressure to the clutch release cylinder and moves the clutch cable to engage or disengage the clutch.

Gear Shift Actuator (GSA) Assembly

The gear shift actuator assembly engages or disengages the clutch and shifts gears based on signals from the transmission control ECU.

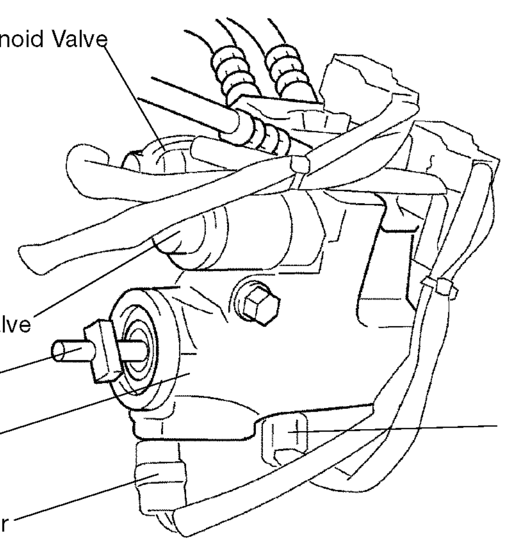


Fig. 7-4
T302f704

The gear shift actuator houses three sensors that monitor the shift stroke and select stroke of the shift and select lever shaft assembly as well as the clutch stroke. These sensors provide input to the ECU on the clutch and select shaft positions.

Stroke Sensors

The gear shift actuator houses three sensors that monitor the shift stroke and select stroke of the shift and select lever shaft assembly, and the clutch stroke.

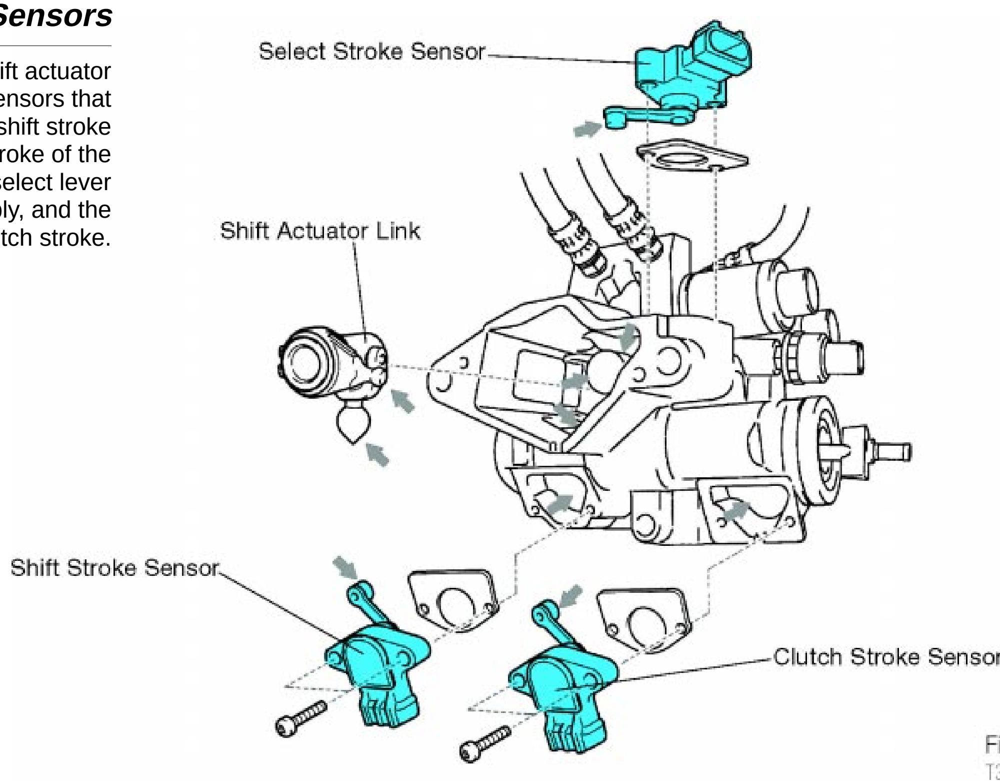


Fig. 7-5
T302f705

Gear Shift Actuator Link Fixing Plate

The gear shift actuator link fixing plate SST is required to keep the shift actuator link in a neutral position whenever the gear shift actuator is removed or a new unit is installed. Failure to use the SST may result in the inability to shift the transmission.

Gear Shift Actuator Link Fixing Plate SST

The link fixing plate must be installed prior to the removal or installation of the gear shift actuator.

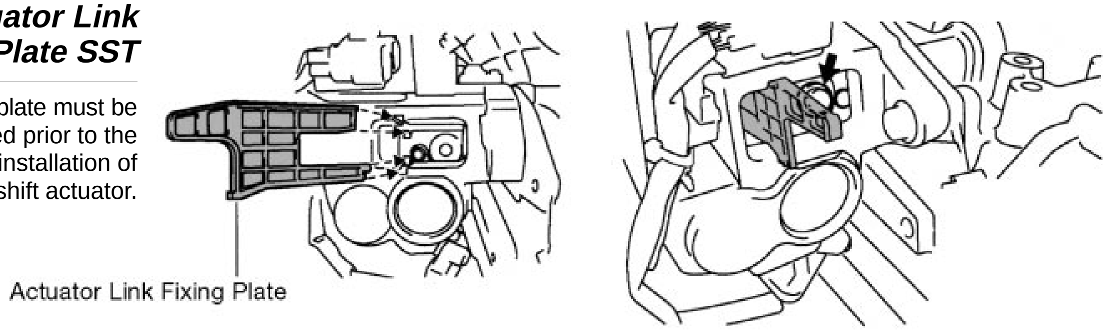


Fig. 7-6
T302f706

Shift Lever

The sequential manual transmission uses a control-by-wire type shift mechanism that detects the movement of the shift lever based on the combination of four switches; this shift mechanism is integrated into the shift lever position sensor. The three ranges are R for reverse, N for neutral and S for sequential range. Shift lever position is maintained by spring-loaded detents, which provide shift feedback to the driver.

Shift Lever

The sequential manual transmission uses a control-by-wire type shift lever.

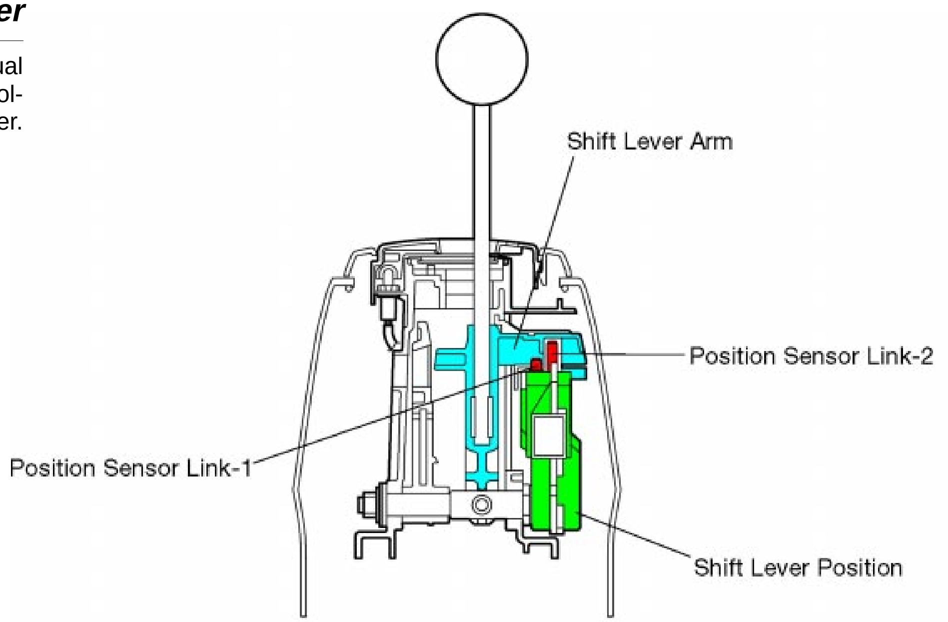


Fig. 7-7
T302f707

Shift Lever Switches

The shift position and the movement of the shift lever are detected through the combination of the four switches integrated into the shift lever position sensor. Switch positions are determined by the shift lever arm and the two position sensor links. The operating conditions of the switches are detected and the signals are sent to the transmission control ECU.

Shift Lever Switches

The shift position and the movement of the shift lever are detected through the combination of the four switches that are integrated in the shift lever position sensor.

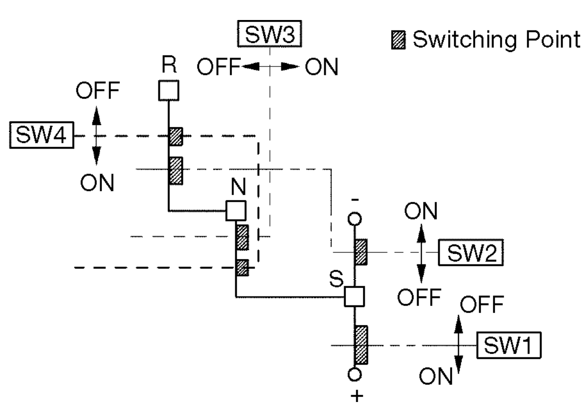


Fig. 7-8
T302f708

Steering Wheel Shift Switches

Steering wheel switches (optional equipment) are available and are located on the steering wheel. Two switches are located on each steering wheel spoke; the two facing the driver provide for downshifts and the two switches facing away from the driver provide for upshifts.

Steering Wheel Shift Switches

Two switches are located on each steering wheel spoke; the two facing the driver provide for downshifts and the two switches facing away from the driver provide for upshifts.

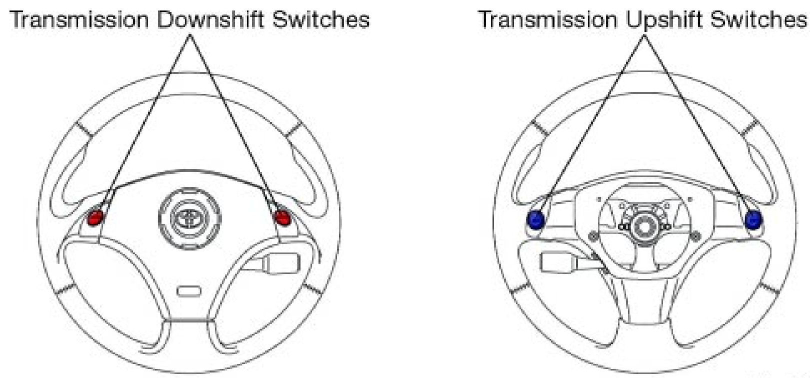


Fig. 7-9
T302f709

Stop Light Switch

The stop light switch detects when the brake pedal is applied. The ECM must see the brake pedal signal before it allows the engine to start.

Transmission Revolution Sensor

The transmission revolution sensor detects input shaft speed so the ECU can disengage the clutch when shaft speed reaches a predetermined speed threshold. The ECU matches input shaft and engine speed when shifting with the pedal released.

Gear Position Indicator

The gear position indicator is located in the combination meter and shows the gear position of the transmission. The indicator blinks if the shift lever position and the gear position become mismatched.

System Warning Light

The System Warning Light activates to alert the driver when the transmission control ECU detects a malfunction in the sequential manual transmission.

Gear Position Indicator & System Warning Light

The gear position indicator can be found in the combination meter as well as the system warning light, which illuminates when the transmission control ECU detect an error in the sequential manual transmission.

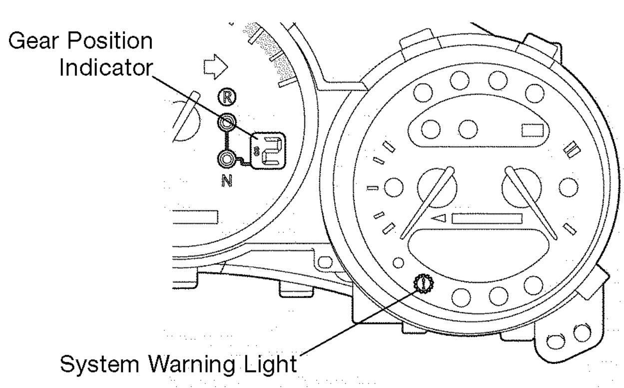


Fig. 7-10
T302f710

Courtesy Light Switch

The courtesy light switch is located on the driver's door to indicate the driver's entry to the vehicle. This input to the ECU starts the HPU to build hydraulic pressure for actuator operation.

Throttle Control (ETCS-i)

Throttle position is determined by the accelerator pedal position sensor input and the ECM. The throttle opening is controlled by the ECM's signal to the throttle motor. The ECM matches engine speed to the transmission input shaft speed for proper gear engagement.

Shift Lock Mechanism

A shift lock mechanism locks the shift lever when the ignition switch is turned to OFF or ACC. Since there is no mechanical linkage, this mechanism prevents the shift lever position and the transmission gear position from becoming mismatched.

The shift lock mechanism contains:

- Shift lock solenoid
- Stopper plate
- Lock plate (integrated with No. 2 lever)

The lock plate and No. 2 lever move in unison with the shift lever when shifting between ranges. The lock plate has holes for R, N, and S, so that it can be locked in any range. When the ignition is switched OFF, the stopper plate rotates due to the movement of the shift lock solenoid, causing the protrusion on the plate to engage with the hole in the lock plate.

A shift lock override button is accessible under the cover in the top of the center console. Pressing the button causes the linkage to disengage the stopper plate from the lock plate.

Shift Lock Mechanism

A shift lock mechanism locks the shift lever when the ignition switch is turned to OFF or ACC.

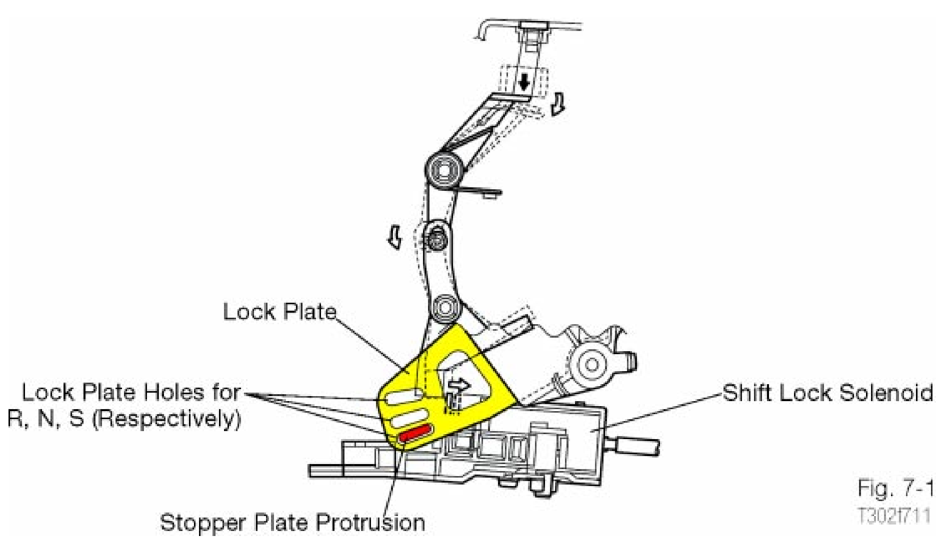


Fig. 7-11
T302f711

Shift Lock Solenoid

The shift lock solenoid locks the movement of the shift lever when the ignition switch is turned to OFF or ACC and prevents the lever position and gear position from becoming mismatched.

Shift Lock Solenoid

The shift lock solenoid pulls the stopper plate to the green position shown here to disengage it from the lock plate.

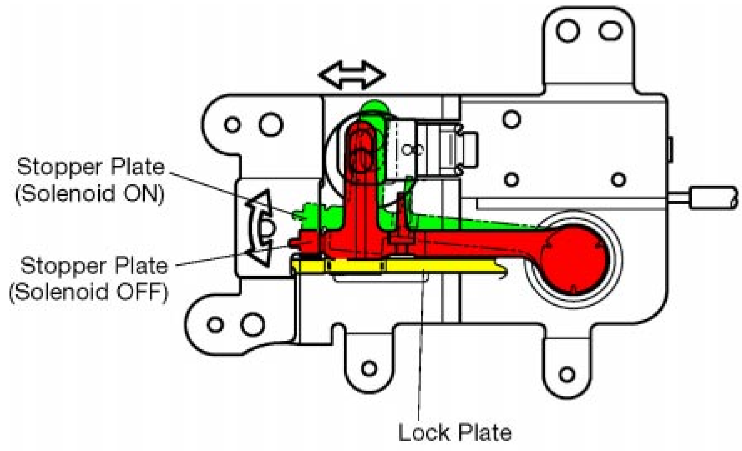


Fig. 7-12
T302f712

System Operation

When the driver's door is opened, the signal from the courtesy light switch activates the transmission control ECU, causing the hydraulic power unit to operate, creating hydraulic pressure for gear shift actuator operation.

When the ignition switch is turned on, the shift lock mechanism unlocks, enabling the driver to operate the shift lever. The ECM allows the starter to crank the engine only when the brake pedal is pressed, the shift lever is in the N range and the transmission is in neutral.

When the transmission is shifted to 1st, 2nd, or reverse gear and the accelerator pedal is pressed, the ECU engages the clutch by controlling the clutch solenoid valve and the clutch release cylinder.

When an up-shift or downshift signal, generated by the operation of the shift lever or the transmission shift switches, is input to the transmission control ECU, the control ECU disengages the clutch. The control ECU shifts gears by controlling the shift solenoid and the select solenoid in the gear shift actuator assembly. When the shift is completed, the shift stroke sensor and the select stroke sensor send signals to the ECU that engages the clutch while controlling clutch application speed.

The clutch is disengaged when the vehicle is stopped with the engine running.

To park the vehicle with the transmission in reverse or 1st gear, place the shift lever in R or S before the key is turned off. The ECU engages the clutch approximately one second after the key is turned off.

System Diagnosis

The Diagnostic Tester is a very useful tool when diagnosing electronic control transmission problems. It can be used to:

- Retrieve Diagnostic Trouble Codes (DTCs).
- View freeze-frame data.
- Display and monitor sensor and actuator data.
- Display data graphically.
- View oscilloscope waveforms.
- Perform actuator function tests.
- Record and recall data using the snapshot feature.
- Print data lists, graphs, scope displays and test results.
- Perform ECU relearning.

Diagnostic Tester

The Diagnostic Tester provides access to large quantities of information from a conveniently located diagnostic connector.

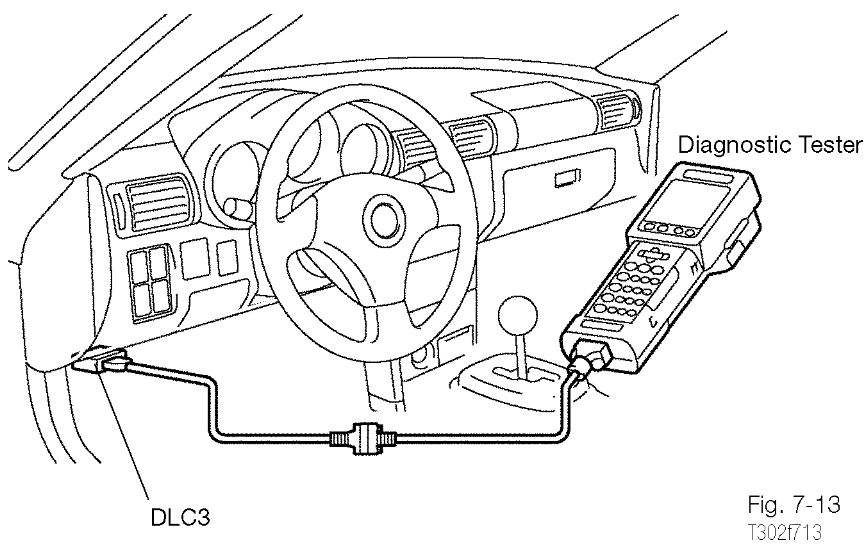


Fig. 7-13
T302f713

Diagnostic Tester Usage

The Diagnostic Tester provides access to large quantities of information from a conveniently located diagnostic connector rather than performing tedious pin checks with a DVOM.

A Diagnostic Tester allows a "quick check" of sensors, actuators, and **ECM** calculated data. Scan data allows you to quickly compare selected data to repair manual specifications or known good data.

When checking intermittent fault conditions, it provides an easy way to monitor input signals while wiring or components are manipulated, heated or cooled.

Serial Data

Serial data is electronically coded information, which is transmitted by one computer and received and displayed by another computer. The transmitting computer digitizes the data sensors, actuators and other calculated information and receives and displays it as an analog voltage, temperature, speed, time or other familiar unit of measurement.

NOTE

When attempting to diagnose certain types of problems using **serial data**, it is important to remember serial data is processed information, not a live signal. It represents what the ECM "thinks" it is seeing rather than the actual signal measured at the ECM terminal. Serial data can also reflect a "default" ECM signal value, rather than the actual signal.

On-Board Diagnostics System

The vehicle's onboard computer lights up the MIL on the instrument panel when the computer detects a malfunction in the transmission control ECU or in the drive system components that affect the vehicle emissions. In addition, diagnostic trouble codes are recorded in the ECU's memory.

If the malfunction does not reoccur in three trips, the MIL goes off but the DTC remains recorded in the ECU memory. Although there may be no MIL light on, there may be stored codes to help in the diagnosis.

The diagnostic system operates in the normal mode during normal vehicle use, and also has a check mode for technicians to simulate malfunction symptoms and perform troubleshooting. Most DTCs use 2-trip detection logic to prevent erroneous detections. By switching the ECM to the check mode when troubleshooting, a technician can cause the MIL to light up for a malfunction that is only detected once or momentarily.

When the diagnostic system is switched from the normal mode to the check mode, all DTCs and freeze frame data recorded in normal mode will be erased. So before switching modes, always check the DTCs and freeze frame data, and note them down.

2-Trip Detection Logic

When a logic malfunction is first detected, the malfunction is temporarily stored in the ECM memory. If the same malfunction is detected again during the second drive test, the second detection causes the MIL to light up (2nd trip). However, the ignition switch must be turned OFF between the 1st trip and 2nd trip.

Freeze Frame Data

Freeze frame data records the sequential transmission condition when a malfunction (first malfunction only), is detected. When troubleshooting, it is useful for determining whether the vehicle was running or stopped, the engine was warmed up or not, etc., at the time of the malfunction.

Verify Customer Complaint

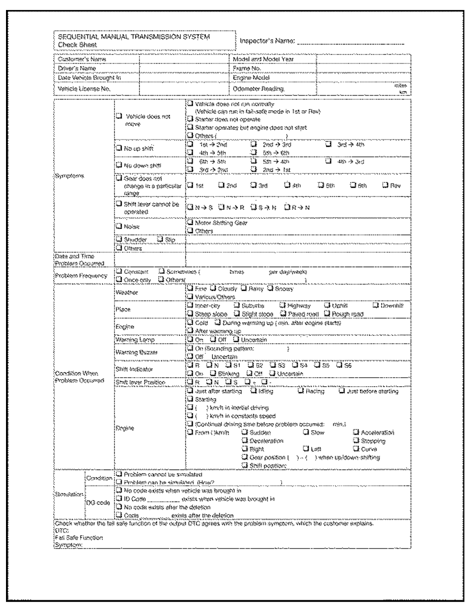
Communication between the customer and the technician is essential to verifying the complaint. The technician is frequently isolated from the customer and receives his information third-hand from the Service Writer. To bridge this gap, a customer interview sheet is strongly recommended to ensure the technician has as much information as possible to begin his diagnostic effort. The more details that are available, the more likely the condition can be found quickly. A sample Customer Problem Analysis Check Sheet can be found in Appendix E.

If the complaint cannot be verified, it may be necessary to speak with the customer and have him/her accompany you on the road test to identify their concern.

After verifying the customer's complaint, consult TIS for additional information and check Technical Service Bulletins, which may be related to the vehicle condition.

Customer Interview Sheet

The Customer Interview Sheet is a form found in the Repair Manuals and has also been included as Appendix E in this handbook. Utilizing this form insures that correct and accurate data is received.



SEQUENTIAL MANUAL TRANSMISSION SYSTEM Check Sheet

Inspector's Name: ______________________

Customer's Name		Model and Model Year	
Driver's Name		Frame No.	
Date Vehicle Brought In		Engine Model	
Vehicle License No.		Odometer Reading	miles / km

Symptoms	❑ Vehicle does not move	❑ Vehicle does not run normally (Vehicle can run in fail-safe mode in 1st or Rev) ❑ Starter does not operate ❑ Starter operates but engine does not start ❑ Others ( )
	❑ No up shift	❑ 1st → 2nd ❑ 2nd → 3rd ❑ 3rd → 4th ❑ 4th → 5th ❑ 5th → 6th
	❑ No down shift	❑ 6th → 5th ❑ 5th → 4th ❑ 4th → 3rd ❑ 3rd → 2nd ❑ 2nd → 1st
	❑ Gear does not change in a particular range	❑ 1st ❑ 2nd ❑ 3rd ❑ 4th ❑ 5th ❑ 6th ❑ Rev
	❑ Shift lever cannot be operated	❑ N → S ❑ N → R ❑ S → N ❑ R → N
	❑ Noise	❑ Motor Shifting Gear ❑ Others
	❑ Shudder ❑ Slip ❑ Others	
Date and Time Problem Occurred		
Problem Frequency	❑ Constant ❑ Sometimes (times per day/week) ❑ Once only ❑ Others( )	
Condition When Problem Occurred	Weather	❑ Fine ❑ Cloudy ❑ Rainy ❑ Snowy ❑ Various/Others
	Place	❑ Inner-city ❑ Suburbs ❑ Highway ❑ Uphill ❑ Downhill ❑ Steep slope ❑ Slight slope ❑ Paved road ❑ Rough road
	Engine	❑ Cold ❑ During warming up (min. after engine starts) ❑ After warming up
	Warning Lamp	❑ On ❑ Off ❑ Uncertain
	Warning Buzzer	❑ On (Sounding pattern:) ❑ Off Uncertain
	Shift Indicator	❑ R ❑ N ❑ S1 ❑ S2 ❑ S3 ❑ S4 ❑ S5 ❑ S6 ❑ On ❑ Blinking ❑ Off ❑ Uncertain
	Shift lever Position	❑ R ❑ N ❑ S ❑ + ❑ -
	Engine	❑ Just after starting ❑ Idling ❑ Racing ❑ Just before starting ❑ Starting ❑ ( ) km/h in inertial driving ❑ ( ) km/h in constants speed ❑ (Continual driving time before problem occurred: min.) ❑ From ( )km/h ❑ Sudden ❑ Slow ❑ Acceleration ❑ Deceleration ❑ Stopping ❑ Right ❑ Left ❑ Curve ❑ Gear position ( ) → ( ) when up/down shifting ❑ Shift position:
Simulation	Condition	❑ Problem cannot be simulated ❑ Problem can be simulated. (How?)
	DG code	❑ No code exists when vehicle was brought in ❑ ID Code ________ exists when vehicle was brought in ❑ No code exists after the deletion ❑ Code ________ exists after the deletion

Check whether the fail safe function of the output DTC agrees with the problem symptom, which the customer explains.
DTC:
Fail Safe Function
Symptom:

Fig. 7-14
T302f714

Warning Light Check

Turn the ignition switch ON and check that the warning light goes off after 5 seconds.

