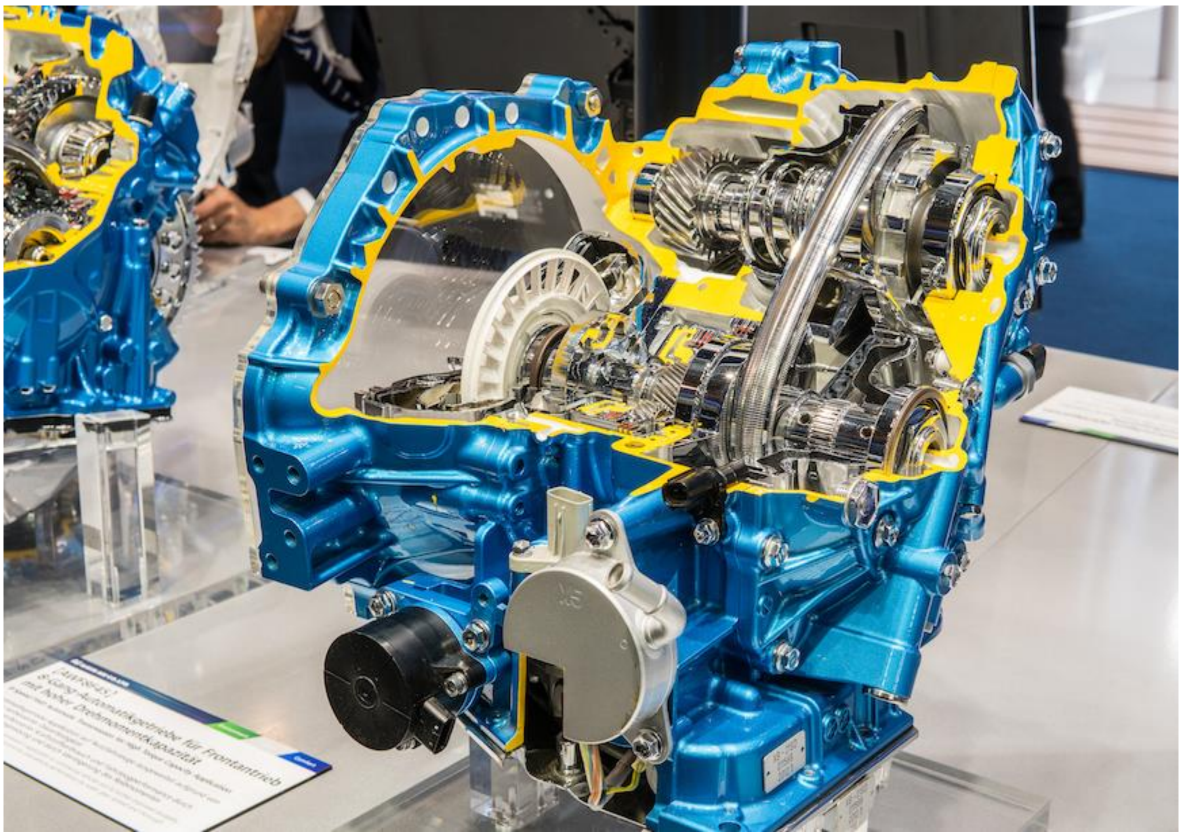
Automotive Mechanics

Level-II

Based on March 2022, Curriculum Version 1



Module Title: - Service Power Train System

Module code: EIS AUM2 M05 0322

Nominal duration: 70 Hour

Prepared by: Ministry of Labor and Skill

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Addis Ababa, Ethiopia

Table of Contents

Acknowledgment

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Acronym

2WD	Two wheel drive
4WD-	Four Wheel drive
AWD	All wheel drive
CAN	Computer area network
CV	Continues Variable
FWD	Front wheel drive
Lap-Test	Learning activity performance
LSD	Limited Slip Differentials
MP	Multi-purpose
RWD	Rear wheel drive
SST	Special service tools
SUV	Sport utility vehicle
TTLM	Teaching, Training and Learning Materials
U-joint	Universal joint

Introduction to module

In Automotive field of study; servicing powertrain system is one of important task the mechanic undertaking during servicing. This module contain how to remove, check and refit automotive power train drive line assemblies. Also, it involves minor inspections to identify deviations from correct operation, removal, disassembly and fitting procedures for main and interrelated components following manufacturer specification.

This module is designed to meet the industry requirement under the automotive mechanics level II occupational standard, particularly for the unit of competency: Service power train system.

This module covers the units:

- Power train drive line assemblies
- Remove and inspect power train drive line assemblies
- Service power train drive line assemblies
- Clean-up work area and finalize work processes

Learning Objective of the Module

- Comprehending Power train drive line assemblies
- Removing and inspecting power train drive line assemblies
- Servicing power train drive line assemblies
- Clean-up work area and finalize work processes

Module Instruction

For effective use this modules trainees are expected to follow the following module instruction:

1. Read the information written in each unit
2. Accomplish the Self-checks at the end of each unit
3. Perform Operation Sheets which were provided at the end of units
4. Do the “LAP test” giver at the end of each unit and
5. Read the identified reference book for Examples and exercise

Unit one: Introduction to Power train drive line assemblies

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Overview of automotive powertrain
  - Basic concepts of power train system gear train
  - Fundamentals of transmission/transaxle
  - Final drive and axle shafts
  - Differential
  - Wheel bearing

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Overviewing of automotive powertrain
- Basic concepts of power train system gear train
- Fundamentals of transmission/transaxle
- Understand Final drive and axle shafts
- Knowing the purpose of Differential/ Wheel bearing

1.1 Overview of Automotive Powertrain

In a motor vehicle, the term powertrain describes the main components that generate power and deliver it to the road surface, water, or air. This includes the engine, clutch, transmission, drive shafts, differentials, and the final drive (drive wheels). The power train serves two functions: it transmits power from the engine to the drive wheels, and it varies the amount of speed and torque.

There are commonly two sets of gears in the power train, the transmission and the differential. The transmission provides a means for changing the speed and torque of the engine before it reaches to the driving wheels to best meet each particular driving situation. Manual transmissions require use of a clutch to apply and remove engine torque to the transmission input shaft as needed by the driver. The drive shaft, or propeller shaft, connects the transmission output shaft to the differential pinion shaft.

When a car makes a turn, the outer wheel has to turn faster than the inner wheel, due to the difference in the length of the paths they take. The differential lets the outer and inner wheels to turn at different speeds.

1.1.1 Engine and transmission position

Location of engine and transmission assemblies in the vehicle, vary with different makes and models. This makes it essential that you refer to the maker's instruction manuals to a certain in a correct and safe method of removal and replacement of these assemblies. Engine and transmission position in the vehicle may be:

Front engine and rear wheel drive **Front engine with front and rear wheel drive**

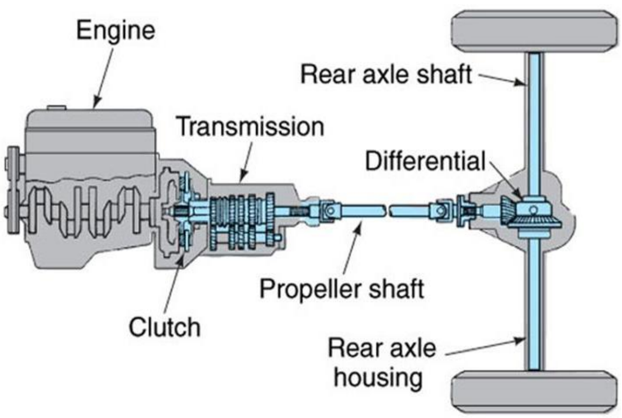


Figure 1-2 Front engine with front and rear wheel drive

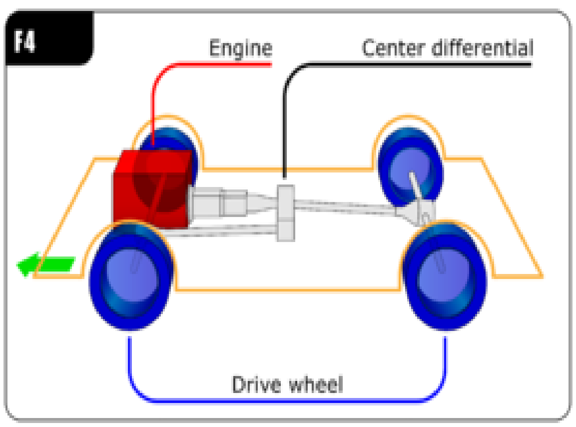


Figure 1-1 Front engine and rear wheel drive

Front engine and front wheel drive **Rear engine and rear wheel drive**

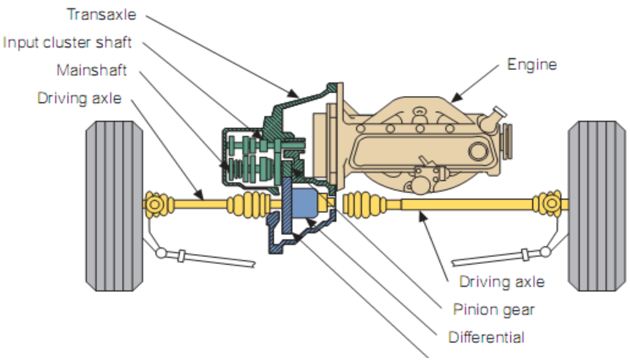


Figure 1-4 Rear engine and rear wheel drive

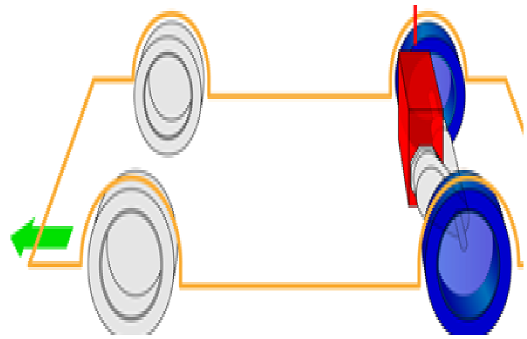


Figure 1-3 Front engine with front and rear wheel drive.