If the warning light does not light up, check the sequential manual transmission warning light circuit. If the light does not go off, check for a DTC.

Check Sequential Manual Transmission Warning Light

If the warning light does not light up or does not go off, check the sequential manual transmission warning light circuit.

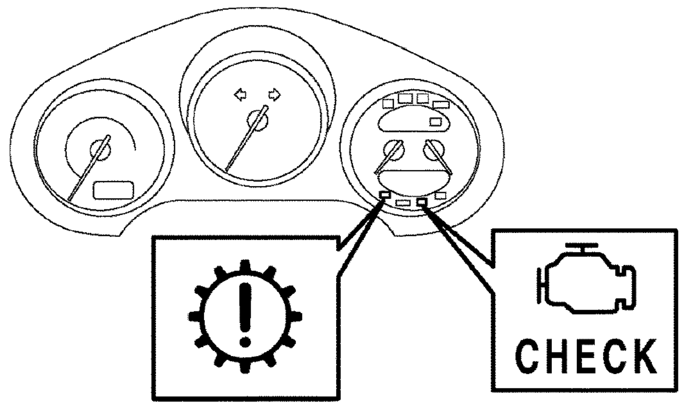


Fig. 7-15
T302f715

Prepare the Diagnostic Tester

To prepare the Diagnostic Tester:

1. Connect the Diagnostic Tester to the DLC3 at the lower left portion of the instrument panel.
2. Turn the ignition switch ON and press the ON button.
3. Check the DTCs and freeze frame data; note them down.
4. See the diagnostic section of the MR2 Repair Manual to confirm the details of the DTCs.

Using the Diagnostic Tester

To check the DTCs, connect the Diagnostic Tester to the DLC3 of the vehicle.

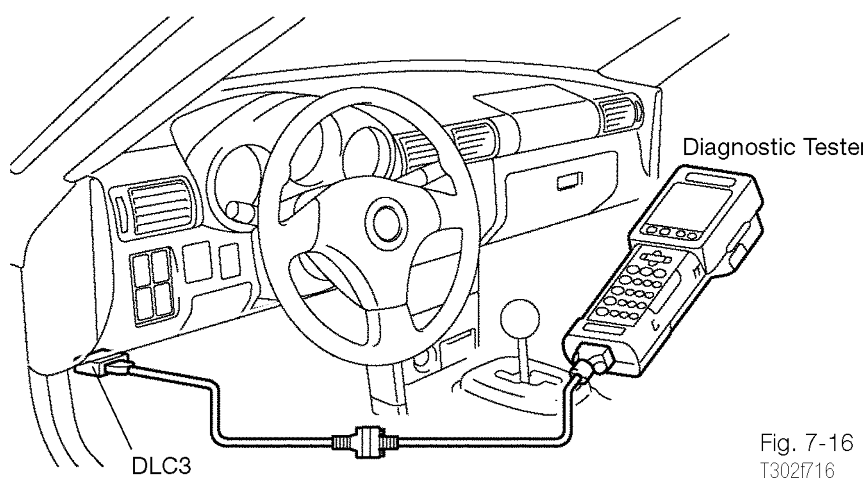


Fig. 7-16
T302f716

Diagnostic Trouble Codes (DTC)

Diagnostic Trouble Codes (DTC) retrieved using the Diagnostic Tester indicate that a malfunction has occurred. The left column of the DTC chart directs you to the proper page to begin a circuit diagnosis and provides a description of the trouble code.

Using the chart in figure 7-17, DTC P0820 refers you to the circuit diagnosis on page DI-284 of the MR2 Repair Manual. The item detects a Shift Lever Switch malfunction. The components to check are the switch, circuits and ECU.

Diagnostic Trouble Codes (DTC) Chart

This is a sample page of the Diagnostic Trouble Codes Chart found in the Repair Manual.

DI–250

DIAGNOSTICS – SEQUENTIAL MANUAL TRANSMISSION

DTC No.	Detection Item	Trouble Area	SMT	Memory
P0562 (DI–256)	System Voltage Low	• SMT B fuse • Open or short in +B circuit • Open or short in +B1 signal circuit • Battery • Transmission control ECU		
P0703 (DI–260)	Brake Switch "B" Circuit	• Stop light switch • STP fuse • Open or short in STP signal circuit • Transmission control ECU		
P0715 (DI–263)	Input/Turbine Speed Sensor "A" Circuit	• Input shaft revolution sensor • Open or short in NIP signal circuit • Transmission control ECU		
P0725 (DI–266)	Engine Speed Input Circuit	• Open or short in NEO or CAN circuit • ECM • Transmission control ECU		
P0807 (DI–268)	Clutch Position Sensor Circuit Low	• Clutch stroke sensor • Open in clutch stroke sensor circuit • Transmission control ECU		
P0808 (DI–268)	Clutch Position Sensor Circuit High	• Clutch stroke sensor • Short in clutch stroke sensor circuit • Transmission control ECU		
P0810 (DI–274)	Clutch Position Control Error	• Clutch stroke sensor • Open or short in clutch stroke sensor circuit • Open or short in clutch solenoid circuit • GSA (System hoses) • HPU (Clutch solenoid) • Transmission control ECU		
P0812 (DI–278)	Reverse Input Circuit	• Shift stroke sensor • Select stroke sensor • Back–up light switch • Back–up light switch No. 2 • Open or short in reverse switch circuit • Transmission control ECU • Open or short in shift stroke sensor circuit • Open or short in select stroke sensor circuit • GSA • Shift and select lever shaft		
P0820 (DI–284)	Gear Lever X–Y Position Sensor Circuit	• Shift lever switch • Open or short in LSW1 – LSW4 signal circuit • Open or short in LS1C – LS4C signal circuit • Transmission control ECU		
P0847 (DI–288)	Transmission Fluid Pressure Sensor/Switch "B" Circuit Low	• GSA (Master pressure sensor) • Open in master pressure sensor circuit • HPU (Master solenoid) • Transmission control ECU		
P0848 (DI–288)	Transmission Fluid Pressure Sensor/Switch "B" Circuit High	• GSA (Master pressure sensor) • Short in master pressure sensor circuit • HPU (Master solenoid) • Transmission control ECU		

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Fig. 7-17

T302f717

Circuit Diagnosis The circuit diagnosis in the Repair Manual contains a description, the electrical diagram, inspection procedures, and the appropriate steps for diagnosing the concern. Testing the circuit may now be required.

Circuit Diagnosis

This is a the Circuit Diagnosis page for the DTC P0820 from the Repair Manual. It contains a DTC description and the electrical diagram for the circuit.

DI–284

DIAGNOSTICS – SEQUENTIAL MANUAL TRANSMISSION

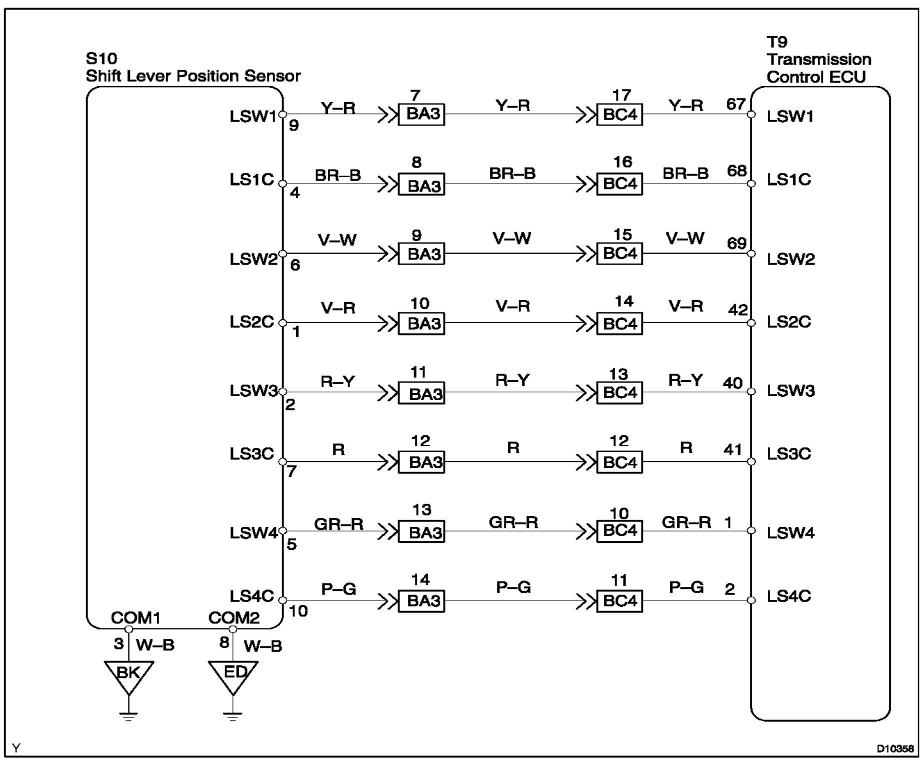
DIADT–01

DTC	P0820	Gear Lever X–Y Position Sensor Circuit

CIRCUIT DESCRIPTION

DTC No.	DTC Detection Condition	Trouble Area
P0820	8 switches inside shift lever switch are improperly combined.	• Shift lever switch • Open or short in LSW1 – LSW4 signal circuit • Open or short in LS1 – LS4C signal circuit • Transmission control ECU

WIRING DIAGRAM



2003 MR2 (RM967U)

Fig. 7-18

T302f718

Inspection Procedure

The inspection procedure in the Circuit Diagnosis section of the Repair Manual describes the steps to take to determine the cause of the system malfunction. In this case, the Diagnostic Tester is used to check the shift lever switch and circuit. If the check fails, a pin check of the switch narrows the cause to the switch, circuit, or transmission ECU.

Inspection Procedure

In this example of the inspection procedure from the Circuit Diagnosis section of the Repair Manual, the Diagnostic Tester is used to check the shift lever switch and circuit.

DI–285

DIAGNOSTICS – SEQUENTIAL MANUAL TRANSMISSION

INSPECTION PROCEDURE

HINT:

Read freeze frame data using hand–held tester or OBD II scan tool, as freeze frame data records the engine conditions when a malfunction is detected. When troubleshooting, it is useful for determining whether the vehicle was running or stopped, the engine was warmed up or not, etc. at the time of the malfunction.

1	**Connect hand–held tester, check shift lever switch signal.**

PREPARATION:

(a) Start the engine and warm it up.

(b) Connect the hand–held tester to the DLC3.

CHECK:

Read the value of the shift lever switch by using the hand–held tester.

OK:

Shift lever position	Tester display							
	SHIFT SW SIG1	SHIFT SW SIG2	SHIFT SW SIG3	SHIFT SW SIG4	SHIFT CHECK SIG1	SHIFT CHECK SIG2	SHIFT CHECK SIG3	SHIFT CHECK SIG4
R	OFF	ON	OFF	OFF	ON	OFF	ON	ON
N	OFF	OFF	OFF	ON	ON	ON	ON	OFF
S	OFF	OFF	ON	OFF	ON	ON	OFF	ON
–	OFF	ON	ON	OFF	ON	OFF	OFF	ON
+	ON	OFF	ON	OFF	OFF	ON	OFF	ON

OK → **Replace transmission control ECU.**

NG

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Fig. 7-19

T302f719

Problem Symptoms Table

The Problem Symptom Table in the Repair Manual provides access to the diagnostic test procedure if a malfunction occurs and no DTCs are present. An example is shown in figure 7-20: The symptom is found in the left column. The suspect components are listed in the second column, and the page reference is located in the column to the right of the components.

Problem Symptoms Table

If no DTC is displayed during the DTC check, use the Problem Symptoms Table to proceed to the relevant troubleshooting page.

DI–256

DIAGNOSTICS – SEQUENTIAL MANUAL TRANSMISSION

PROBLEM SYMPTOMS TABLE

If a normal code is displayed during the DTC check but the problem still occurs, check the problem symptom in the order given in the table below and proceed to the relevant troubleshooting page.

NOTICE:

When replacing the transmission control ECU or sensor, turn the ignition switch OFF and close the driver's door, and after replacing the transmission control ECU, make the transmission control ECU learn characteristics (See page DI–236, step 8).

Symptom	Suspected Area	See page
No–up shift No–down shift	3. Transmission 4. Clutch disc 5. HPU (Master solenoid) 6. HPU (Accumulator) 7. HPU (Accumulator pressure sensor) 8. HPU (Motor pump) 9. HPU (Clutch solenoid) 10.GSA (Shift solenoid) 11.GSA (Select solenoid) 12.GSA (Master pressure sensor) 13.GSA (System hoses) 14.Shift lever 15.Shift lever switch 16.Input shaft speed sensor 17.Input shaft speed sensor circuit 18.Transmission control ECU	SM–3 CL–1 DI–352 DI–338 DI–338 DI–338 DI–304 DI–332 DI–312 DI–321 SM–67 SM–91 DI–284 DI–263 DI–263 –
SMT warning light defective.	1. SMT warning light circuit 2. Transmission control ECU	DI–362 –
DTC check cannot be performed.	1. SMT warning light circuit 2. TC terminal circuit	DI–362 DI–230
Transmission control ECU buzzer does not sound when a miss operation occurs.	1. Door courtesy switch circuit 2. Stop light switch circuit 3. Transmission control ECU	DI–357 DI–293 –

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Fig. 7-20
T302f720

Service Procedures

There are a number of procedures specific to the sequential manual transmission that may need to be performed when servicing.

Reducing Accumulator Pressure

Before removing any of the parts listed below, the hydraulic power unit accumulator pressure must be reduced using the Diagnostic Tester and the procedure listed in the Diagnostics section of the Repair Manual.

- Hydraulic power unit assembly
- Gear shift actuator assembly
- Shift stroke sensor
- Select stroke sensor
- Sub-wire harness
- Clutch stroke sensor
- Transmission assembly or transmission component parts
- Clutch disc or related components

Use the Diagnostic Tester to access the REDUC ACCM PRS in the active test menu. The amount of accumulator pressure will be displayed on the screen when the procedure is complete. The pressure should be zero.

Hydraulic Power Unit Fluid Level Check

After the fluid pressure has been reduced to zero, the fluid level in the hydraulic power unit must be checked with the hydraulic power unit and gear shift actuator hoses connected,

The vehicle should be parked on a level surface with the park brake set. The vehicle air cleaner box must be removed to access the fluid reservoir that is protected by a plastic cover. The level can be viewed through a check window on the reservoir tank.

The required fluid type is Toyota's Sequential M/T Fluid.

Fluid Level Check

The level can be viewed through a check window on the reservoir tank

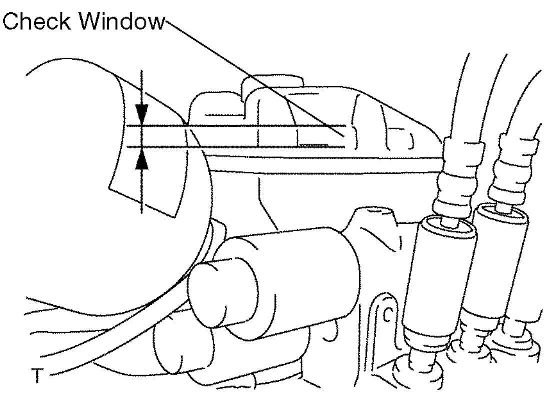


Fig. 7-21
T302f721

ECU Relearning

The Diagnostic Section of the Repair Manual as well as the latest Technical Service Bulletins should be consulted when performing ECU relearning. Since the ECU monitors a number of sensors and controls the shift, clutch and throttle functions with precision, the ECU must be able to learn the values of each sensor to compensate for both manufacturing tolerances and mixing new parts with existing parts when repairs are made. ECU relearning should be performed whenever any of the following parts are replaced:

- Hydraulic power unit assembly
- Gear shift actuator assembly
- Shift stroke sensor
- Select stroke sensor
- Clutch stroke sensor
- Transmission assembly or transmission component parts
- Clutch disc or related components

NOTE Because the ECU will be looking for events to occur in a specific order, it is important to follow the procedure in the order listed, and that both the time and speed requirements be precisely met.

Vehicle Staging

Before beginning the relearning procedure ensure the following steps are taken:

- Stop the vehicle
- Close the driver's side door (door courtesy light switch provides a ground for the transmission control ECU)
- Shift lever into the N position
- Verify the ignition switch is OFF

Diagnostic Tester Use

Follow the procedure in the repair manual by installing the diagnostic tester to DLC3.

- Access PARTS EXCHANGE through the OBD/MOBD Diagnostic menu because Enhanced OBD II is not supported on the SMT MR2
- Follow the screen prompts, and when prompted turn the key OFF for 15 seconds or more, then turn it ON.

The N position indicator light should light up. If the light comes ON steady, then relearning is NOT required.

Relearn Procedure

If the N light does not light up or it flashes, do the following:

- Turn the ignition switch OFF and remove the key
- Disconnect the battery negative cable for at least one minute
- Make sure the transmission shift and select rod is in the neutral position (hole pointing straight up and down)
- Turn the wheels slowly so the gears rotate in the transmission allowing the synchronizers and gears to align properly while doing the following:
  - Connect the negative battery terminal
  - Insert the key and turn the ignition switch to ON
  - Wait about one minute for the gear shift actuator to actuate various gear positions and the N light to come ON

NOTE The gear position indicator may display S5, S4, S3, S2, and S1 consecutively before the N light comes ON.

Gear Position Indicator

During the relearn procedure, the gear position indicator may display S5, S4, S3, S2, and S1 consecutively before the N light comes ON.

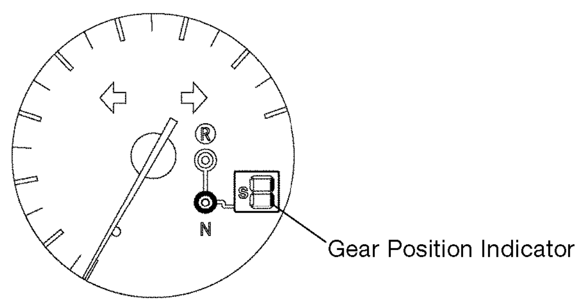


Fig. 7-22
T302f722

- Move the select lever to the S position and drive up to 20 mph in 1st gear
- When the vehicle runs above 3 mph or more the sequential indicator light lights up for one second. ECU learning is complete

ECU Replacement

When replacing the SMT transmission control ECU be sure to follow the specific procedure outlined in Technical Service Bulletin TC003-02. Highlights include:

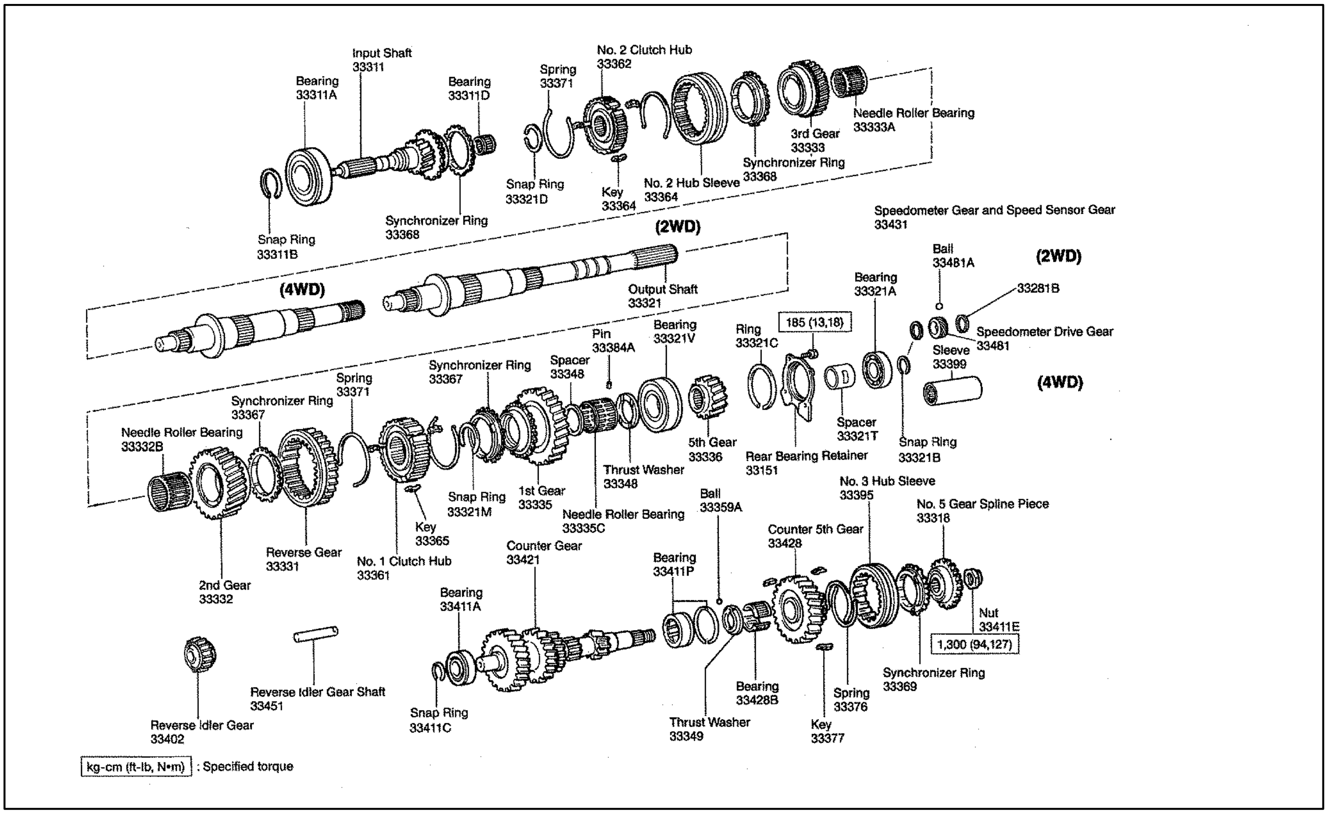
- Remove the key from the ignition when turning the ignition OFF.
- Remove the four retaining bolts from the transmission control ECU mounting flanges before removing the electrical connector.
- Attach the electrical connector before securing the transmission control ECU with the retaining bolts.
- Visually confirm that the electrical connector attaching hook is properly engaged under the transmission control ECU pin when reconnecting.
- Visually confirm that the connectors are properly aligned, and that the metal arm can easily be fully closed.
- Swing the wire harness electrical connector in a single, fluid motion into the transmission control ECU connector.

ECU Replacement

Swing the wire harness electrical connector in a single, fluid motion into the Transmission control ECU connector.

Fig. 7-23
T302f723

Appendix



Learning Objectives:

Appendix A: Glossary of Terms

Appendix B: Safety

Appendix C: Special Service Tools (SSTs)

Appendix D: Transmission and Transaxle Identification Charts

Appendix E: Customer Interview Sheet

Appendix A
Glossary of Terms

A

Axial Runout – Warpage in the flywheel or clutch disc in a direction parallel to the axis of the shaft or bearing bore.

Axis – The centerline around which a gear or shaft rotates.

All-Wheel Drive (AWD) – A drive system that provides full-time drive to the front and rear wheels. Also called full-time 4WD. The vehicle has a center differential and can be driven on dry pavement in 4WD.

B

Bearing – A member that supports a rotating shaft and reduces friction between stationary and rotating parts.

C

Center Bearing – A sealed double row center ball bearing that carries the load between the inner and outer halves of the flywheel damper.

Center Differential – A differential used in four-wheel-drive systems to distribute power to the front and rear differentials.

Centerline – The axis around which a gear or shaft rotates.

Centrifugal Force – The tendency of objects to move away from the center of rotation when rotated.

Chamfer – A beveled edge on a shaft or bore.

Cluster Gear – A group of gears machined from one piece of metal, or individual gears combined into a group so that they operate together.

Clutch Assembly – The clutch assembly consists of the following components: clutch disc, flywheel, clutch cover assembly, release bearing, and release fork. It interrupts the power flow between the engine and the transmission when the vehicle is brought to a stop with the engine running or when shifting gears.

Clutch Cover Assembly – The clutch cover assembly consists of a clutch cover, diaphragm spring, pressure plate, and pivot rings and straps; the pivot rings and straps are bolted to the flywheel and provide the pressure needed to hold the clutch disc to the flywheel for proper power transmission. Toyota uses three different types of clutch cover assemblies: Diaphragm Spring, Diaphragm Spring Turnover (DST) and Pull Release Mechanism.

Clutch Disc – The clutch disc is connected to the input shaft of the transmission, and is the connecting link between the engine and transmission. A clutch disc is made up of several major parts: the facing or lining, the cushion plate or web, and the hub and damper assembly.

Clutch Hub – A hub constructed with internal splines that fit over the external splines of the transmission input shaft.

Clutch Pack – The assembly of clutch discs and steel plates that provide the frictional surfaces in a multi-plate clutch or brake.

D

Damper – A device that reduces the torsional vibrations between the engine and transmission. See Flywheel Damper.

Detent – A spring-loaded device used to position a shift fork correctly.

Dial Indicator – A measuring device that indicates linear travel by a rotating needle.

Diaphragm Spring – A round, conical shaped spring that provides the clamping force against the pressure plate.

Differential – The assembly of a carrier, pinion gears and side gears that allows the drive axles to rotate at different speeds as a vehicle turns a corner.

Direct Drive – A one to one (1:1) gear ratio in which the input shaft and output shaft rotate at the same speed.

Dual Mass Flywheel (DMF) – See Flywheel Damper.

E

End Play – The amount of motion a shaft or gear has in a direction parallel to the shaft. This clearance allows space for oil to fit between moving parts.

Energy Absorbing Flywheel – See Flywheel Damper.

F

Final Drive – The last set of reduction gears in a transaxle before power flows to differential gears and drive axles.

Flywheel – A large metal disc that stores and releases energy pulses from the crankshaft. It drives the clutch by providing a friction surface for the clutch disc, and provides a mounting surface for the clutch cover.