Rear mounted engine front wheel drive

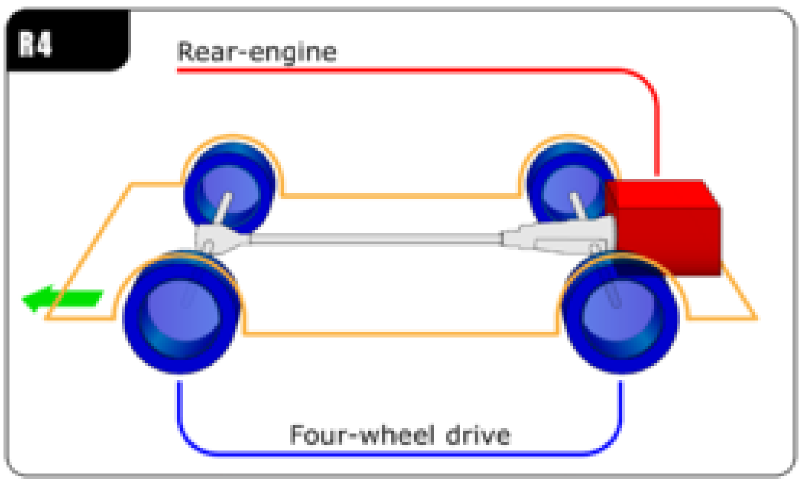


Figure 1-5 Rear mounted engine front wheel drive

1.2 Clutch

Clutch is a device used in engineering to engage smoothly two shafts in relative motion, one of which may be stationary, and to release them quickly or slowly at will.

The purpose of fitting a clutch between the engine and gearbox of a motor vehicle is to satisfy the following requirements:

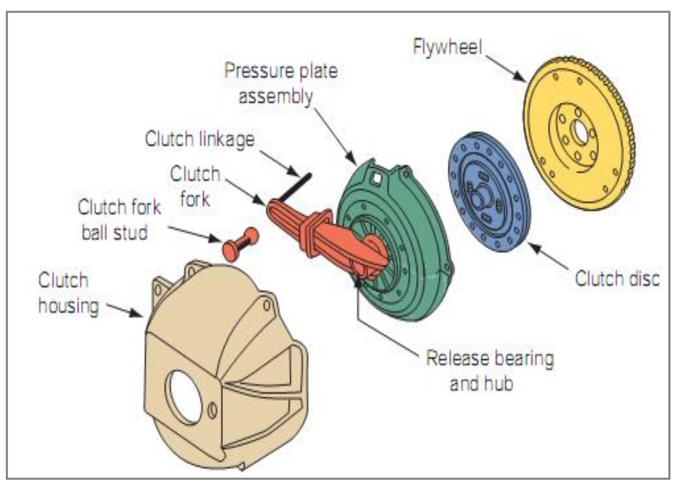


Figure 1-6 Clutch component

1. To connect a running engine smoothly and gradually the remainder of the transmission system.
2. To permit gear changing when a vehicle is in motion.
3. To allow the engine to continue running when a vehicle temporarily halted in gear with the clutch pedal pressed to disengage.

1.2.1 Types of clutch

Clutches can be categorized into two main classifications: friction clutches and fluid flywheel. Friction clutches rely on the principle of friction. The friction between the driving component shaft and the driven component shaft when they are engaged (i.e., brought into contact) allows the rotational energy to transfer from the former to the later. Fluid flywheels utilize a hydraulic fluid to transfer torque from the driving component to the driven component.

Figure 1-7 Automobile Clutches

Friction clutches and fluid wheels can be further broken down into sub-types. Some of the most common types of friction clutches are:

• **Manual clutches.** Manual clutches must be engaged and disengaged by the machine operator. They are suitable for applications where engagement and disengagement must occur at a specific or consistent rotational speed.

•**Hydraulic clutches.** Hydraulic clutches utilize hydraulic fluid (e.g., oil) to extend and retract pistons, which engage and disengage the clutch. They are suitable for hydraulic systems where engagement and disengagement must occur at a specific or consistent rotational speed.

•**Electric clutches**. Electric clutches convert electrical energy into mechanical energy. The electrical power source passes a current, which generates an electromagnetic field. The generated electromagnetic field then attracts a pressure plate, which engages the clutch. The clutch disengages when the power source stops passing a current. These clutches are suitable for use in applications where engagement and disengagement must occur at a specific or consistent rotational speed and with a readily accessible power source.

•**Centrifugal clutches**. Centrifugal clutches automatically engage and disengage when the proper rotational speeds are achieved. They are suitable for applications requiring engagement and disengagement at moderate or inconsistent rotational speeds.

A friction type of clutch is used in motor vehicles with manually operated gearboxes. Its functioning depends on sufficient friction being developed between the contact surfaces of two or more members to transmit the torque without their slipping relative to each other. Their ability to slip before full engagement is, nevertheless, a decided advantage because it allows shock-free connection to be made between engine and gear box. Heat is necessarily generated during any slip¬ of the clutch, but with fairly infrequent use there is usually sufficient time for it to cool.

1.2.2 Component Parts of a Clutch

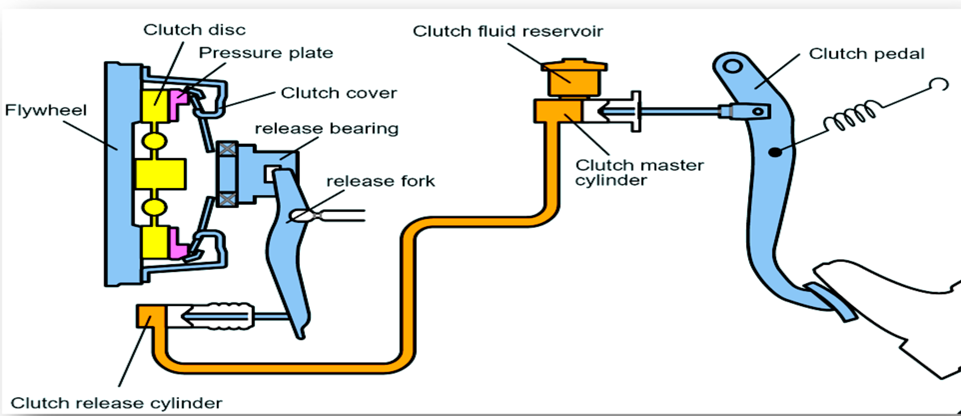


Figure 1-8 Component parts of clutch

- **Clutch fork -** connects the slave cylinder to the clutch release bearing, commonly called the throw out bearing.
- **Release bearing -** is connected to the end of the fork inside the transmission bell housing and rests on the tranny input shaft and the clutch unit. When the fork swings, the bearing applies pressure to the clutch and gives the force necessary for disengagement.
- **Clutch (bell) housing-** is fitted to the flywheel of the engine by several bolts, and rotates integrally with the clutch disc at the same speed as the engine.

- **Flywheel -** connects the clutch and driveline to the engine. On one side it is bolted directly to the crank shaft, on the other the clutch assembly. When a clutch is installed, the pressure plate is bolted to the flywheel with the clutch disc wedged in-between the two.

- **Clutch Disc**

The clutch disc is splined to the trans-mission's input shaft and receives the driving motion from the flywheel and pressure plate assembly and transmits that motion to the transmission input shaft. It consists of a splined metal hub and a round metal plate covered with friction material (lining) and Splined to the transmission input shaft.

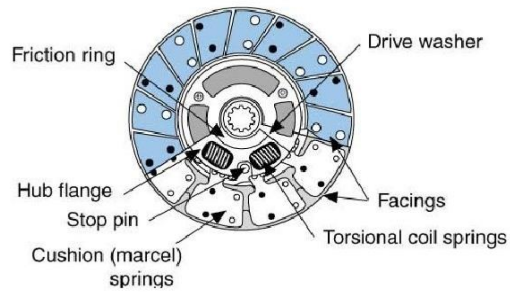


Figure 1-9 Clutch Disc parts

Made of heat-resistant substances especially asbestos and also Grooves cut in the material air cooling. Rivets are commonly used to bond the friction material to both sides of the metal body of the disc.

Clutch Disc Torsion Springs: Help absorb some of the vibration and shock produced by clutch engagement and Small coil springs located between the clutch disc hub and the friction disc.

Clutch Disc Facing Springs: Flat, metal springs located under the disc's friction material and springs have a slight wave (curve). This curve allows the friction material to flex inward slightly during clutch engagement flexing smoothest engagement

- **Pressure Plate Assembly**

The purpose of the pressure plate assembly is twofold. First, it must squeeze the clutch disc onto the flywheel with sufficient force to transmit engine torque efficiently. Second, it must move away from the clutch disc so the clutch disc can stop rotating, even though the flywheel and pressure plate continue to rotate. It is Spring-loaded device and locks or unlocks the clutch disc and the flywheel. The clutch disc fits between the flywheel and pressure plate. Two basic Types

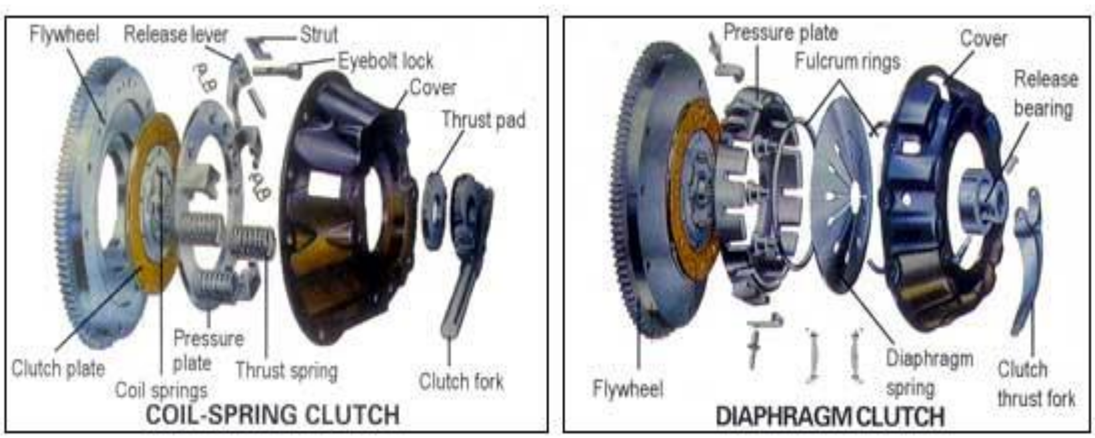


Figure 1-10 Types of Pressure plate

- **Clutch Release Bearing**

The clutch release bearing, also called a throw-out bearing, is usually a sealed, pre lubricated ball bearing. Its function is to smoothly and quietly move the pressure plate release levers or diaphragm spring through the engagement and disengagement process.

The release bearing is mounted on a hub, which slides on a hollow shaft at the front of the transmission housing. This hollow shaft is part of the transmission bearing retainer.

To disengage the clutch, the release bearing is moved on its shaft by the clutch fork. As the release light pressure against the release bearing. As a result, the release bearing is kept in contact with the release levers or diaphragm spring of the rotating pressure plate assembly. The release bearing rotates with the pressure plate.

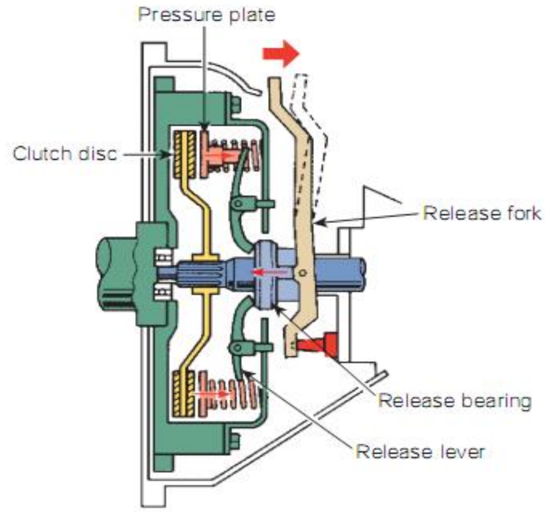


Figure 1-11 Clutch Release Bearing

- **Clutch Fork**

The clutch fork is a forked lever that pivots on a support shaft or ball stud located in an opening in the bell housing. The forked end slides over the hub of the release bearing and the small end protrudes from the bell housing and connects to the clutch linkage and clutch pedal. The clutch fork moves the release bearing and hub back and forth during engagement and disengagement.

1.2.3 Clutch Operation

A.Clutch disengaged

When the clutch is depressed, the clutch fork is applying a force to the throw out (release) bearing, which pushes on the diaphragm spring, releasing the pressure on the friction disc.

The engine can be operated without transferring torque to the transmission/ transaxle.

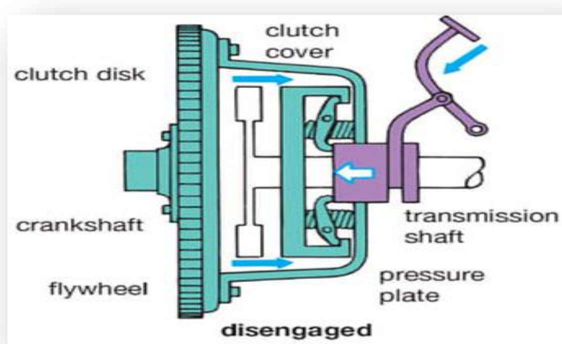


Figure 1-12 Clutch disengaged

B. Clutch engaged

When the clutch is in the engaged position (clutch pedal up), the pressure on the throw out bearing is released and the force against the pressure plate spring(s), the diaphragm spring exerts force on the clutch disc, holding (Clamping) it between the flywheel and the pressure plate.

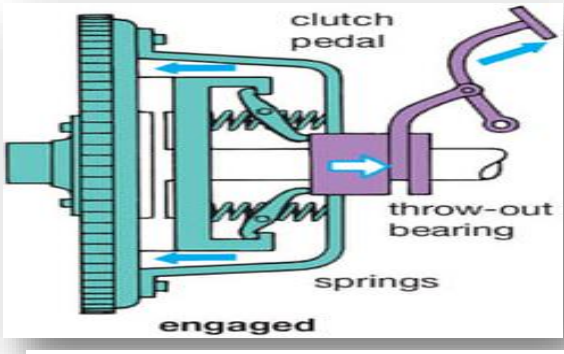


Figure 1-13 Clutch engaged

1.2.4 Clutch Release Mechanisms

A. Mechanical clutch release mechanism

a. Levers and rod

Through a series of levers and rods, the release fork is forced against the throw-out bearing. This method was commonly used on many older vehicles.

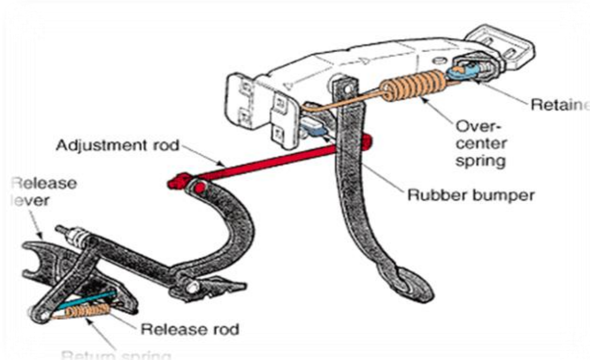


Figure 1-14 Levers and rod

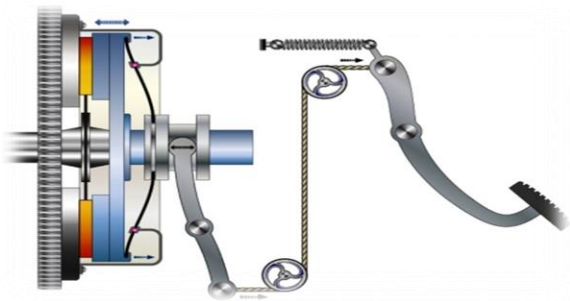


Figure 1-15 Cable Operation

b. Cable Operation

A cable is used similar to a brake cable used on a bicycle.

B. Hydraulic clutch release mechanism

- ✓ This type of clutch has a reservoir containing hydraulic fluid, and when you push down on the clutch pedal, the fluid becomes pressurized.
- ✓ It works along with the clutch plate to disengage the gear you are in, and engage the new gear.

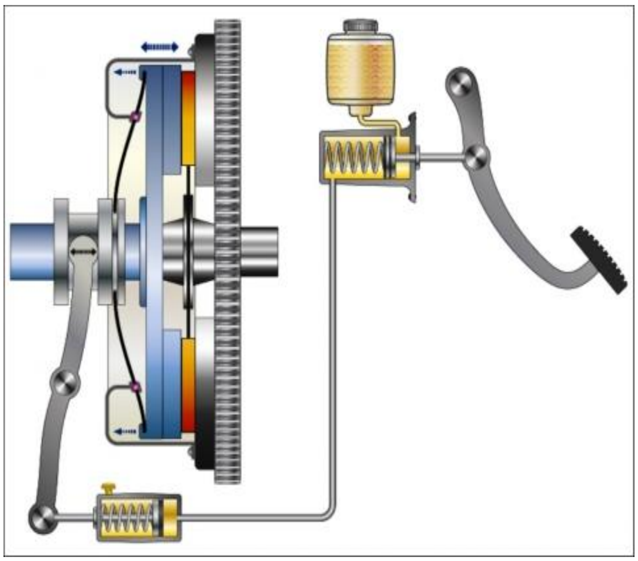


Figure 1-16 Hydraulic clutch release mechanism

- ✓ **Clutch Master Cylinder:** is a device that transforms mechanical force into hydraulic pressure. As the driver presses the clutch pedal, the pedal lever applies force to the clutch master cylinder which transmits hydraulic pressure to the clutch release (sleeve) cylinder that disconnects engine power to the transmission.

Figure 1-17 Clutch Master Cylinder

Clutch Master Cylinder Operation

A. Clutch pedal depressed

The piston is moved to the left via the push rod when the clutch pedal is depressed. The fluid in the cylinder flows through the inlet valve to the reservoir and at the same time to the release cylinder. When the piston moves further to the left, the connecting rod is separated from the spring retainer, and the inlet valve closes the passage into the reservoir by the conical spring, as a result, a buildup of a hydraulic pressure in chamber A occurs which is transmitted to the release cylinder piston.

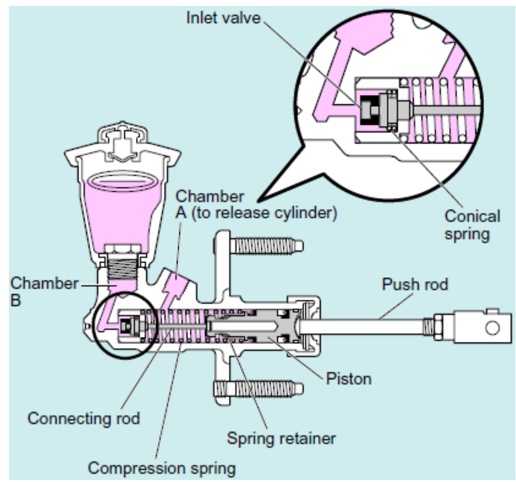


Figure 1-18 Clutch pedal depressed

B. Clutch pedal released

When the clutch pedal is released, the piston is pushed back to the right by the compression spring and hydraulic pressure decreases. As the piston returns completely, the connecting rod is pulled to the right by the spring retainer. The inlet valve thus opens the passage to the reservoir and chamber A and B are connected.

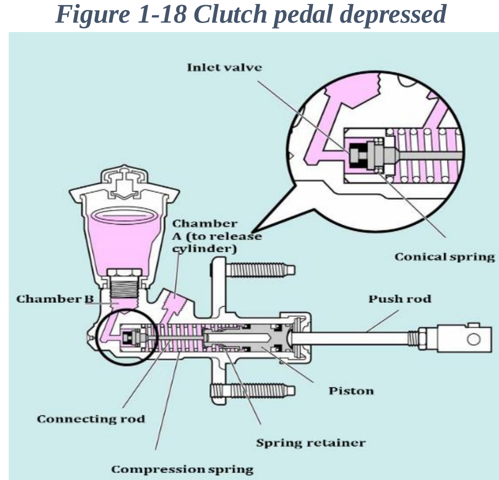


Figure 1-19 Clutch pedal released

C. Sleeve Cylinder

Uses hydraulic pressure to cause clutch fork movement.