Flywheel Damper – A type of flywheel, sometimes referred to as the energy absorbing flywheel or dual mass flywheel (DMF); it is designed to isolate torsional crankshaft spikes created by engines with high compression ratios.

Formed-In-Place Gasket (FIPG) – A gasket material from a tube applied to metal surfaces before assembly.

Four Wheel Drive (4WD) – A drivetrain configuration that delivers power to all wheels.

Front Engine Front Drive (FF) – A drivetrain configuration that delivers power to the front wheels in a vehicle equipped with a front engine.

Front Engine Rear Drive (FR) – A drivetrain configuration that delivers power to the rear wheels in a vehicle equipped with a front engine.

G

Gear – A wheel with teeth on the inside or outside circumference that transmits motion or power to another gear.

Gear Ratio – The number of turns made by a drive gear compared to the number of turns by the driven gear. Computed by the number of driven gear teeth divided by the number of drive gear teeth.

Gear Reduction – A condition when the drive gear rotates faster than the driven gear. Speed is reduced but torque is increased.

Gear Shift Actuator (GSA) – Engages or disengages the clutch and selects gears based on signals from the transmission control ECU in vehicles equipped with the sequential manual transmission.

H

Helical Gear – A gear with teeth cut at an angle or helix. The threads on a bolt are a helix.

Hub – The center part of a wheel, the surface where a wheel mounts.

Hydraulic Clutch – A clutch operating system using hydraulic pressure to transfer motion and pressure.

Hydraulic Power Unit (HPU) – Generates hydraulic pressure for the shift operating system and the clutch release cylinder in vehicles equipped with the sequential manual transmission.

Hypoid Gear – A bevel gear that positions the gear axis on non-intersecting planes. Commonly used in ring and pinion type axles where the driveline is connected to pinion and axles are driven by ring. Changes direction of rotation by 90 degrees.

I

Idler Gear – A gear positioned between two other gears, which causes a change in direction of rotation. Allows output to turn in the same direction as input.

Inertia – The physical property maintaining that a body at rest tends to remain at rest and a body at motion tends to remain in motion and travel in a straight line.

Input Shaft – The shaft that carries the driving torque into a gearbox.

Internal Ring Gear – A gear with teeth on its inner circumference.

J

Journal – A bearing surface for a shaft, gear or bearing to rotate on.

L

Limited Slip Differential (LSD) – A differential that uses internal clutches, gears, or viscous couplers to limit the speed difference between the axles.

Linkage – A series of rods, levers or cables, etc., used to transmit motion of force from one point to another.

M

Master Cylinder – The primary device holding hydraulic fluid in a hydraulic clutch system. Activated by the clutch pedal.

Micrometer – A precision measuring device used to measure outside diameters or thickness, and internal diameters or depth.

O

O-Ring – A round sealing ring.

Orifice – A small opening or restriction in a hydraulic passage used to regulate pressure and flow.

Output Shaft – The shaft that carries torque out of a gearbox.

Overdrive – Occurs when the drive gear rotates at a slower speed than the driven gear. Speed of the driven gear is increased and torque is decreased.

P

Pinion Gear – A small gear that meshes with a larger gear.

Pivot Rings – Circular steel rings installed in the clutch cover assembly on both sides of the diaphragm spring. They serve as a pivot point when the release bearing is forced against the diaphragm spring.

Planetary Gear Set – A gear assembly consisting of a sun gear, ring gear and carrier assembly with planetary pinion gears meshed between the sun gear and ring gear.

Planetary Gear Unit – The assembly that includes the planetary gear set, holding devices and shafts, which provides gear reduction for L4 in a transfer case.

Planetary Carrier – Member of the planetary gear set that house the planetary pinion gears.

Planetary Pinion Gears – Mounted to the planetary carrier by pinion shafts. Operate between the ring gear and sun gear.

Pressure Plate – A plate attached to the clutch cover that provides the pressure needed to hold the clutch disc to the flywheel for proper transmission power.

Pull Release Mechanism – A style of clutch cover with the following characteristics: release bearing and hub are fit into the diaphragm spring, the diaphragm spring is pulled out instead of pushed in.

R

Race – A hardened surface for bearings to roll on. Part of the bearing that can be replaced instead of replacing the shaft or case.

Release Cylinder – The device that reacts to pressure sent by the master cylinder, causing the clutch fork to move. Also called the release cylinder.

Retracting Springs – The steel springs attached to the clutch cover that connect the diaphragm spring and the pressure plate.

Reverse Idler Gear – See Idler Gear.

Room Temperature Vulcanizing (RTV) – A type of Formed-In-Place Gasket (FIPG) material; it is a rubber like material that vulcanizes at room temperature.

Runout – Deviation in an item's rotation or a mounting plane. Runout is measured axially (parallel to the axis) and radially (perpendicular to the axis).

S

Sensor – The generic name for a device that senses either the absolute value or a change in a physical quantity such as temperature, pressure or flow rate and converts that change into an electrical quantity signal.

Serial Data – Information about a computer system inputs, outputs, and other operating parameters, which is transmitted from the vehicle (one computer to another) to the scan tool on a single wire in the Data Link Connector (DLC).

Slave Cylinder – The device that reacts to pressure sent by the master cylinder, causing the clutch fork to move. Also called the release cylinder.

Snapshot – A mode of operation where basic diagnostic parameters are stored in the Diagnostic Tester during a road test and can be examined, printed, or transferred to a computer at the end of the test.

Speed Gear – A gearset fit on the transmission output shaft. These gearsets are in constant mesh and always rotate at their design speed relative to the input speed.

Spline – Slots or grooves cut around a shaft or bore that is used to connect a hub or a gear to a shaft.

Spur Gear – A gear with teeth cut parallel to the axis of the gear. Sometimes called a straight cut gear.

Sun Gear – The center gears of a planetary gear set around which the other gears rotate.

Synchronize – To bring two objects to the same rotating speed to cause two events to occur at the same time.

T

Throw-Out Bearing – Another name for the clutch release bearing.

Thrust – A motion, or force, of a gear or shaft along its axis.

Torque – Twisting or turning force measured in foot pounds or inch pounds of force (ft-lbf) or Newton-meters (N•m).

Torsion Dampers – The springs or rubber blocks attached to the clutch disc that reduce or eliminate torsional vibrations resulting from uneven engine and drivetrain power impulses.

Transaxle – A transmission that includes the final drive and differential, and is normally used in Front Engine Front Drive (FF) or Front Wheel Drive (FWD) vehicles.

Transfer Case – An auxiliary transmission used in most 4WD systems to provide and control powerflow to the front and rear drive axles.

Transmission – A device in the powertrain that provides different forward gear ratios, neutral and reverse. It transfers power from the engine to the propeller shaft. It converts and multiplies rotational speed, which in turn, controls vehicle speed.

Transmission Control ECU – Controls the Hydraulic Power Unit (HPU) and Gear Shift Actuator (GSA) assembly to engage and disengage the clutch and shift the gears based on signals from the ECM, sensors and switches in vehicles equipped with the sequential manual transmission.

U

Universal Joint (U-Joint) – A mechanical device used to transfer power and motion at changeable angles in the propeller shaft or driveline.

V

Viscosity – The tendency of a liquid to resist flowing. High viscosity fluid is thick. Low viscosity fluid flows easily.

Viscous – Thick, tending to resist fluid flow.

W

Wave Spring – A spring resembling a flat, wavy washer.

Worm Gear – A type of gear with teeth resembling screw threads.

Appendix B
Safety

Introduction

Automotive repair and service work can be extremely dangerous unless undertaken with adequate training and full knowledge of the consequences.

Before attempting any automotive repair or service work, formal automotive repair and service training is required as well as a thorough understanding of Toyota written repair and service procedures.

Your alertness, mental condition, and level of mechanical skill should be assessed along with the condition of the vehicle before attempting any automotive work that might cause you injury, damage to the vehicle, or result in an unsafe modification or condition.

Before attempting any work on the vehicle, all safety precautions as outlined by the Toyota service publications should be read and understood. Common sense and good judgment are important and crucial aspects of successful automotive work.

General Safety Guidelines

Follow these guidelines for general shop safety:

- Know the hazards associated with your work. Be sure you are fully educated on the proper use and operation of any tool before beginning a job.
- Always wear appropriate safety gear and protective clothing.
- Maintain good housekeeping standards.
- Keep the work area free from slipping/tripping hazards (oil, cords, debris, etc.).
- Clean all spills immediately.
- Remove metal chips regularly.
- It is recommended that electrical cords pull down from an overhead pulley rather than lying on the floor.
- Leave tool and equipment guards in place.
- Make sure all tools and equipment are properly grounded and that cords are in good condition.
- Double-insulated tools or those with three-wire cords are essential for safety.
- Use extension cords that are large enough for the load and distance.
- Secure all compressed gas cylinders. Never use compressed gas to clean clothing or skin.
- Know where fire extinguishers are located and how to use them.

Personal Protection

There are several measures you must take to protect yourself from shop hazards. For example, do not wear the following when working around machinery:

- Loose fitting clothing
- Neckties
- Jewelry

The hazards associated with shop work require special safety considerations.

Eye Protection

Always wear safety glasses when working with shop equipment. This is especially important when using compressed air, or when using a shop hammer to aid in removing or installing gears and bearings onto shafts.

- If you wear prescription glasses, wear goggles or other safety protection over the glasses.
- Safety glasses with side shields provide primary protection to eyes and are four times as resistant as prescription glasses to impact injuries.
- Goggles protect against impacts, sparks, chemical splashes, dust, and irritating mist. Wear full goggles, not just safety glasses, when working with cleaning chemicals.

Cleaning Components

When cleaning transmission components, wash the parts with a commercially available solvent. Remember to use gloves to protect your hands, and a respirator mask with proper filters. Remember to properly dispose of all waste.

CAUTION

Do **not** used compressed air for cleaning components or spinning up bearings.

Tools & Equipment

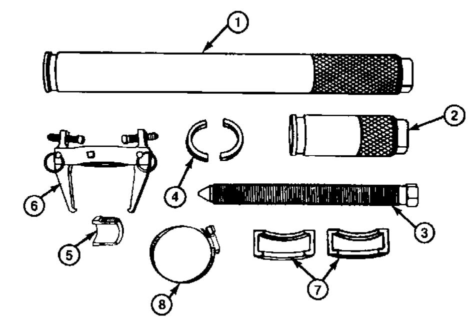
SST: Transmission Bearing Service Set

A division of SPX Corporation
655 Eisenhower Drive
Owatonna, MN 55060-0995 USA
Phone: (507) 455-7000
Tech. Serv.: (800) 533-6127
Order Entry: (507) 455-1480
International Sales: (507) 455-7223

Form No. 104857

Parts List & Operating Instructions
for: 00002-00907-01

Toyota
Transmission Bearing Service Set



Item No.	Part No.	No. Req'd	Description
1	00002-00907-7	1	Remover/Repl-acer (15-3/4")
2	00002-00907-12	1	Remover/Repl-acer (5-1/2")
3	00002-00907-8	1	Forcing Screw
4	00002-00907-10	1	Puller Ring Half
5	00002-00907-11	1	Replacer Shaft Collar
6	00002-00907-9	1	Bearing Puller
7	00002-00907-13	2	Collet Halves
8		1	Clamp
PARTS INCLUDED BUT NOT SHOWN			
	206613	1	Storage Box

NOTE: The tool set listed above is used in conjunction with a previously released Output Shaft Rear Bearing/Fifth Gear Service Set No. 00002-00907. The parts list and illustration for the previously released service set is shown on sheet 2 of 2.

OPERATING INSTRUCTIONS

BEARING REMOVAL - FRONT/REAR COUNTER SHAFT AND OUTPUT SHAFT

1. Remove the hitch pins from the Bearing Puller (Item 6) and slide the puller head onto the proper length Remover/Replacer (Item 1 or 2).
2. Position the puller ring halves (Items 4) into the groove on the remover/replacer tool (see Figure 1). Slide the puller head over the puller ring halves (see Figure 2). Tighten the set screw onto the ring halves as shown.

FIGURE 1

FIGURE 2

SHEET 1 OF 2
ISSUE DATE: 4-25-83

Fig. C-1
T302fC01

SST: Transmission Bearing Service Set

Parts List & Operating Instructions

Form No. 104857, Sheet 1 of 2, Back

3. Position the puller jaws behind the snap ring as shown in Figure 3.

NOTE: To provide clearance for the puller jaws, pull the transmission shaft out from the case as far as possible.

4. Slide the remover/replacer, with the puller head assembled, over the shaft and replace the hitch pins as shown in Figure 4.
5. Adjust the preload screws, as shown in Figure 5, until the remover/replacer is visually centered. Wrench tighten evenly.
6. Thread the Forcing Screw (Item 3) into the remover/replacer and turn clockwise until the bearing is pulled from the case.

FIGURE 3

FIGURE 4

FIGURE 5

BEARING INSTALLATION - FRONT/REAR COUNTER SHAFT AND OUTPUT SHAFT

FRONT/REAR COUNTERSHAFT BEARINGS

1. Position the bearing components to be installed onto the shaft. Place a remover/installer tube on the bearing and install the bearing.

IMPORTANT: Use a ''dead-blow'' type hammer to prevent damage to the threaded end of the remover/installer tube.

OUTPUT SHAFT BEARINGS

NOTE: Output shaft bearing replacement requires the use of a previously released Output Shaft Rear Bearing/Fifth Gear Service Set No. 00002-00907 in conjunction with the Replacer Shaft Collar (Item 5).

1. Position the bearing onto the output shaft. Place the Washer (Item 6 of tool set no. 00002-00907) against the bearing.
2. Place the Replacer Shaft Collar (Item 5 from tool set no. 00002-00907-01) onto the output shaft. Thread the Replacer Shaft (Item 4 of tool set no. 00002-00907) onto the replacer shaft collar. See Figure 8.
3. Slide the remover/replacer tube over the replacer shaft and up to the washer. Thread the hex nut onto the threaded shaft and wrench tighten until the bearing is installed.

Fig. C-2
T302fC02

SST: 5th Gear Service Set

A division of SPX Corporation
655 Eisenhower Drive
Owatonna, MN 55060-0995 USA
Phone: (507) 455-7000
Tech. Serv.: (800) 533-6127
Order Entry: (507) 455-1480
International Sales: (507) 455-7223

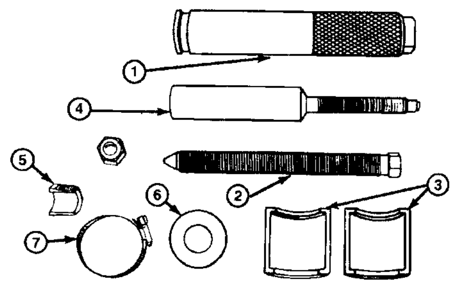
Form No. 104857

Parts List & Operating Instructions for: 00002-00907-01

5TH GEAR SERVICE SET

NOTE: 5th gear removal and installation requires use of a previously released Output Shaft Rear Bearing/Fifth Gear Service Set No. 00002-00907 in conjunction with the Replacer Shaft Collar (Item 5).

**OUTPUT SHAFT REAR BEARING/
5TH GEAR SERVICE SET**



Item No.	Part No.	No. Req'd	Description
1	**00002-00907-1**	1	Remover/Replacer Tube (10-3/4")
2	**00002-00907-2**	1	Forcing Screw
3	**00002-00907-3**	1	Collet—Pair
4	**00002-00907-4**	1	Replacer Shaft
5	**00002-00907-5**	1	Replacer Shaft Collar
6	**00002-00907-6**	1	Washer
7		1	Clamp

5TH GEAR REMOVAL

1. Slide the proper length Remover/Replacer Tube over the transmission output shaft. Position the two halves of the Collet (Item 3) over the fifth gear and into the groove of the remover/replacer tube as shown in Figure 6.
2. Slide the clamp over the collets and tighten it securely. See Figure 7.
3. Thread the Forcing Screw (Item 2) into the remover/replacement tube. Hold the tube securely and wrench turn the forcing screw until the gear is removed.

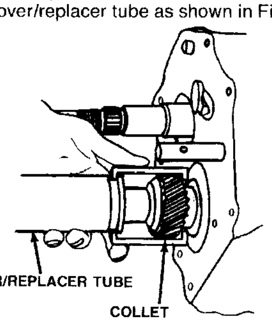


FIGURE 6

5TH GEAR INSTALLATION

1. Position 5th gear onto the output shaft. Place the Washer (Item 6) against the 5th gear.
2. Place the Replacer Shaft Collar (Item 5 from tool set 00002-00907-01 [Part No. 00002-00907-11]) onto the output shaft. Thread the Replacer Shaft (Item 4) onto the replacer shaft collar. See Figure 8.
3. Slide the remover/replacer tube over the replacer shaft and up to the washer. Thread the hex nut onto the threaded shaft and wrench tighten until the gear is installed.

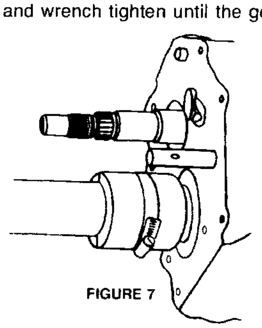


FIGURE 7

FIGURE 8

LITHO IN U.S.A.

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ISSUE DATE: 4-25-83

Fig. C-3
T302fC03

SST: 5th Gear Service Set

Parts List & Operating Instructions

Form No. 104857, Sheet 2 of 2, Back

AUTOMATIC TRANSMISSION FRONT PUMP PULLER

1. Thread the Forcing Screw (Item 3) into the Remover/Replacer Tube (Item 2).
2. Position the pulling flange of the Collet Halves (Item 7) over the pump shaft splined area and the remover/replacer tube. Slide the clamp over the collet halves and tighten securely. See Figure 9.
3. Wrench turn the forcing screw to pull the pump from the transmission housing.

FIGURE 9

Fig. C-4
T302fC04

SST: Output Shaft Rear Bearing/5th Gear Service Set

Form No. **104638**

OTC®

OWATONNA TOOL COMPANY
OWATONNA, MINNESOTA 55060, U.S.A. — TELEX: 29-0777

OPERATING INSTRUCTIONS FOR | MAJOR MOTORS **00002-00907**

OUTPUT SHAFT REAR BEARING/ FIFTH GEAR SERVICE SET

OUTPUT SHAFT REAR BEARING AND FIFTH GEAR REMOVAL:

1. Position the forcing screw (00002-00907-2) into the end of the remover/ replacer tube (00002-00907-1).
2. Slide the clamp over the remover/ replacer tube. Do not tighten at this time.
3. Slide the remover/replacer tube over the transmission output shaft.
4. Position the two halves of the collet (00002-00907-3) into the tube groove and over the rear bearing and fifth gear. (Fig. A)
5. Slide the clamp over the collet to hold the collet in place and tighten it with a screw driver. (See Fig. B)
6. Turn the forcing screw in to remove the bearing and gear. (Fig. C)

FIGURE A

FIGURE B

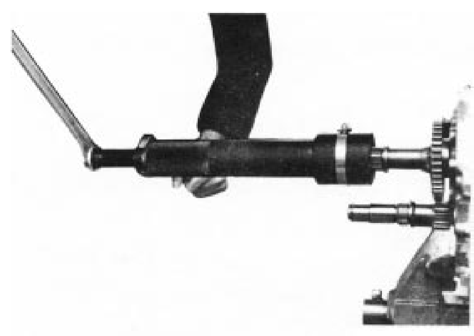


FIGURE C

36

Fig. C-5
T302fC05

SST: Output Shaft Rear Bearing/5th Gear Service Set

OPERATING INSTRUCTIONS (CONT'D)

OUTPUT SHAFT REAR BEARING AND FIFTH GEAR INSTALLATION:

1. Position the fifth gear and output shaft rear bearing onto the shaft.
2. Install the washer (00002-00907-6) over the shaft and slide the washer up to the bearing. (Fig. D)
3. Position the replacer shaft collar (00002-00907-5) on the output shaft. Slide the shaft sleeve replacer (00002-00907-4) over the shaft and thread it onto the collar (00002-00907-5). (Fig. D)
4. Slide the remover/replacer tube (00002-00907-1) over the assembly. Install the washer and forcing nut.
5. Tighten the forcing nut until the bearing is properly seated. (Fig. E)

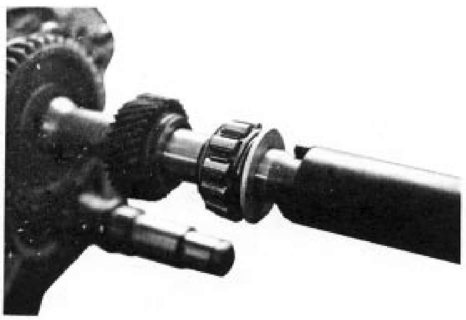


FIGURE D

FIGURE E

37

Fig. C-6
T302fC06

SST: 5th Gear/Hub Puller Installation Instructions

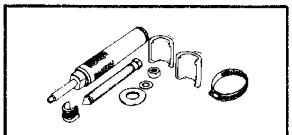
Form No. **10501**

OPERATING INSTRUCTIONS FOR

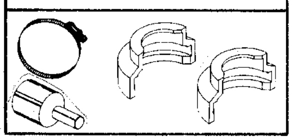
O.E.M. **0002-00907-1**

OWATONNA TOOL COMPANY
OWATONNA, MINNESOTA 55060, U.S.A. —— TELEX RCA 201674

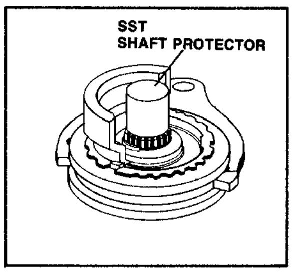
TOYOTA FIFTH GEAR/HUB PULLER INSTALLATION INSTRUCTIONS



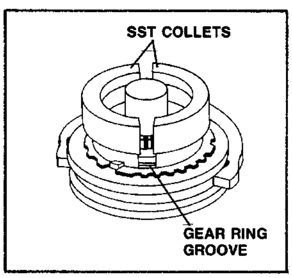
Previously released Essential Tool 00002-00907



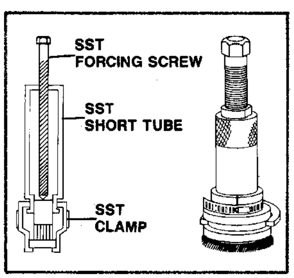
Additional Essential Tool 00002-00907-14



1. Position SST shaft protector on output shaft as shown.
   SST 00002-00907-14



2. Assemble SST collets into groove in gear ring.
   SST 00002-00907-14



3. Assemble short tube and forcing screw from previous SST set into the collets.
   SST 00002-00907
   Clamp as shown.

4. Turn forcing screw to remove gear.

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ISSUE DATE:11-19-84

Fig. C-7
T302fC07

Micrometers

Two different types of micrometers are used in the automotive trade: the inside micrometer and the outside micrometer. The measurements that the technician will be performing on the manual transmission and transaxle components will only be of the thickness and diameter of a part. For this reason, only outside micrometers (both English and Metric) will be covered.

An outside micrometer measures the distance between the measuring face of the anvil and the measuring face of the spindle. By turning the thimble, the spindle is moved along the axis of measurement creating a smaller or larger gap between the measuring faces. On the thimble and sleeve are reading lines for determining the distance between the measuring faces. Digital micrometers feature a digital readout mounted in the frame of the micrometer; this feature allows for faster, more accurate readings to be taken.

Micrometer

An outside micrometer measures the distance between the measuring face of the anvil and the measuring face of the spindle.

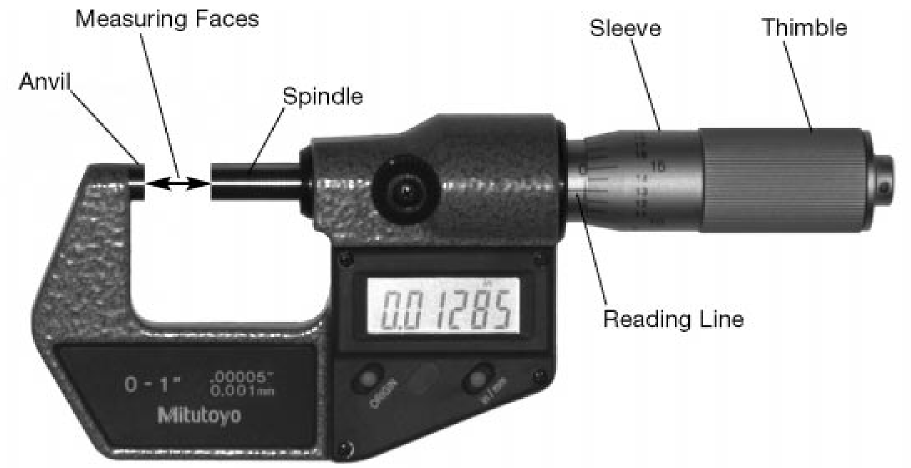


Fig. C-8
T302fC08

English Micrometers

Each division on the reading line of the sleeve equals 0.025 in. or 25/1000 in. Each number division on the reading line equals 0.1 in. or 100/1000 in. (4 X 0.025 in.). The thimble has 25 divisions each one equaling 0.001 in. One full rotation of the thimble will equal one division (0.025 in.) on the reading line of the sleeve.

English Micrometer

Each division on the reading line of the sleeve equals 0.025 in. or 25/1000 in.

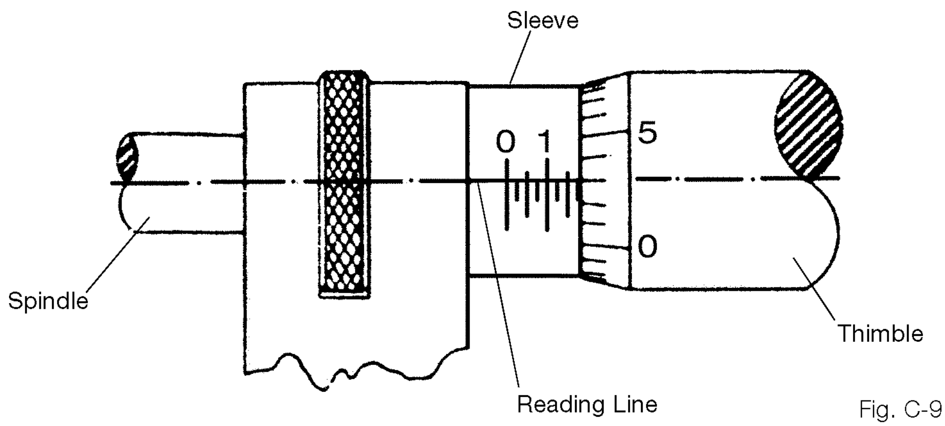


Fig. C-9
T302fC09

Metric Micrometer

Each upper and lower division on the reading line of the sleeve equals 1.0mm. They are staggered on the reading line in 0.5mm increments. The thimble has 50 divisions each one equaling 0.01mm. One full rotation of the thimble will equal one division (0.5mm) on the lower portion of the reading line.