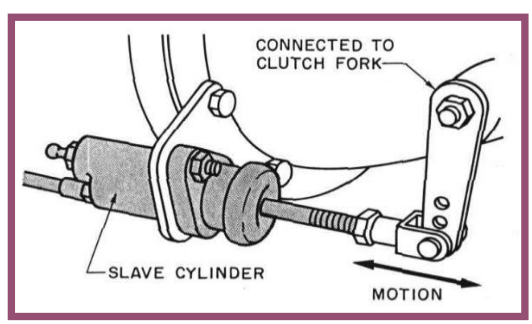


Figure 1-20 Sleeve Cylinder

1.3 Basic concepts of gear train

Gears are machine elements that transmit motion by means of successively engaging teeth. The gear teeth act like small levers.

1.3.1 Types of gears in powertrain system

1. **Spur Gear** consisting of a gear blank with straight-cut teeth around its entire circumference. All gear teeth lie parallel to the centers s line, or axis, of the gear.

   The teeth are shaped so they can mesh without slippage with a second spur gear's teeth positioned along a parallel axis.

Figure 1-21 Spur Gear

2. **Helical Gear** although similar to a spur gear, has its teeth cut at an angle to the axis of the gear. This enables more teeth to mesh at a time than the spur gear.

The angle allows the teeth to mesh. Gradually, rather than all at once. As a result, helical gears run quieter than spur gears.

Figure 1-22 Helical Gear

Spur and helical gears have teeth on their outside circumference and, for this reason, are called external gears. This type of gear is the most commonly used in manual transmissions and transaxles. Gears having teeth along the inside circumference are called internal ring gears. An internal ring gear may mesh with a smaller external gear designed to rotate as it travels around the inside of the internal ring gear. This type of external gear is called a pinion gear because of its smaller diameter. When an external gear meshes with an internal ring gear, both gears rotate in the same direction. When an external gear meshes with another external gear, the gears rotate in opposite directions.

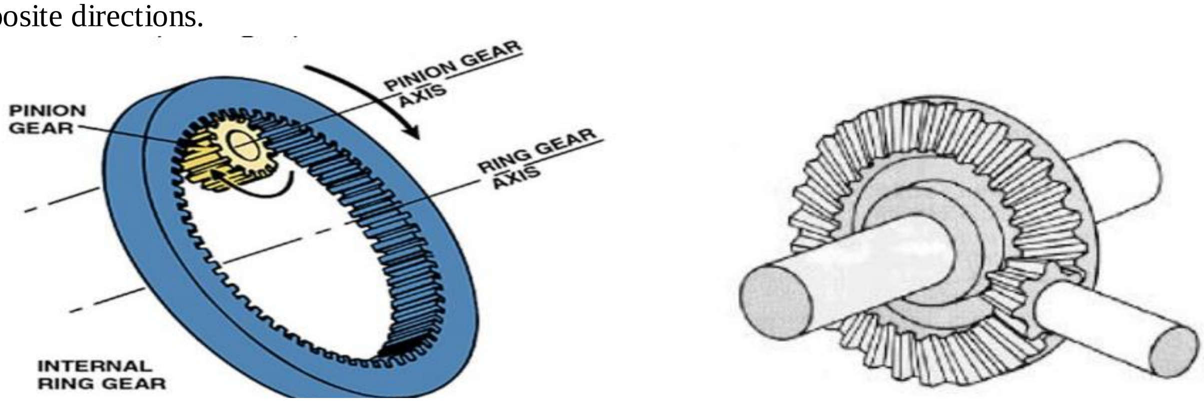


Figure 1-23 Internal and external teeth

1.3.2 Gear Ratios

Gear ratio – is the speed that the two gears turn in relation to each other. It is expressed as the number of rotations the drive gear must make in order to rotate the driven gear through one revolution. To obtain a gear ratio, divide the number of teeth on the driven gear by the number of teeth on the drive gear. Gear ratios, fall into three categories:

1. **Direct Drive** - If two meshed gears are the same size and have the same number of teeth, they will turn at the same speed. Since the drive gear turns once for each revolution of the driven gear, the gear ratio is 1:1; this is called a direct drive. When a transmission is in direct drive, the engine and transmission turn at the same speed.

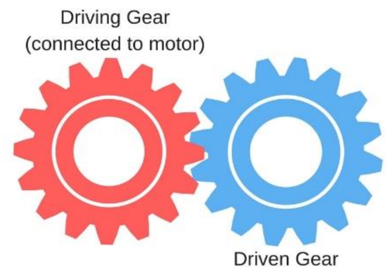


Figure 1-24 Direct Drive

2. **Gear Reduction** - If one gear drives a second gear that has three times the number of teeth, the smaller drive gear must travel three complete revolutions in order to drive the larger gear through one rotation. Divide the number of teeth on the driven gear by the number of teeth on the drive gear and you get a 3:1 gear ratio (pronounced three to one).

This type of gear arrangement, where driven gear speed is slower than drive gear speed, provides gear reduction. Gear reduction may also be called under drive as drive speed is less than, or under, driven speed and is used for the lower gears in a transmission. When the rotation and torque of the input shaft is transmitted to the output shaft, the speed of the rotation decreases and the torque increases according to the reduction ratio of the gears.

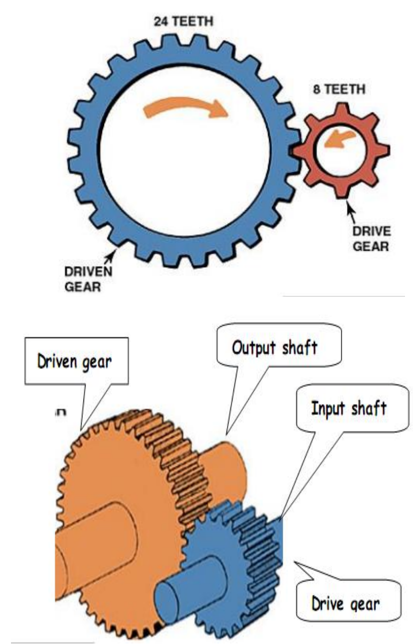


Figure 1-25 Gear Reduction

3. **Overdrive** - The opposite of a gear reduction is called Overdrive and occurs when a driven gear turns faster than its drive gear.
   For the gears shown here, the driven gear turns three times for each turn of the drive gear. The gear ratio is 0.33:1.

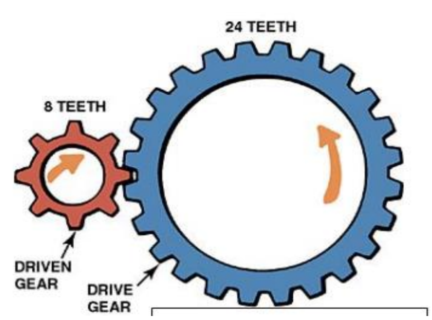


Figure 1-26 Overdrive

4. **Idler Gears** - A gear that operates between the drive and driven gears is called a floating, or idler gear. The do not affect the speed relationship between the drive and driven gears; they do affect the direction of rotation. When an idler gear is installed between the drive and driven gears both gears rotate in the same direction.

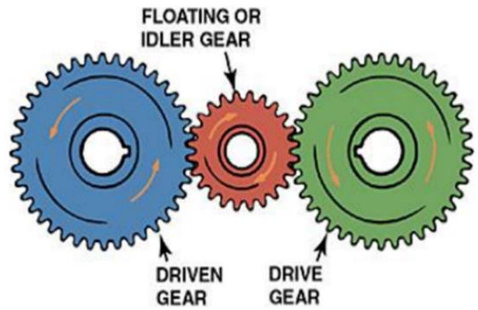


Figure 1-27 Idler gear operation

1.4 Automotive transmission

The torque which is generated by the engine remain nearly constant, while the output (horsepower) increase in near proportion to engine rpm. However, automobiles will require enough power to start off or climb a hill. Likewise, it also needs strong velocity to meet during high-speed travels. Thus, an automotive transmission is installed to every vehicle to meet its demand.

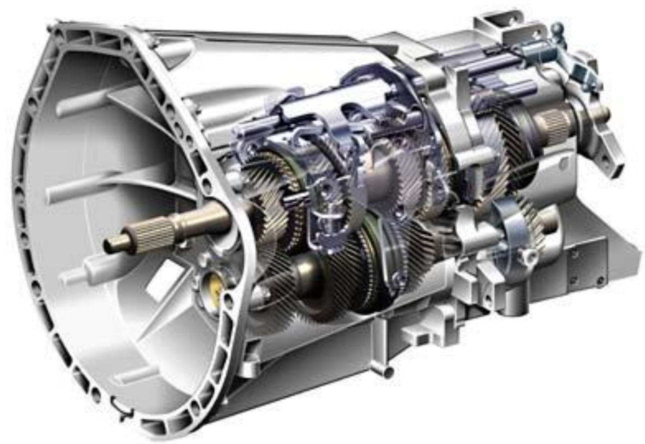


Figure 1-28 Automotive Transmission

According to Crouse and Anglin, automotive transmission is an assembly of gears, shafts, and other parts that transfer selected amounts of engine power to a vehicle's wheels. It enables the vehicle to accelerate forward or backward or to maintain high cruising speeds - all while the engine operates at efficient speeds and within its safety limits.

1.4.1 Types of Transmission

1. **Manual Transmission**: The simplest and oldest type of transmission still in use is the trusty manual. This gearbox uses a friction clutch modulated by the driver's foot to connect the engine's rotational energy to the transmission's input shaft. From there, a fixed set of gears are engaged using a syncro and gear-selector fork connected to the shifter operated by the driver's right hand (or left, in certain countries).