Metric

Each upper and lower division on the reading line of the sleeve equals 1.0mm.

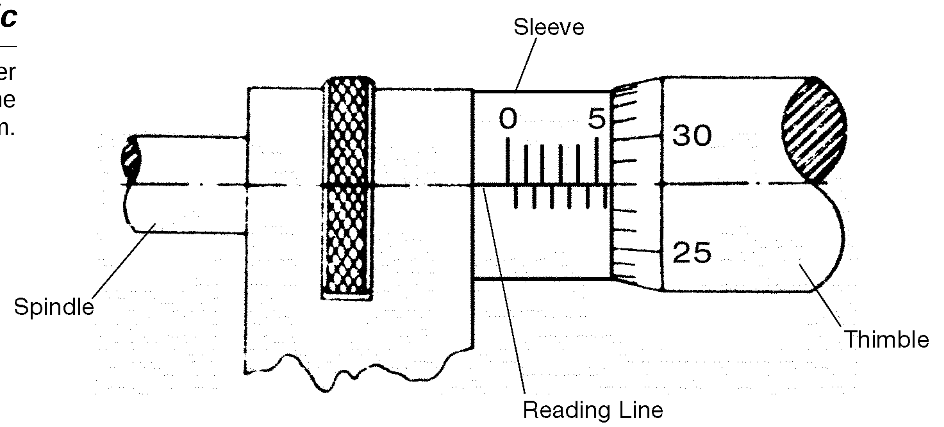


Fig. C-10
T302fC10

Operation

Measurements are made between the measuring faces of the anvil and spindle. A measurement is taken in the following manner:

- Turn the thimble until both measuring faces contact the work.
- To achieve a consistent measurement, the ratchet stop is now turned clockwise to create a constant pressure on the faces.
- Remove the micrometer and set the locking mechanism to hold the spindle in place. The locking mechanism may either be a lock lever (as shown in the illustration) or a locknut mounted in the same location.

Reading a Micrometer

There are three steps to reading a micrometer. Using figures C-11 and C-12, it will be easy to understand how the measurement is read.

English Readings

1. Count the number of 0.100 in. divisions that are visible on the reading line – 1 or 0.100 in.
2. Count the number of 0.025 in. divisions that are visible on the reading line – 3 or 0.075 in.
3. Count the number of 0.001 in. divisions on the thimble from 0 to the reading line of the sleeve – 3 or 0.003 in.

Adding the 3 values = 0.178 in.

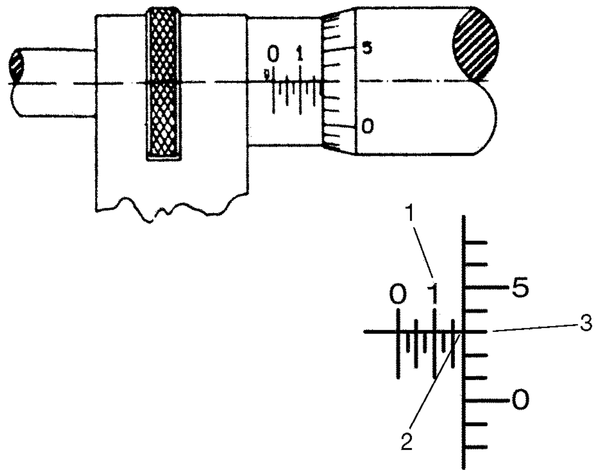


Fig. C-11
T302fC11

Metric Readings

1. Count the number of millimeter divisions that are visible on the reading line – 5 or 5.00mm.
2. Count the number of 0.50 millimeter divisions that are visible on the reading line – 1or 0.50mm.
3. Count the number of 0.01 millimeter divisions on the thimble from 0 to the reading line – 28 or 0.28 mm.

Adding the 3 values = 5.78mm.

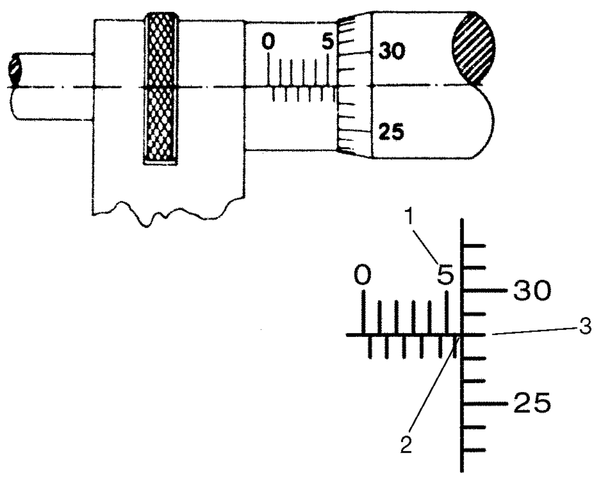


Fig. C-12
T302fC12

Vernier Scale

Outside micrometers are available to measure to the 0.0001 in. This is helpful when the thimble reading is between the 0.001 in. divisions and an exact measurement is necessary. The vernier scale is on the sleeve of the micrometer and has 10 divisions equaling 0.0001 in. each.

The number of 0.0001 in. that the reading is between the thimble divisions is determined by a thimble division mark lining up with a vernier scale division mark. In the example, the 0.005 in. mark lines up with the 0.0006 in. mark. The 0.0006 in. is then added to the measurement.

Vernier Scale

The vernier scale is on the sleeve of the micrometer and has 10 divisions equaling 0.0001 in. each.

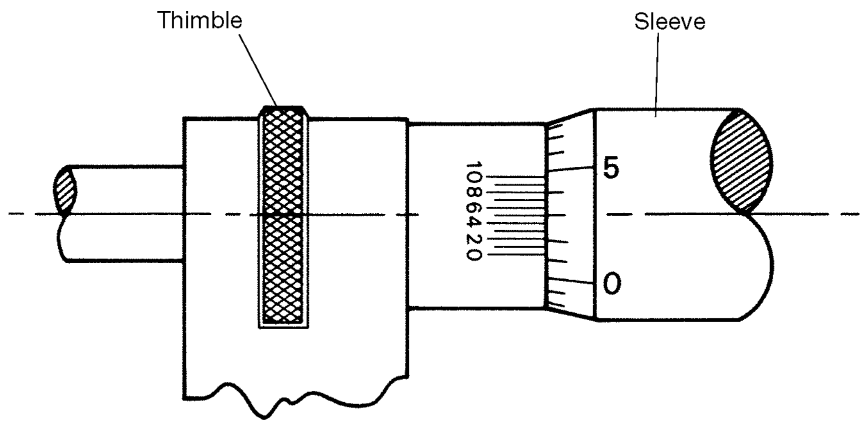


Fig. C-13
T302fC13

NOTE

Before using a micrometer:

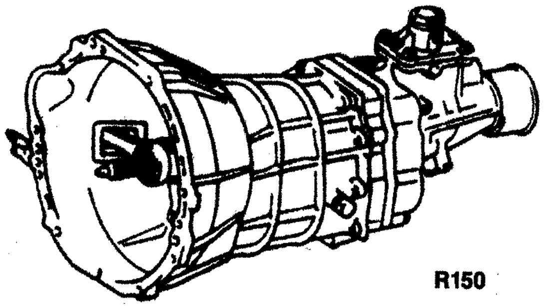
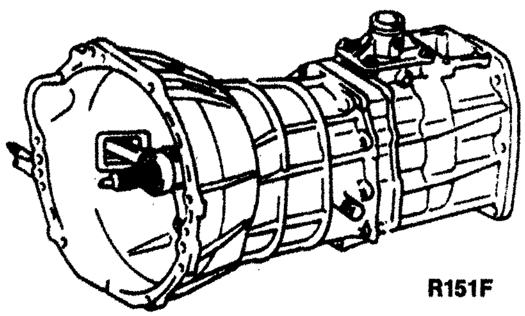
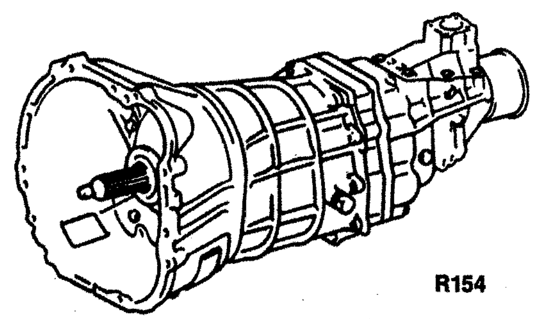
- Check the accuracy of the unit with a standard.
- Rotate the thimble for free movement.
- Make sure the spindle and frame are not bent.

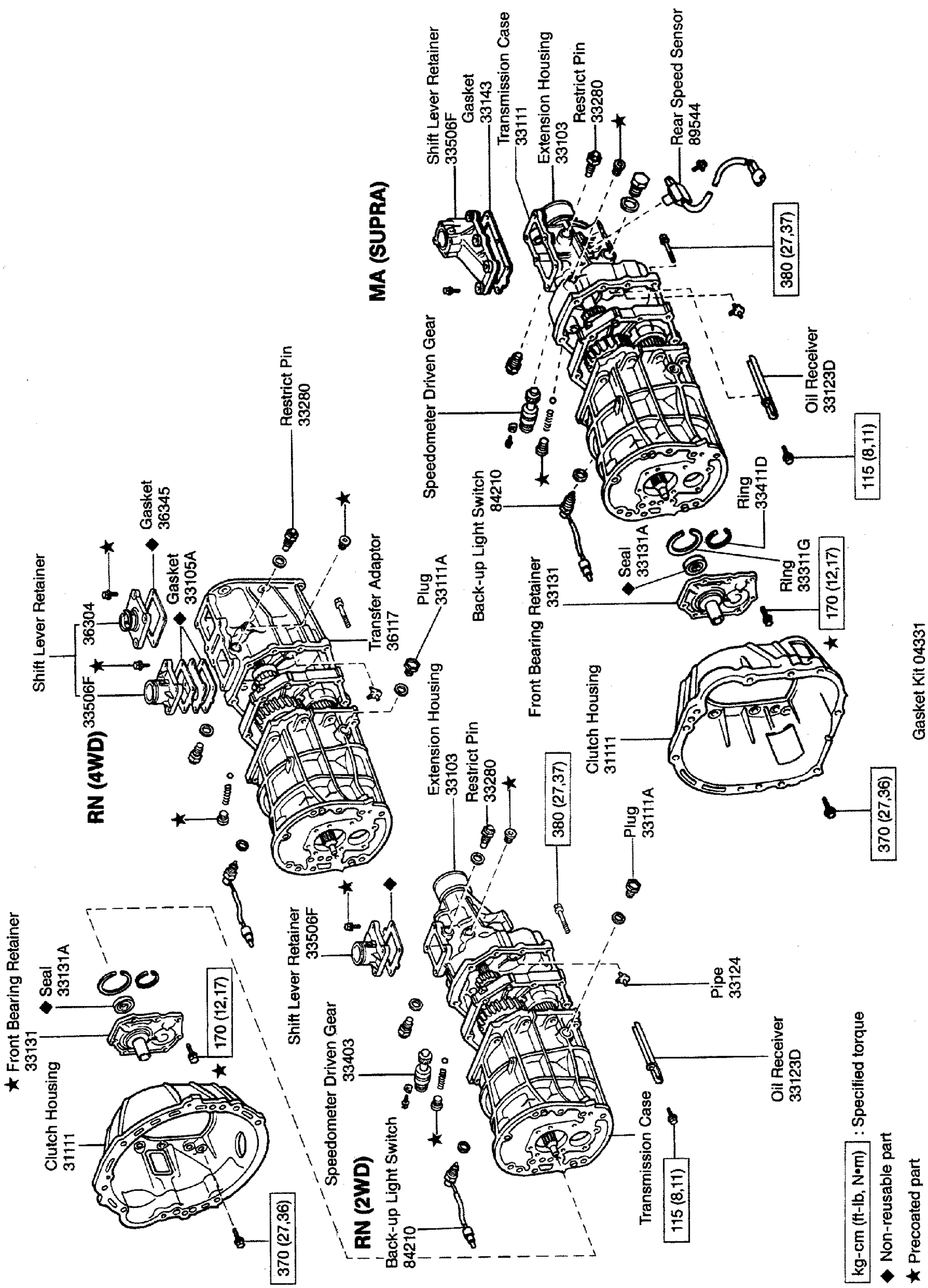
Notes

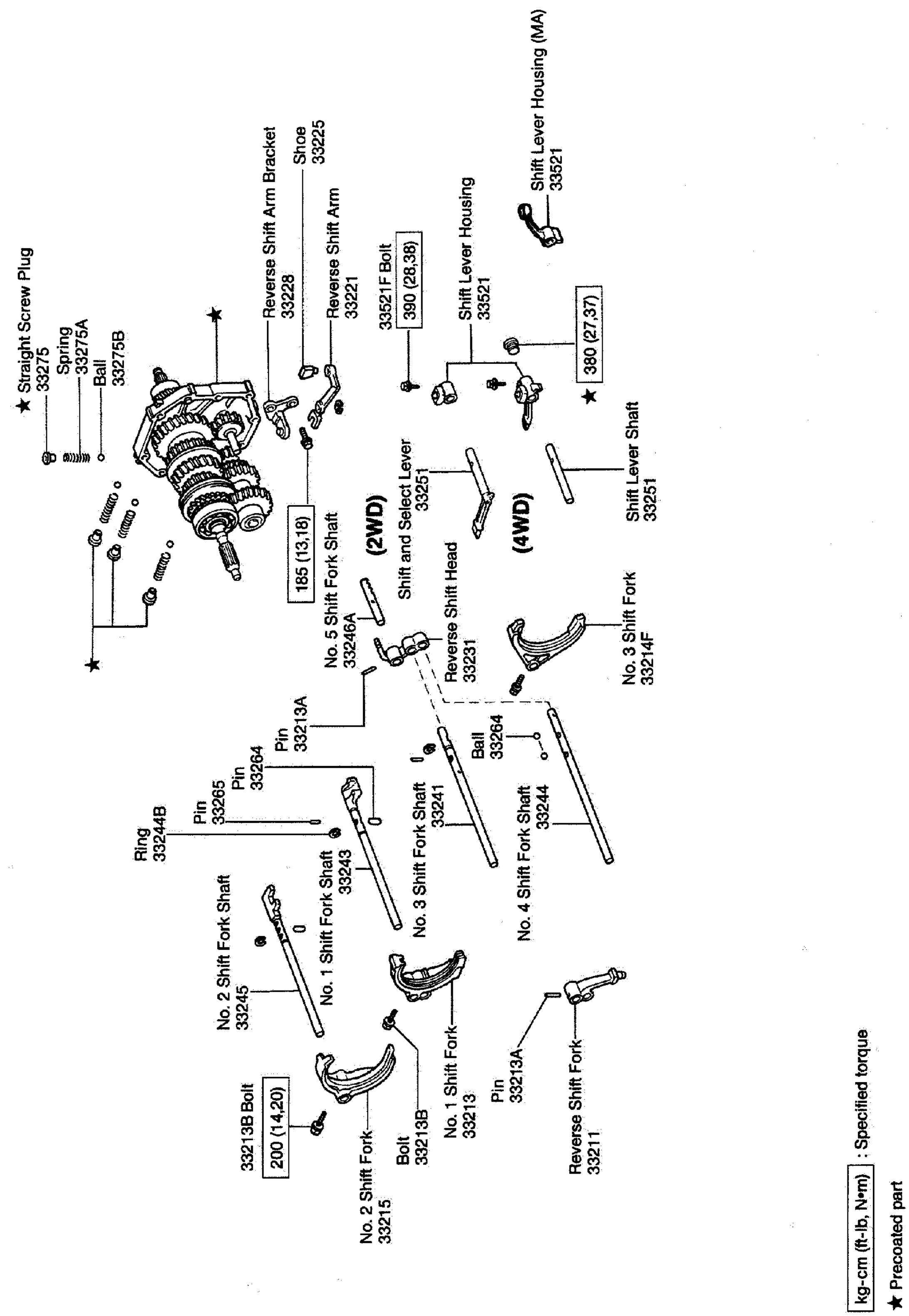
Appendix D

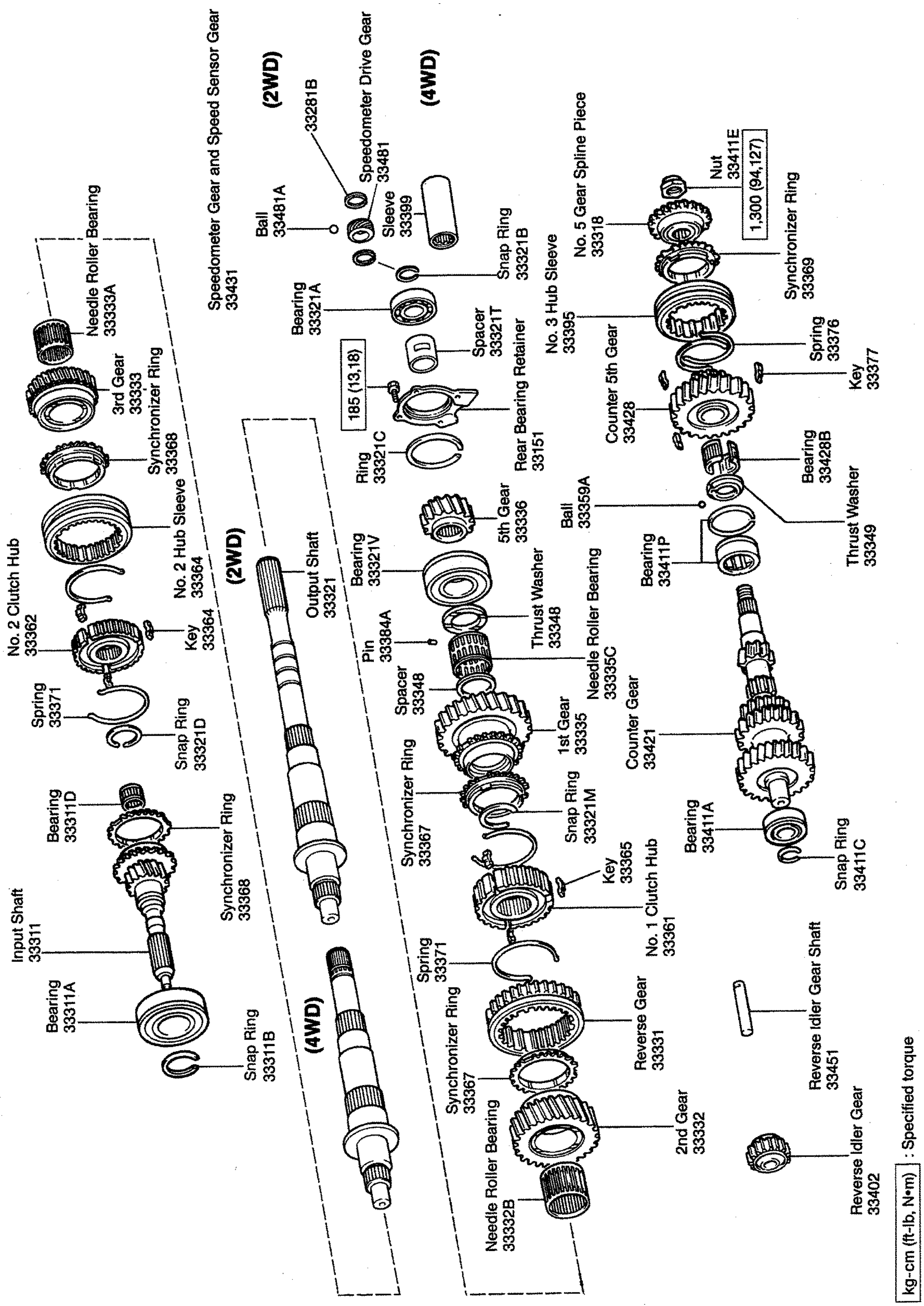
Identification Charts

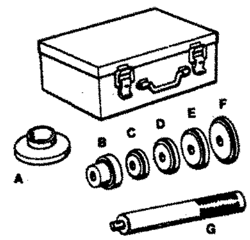
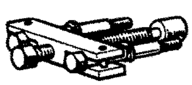
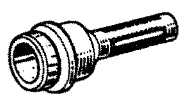
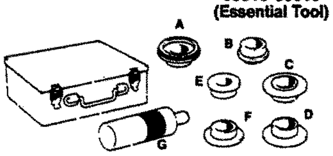
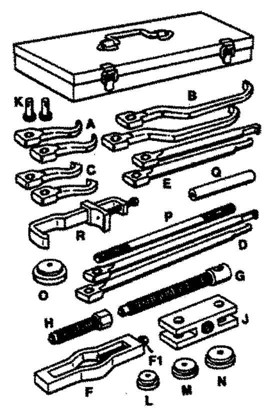
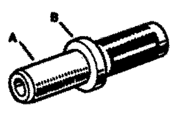
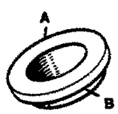
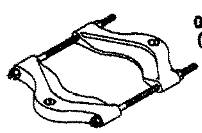
R SERIES TRANSMISSIONS

TRANSMISSION SERIES	MODEL/YEAR	KEY DIFFERENCES	LUBRICANT/CAP.
 R150	RN55 TRUCK/ 1986 - ON	▶ Starter mounts on right side of clutch housing ▶ Shift lever retainer is smaller than R154 and mounts flat on extension housing ▶ Release fork opening is on right side of the clutch housing ▶ Cast iron intermediate plate	SAE 75W-90 or 80W-90/ 2.6L (2.7 qt.)
 R151F	1986 - ON	▶ Basically the same as the R150 ▶ Extension housing is changed for adding the transfer case ▶ Output shaft is shorter than the R150 ▶ I.D. No. - Bottom side of intermediate plate (all transmissions)	SAE 75W-90 or 80W-90/ 3.0L (3.2 qt.)
 R154	MA70 SUPRA 1986½ - ON	▶ Starter mount on left side of clutch housing ▶ Access holes in clutch housing for clutch cover bolts ▶ Intermediate plate is cast iron ▶ Speed sensor mounted on extension housing ▶ Shift lever retainer mounted at an angle on the extension housing	**I.D. No. NOTE:** 3 0 9 0 0 0 0 0 5-digit Production Number or 2-Digit Production Number Manufacturing Month: January → 01 December → 12 Last Digit of Manufacturing Year: 1983


MA (SUPRA)
Shift Lever Retainer 33506F
Gasket 33143
Transmission Case 33111
Extension Housing 33103
Restrict Pin 33280
Rear Speed Sensor 89544
380 (27,37)
Speedometer Driven Gear
Oil Receiver 33123D
115 (8,11)
Back-up Light Switch 84210
Ring 33411D
Seal 33131A
Ring 33311G
170 (12,17)
Front Bearing Retainer 33131
Clutch Housing 33111
Gasket Kit 04331
370 (27,36)
RN (4WD)
Shift Lever Retainer
33506F
36304
Gasket 36345
Gasket 33105A
Restrict Pin 33280
Transfer Adaptor 36117
Plug 33111A
Extension Housing 33103
Restrict Pin 33280
380 (27,37)
Plug 33111A
Pipe 33124
Oil Receiver 33123D
Transmission Case
115 (8,11)
RN (2WD)
Shift Lever Retainer 33506F
Speedometer Driven Gear 33403
Back-up Light Switch 84210
Clutch Housing 31111
Front Bearing Retainer 33131
Seal 33131A
170 (12,17)
370 (27,36)
kg-cm (ft-lb, N•m) : Specified torque
◆ Non-reusable part
★ Precoated part

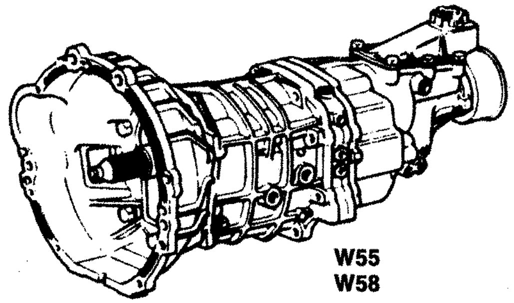
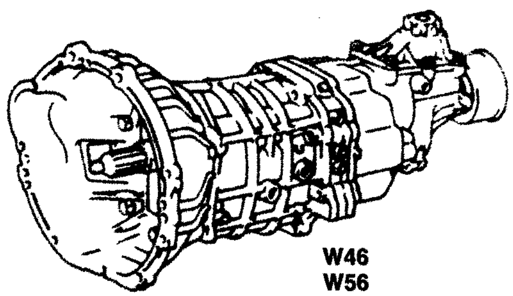
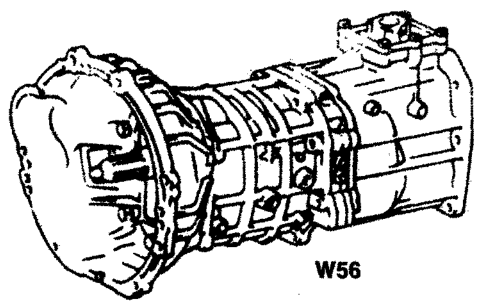

★ Straight Screw Plug
33275
Spring
33275A
Ball
33275B
★
Reverse Shift Arm Bracket
33228
Shoe
33225
Reverse Shift Arm
33221
33521F Bolt
390 (28,38)
Shift Lever Housing
33521
Shift Lever Housing (MA)
33521
380 (27,37)
★
185 (13,18)
(2WD)
Shift and Select Lever
33251
(4WD)
Shift Lever Shaft
33251
No. 5 Shift Fork Shaft
33246A
Shift and Select Lever
Reverse Shift Head
33231
No. 3 Shift Fork
33214F
Pin
33213A
Pin
33264
Pin
33265
Ring
33244B
Ball
33264
No. 3 Shift Fork Shaft
33241
No. 4 Shift Fork Shaft
33244
No. 1 Shift Fork Shaft
33243
No. 2 Shift Fork Shaft
33245
33213B Bolt
200 (14,20)
No. 2 Shift Fork
33215
Bolt
33213B
No. 1 Shift Fork
33213
Pin
33213A
Reverse Shift Fork
33211
kg-cm (ft-lb, N•m) : Specified torque
★ Precoated part

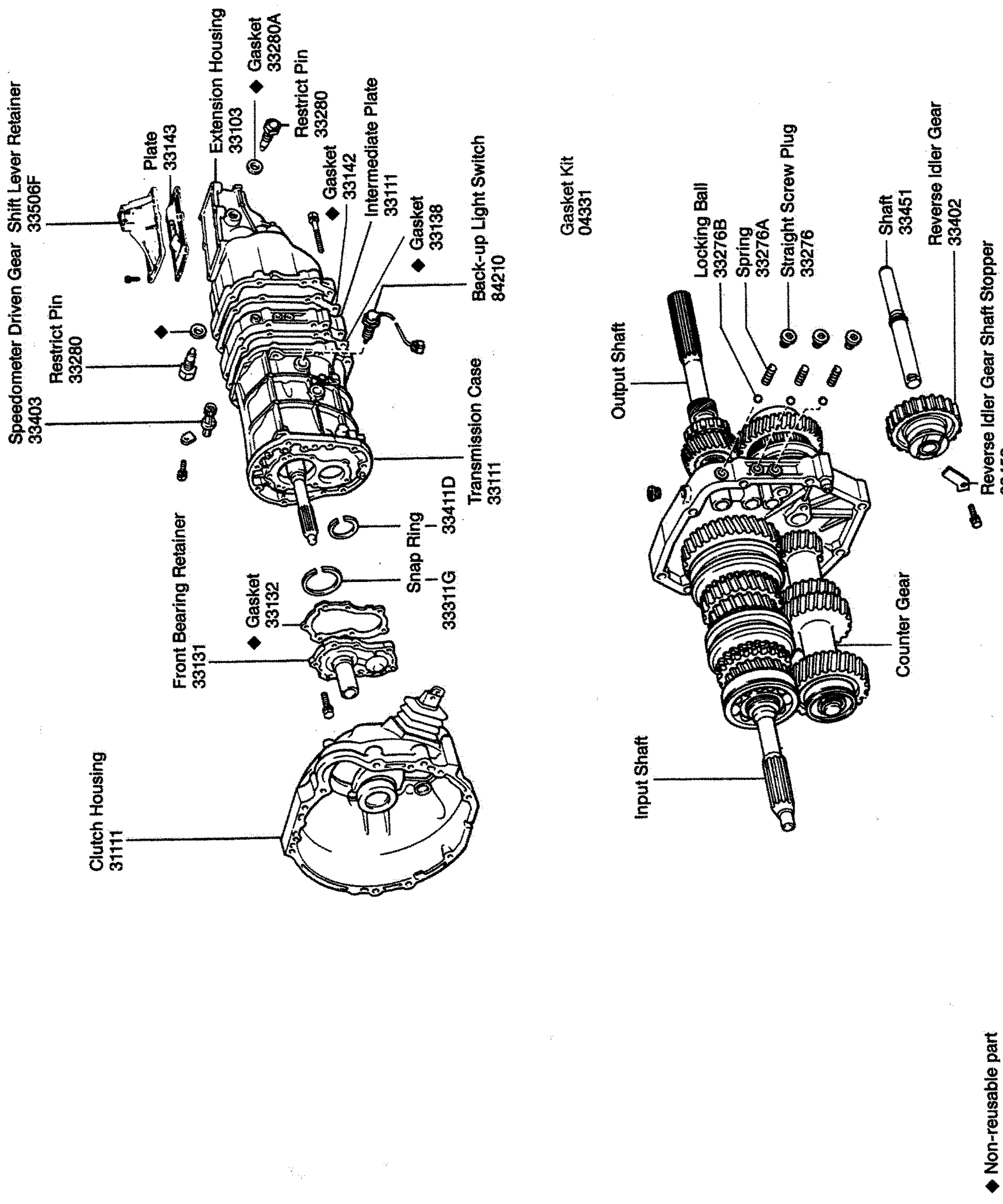

Speedometer Gear and Speed Sensor Gear
33431
(2WD)
Ball
33481A
33281B
Speedometer Drive Gear
33481
Sleeve
33399
(4WD)
Snap Ring
33321B
Bearing
33321A
185 (13,18)
Spacer
33321T
Rear Bearing Retainer
33151
Ring
33321C
No. 5 Gear Spline Piece
33318
Nut
33411E
1,300 (94,127)
Synchronizer Ring
33369
No. 3 Hub Sleeve
33395
Spring
33376
Key
33377
Counter 5th Gear
33428
Bearing
33428B
Thrust Washer
33349
Ball
33359A
Bearing
33411P
5th Gear
33336
Needle Roller Bearing
33333A
3rd Gear
33333
Synchronizer Ring
33368
No. 2 Hub Sleeve
33364
No. 2 Clutch Hub
33362
Key
33364
Spring
33371
Snap Ring
33321D
(2WD)
Output Shaft
33321
Bearing
33321V
Thrust Washer
33348
Pin
33384A
Needle Roller Bearing
33335C
Spacer
33348
1st Gear
33335
Counter Gear
33421
Synchronizer Ring
33367
Snap Ring
33321M
Bearing
33411A
Snap Ring
33411C
Key
33365
No. 1 Clutch Hub
33361
Bearing
33311D
Synchronizer Ring
33368
Input Shaft
33311
Bearing
33311A
Snap Ring
33311B
(4WD)
Spring
33371
Synchronizer Ring
33367
Reverse Gear
33331
Reverse Idler Gear Shaft
33451
2nd Gear
33332
Needle Roller Bearing
33332B
Reverse Idler Gear
33402
kg-cm (ft-lb, N•m) : Specified torque

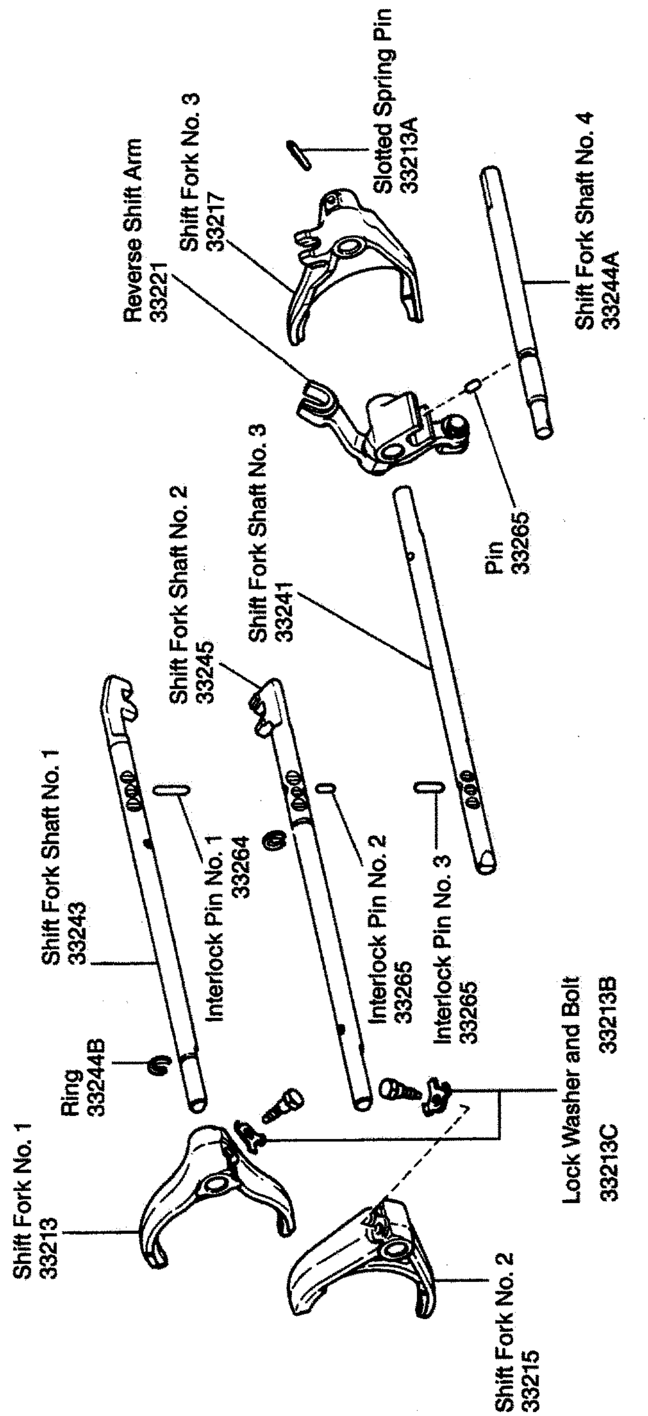
Tool No.	Description	Tool No.	Description
 09201-60011 (Essential Tool)	Remover & Replacer, Speedometer driven gear oil seal	09608-12010 	Replacer Set, E. 09608-00030 Counter rear bearing G. 09608-00020 Handle
 09213-31021	Puller, No. 5 gear spline piece		
 09223-50010	Replacer, Front bearing retainer oil seal		
09316-60010 (Essential Tool) 	Replacer, F. 09316-00020 5th gear	09950-20017 (Essential Tool) 	Puller, Universal A. 09953-20010 Jaw (Pair) B. 09953-20021 Jaw (Pair) C. 09953-55010 Jaw (Pair) D. 09953-35021 Jaw (Pair) E. 09953-35011 Jaw (Pair) F. 09956-20010 Tightening Piece F1. 09954-20011 Adjusting Screw G. 09952-20010 Screw H. 09952-36010 Screw J. 09955-20012 Prop K. 09957-20010 Pin (Pair) L. 09958-20010 Disc E M. 09958-30020 Disc D N. 09958-30010 Disc C O. 09958-55010 Disc A P. 09959-20010 Handle Q. 09964-35010 Adapter R. 09956-00010 Tightening Piece
 09325-40010 (Essential Tool)	Plug, Transmission Oil A. 39.75mm B. 57mm		
 09506-35010	Input shaft bearing, output shaft center bearing, output shaft rear bearing and 5th gear		
 09555-55010-01 (Essential Tool)	Differential Drive Pinion Bearing Remover		

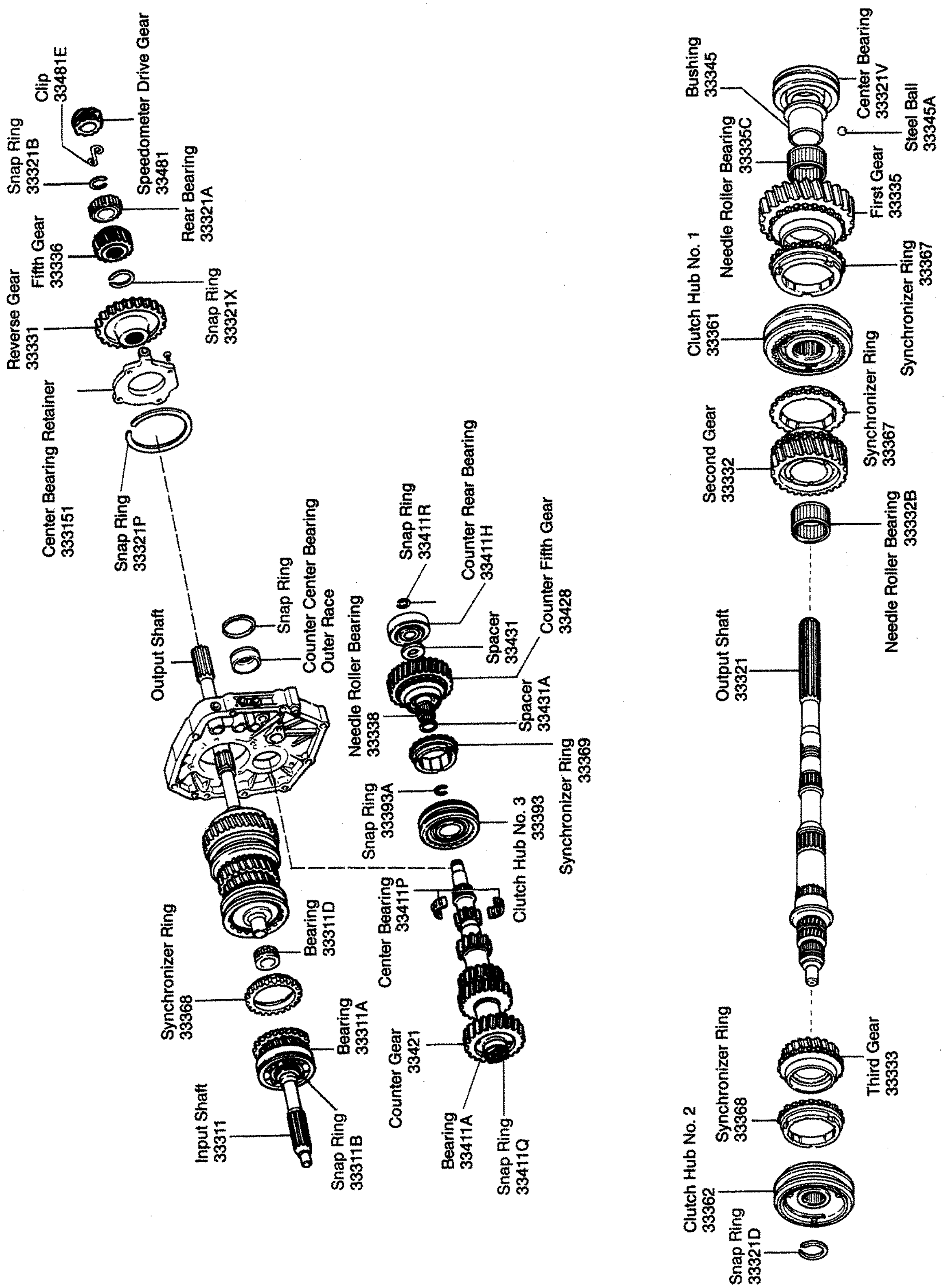
*SST's not listed are common tools which are available locally (refer to SST Catalog).

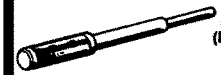
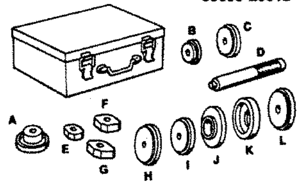
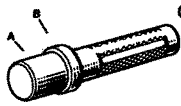
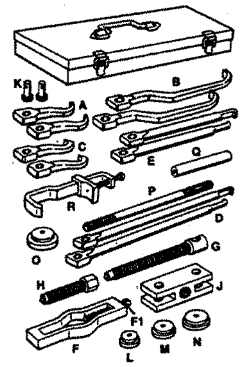
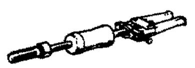
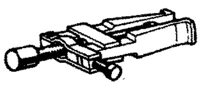
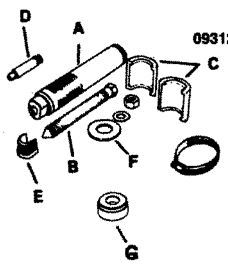
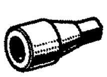
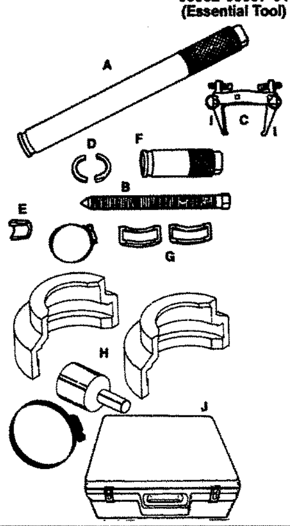
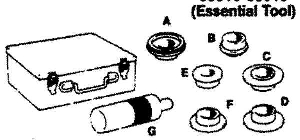
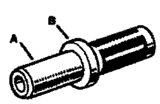
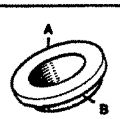
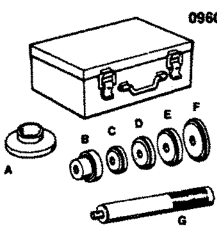
W SERIES TRANSMISSIONS

TRANSMISSION SERIES	MODEL/YEAR	KEY DIFFERENCES	LUBRICANT/CAP.
	**W55** RA43B, CELICA/ 1981 - **W58** MX7# CRESSIDA/ 1985 - 1989 JZA, MA7# SUPRA/ 1986 - 1997	▶ Starter mounts on right side of clutch housing ▶ Shift lever retainer is mounted at an angle on the extension housing ▶ Case parts are cast aluminum	RA CELICA W58 1982 - 1985 MA, SUPRA JZA W58 1982 - 1997
	**W46** RN5#, LN56 TRUCK/ 1985 - 1991 **W56** RN5#, 7# TRUCK/ 1985 - 1993 W55 RN TRUCK 1987 - 1995	▶ Basically the same as the W55, W58 ▶ Extension housing is changed in construction ▶ I.D. No. - Bottom side of intermediate plate (W46, 55, 56, 58)	SAE 75W-90 or 80W-90/ **4x2** - 2.4L (2.5 qt.) **4x4** - 3.0L (3.2 qt.)
	**W56** RN6# TRUCK/ 1986 - 1995	▶ Addition of the transfer case housing	**I.D. No. NOTES:** 3 0 9 0 0 0 0 0 5-digit Production Number or 2-Digit Production Number Manufacturing Month: January → 01 December → 12 Last Digit of Manufacturing Year: 1983


Speedometer Driven Gear
33403
Shift Lever Retainer
33506F
Plate
33143
Extension Housing
33103
◆ Gasket
33280A
Restrict Pin
33280
◆ Gasket
33142
Intermediate Plate
33111
◆ Gasket
33138
Back-up Light Switch
84210
Restrict Pin
33280
◆
Transmission Case
33111
Snap Ring
33411D
33311G
Front Bearing Retainer
33131
◆ Gasket
33132
Clutch Housing
31111
Gasket Kit
04331
Output Shaft
Locking Ball
33276B
Spring
33276A
Straight Screw Plug
33276
Shaft
33451
Reverse Idler Gear
33402
Reverse Idler Gear Shaft Stopper
33452
Counter Gear
Input Shaft
◆ Non-reusable part

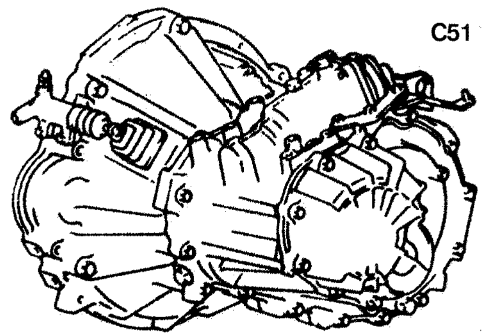
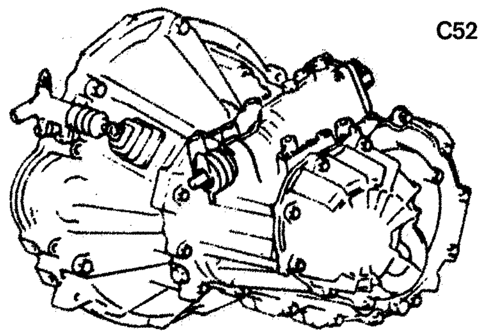
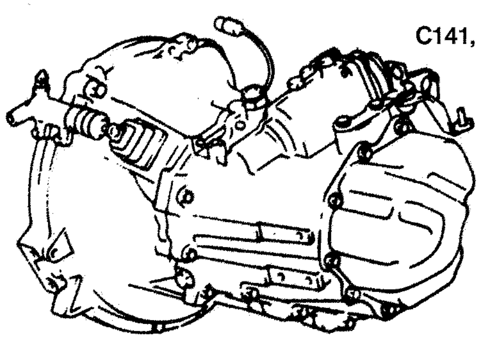

Shift Fork No. 1
33213
Ring
33244B
Shift Fork Shaft No. 1
33243
Interlock Pin No. 1
33264
Shift Fork Shaft No. 2
33245
Interlock Pin No. 2
33265
Interlock Pin No. 3
33265
Shift Fork Shaft No. 3
33241
Reverse Shift Arm
33221
Shift Fork No. 3
33217
Slotted Spring Pin
33213A
Shift Fork Shaft No. 4
33244A
Pin
33265
Lock Washer and Bolt
33213C
33213B
Shift Fork No. 2
33215

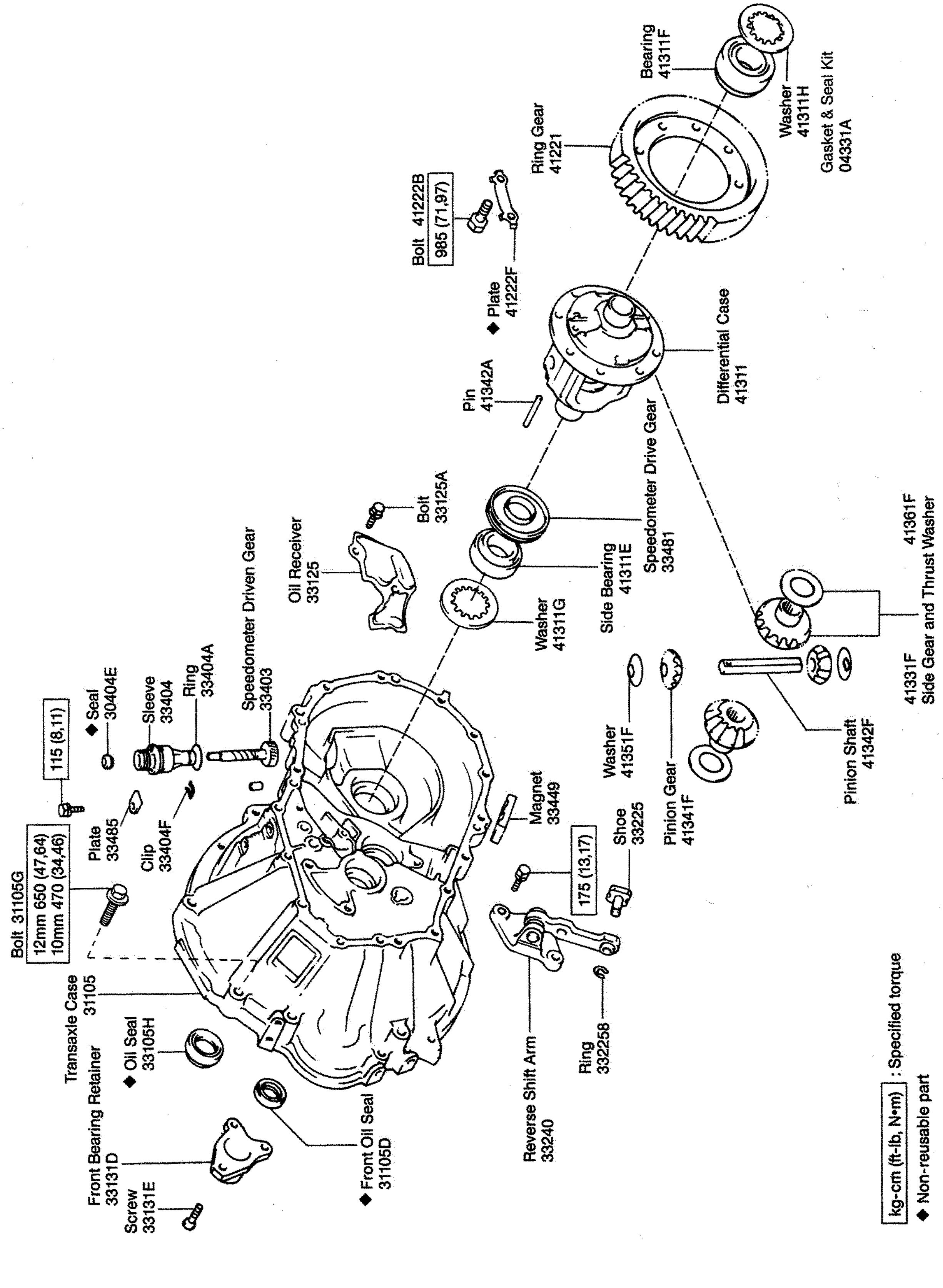

Clip
33481E
Snap Ring
33321B
Speedometer Drive Gear
33481
Rear Bearing
33321A
Fifth Gear
33336
Reverse Gear
33331
Snap Ring
33321X
Center Bearing Retainer
33151
Snap Ring
33321P
Output Shaft
Snap Ring
Counter Center Bearing
Outer Race
Needle Roller Bearing
33338
Snap Ring
33411R
Counter Rear Bearing
33411H
Spacer
33431
Counter Fifth Gear
33428
Spacer
33431A
Synchronizer Ring
33369
Snap Ring
33393A
Clutch Hub No. 3
33393
Synchronizer Ring
33368
Bearing
33311D
Center Bearing
33411P
Bearing
33311A
Input Shaft
33311
Snap Ring
33311B
Counter Gear
33421
Bearing
33411A
Snap Ring
33411Q
Bushing
33345
Center Bearing
33321V
Steel Ball
33345A
Needle Roller Bearing
33335C
First Gear
33335
Clutch Hub No. 1
33361
Synchronizer Ring
33367
Synchronizer Ring
Second Gear
33332
Synchronizer Ring
33367
Needle Roller Bearing
33332B
Output Shaft
33321
Synchronizer Ring
33368
Third Gear
33333
Clutch Hub No. 2
33362
Snap Ring
33321D