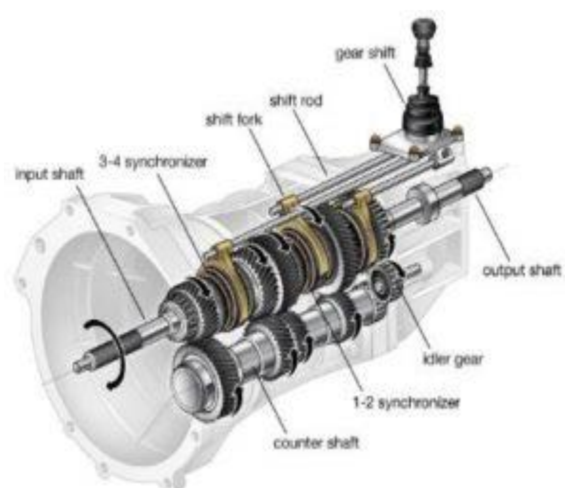


Figure 1-29 Manual Transmission:

2. Automatic Transmission: The ubiquitous automatic is by far the most common transmission on the road today. It uses a highly-complex torque converter to transmit the engine's rotational energy, while gear shifts are controlled by the vehicle's computer and accomplished with a planetary gear set and a series of clutches and brakes. Though the behind-the-scenes action is quite complicated, all the driver has to do is select from the familiar P-R-N-D-L choices on the gear selector. The advantage is, of course, a simplified driving experience and a gentle learning curve. The trade-off for the driving simplicity is mechanical complexity, which makes the automatic more prone to failure and pricier to fix.

Figure 1-30 Automatic Transmission

3. Continuously Variable Transmission

The CVT offers a similar driving experience to an automatic, but operates using a completely different mechanism. In fact, the CVT doesn't have gears at all — instead, it uses a system of belts and pulleys to produce an infinite range of ratios. The car's computer decides how to adjust the pulleys to create the optimal ratio for the particular driving situation. This creates the CVT's primary advantage: fuel economy. No other transmission type can offer more MPGs than a CVT (yet).

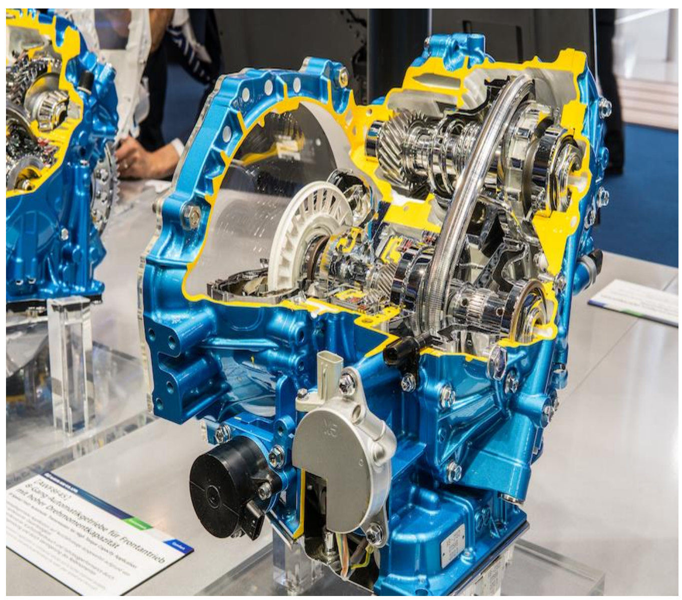


Figure 1-31 Continuously Variable Transmission

Since they're not as complicated as automatics, CVTs are less prone to failure and costly repairs (though not as much so as manuals). Their biggest drawback may be a subjective one the driving experience. Since there are no gearshifts, just smooth and seamless acceleration, CVTs may leave a true driving enthusiast feeling like he or she is operating an appliance instead of driving a car.

Figure 1-32 Continuously Variable Transmission

4. **Semi-Automatic and Dual-Clutch Transmission**

Think of it as a hybrid between a fully automatic and manual transmission. A semi-automatic uses a similar mechanical layout to a conventional transmission, but uses a system of pneumatics and actuators to change gears. In a Dual-Clutch Transmission (DCT), there are separate clutches for both odd and even gears, which allows for incredibly fast shifts. These gearboxes can generally be operated in a fully automatic mode, or manually shifted via paddles on the steering wheel.

Figure 1-33 Semi-Automatic and Dual-Clutch Transmission

Semi-Auto and DCT transmissions offer cutting-edge performance with lightning fast gear changes that a pure manual just can't match. Currently, these gearboxes are mainly found on race and high-end sports cars, and are, therefore, quite expensive. This disadvantage is magnified by their extreme complexity, which leads to more frequent and costly repairs.

1.4.2 Major components of a manual transmission

Before understanding the operation and power flow through a transmission, you first must understand the construction of the transmission. This is necessary for you to be able to diagnose and repair damaged transmissions properly.

1. **Transmission Case (20**) the transmission case provides support for the bearings and shafts, as well as an enclosure for lubricating oil. A manual transmission case is cast from either iron or aluminium. A drain plug and fill plug are provided for servicing. The drain plug is located on the bottom of the case, whereas the fill plug is located on the side.
2. **Extension Housing (21)** Also known as the tail shaft, the extension housing bolts to the rear of the transmission case. It encloses and holds the transmission output shaft and rear oil seal. On the bottom of the extension housing is a flange that provides a base for the transmission mount.
3. **Transmission Shafts:** commonly a manual transmission has four steel shafts mounted inside the transmission case. These shafts are the input shaft, the countershaft, the reverse idler shaft, and the main shaft.

   a) **Input shaft. (1)** - The input shaft, also known as the clutch shaft, transfers rotation from the clutch disc to the countershaft gears. The outer end of the shaft is splined to the hub of the clutch disc. The inner end has a machined gear that meshes with the countershaft. A bearing in the transmission case supports the input shaft in the case. Anytime the clutch disc turns, the input shaft gear and gears on the countershaft turn.

b) **Countershaft. (12)**- The countershaft, also known as the cluster gear shaft, holds the countershaft gear into mesh with the input shaft gear and other gears in the transmission. It is located slightly below the clutch shaft.

c) **Reverse idler shaft. (**14)**-** The reverse idler shaft is a short shaft that supports the reverse idle gear. It mounts stationary in the transmission case about halfway between the countershaft and output shaft, allowing the reverse idle gear to mesh with both shafts.

d) **Main shaft. (5)-** The main shaft, also called the output shaft, holds the output gears and synchronizers. The rear of the shaft extends to the rear of the extension housing where it connects to the drive shaft to turn the wheel of the vehicle. Gears on the shaft are free to rotate, but the synchronizers are locked on the shaft by splines. The synchronizers will only turn when the shaft itself turns.

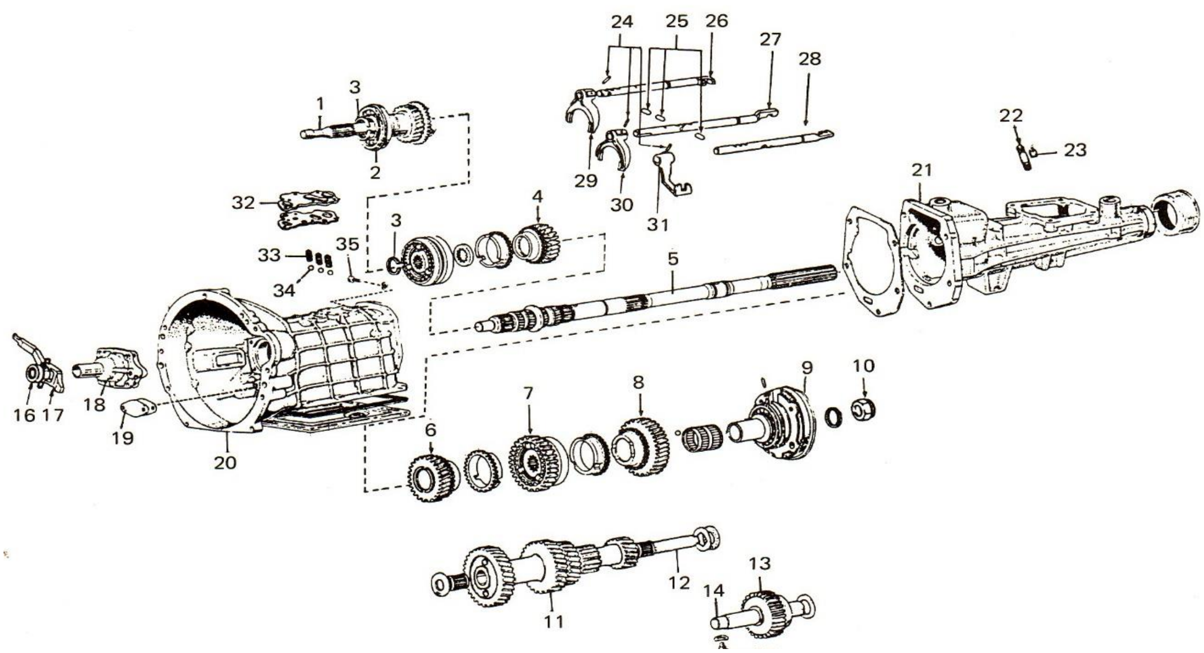


Figure 1-34 Exploded view manual transmission

4. **Transmission Gears**

Transmission gears can be classified into four groups- input gear, countershaft gears(11), main shaft gears(4,6,7,8), and the reverse idler gear(13). The input gear turns the countershaft gears, the countershaft gears turns the main shaft gears, and, when engaged, and the reverse idler gear. In low gear, a small gear on the countershaft drives a larger gear on the main shaft, providing for a high gear ratio for accelerating. Then, in high gear, a larger countershaft gear turns a small main shaft gear or a gear of equal size, resulting in a low gear ratio, allowing the vehicle to move faster. When reverse is engaged, power flows from the countershaft gear, to the reverse idler gear, and to the engaged main shaft gear. This action reverses main shaft rotation.

5. Shift Linkage and Levers

They are the ***external rod*** and the ***internal shift rail***. They both perform the same function. They connect the shift lever with the shift fork mechanism. The transmission shift lever assembly can be moved to cause movement of the shift linkage, shift forks, and synchronizers.

Types: The shift lever may be either floor mounted or column mounted, depending upon the manufacturer. ***Floor-mounted shift levers*** are generally used with an internal shift rail linkage, whereas ***Column-mounted shift*** levers are generally used with an external rod linkage.

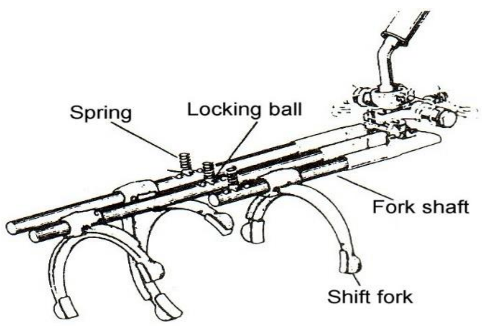


Figure 1-35 Floor-mounted shift levers

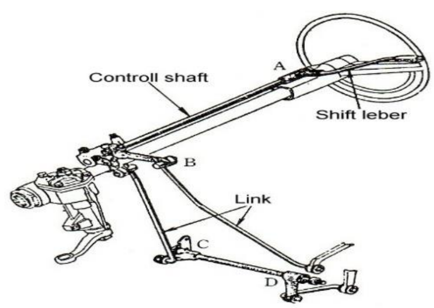


Figure 1-36 Column-mounted shift

1.4.3 Necessity of Shifting Gears

The diagram shows driving performance curves, which indicate the relationship between the driving force and the vehicle speed for the 1st through 6th gears.

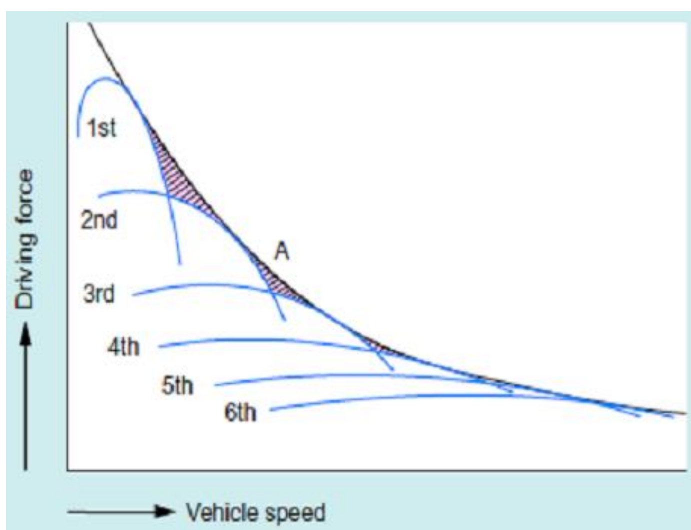


Figure 1-37 Graph of driving force and vehicle speed

1. Starting off - When the vehicle starts off, a large amount of power is required, so the 1st gear, which has the largest driving force, is used.

2. Driving - After starting off, the 2nd and 3rd gears are used to increase the Vehicle speed. These gears are used because there is an upper limit to the vehicle Speed in 1st gear and that not as much driving force is required.

3. High-speed driving - For high-speed driving, the 4th, 5th, and 6th gears are used to further increase the vehicle speeds.

4. **Backing up** - When the reverse gear is used, the reverse idler gear is added, the Reverse gear turns in reverse, and the vehicle backs up.

1.4.4 Power flow of Transmission

The engine torque is applied to the input shaft when the clutch is engaged. This torque is applied to the main gear, which is in constant mesh with the countershaft gear. The engine torque is multiplied by the ratio difference between the main gear and the cluster gear, then transferred and multiplied again when first gear is in mesh with the corresponding first gear on the main (output) shaft. The engine torque then is applied to the drive wheels.

Speed Gears- All gears on the countershaft are permanently attached to the shaft. The input shaft gear is also part of the input shaft. The gears on the main shaft are free to move on the shaft and are connected to the main shaft through the synchronizer hub when a shift is made. All speed gears use bearings that allow the speed gears to move independently of the main shaft.

The concept of torque flow, or torque transfer, is the same for any transmission, regardless of the number of gear ratios available. The differences are in how the parts assemble and where they are located in the transmission.

Five-Speed Transmission- A five-speed transmission has six gear sets that provide five forward speeds and one reverse speed. Either a sliding gear or constant-mesh gears may be used for reverse. All forward gears are the constant-mesh type. It provides three gear reduction ratios (first, second, and third), direct drive (fourth), and an overdriven ratio (fifth). A sliding idler gear is used to change output shaft direction and provide reverse.

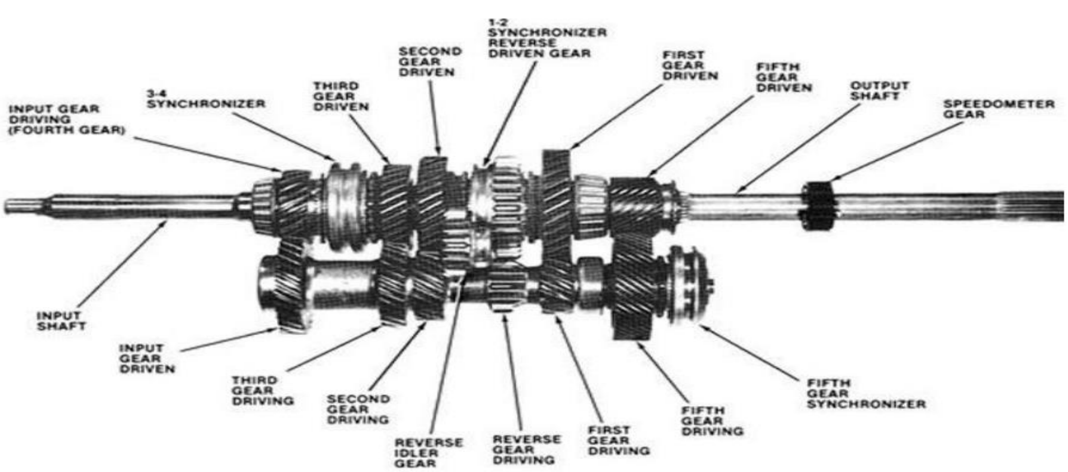


Figure 1-38 Five speed transmission

5. **First Gear-** The shift linkage slides the 1–2 synchronizer sleeve rearward toward the first speed gear. The synchronizer assembly locks the speed gear to the output shaft. With the clutch engaged, the input shaft drives the countershaft, delivering engine torque to the gearbox. Torque transfers from the first counter gear to the first speed gear, which drives the output shaft through the 1–2 synchronizer hub splines. Torque flows through the transmission in gear reduction at the first gear ratio

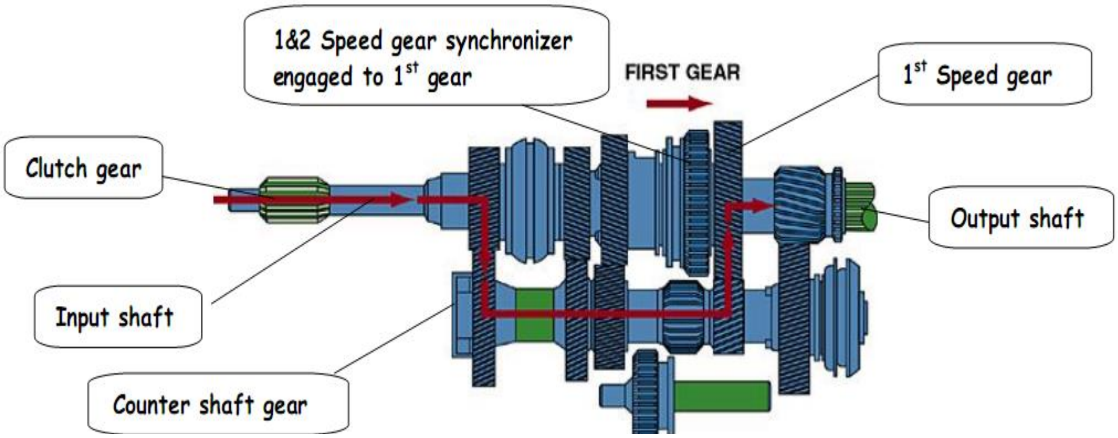


Figure 1-39 First Gear power flow

6. **Second Gear-** The shift linkage slides the 1–2 synchronizer sleeve forward, away from the first speed gear and toward the second speed gear. The synchronizer assembly releases first gear, then locks the second speed gear to the output shaft. With the clutch engaged, the input shaft is driven at crankshaft speed and turns the countershaft. Engine torque transfers from the second counter gear to the second speed gear, which drives the output shaft through the 1–2 synchronizer hub splines. Torque flows through the transmission in gear reduction at the second gear ratio.

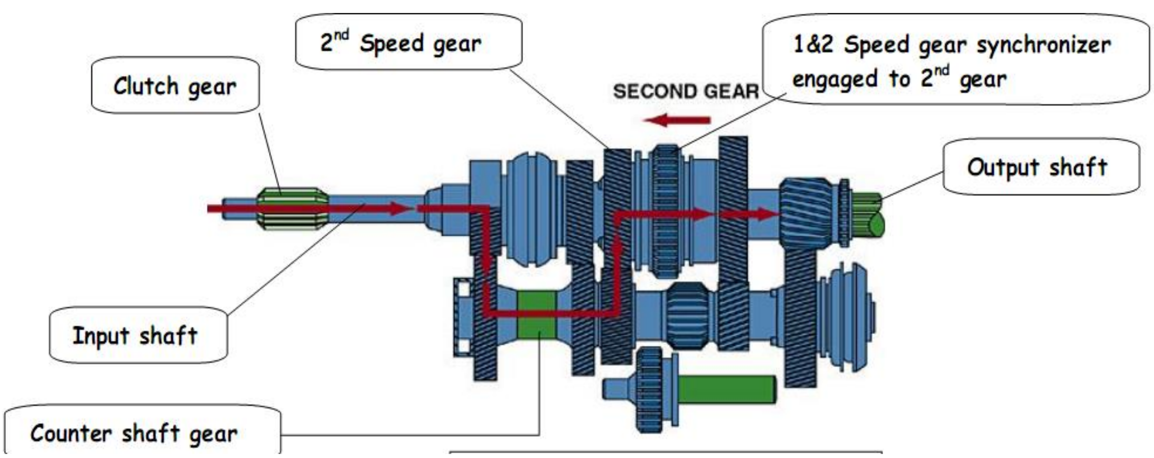


Figure 1-40 Second Gear power flow

7. **Third Gear-** The shift linkage centres the 1–2 synchronizer sleeve and moves the 3–4 synchronizer sleeve back toward the third speed gear. The synchronizer assembly locks the third speed gear to the output shaft. With the clutch engaged and the input shaft driving the countershaft, the third counter gear transfers torque to the third speed gear. The speed gear drives the output shaft through the 3–4 synchronizer hub splines. Torque flows through the transmission in gear reduction at the third gear ratio.