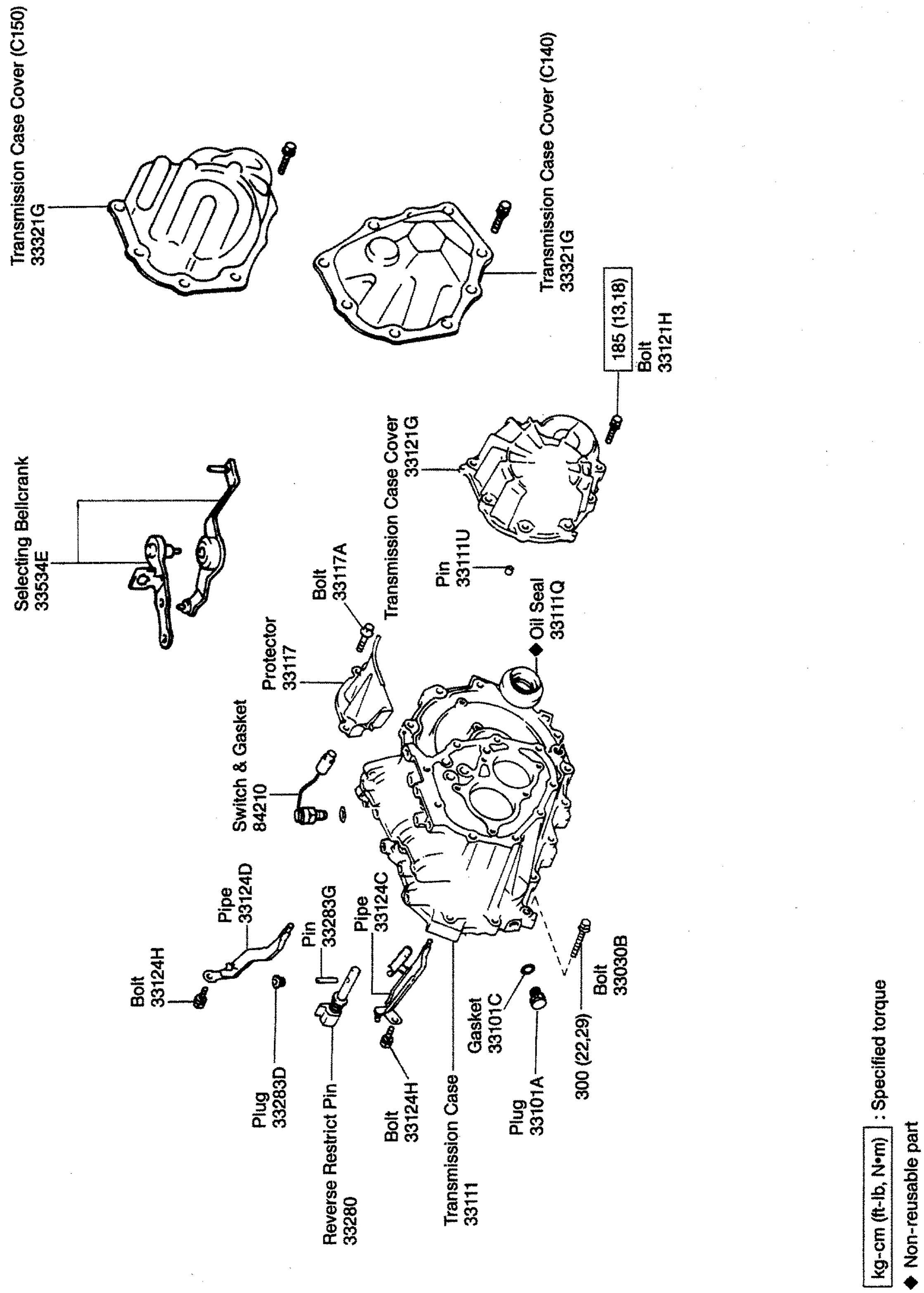
Tool No.	Description	Tool No.	Description
 09201-60011 (Essential Tool)	Remover & Replacer, Speedometer driven gear oil seal	 09608-20012	Tool Set, A. 09608-00080 Front bearing retainer oil seal
 09307-30010	Replacer, Extension Housing Bushing A. 38mm B. 42mm	 09950-20017 (Essential Tool)	Puller, Universal A. 09953-20010 Jaw (Pair) B. 09953-20021 Jaw (Pair) C. 09953-55010 Jaw (Pair) D. 09953-35021 Jaw (Pair) E. 09953-35011 Jaw (Pair) F. 09956-20010 Tightening Piece F1. 09954-20011 Adjusting Screw G. 09952-20010 Screw H. 09952-36010 Screw J. 09955-20012 Prop K. 09957-20010 Pin (Pair) L. 09958-20010 Disc E M. 09958-30020 Disc D N. 09958-30010 Disc C O. 09958-55010 Disc A P. 09959-20010 Handle Q. 09964-35010 Adapter R. 09956-00010 Tightening Piece
 09308-00010	Puller, Oil Seal		
 09308-10010	Puller, Oil Seal		
 00002-00907 (Essential Tool) 09312-20011	5th Gear Remover/Replacer A. 00002-00907-1 Remover/ Replacer Tube (273mm/10¾") B. 00002-00907-8 Forcing Screw C. 00002-00907-3 Collet Pair D. 00002-00907-4 Replacer Shaft E. 00002-00907-5 Replacer Shaft Collar F. 00002-00907-6 Washer G. 211206 Bearing		
 09313-30021	Socket, Detent Ball Plug (6mm Hex)	 00002-00907-01 (Essential Tool)	Transmission Bearing Service Set A. 00002-00907-7 Remover/ Replacer (400mm/15¾") B. 00002-00907-8 Forcing Screw C. 00002-00907-9 Bearing Puller D. 00002-00907-10 Puller Ring Half E. 00002-00907-11 Replacer Shaft Collar F. 00002-00907-12 Remover/ Replacer (140mm/5½") G. 00002-00907-13 Collet Halves (for ATM Front Pump) H. 00002-00907-14 5th Gear Hub Puller (Use with 00002-00907) I. 304839 Jaw (ea.) J. 00002-10001 Carrying Case
 09316-60010 (Essential Tool)	Replacer, B. 09316-00070 counter gear center outer race bearing G. Handle		
 09325-20010	Plug, Transmission Oil A. 32mm B. 57mm		
 09506-35010	Replacer, Input shaft bearing A. 70mm B. 48mm		
 09608-12010	Replacer Set, C. 09608-00030 Output shaft rear bearing outer race G. Handle		

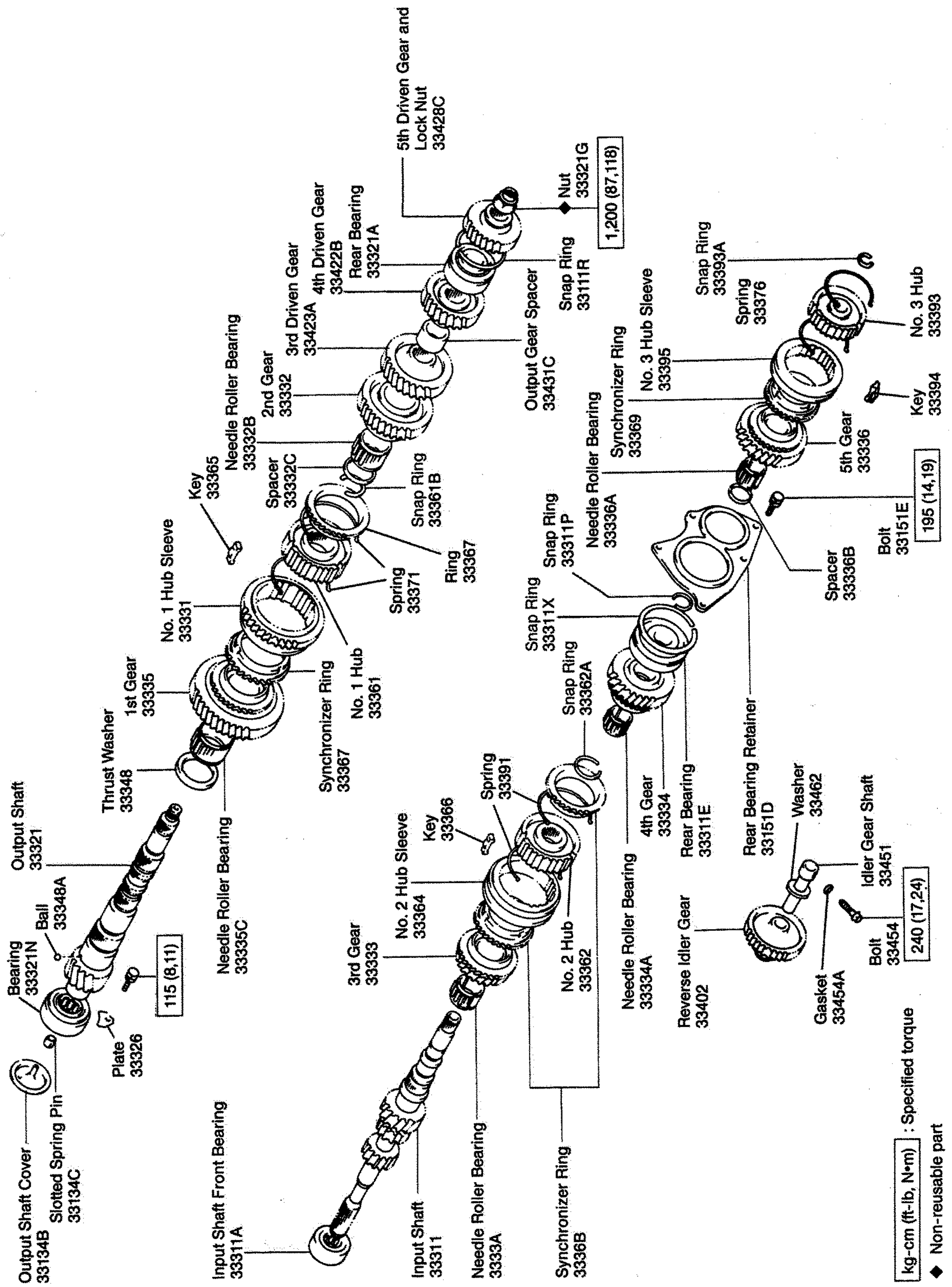
*SST's not listed are common tools which are available locally (refer to SST Catalog).

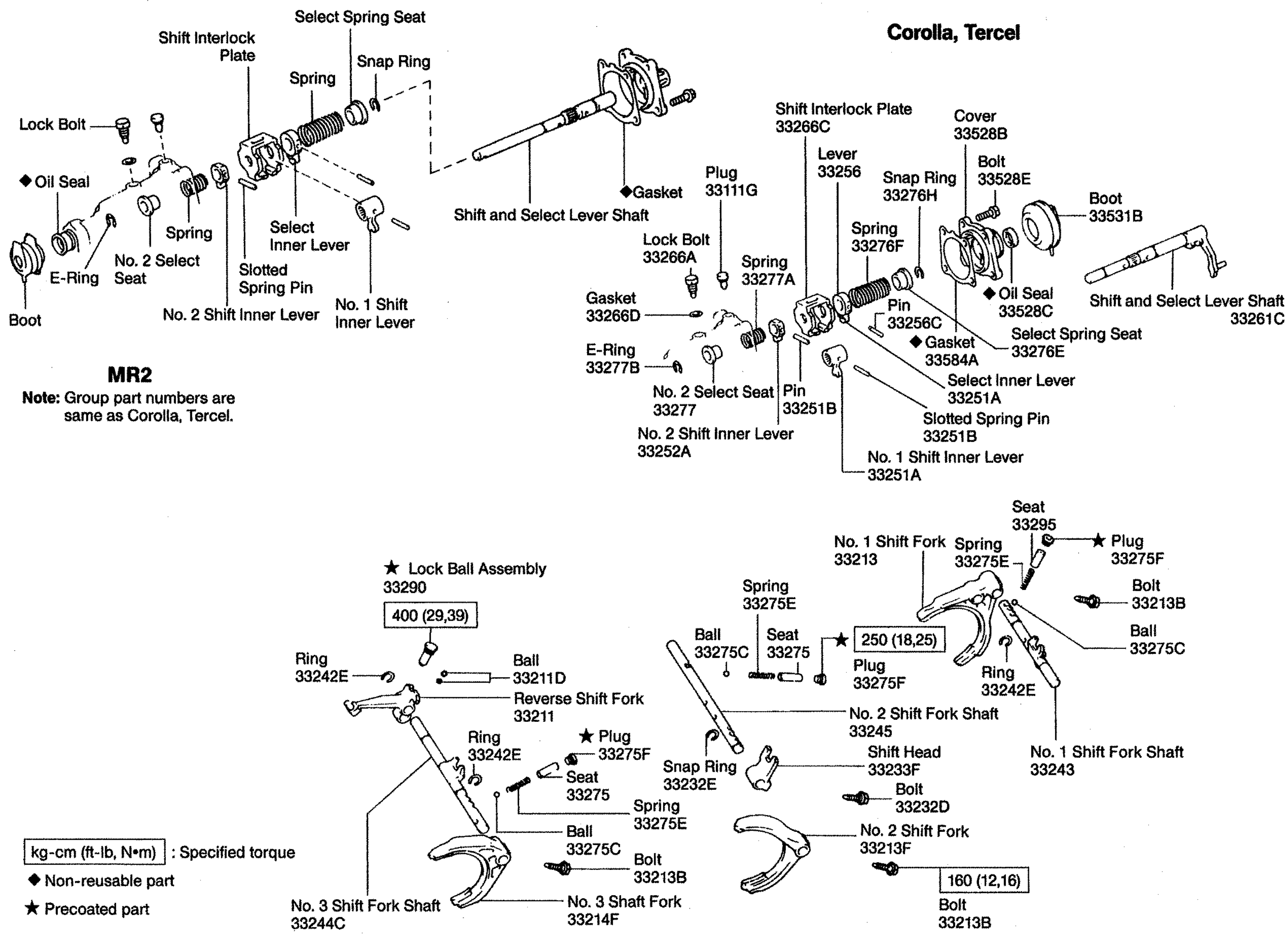
C SERIES TRANSAXLES

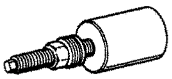
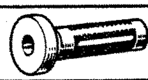
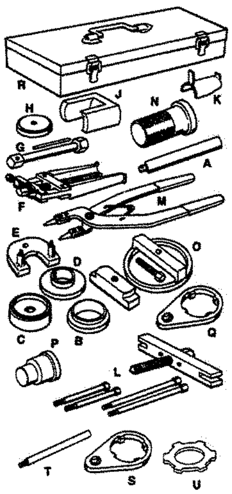
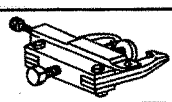
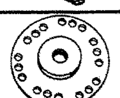
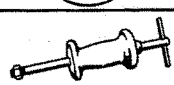
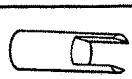
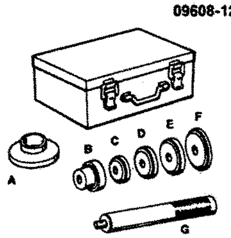
TRANSAXLE SERIES	MODEL/YEAR	KEY DIFFERENCES	LUBRICANT/CAP.
C51 	AE82 COROLLA/ 1984 - 1988 AE92, 95, 101, 102 C50, C52 1989 - 1997 ZE110 C59 1998 - 2001 ZZE110 C56 2002 ZZE130 C59 2003	▶ Starter mounts on left side of clutch housing ▶ Shift lever retainer is bolted to the case ▶ I.D. No. - Top front edge of clutch housing	
C52 	AW11 MR2/ 1985 - 1990 2000 ZZW30 2002 C56 2003 ZZW30 C65	▶ Basically the same as the C51 ▶ Shift and select levers connect on the opposite side of the shift shaft ▶ I.D. No. - Top front edge of clutch housing	SAE 75W-90 or 80W-90/ **C5#** - 2.6L (2.7 qt.) **C140, 150** - 2.4L (2.5 qt.)
C141, 150 	EL31 TERCEL 1987 - 1996 C151 1996 - 1999	▶ Starter mounts on right side of clutch housing ▶ Smaller version of the C51 ▶ End covers are pressed steel, C140 is flatter than C150 ▶ I.D. No. - Top front edge of clutch housing	**I.D. No. NOTES:** 3 0 9 0 0 0 0 0 5-digit Production Number or 2-Digit Production Number Manufacturing Month: January → 01 December → 12 Last Digit of Manufacturing Year: 1983
UCP12 ECHO C180 2000-2003	ZZT230 CELICA C56, C60 2000-2003		

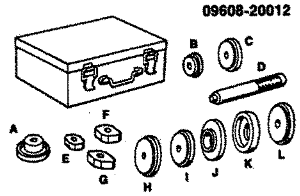
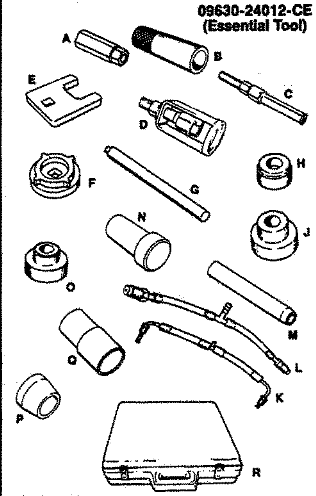
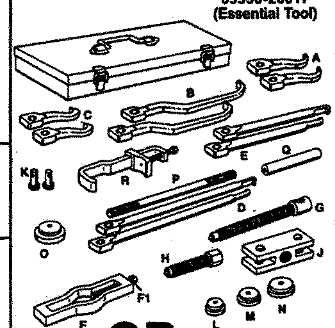
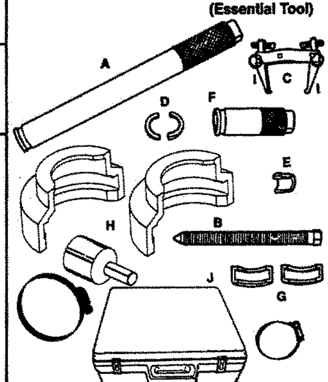

Bolt 31105G
12mm 650 (47,64)
10mm 470 (34,46)
Transaxle Case
31105
◆ Oil Seal
33105H
Front Bearing Retainer
33131D
Screw
33131E
◆ Front Oil Seal
31105D
115 (8,11)
Plate
33485
Clip
33404F
◆ Seal
30404E
Sleeve
33404
Ring
33404A
Speedometer Driven Gear
33403
Oil Receiver
33125
Bolt
33125A
Magnet
33449
175 (13,17)
Shoe
33225
Reverse Shift Arm
33240
Ring
332258
Washer
41311G
Side Bearing
41311E
Speedometer Drive Gear
33481
Washer
41351F
Pinion Gear
41341F
Pinion Shaft
41342F
41331F
Side Gear and Thrust Washer
41361F
Pin
41342A
◆ Plate
41222F
Bolt 41222B
985 (71,97)
Differential Case
41311
Ring Gear
41221
Bearing
41311F
Washer
41311H
Gasket & Seal Kit
04331A
kg-cm (ft-lb, N•m) : Specified torque
◆ Non-reusable part


Transmission Case Cover (C150)
33321G
Transmission Case Cover (C140)
33321G
185 (13,18)
Bolt
33121H
Selecting Bellcrank
33534E
Transmission Case Cover
33121G
Bolt
33117A
Pin
33111U
Protector
33117
◆ Oil Seal
33111Q
Switch & Gasket
84210
Bolt
33124H
Pipe
33124D
Pin
33283G
Pipe
33124C
Plug
33283D
Reverse Restrict Pin
33280
Bolt
33124H
Transmission Case
33111
Gasket
33101C
Plug
33101A
300 (22,29)
Bolt
33030B
kg-cm (ft-lb, N•m) : Specified torque
◆ Non-reusable part


Output Shaft Cover
33134B
Slotted Spring Pin
33134C
Bearing
33321N
Ball
33348A
Output Shaft
33321
Plate
33326
115 (8,11)
Thrust Washer
33348
Needle Roller Bearing
33335C
1st Gear
33335
Synchronizer Ring
33367
No. 1 Hub Sleeve
33331
No. 1 Hub
33361
Key
33365
Spring
33371
Ring
33367
Snap Ring
33361B
Spacer
33332C
Needle Roller Bearing
33332B
2nd Gear
33332
3rd Driven Gear
33423A
4th Driven Gear
33422B
Rear Bearing
33321A
5th Driven Gear and
Lock Nut
33428C
Output Gear Spacer
33431C
Snap Ring
33111R
Nut
33321G
1,200 (87,118)
Input Shaft Front Bearing
33311A
Input Shaft
33311
Needle Roller Bearing
3333A
3rd Gear
33333
No. 2 Hub Sleeve
33364
Key
33366
Spring
33391
No. 2 Hub
33362
Synchronizer Ring
3336B
Snap Ring
33362A
Needle Roller Bearing
33334A
4th Gear
33334
Rear Bearing
33311E
Snap Ring
33311X
Snap Ring
33311P
Needle Roller Bearing
33336A
Synchronizer Ring
33369
No. 3 Hub Sleeve
33395
Spring
33376
Snap Ring
33393A
No. 3 Hub
33393
Key
33394
5th Gear
33336
Spacer
33336B
Bolt
33151E
195 (14,19)
Rear Bearing Retainer
33151D
Reverse Idler Gear
33402
Washer
33462
Idler Gear Shaft
33451
Gasket
33454A
Bolt
33454
240 (17,24)
kg-cm (ft-lb, N•m) : Specified torque
◆ Non-reusable part

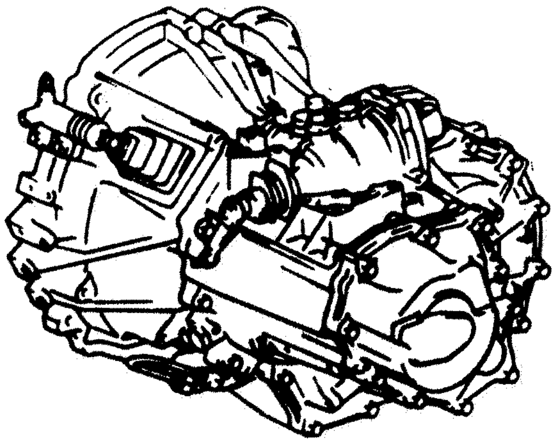
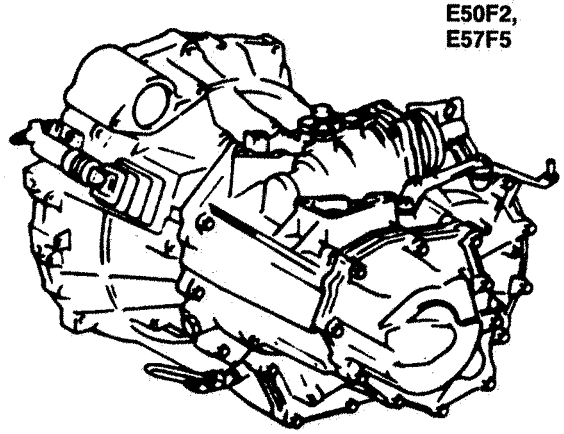

Corolla, Tercel
Shift Interlock Plate
33266C
Lever
33256
Cover
33528B
Bolt
33528E
Snap Ring
33276H
Boot
33531B
Spring
33276F
Plug
33111G
Lock Bolt
33266A
Spring
33277A
Gasket
33266D
E-Ring
33277B
No. 2 Select Seat
33277
Pin
33251B
No. 2 Shift Inner Lever
33252A
Pin
33256C
◆ Gasket
33584A
◆ Oil Seal
33528C
Select Spring Seat
33276E
Select Inner Lever
33251A
Slotted Spring Pin
33251B
No. 1 Shift Inner Lever
33251A
Shift and Select Lever Shaft
33261C
◆Gasket
Shift and Select Lever Shaft
Select Spring Seat
Shift Interlock
Plate
Spring
Snap Ring
Lock Bolt
◆ Oil Seal
Spring
Select
Inner Lever
E-Ring
No. 2 Select
Seat
Slotted
Spring Pin
No. 1 Shift
Inner Lever
Boot
No. 2 Shift Inner Lever
MR2
Note: Group part numbers are
same as Corolla, Tercel.
★ Lock Ball Assembly
33290
400 (29,39)
Ring
33242E
Ball
33211D
Reverse Shift Fork
33211
Ring
33242E
★ Plug
33275F
Seat
33275
Spring
33275E
Ball
33275C
Bolt
33213B
No. 3 Shift Fork
33214F
No. 3 Shift Fork Shaft
33244C
Spring
33275E
Ball
33275C
Seat
33275
★ 250 (18,25)
Plug
33275F
No. 2 Shift Fork Shaft
33245
Snap Ring
33232E
Shift Head
33233F
Bolt
33232D
No. 2 Shift Fork
33213F
160 (12,16)
Bolt
33213B
Seat
33295
No. 1 Shift Fork
33213
Spring
33275E
★ Plug
33275F
Bolt
33213B
Ball
33275C
Ring
33242E
No. 1 Shift Fork Shaft
33243
kg-cm (ft-lb, N•m) : Specified torque
◆ Non-reusable part
★ Precoated part

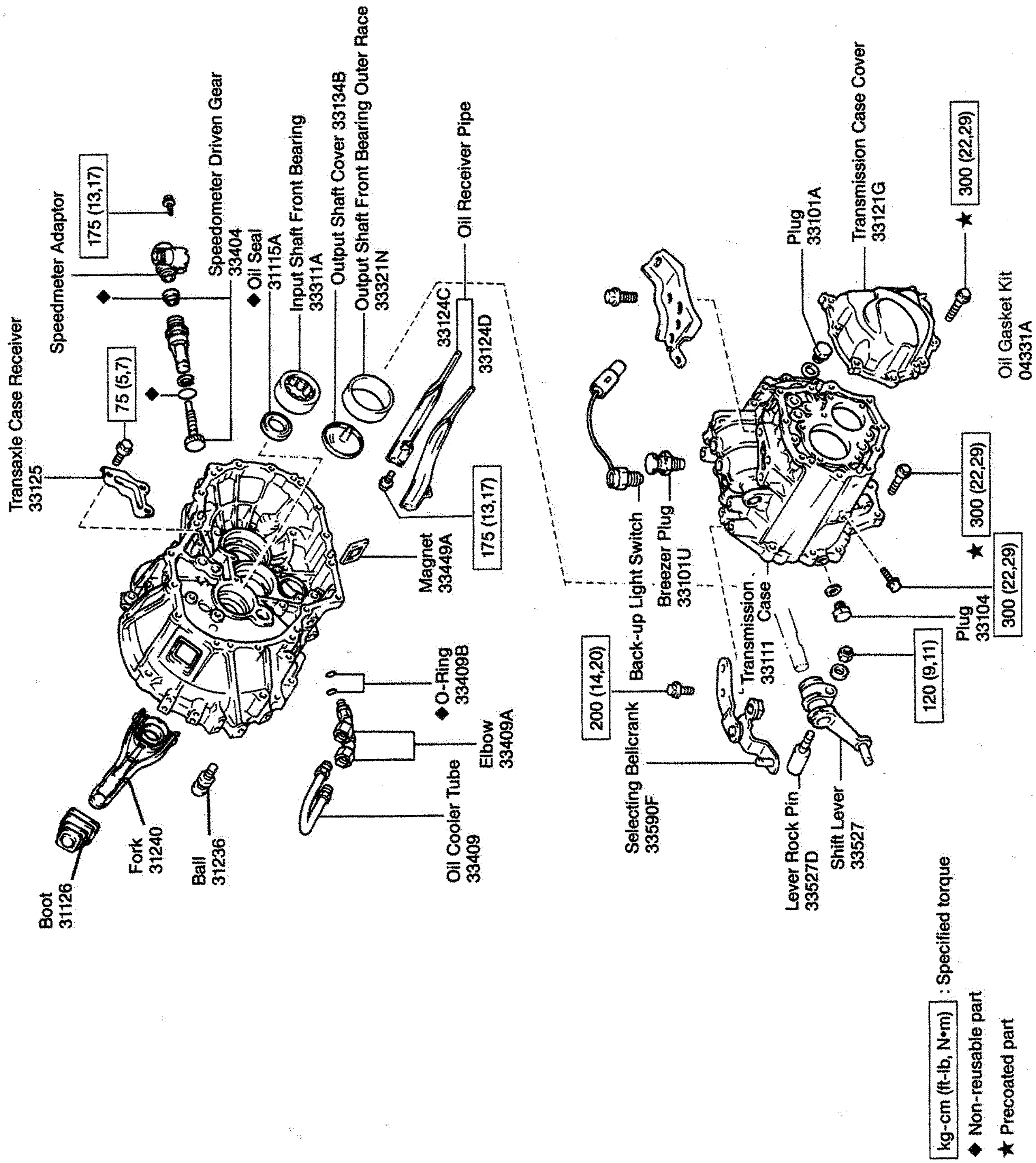
Tool No.	Description
 09201-60011 (Essential Tool)	Remover & Replacer, Speedometer driven gear oil seal
 09308-00010	Puller, Oil Seal
 09309-12020-01A (Essential Tool)	5th Gear Replacer (RH Female Thread)
 09310-35010	Replacer, Counter Shaft Bearing
09350-32013 (Essential Tool) 	Automatic Transmission Tool Set A. 09351-32130 Handle B. 09351-32120 Overdrive Bearing Replacer C. 09351-32150 Oil Seal Replacer H. 09351-32111 Side Bearing Race Replacer P. 09351-32090 Oil Seal Remover/Replacer
 09502-10012 (Essential Tool)	Differential Side Bearing Puller
 09520-32021-01 (Essential Tool)	Differential Side Gear Shaft Puller (Use with 09520-32040-01)
 09520-32040-01 (Essential Tool)	Slide Hammer ⅝-18 Thread (Use with 09520-32021-01)
 09564-32011-01 (Essential Tool)	Preload Adapter
09608-12010 	Replacer Set, A. 09608-00070 Input shaft rear bearing, output shaft rear bearing B. 09608-00080 Input shaft front oil seal G. 09608-00020 Handle