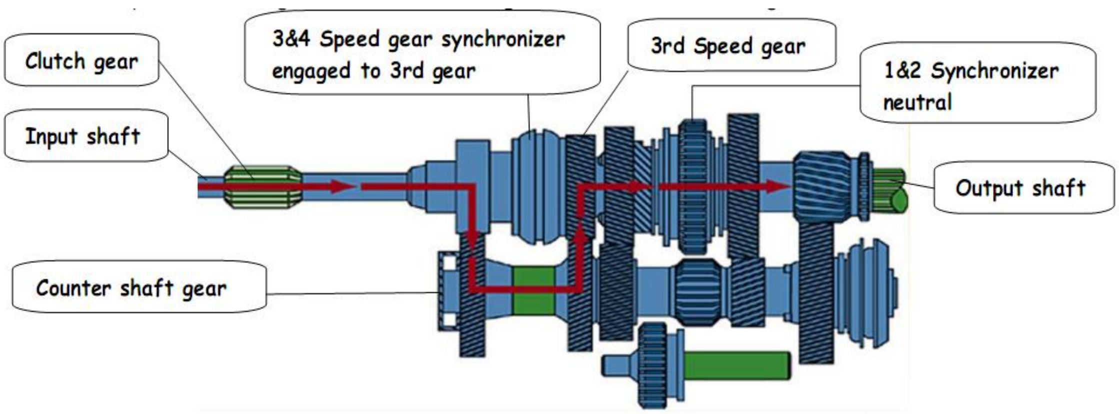


Figure 1-41 Third Gear power flow

8. **Fourth Gear-** The shift linkage moves the 3–4 synchronizer sleeve forward, away from the third speed gear and toward the input shaft drive gear. The synchronizer assembly locks the input shaft drive gear to the output shaft. With the clutch engaged, the input shaft drives the output shaft through the 3–4 synchronizer hub splines and both shafts rotate at crankshaft speed. Torque flows straight through the transmission at a 1:1 ratio, delivering engine torque to the drive shaft. This is called direct drive because there is no gear reduction through the transmission. The counter gears also turn because they are in constant mesh, but they do not affect torque flow because all of the speed gears are freewheeling on the output shaft.

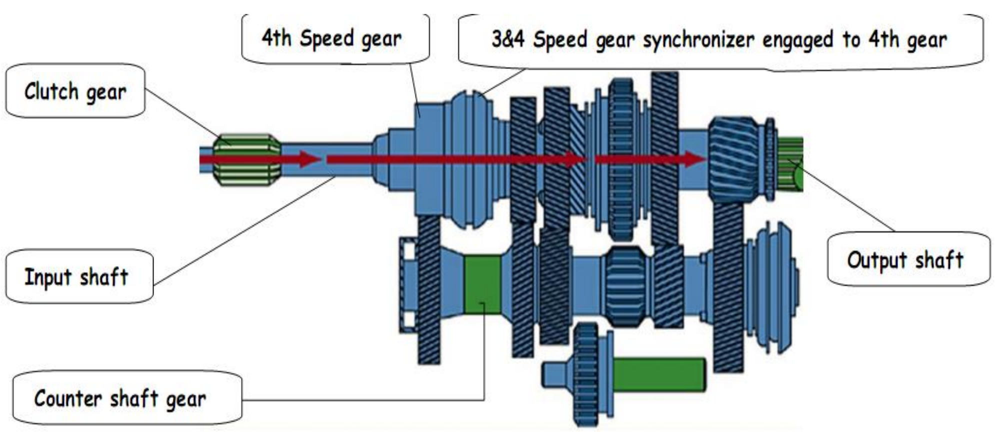


Figure 1-42 Fourth Gear power flow

9. Fifth Gear

The shift linkage centres the 3–4 synchronizer sleeve and moves the fifth synchronizer sleeve toward the fifth speed gear. On the T5 transmission the synchronizer assembly locks the fifth speed gear to the countershaft. The speed gear drives a fixed gear on the output shaft.to the countershaft, so it is driven and driving the speed gear when fifth gear is engaged. This transfers torque to the output shaft through the fixed fifth gear. Note the countershaft gear is larger than the output shaft gear. Therefore, fifth gear is overdriven. Torque flows through the transmission at the fifth gear, or overdrive, ratio. Typical overdrive gear ratios are between 0.6:1 and 0.8:1.

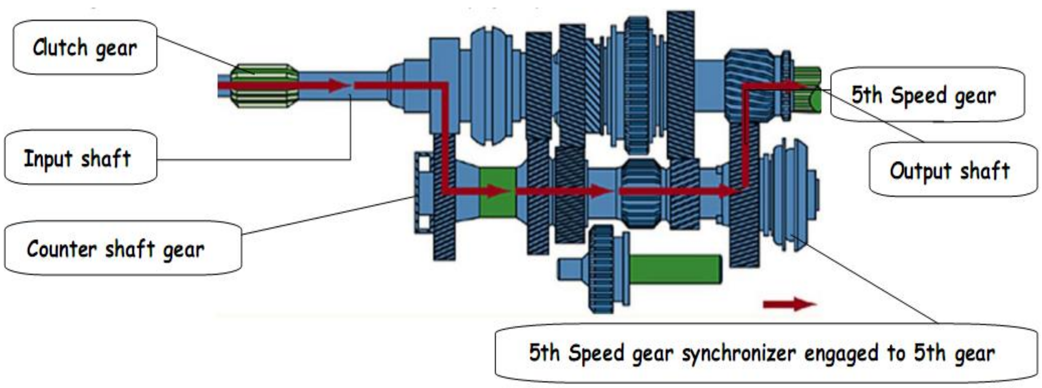


Figure 1-43 fifth speed power flow

Reverse- Two common reverse gear designs:

1. Sliding gear
2. Constant-mesh gear.

With a sliding reverse gear design, such as on the T5, the shift linkage slides the reverse idler gear on its shaft until it engages the reverse gears on the countershaft and output shaft gear. Both gears are fixed to their respective shafts. This design uses spur gears for reverse, not helical gears, because the gear teeth must move into and out of mesh. On some gearboxes, the sliding gear splines to the output shaft.

The linkage moves the gear along the output shaft splines to engage the reverse idler gear. Spur teeth machined around the outside of the 1–2 synchronizer sleeve act as the reverse output gear. When the T5 is shifted into reverse, the linkage moves the reverse idler gear rearward so it simultaneously meshes with the countershaft reverse gear and the gear on the synchronizer sleeve.

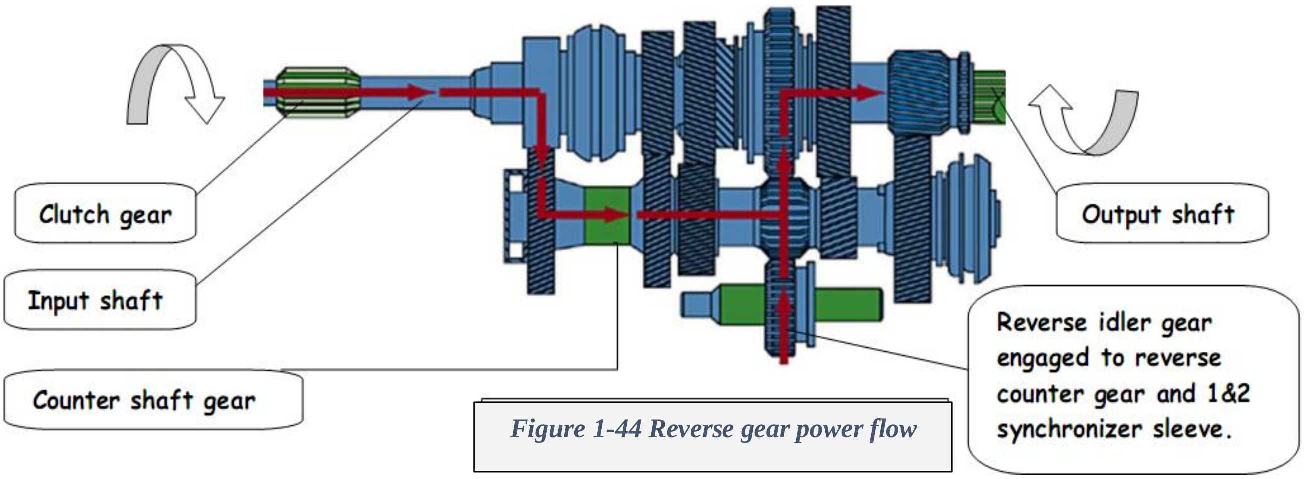


Figure 1-44 Reverse gear power flow

1.5 Automotive Transaxle

The shift dog can now distort the synch ring back to its centered position and can pass. The shift dog enters the lock gear section of the gear - the gear is now shifted. At this time the inserts are pressed inward by overcoming the locking spring force, therefore they leave their centered position below the shift dog and sit below the "shoulder" of the shift dog.

Transaxles use many of the design and operating principles found in transmissions. But because the transaxle also contains the differential gearing and drive axle connections, there are major differences in some areas of operation.

A transaxle typically has two separate shafts—an input shaft and an output shaft. The input shaft is the driving shaft. It is normally located above and parallel to the output shaft. Because the input shaft in most transversely mounted transaxles are supported by bearings in the housing, these units do not need a pilot bearing or bushing to support the portion of the input shaft that extends into the clutch assembly. This type of shaft is called a self-centering shaft.