Tool No.	Description
09608-20012 	Tool Set, A. 09608-00080 Control shaft seal L. 09608-03090 LH side bearing outer race and RH side bearing outer race D. 09608-03020 Handle
09630-24012-CE (Essential Tool) 	Rack & Pinion Steering Set B. 09612-22011-01 No. 3 hub sleeve assembly
09950-20017 (Essential Tool) 	Puller, Universal A. 09953-20010 Jaw (Pair) B. 09953-20021 Jaw (Pair) C. 09953-55010 Jaw (Pair) D. 09953-35021 Jaw (Pair) E. 09953-35011 Jaw (Pair) F. 09956-20010 Tightening Piece F1. 09954-20011 Adjusting Screw G. 09952-20010 Screw H. 09952-36010 Screw J. 09955-20012 Prop K. 09957-20010 Pin (Pair) L. 09958-20010 Disc E M. 09958-30020 Disc D N. 09958-30010 Disc C O. 09958-55010 Disc A P. 09959-20010 Handle Q. 09964-35010 Adapter R. 09956-00010 Tightening
OR	
00002-00907-01 (Essential Tool) 	Transmission Bearing Service Set A. 00002-00907-7 Remover/Replacer (400mm/15¾") B. 00002-00907-8 Forcing Screw C. 00002-00907-9 Bearing Puller D. 00002-00907-10 Puller Ring Half E. 00002-00907-11 Replacer Shaft Collar F. 00002-00907-12 Remover/Replacer (140mm/5½") G. 00002-00907-13 Collet Halves (for ATM Front Pump) H. 00002-00907-14 5th Gear Hub Puller (Use with 00002-00907) I. 304839 Jaw (ea.) J. 00002-10001 Carrying Case

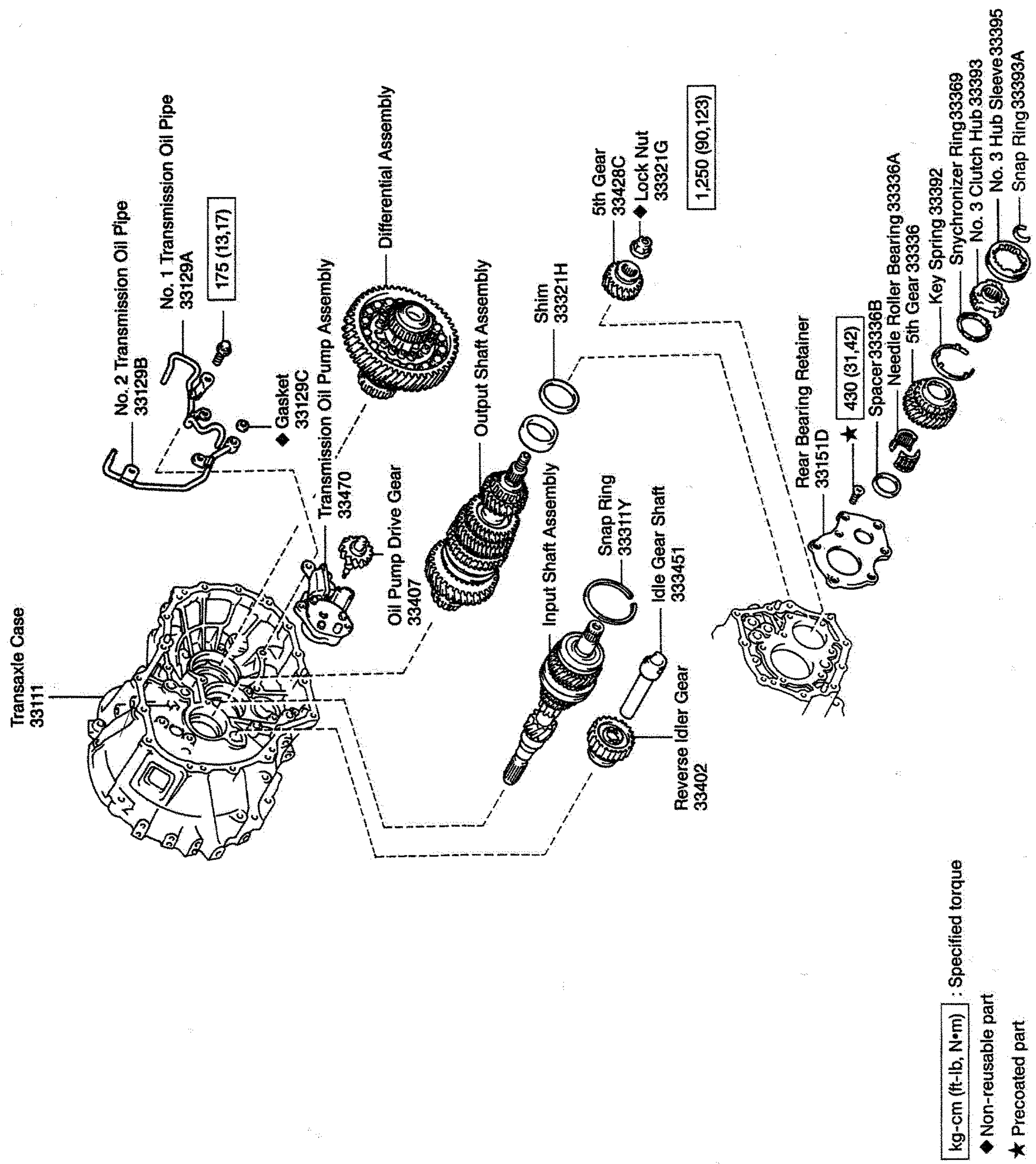
*SST's not listed are common tools which are available locally (refer to SST Catalog).

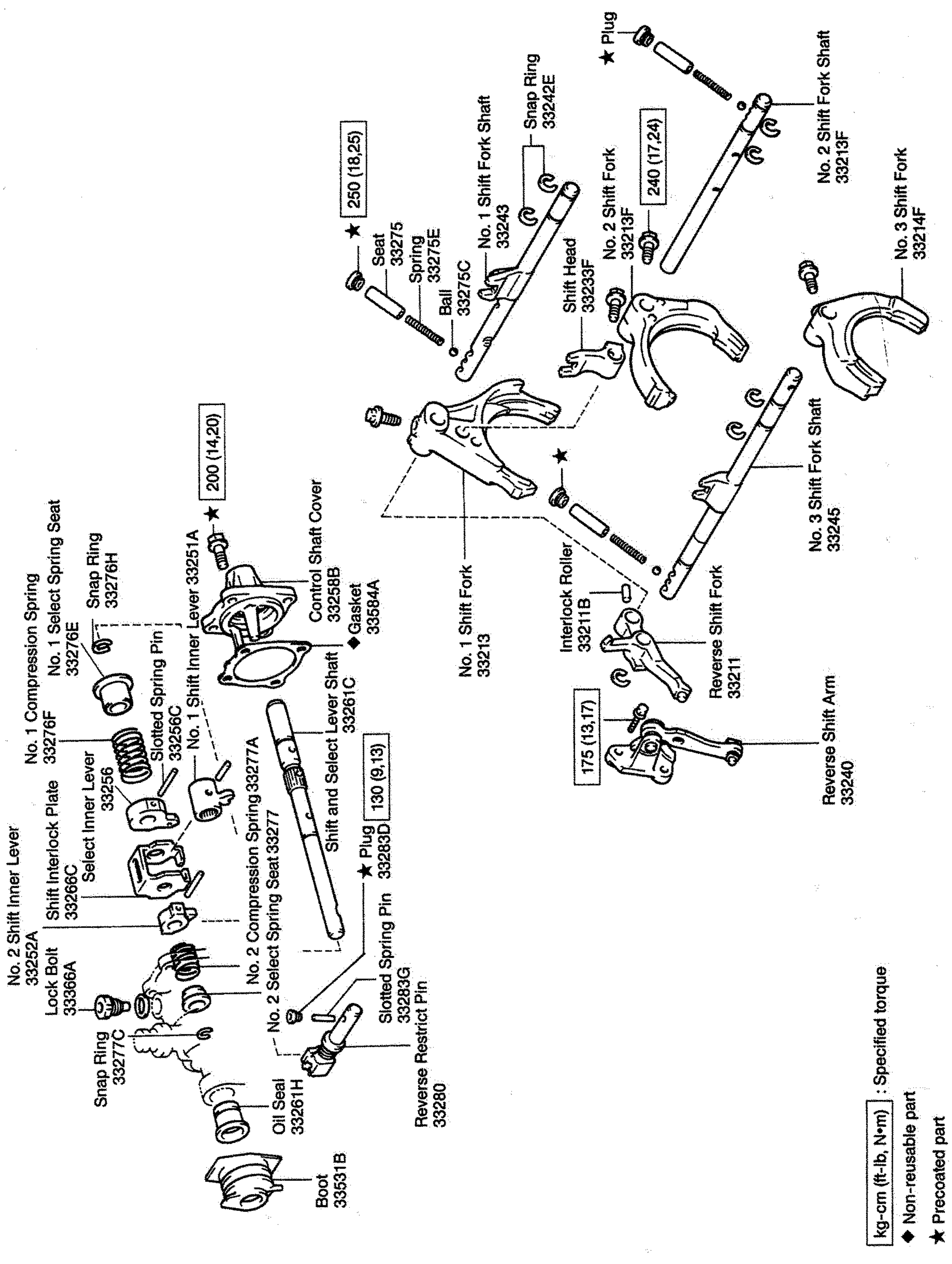
E SERIES TRANSAXLES

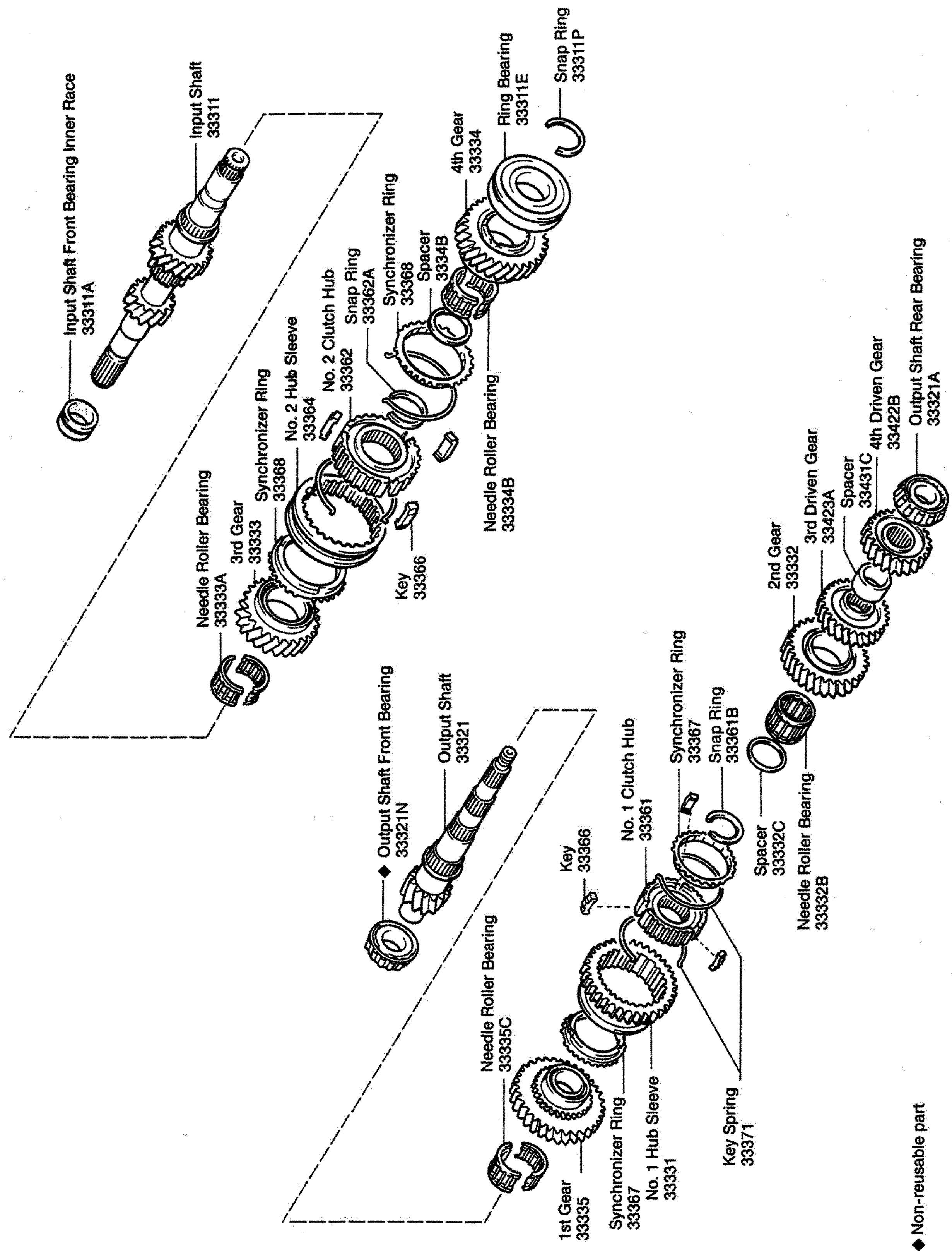
TRANSAXLE SERIES	MODEL/YEAR	KEY DIFFERENCES	LUBRICANT/CAP.
E5# 	AW11 MR2/ 1988 - 1990 SW20, 21 1991 - 1995 E153	▶ Starter mounts on right side of clutch housing ▶ Shift lever is on the opposite side of case ▶ Oil cooler on bottom side of main case ▶ Similar in construction but larger than "C" series transaxle ▶ I.D. No. - Top front edge of clutch housing	API GL-5 SAE 75W-90/ 4.2L (4.4 qt.)
E56F5, E50F2, E57F5 	**E56F5** ALL-TRAC CAMRY 1988 - 1990 **E50F2** ALL-TRAC CELICA 1988 - 1989 **E57F5** ALL-TRAC COROLLA 1988½ - 1989 E150F ALL TRAK CELICA 1990 - 1993 ALL TRAK COROLLA SDN 1990 - 1991 WGN ES5FS ES7F5 ACU30 CAMRY E351 2002-2003 Corolla Alltrack 1992 E57F5	▶ Starter mounts on right side of clutch housing ▶ Shift lever retainer is bolted to the case ▶ Oil cooler on bottom side of main case ▶ Similar in construction but larger than "C" series transaxle ▶ I.D. No. - Top front edge of clutch housing	API GL-5 SAE 75W-90 OR SAE 80W-90/**E56** & **57F5** 5.0L (5.3 qt.) E50F2 4.8L (5.1 qt.) SAE 90W - **ABOVE** -18 °C (0 °F) SAE 80W - **BELOW** -18 °C (0 °F) **NOTE:**

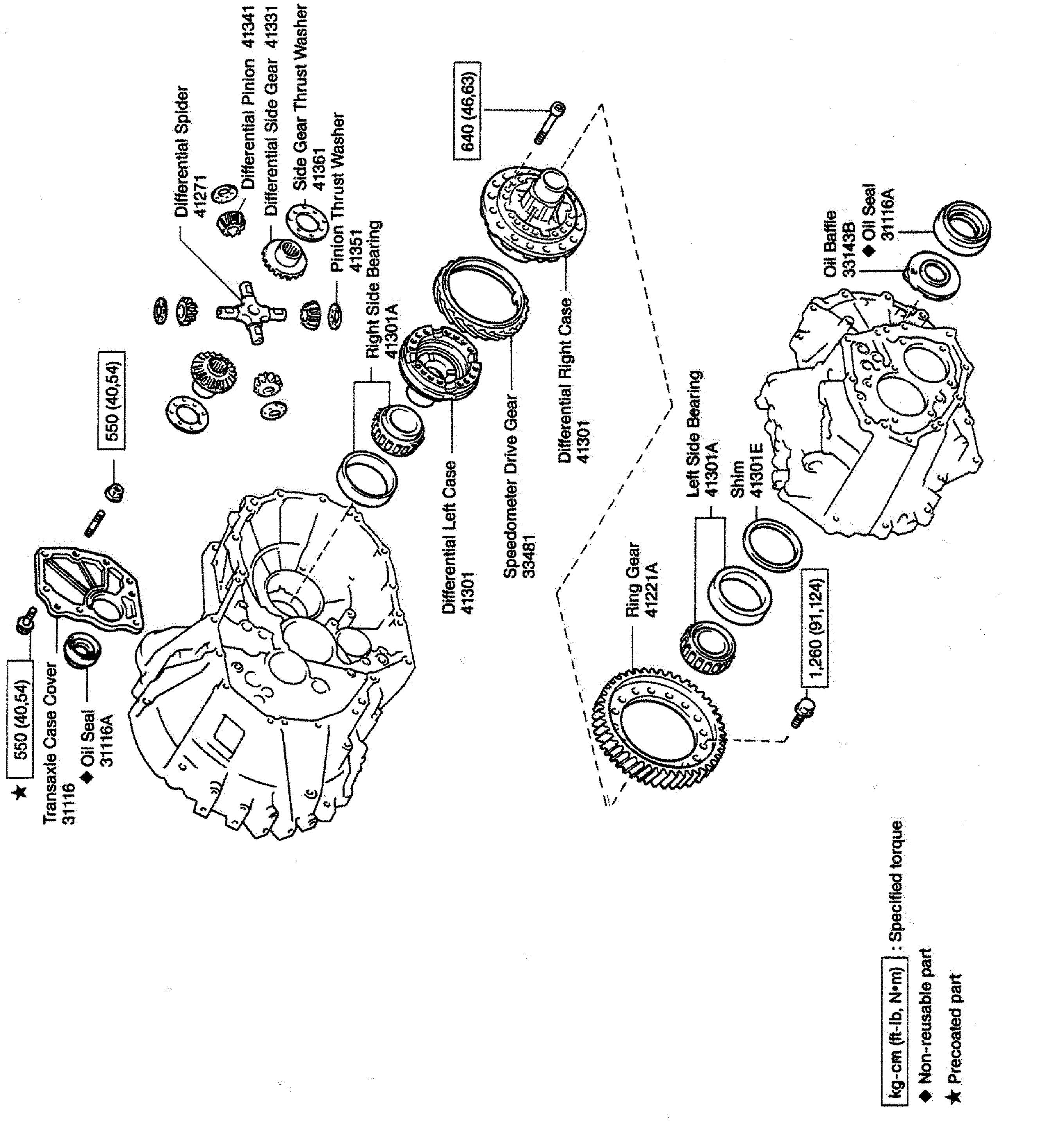


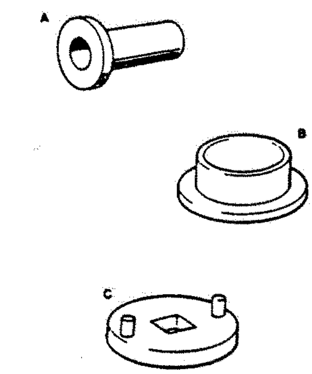
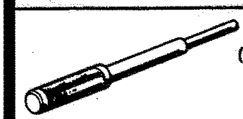
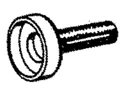
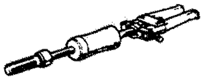
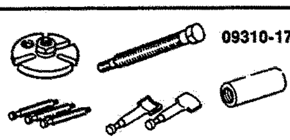
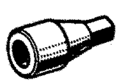
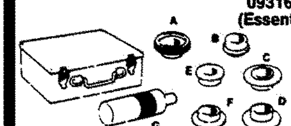
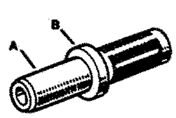
Transaxle Case Receiver
33125
Speedometer Adaptor
175 (13,17)
75 (5,7)
Speedometer Driven Gear
33404
◆ Oil Seal
31115A
Input Shaft Front Bearing
33311A
Output Shaft Cover 33134B
Output Shaft Front Bearing Outer Race
33321N
33124C
Oil Receiver Pipe
33124D
175 (13,17)
Magnet
33449A
Boot
31126
Fork
31240
Ball
31236
◆ O-Ring
33409B
Elbow
33409A
Oil Cooler Tube
33409
200 (14,20)
Back-up Light Switch
Breezer Plug
33101U
Transmission Case
33111
Selecting Bellcrank
33590F
Lever Rock Pin
33527D
Shift Lever
33527
120 (9,11)
Plug
33104
300 (22,29)
★ 300 (22,29)
300 (22,29)
Plug
33101A
Transmission Case Cover
33121G
★ 300 (22,29)
Oil Gasket Kit
04331A
kg-cm (ft-lb, N•m) : Specified torque
◆ Non-reusable part
★ Precoated part

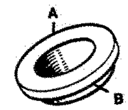
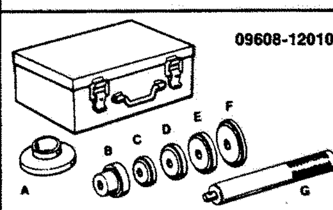
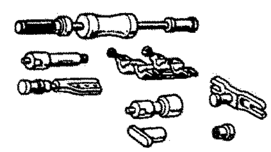
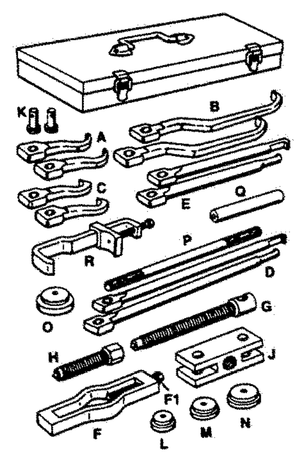

Transaxle Case
33111
No. 2 Transmission Oil Pipe
33129B
No. 1 Transmission Oil Pipe
33129A
175 (13,17)
Gasket
33129C
Transmission Oil Pump Assembly
33470
Differential Assembly
Oil Pump Drive Gear
33407
Output Shaft Assembly
Shim
33321H
5th Gear
33428C
Lock Nut
33321G
1,250 (90,123)
Input Shaft Assembly
Snap Ring
33311Y
Idle Gear Shaft
333451
Reverse Idler Gear
33402
Rear Bearing Retainer
33151D
430 (31,42)
Spacer33336B
Needle Roller Bearing 33336A
5th Gear 33336
Key Spring 33392
Snychronizer Ring33369
No. 3 Clutch Hub 33393
No. 3 Hub Sleeve 33395
Snap Ring 33393A
kg-cm (ft-lb, N•m) : Specified torque
Non-reusable part
Precoated part


No. 2 Shift Inner Lever 33252A
Lock Bolt 33366A
Shift Interlock Plate 33266C
Select Inner Lever 33256
No. 1 Compression Spring 33276F
No. 1 Select Spring Seat 33276E
Snap Ring 33276H
Slotted Spring Pin 33256C
No. 1 Shift Inner Lever 33251A
200 (14,20)
Control Shaft Cover 33258B
Gasket 33584A
Shift and Select Lever Shaft 33261C
130 (9,13)
Plug 33283D
No. 2 Compression Spring 33277A
No. 2 Select Spring Seat 33277
Snap Ring 33277C
No. 2 Select Spring Pin
Slotted Spring Pin 33283G
Reverse Restrict Pin 33280
Oil Seal 33261H
Boot 33531B
250 (18,25)
Seat 33275
Spring 33275E
Ball 33275C
No. 1 Shift Fork Shaft 33243
Snap Ring 33242E
Shift Head 33233F
No. 2 Shift Fork 33213F
240 (17,24)
Plug
No. 2 Shift Fork Shaft 33213F
No. 3 Shift Fork 33214F
No. 1 Shift Fork 33213
Interlock Roller 33211B
Reverse Shift Fork 33211
No. 3 Shift Fork Shaft 33245
175 (13,17)
Reverse Shift Arm 33240
kg-cm (ft-lb, N•m) : Specified torque
◆ Non-reusable part
★ Precoated part


Input Shaft Front Bearing Inner Race
33311A
Input Shaft
33311
Snap Ring
33311P
Ring Bearing
33311E
4th Gear
33334
Synchronizer Ring
33368
Spacer
3334B
Snap Ring
33362A
No. 2 Clutch Hub
33362
No. 2 Hub Sleeve
33364
Synchronizer Ring
33368
3rd Gear
33333
Needle Roller Bearing
33333A
Key
33366
Needle Roller Bearing
33334B
◆ Output Shaft Front Bearing
33321N
Output Shaft
33321
Needle Roller Bearing
33335C
Key
33366
No. 1 Clutch Hub
33361
Synchronizer Ring
33367
Snap Ring
33361B
Spacer
33332C
Needle Roller Bearing
33332B
2nd Gear
33332
3rd Driven Gear
33423A
Spacer
33431C
4th Driven Gear
33422B
Output Shaft Rear Bearing
33321A
1st Gear
33335
Synchronizer Ring
33367
No. 1 Hub Sleeve
33331
Key Spring
33371
◆ Non-reusable part

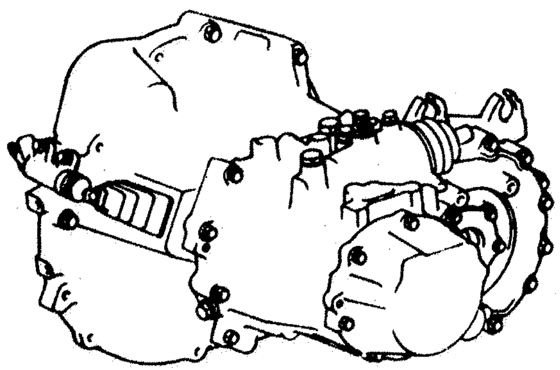

550 (40,54)
★ Transaxle Case Cover 31116
◆ Oil Seal 31116A
550 (40,54)
Differential Spider 41271
Differential Pinion 41341
Differential Side Gear 41331
Side Gear Thrust Washer 41361
Pinion Thrust Washer 41351
Right Side Bearing 41301A
640 (46,63)
Differential Left Case 41301
Speedometer Drive Gear 33481
Differential Right Case 41301
Ring Gear 41221A
Left Side Bearing 41301A
Shim 41301E
1,260 (91,124)
Oil Baffle 33143B
◆ Oil Seal 31116A
kg-cm (ft-lb, N·m) : Specified torque
◆ Non-reusable part
★ Precoated part

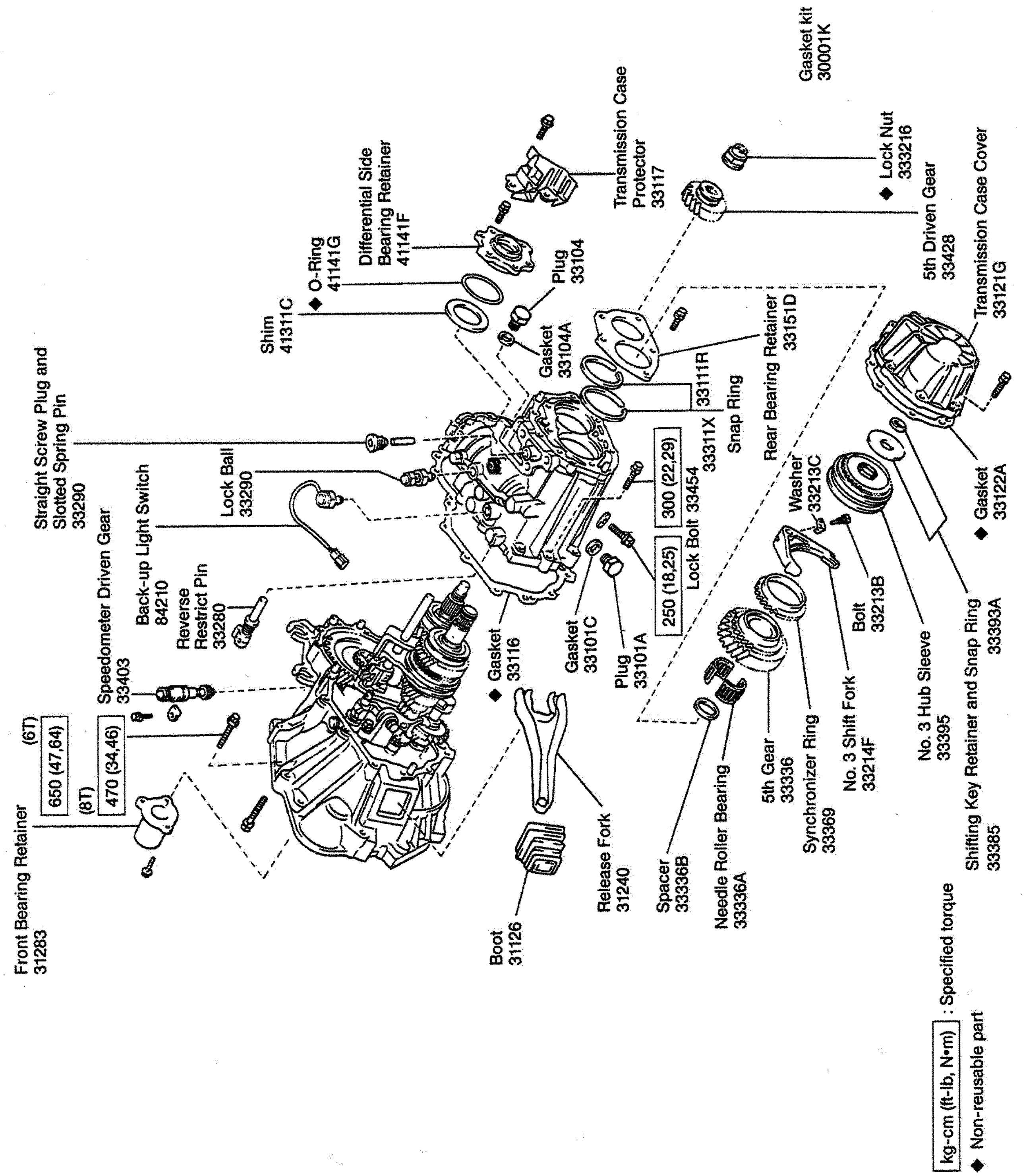
Tool No.	Description
00002-00908-01 	All-trac tool set A. 09309-36010 Transmission Rear Bearing Replacer B. 09316-20011 Transfer Bearing Replacer C. 09318-20010 Transfer Side Bearing Adjusting Nut Wrench
 09201-60011 (Essential Tool)	Remover & Replacer, Speedometer driven gear oil seal
 09223-15010 (Essential Tool)	Transmission case oil seal Replacer
 09308-00010	Puller, Oil Seal
 09310-17010	Transaxle Gear Remover & Replacer
09313-30021 	Socket, Detent Ball Plug (6mm Hex)
09316-60010 (Essential Tool) 	Replacer, Transmission Transfer Bearing
09325-20010 	Plug, Transmission Oil A. 32mm B. 57mm

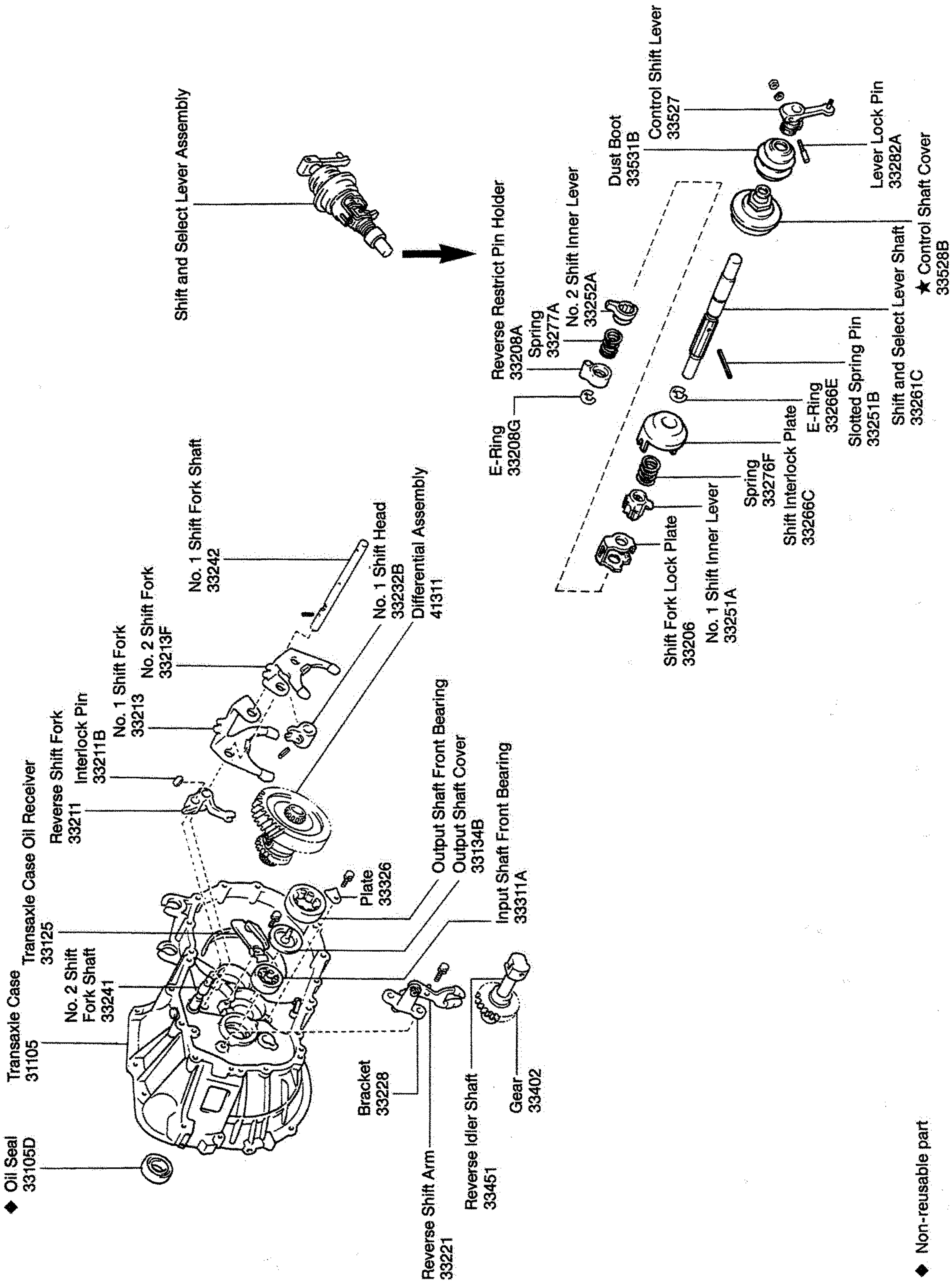
Tool No.	Description
 09326-20011 (Essential Tool)	Wrench, Output Shaft Nut (36mm)
09506-30011 	Replacer, Differential Drive Pinion Rear Bearing Cone A. 70mm B. 45mm
09506-35010	Replacer, Differential Drive Pinion Rear Bearing A. 70mm B. 48mm
 09608-12010	Replacer Set, Front Hub & Drive Pinion Bearing
09910-00015 	Puller Set
09950-20017 (Essential Tool) 	Puller, Universal The following replacement parts are available and may be ordered individually. A. 09953-20010 Jaw (Pair) B. 09953-20021 Jaw (Pair) C. 09953-55010 Jaw (Pair) D. 09953-35021 Jaw (Pair) E. 09953-35011 Jaw (Pair) F. 09956-20010 Tightening Piece F1. 09954-20011 Adjusting Screw G. 09952-20010 Screw H. 09952-36010 Screw J. 09955-20012 Prop K. 09957-20010 Pin (Pair) L. 09958-20010 Disc E M. 09958-30020 Disc D N. 09958-30010 Disc C O. 09958-55010 Disc A P. 09959-20010 Handle Q. 09964-35010 Adapter R. 09956-00010 Tightening Piece

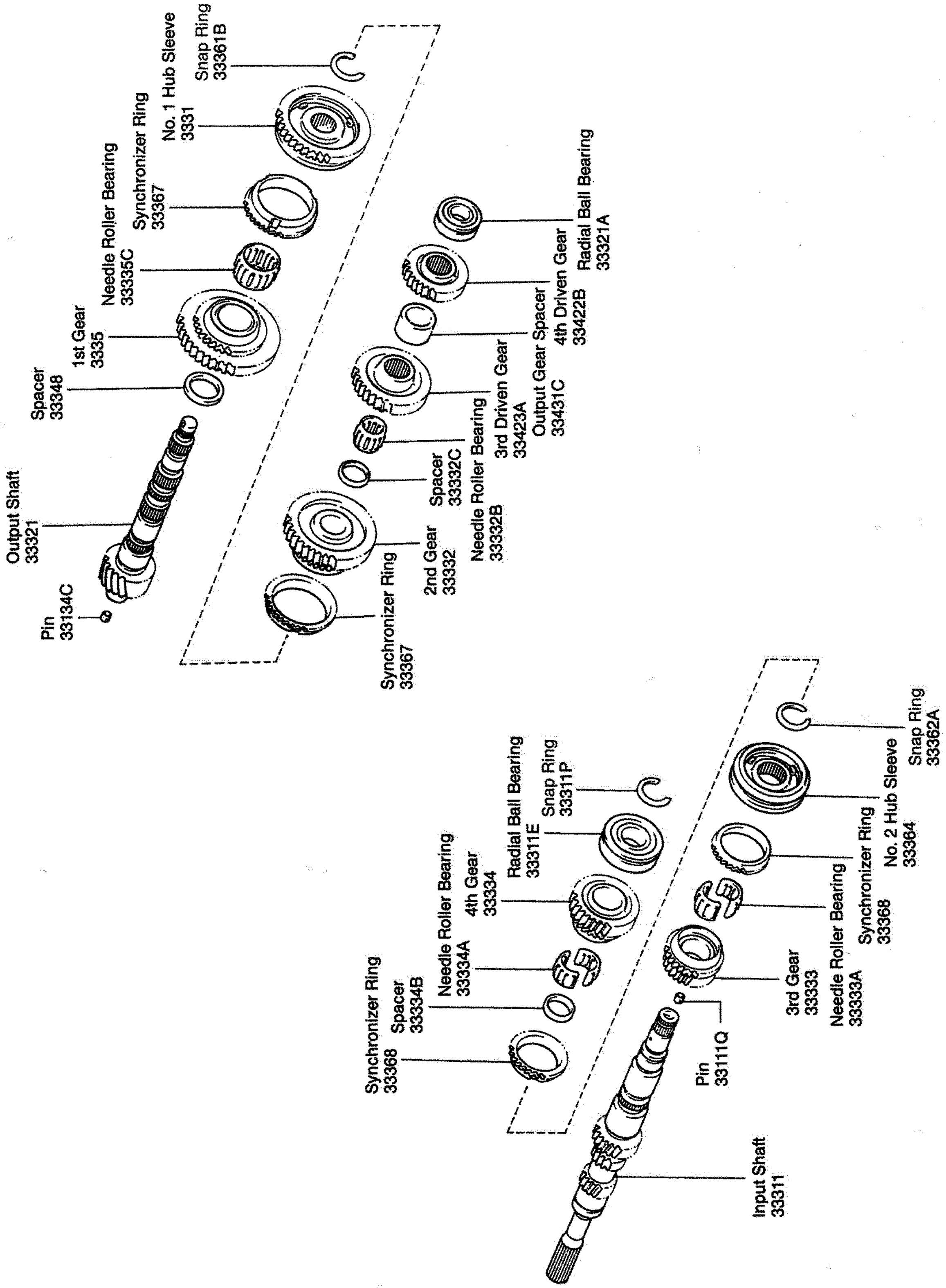
*SST's not listed are common tools which are available locally (refer to SST Catalog).

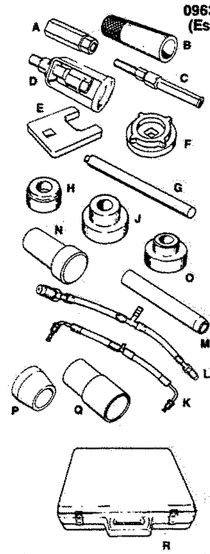
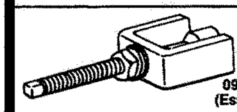
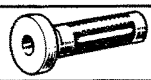
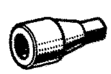
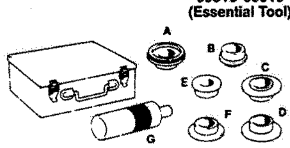
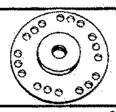
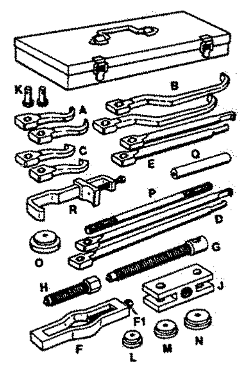
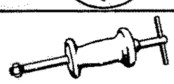
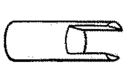
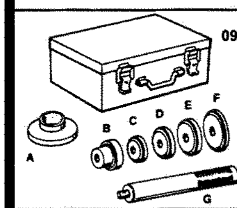
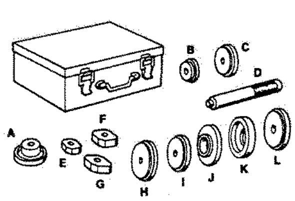
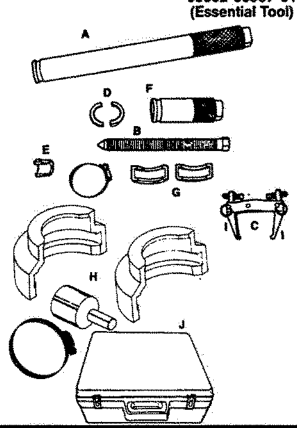
S SERIES TRANSAXLES

TRANSAXLE SERIES	MODEL/YEAR	KEY DIFFERENCES	LUBRICANT/CAP.
S50, 51, 53 	**S50** CE80 COROLLA/ 1984 - 1985 **S51** SV11 CAMRY/ 1983 - 2001 **S53** ST161, 162 CELICA/ 1986 - 1993 S54 1994 - 1991 ST204	▶ Starter mounts on left side of clutch housing ▶ Shift lever retainer is threaded into the case ▶ Shift cable mounts are cast with the case ▶ I.D. No. - Top front edge of clutch housing	ATF DEXRON II/ 2.6L (2.7 qt.) **I.D. No. NOTES:** 3 0 9 0 0 0 0 0 5-digit Production Number or 2-Digit Production Number Manufacturing Month: January → 01 December → 12 Last Digit of Manufacturing Year: 1983


Front Bearing Retainer
31283
(6T)
650 (47,64)
(8T)
470 (34,46)
Speedometer Driven Gear
33403
Straight Screw Plug and
Slotted Spring Pin
33290
Back-up Light Switch
84210
Reverse
Restrict Pin
33280
Lock Ball
33290
Shim
41311C
◆ O-Ring
41141G
Differential Side
Bearing Retainer
41141F
Plug
33104
Gasket
33104A
Transmission Case
Protector
33117
Gasket kit
30001K
◆ Lock Nut
333216
5th Driven Gear
33428
Transmission Case Cover
33121G
Rear Bearing Retainer
33151D
33111R
33311X
Snap Ring
300 (22,29)
Lock Bolt 33454
250 (18,25)
◆ Gasket
33116
Gasket
33101C
Plug
33101A
Washer
33213C
Bolt
33213B
◆ Gasket
33122A
Boot
31126
Release Fork
31240
Spacer
33336B
Needle Roller Bearing
33336A
5th Gear
33336
Synchronizer Ring
33369
No. 3 Shift Fork
33214F
No. 3 Hub Sleeve
33395
Shifting Key Retainer and Snap Ring
33385
33393A
kg-cm (ft-lb, N•m) : Specified torque
◆ Non-reusable part


Shift and Select Lever Assembly
Control Shift Lever
33527
Dust Boot
33531B
Lever Lock Pin
33282A
★ Control Shift Cover
33528B
Shift and Select Lever Shaft
33261C
Slotted Spring Pin
33251B
E-Ring
33266E
Interlock Plate
Shift Interlock Plate
33266C
Spring
33276F
No. 1 Shift Inner Lever
33251A
Shift Fork Lock Plate
33206
E-Ring
33208G
Reverse Restrict Pin Holder
33208A
Spring
33277A
No. 2 Shift Inner Lever
33252A
No. 1 Shift Fork Shaft
33242
No. 1 Shift Head
33232B
Differential Assembly
41311
No. 2 Shift Fork
33213F
No. 1 Shift Fork
33213
Interlock Pin
33211B
Reverse Shift Fork
33211
Transaxle Case Oil Receiver
33125
Transaxle Case
31105
No. 2 Shift Fork Shaft
33241
◆ Oil Seal
33105D
Plate
33326
Output Shaft Front Bearing
Output Shaft Cover
33134B
Input Shaft Front Bearing
33311A
Bracket
33228
Reverse Shift Arm
33221
Reverse Idler Shaft
33451
Gear
33402
◆ Non-reusable part


Snap Ring
33361B
No. 1 Hub Sleeve
3331
Synchronizer Ring
33367
Needle Roller Bearing
33335C
1st Gear
3335
Spacer
33348
Output Shaft
33321
Pin
33134C
Radial Ball Bearing
33321A
4th Driven Gear
33422B
Output Gear Spacer
33431C
3rd Driven Gear
33423A
Needle Roller Bearing
33332B
Spacer
33332C
2nd Gear
33332
Synchronizer Ring
33367
Snap Ring
33362A
No. 2 Hub Sleeve
33364
Synchronizer Ring
33368
Needle Roller Bearing
33333A
3rd Gear
33333
Pin
33111Q
Input Shaft
33311
Snap Ring
33311P
Radial Ball Bearing
33311E
4th Gear
33334
Needle Roller Bearing
33334A
Spacer
33334B
Synchronizer Ring
33368

Tool No.	Description	Tool No.	Description
 09201-60011 (Essential Tool)	Remover & Replacer, Speedometer driven gear oil seal	 09630-24012-CE (Essential Tool)	Rack & Pinion Steering Set B. 09612-22011-01 No. 3 clutch hub
 09308-00010	Puller, Oil Seal		
 09309-32050 (Essential Tool)	5th Gear Replacer (LH Thread)		
 09310-35010	Replacer, Counter Shaft Bearing		
 09313-30021	Socket, Detent Ball Plug (6mm Hex)		
09316-60010 (Essential Tool) 	Replacer		
 09520-32021-01 (Essential Tool)	Differential Side Gear Shaft Puller (Use with 09520-32040-01)	09950-20017 (Essential Tool) 	Puller, Universal A. 09953-20010 Jaw (Pair) B. 09953-20021 Jaw (Pair) C. 09953-55010 Jaw (Pair) D. 09953-35021 Jaw (Pair) E. 09953-35011 Jaw (Pair) F. 09956-20010 Tightening Piece F1. 09954-20011 Adjusting Screw G. 09952-20010 Screw H. 09952-36010 Screw J. 09955-20012 Prop K. 09957-20010 Pin (Pair) L. 09958-20010 Disc E M. 09958-30020 Disc D N. 09958-30010 Disc C O. 09958-55010 Disc A P. 09959-20010 Handle Q. 09964-35010 Adapter R. 09956-00010 Tightening Piece
 09520-32040-01 (Essential Tool)	Slide Hammer ⅝-18 Thread (Use with 09520-32021-01)		
 09564-32011-01 (Essential Tool)	Preload Adapter		
 09608-12010	Replacer Set, A. 09608-00070 Fourth driven gear and radial ball bearing		
		OR	
09608-20012 	Tool Set, A. 09608-00080 Input shaft front oil seal C. 09608-00030 LH side oil seal H. 09608-03060 I. 09608-00060 LH side bearing outer race H. 09608-03060 C. 09608-00030 RH side bearing outer race A. 09608-00080 Control shaft cover oil seal J. 09608-03070 Fourth gear and radial ball bearing D. 09608-03020 Handle	00002-00907-01 (Essential Tool) 	Transmission Bearing Service Set A. 00002-00907-7 Remover/ Replacer (400mm/15¾") B. 00002-00907-8 Forcing Screw C. 00002-00907-9 Bearing Puller D. 00002-00907-10 Puller Ring Half E. 00002-00907-11 Replacer Shaft Collar F. 00002-00907-12 Remover/ Replacer (140mm/5½") G. 00002-00907-13 Collet Halves (for ATM Front Pump) H. 00002-00907-14 5th Gear Hub Puller (Use with 00002-00907) I. 304839 Jaw (ea.) J. 00002-10001 Carrying Case

*SST's not listed are common tools which are available locally (refer to SST Catalog).

Appendix E

Customer Problem Analysis Check

SEQUENTIAL MANUAL TRANSMISSION SYSTEM Check Sheet	Inspector's Name: ______________________

Customer's Name		Model and Model Year	
Driver's Name		Frame No.	
Date Vehicle Brought In		Engine Model	
Vehicle License No.		Odometer Reading	miles km

Symptoms	❑ Vehicle does not move	❑ Vehicle does not run normally (Vehicle can run in fail-safe mode in 1st or Rev) ❑ Starter does not operate ❑ Starter operates but engine does not start ❑ Others ( )
	❑ No up shift	❑ 1st → 2nd ❑ 2nd → 3rd ❑ 3rd → 4th ❑ 4th → 5th ❑ 5th → 6th
	❑ No down shift	❑ 6th → 5th ❑ 5th → 4th ❑ 4th → 3rd ❑ 3rd → 2nd ❑ 2nd → 1st
	❑ Gear does not change in a particular range	❑ 1st ❑ 2nd ❑ 3rd ❑ 4th ❑ 5th ❑ 6th ❑ Rev
	❑ Shift lever cannot be operated	❑ N → S ❑ N → R ❑ S → N ❑ R → N
	❑ Noise	❑ Motor Shifting Gear ❑ Others
	❑ Shudder ❑ Slip	
	❑ Others	
Date and Time Problem Occurred		
Problem Frequency	❑ Constant ❑ Sometimes (times per day/week) ❑ Once only ❑ Others( )	
Condition When Problem Occurred	Weather	❑ Fine ❑ Cloudy ❑ Rainy ❑ Snowy ❑ Various/Others
	Place	❑ Inner-city ❑ Suburbs ❑ Highway ❑ Uphill ❑ Downhill ❑ Steep slope ❑ Slight slope ❑ Paved road ❑ Rough road
	Engine	❑ Cold ❑ During warming up (min. after engine starts) ❑ After warming up
	Warning Lamp	❑ On ❑ Off ❑ Uncertain
	Warning Buzzer	❑ On (Sounding pattern:) ❑ Off Uncertain
	Shift Indicator	❑ R ❑ N ❑ S1 ❑ S2 ❑ S3 ❑ S4 ❑ S5 ❑ S6 ❑ On ❑ Blinking ❑ Off ❑ Uncertain
	Shift lever Position	❑ R ❑ N ❑ S ❑ + ❑ -
	Engine	❑ Just after starting ❑ Idling ❑ Racing ❑ Just before starting ❑ Starting ❑ ( ) km/h in inertial driving ❑ ( ) km/h in constants speed ❑ (Continual driving time before problem occurred: min.) ❑ From ( )km/h ❑ Sudden ❑ Slow ❑ Acceleration ❑ Deceleration ❑ Stopping ❑ Right ❑ Left ❑ Curve ❑ Gear position ( ) ~ ( ) when up/down-shifting ❑ Shift position:

Simulation	Condition	❑ Problem cannot be simulated ❑ Problem can be simulated (How?)
	DG code	❑ No code exists when vehicle was brought in ❑ ID Code ________ exists when vehicle was brought in ❑ No code exists after the deletion ❑ Code ________ exists after the deletion
Check whether the fail safe function of the output DTC agrees with the problem symptom, which the customer explains. DTC: Fail Safe Function Symptom:		

Notes