The out-put shaft is the driven shaft. The transaxle's main (speed) gears freewheel around the output shaft unless they are locked to the shaft by their synchronizer assembly. The main speed gears are in constant mesh with the input shaft drive gears. The drive gears turn whenever the input shaft turns. The names used to describe transaxle shafts vary between manufacturers. The service manuals of some vehicles refer to the input shaft as the main shaft and the output as the driven pinion or drive shaft. Others call the input shaft and its gears the input gear cluster and refer to the output shaft as the main shaft.

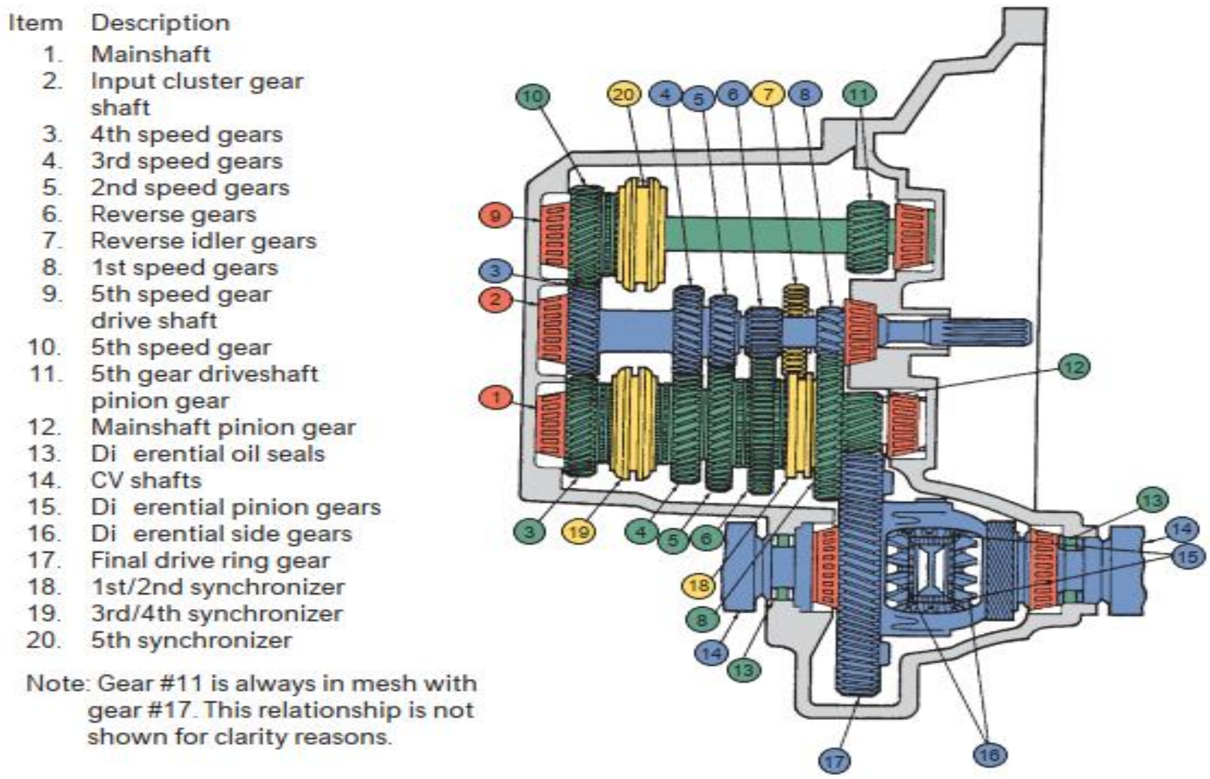


Figure 1-45 Exploded view of Transaxle

1.5.1 Transaxle Power Flows

When studying the power flow patterns in the following section, keep in mind that the views are based on you standing by the right front fender and looking into the engine compartment.

This will give an accurate idea of the true rotational direction of the gears and shaft. The transaxles used in these examples are five-speed, two-shaft units.

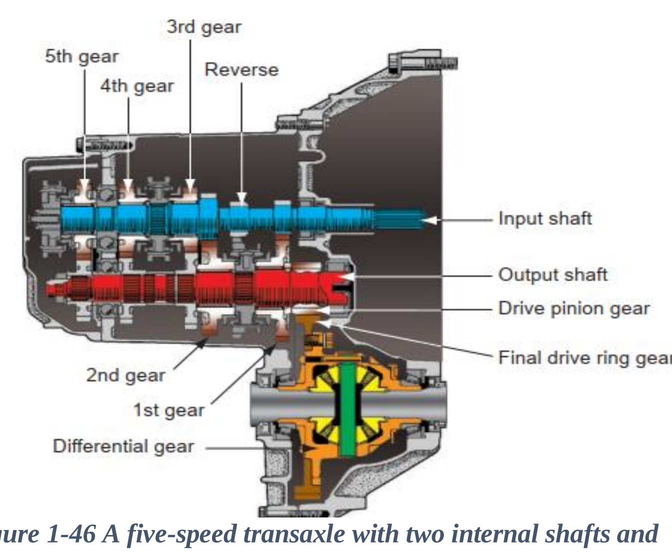


Figure 1-46 A five-speed transaxle with two internal shafts and final

Neutral

When a transaxle is in its “neutral” position, no power is applied to the differential. Because the synchronizer collars are centers s ed between their gear positions, the meshed drive gears are not locked to the output shaft. Therefore, the gears spin freely on the shaft and the output shaft does not rotate.

Forward Gears

When first gear is selected, the first/second gear synchronizer engages with first gear. Because the synchronizer hub is splined to the output shaft, first gear on the input shaft drives its mating gear (first gear) on the output shaft. This causes the output shaft to rotate at the ratio of first gear and to drive the differential ring gear at that same ratio.

As the other forward gears are selected, the appropriate shift fork moves to engage the selected synchronizer with the gear. Because the synchronizer's hub is splined to the output shaft, the desired gear on the input shaft drives its mating gear on the output shaft. This causes the output shaft to rotate at the ratio of the selected gear and drive the differential ring gear at that same ratio.

Reverse

When reverse gear is selected on transaxles that use a sliding reverse gear, the shifting fork forces the gear into mesh with the input and output shafts. The addition of this third gear reverses the normal rotation of first gear and allows the car to change direction.

1.5.2 Differential Action in Transaxle

The final drive ring gear is driven by the transaxle's output shaft. The ring gear then transfers the power to the differential case. The case holds the ring gear with its mating pinion gear. The differential side gears are connected to the drive axles.

One major difference between the differential in a RWD car and the differential in a transaxle is direction of power flow. In a RWD differential, the power flow changes 90 degrees between the drive pinion gear and the ring gear.

This change in direction is not needed with most FWD cars. The transverse engine position places the crankshaft so that it already is rotating in the correct direction. There-fore, the purpose of the differential is only to provide torque multiplication and divide the torque between the drive axle shafts so that they can rotate at different speeds.

Some transaxles need the 90-degree power flow change in the differential. These units are used in rear-engine with RWD applications in longitudinally positioned engines with FWD or some AWD vehicles.

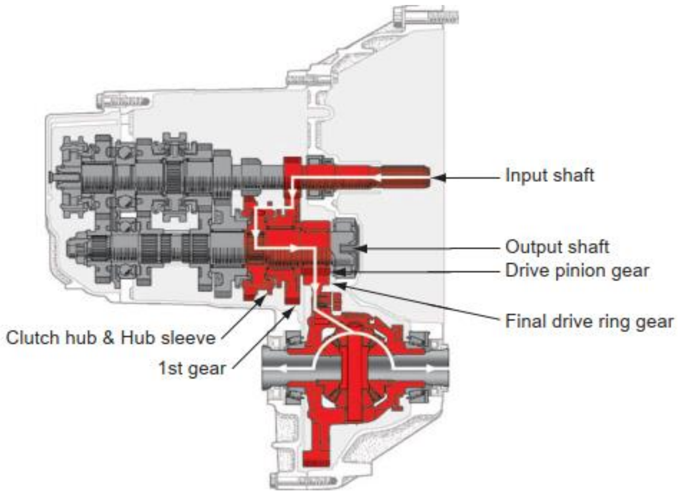


Figure 1-50 Power flow in first gear

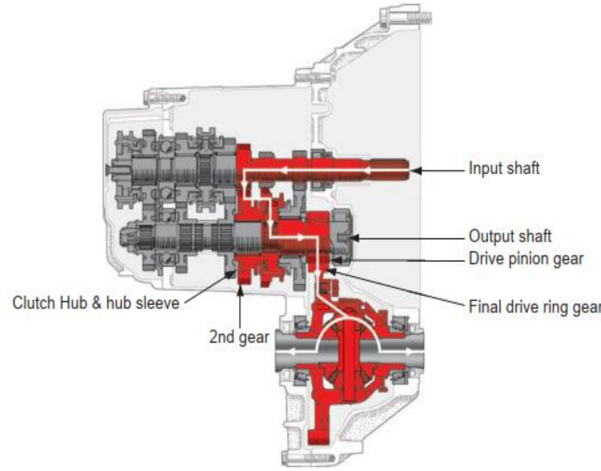


Figure 1-49 Power flow in second gear

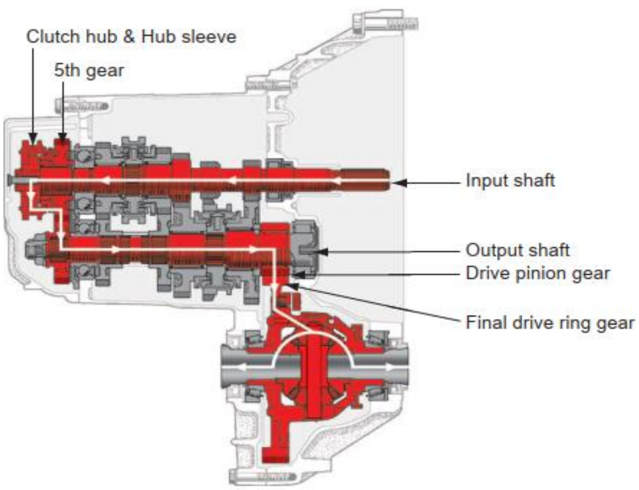


Figure 1-48 Power flow in third gear

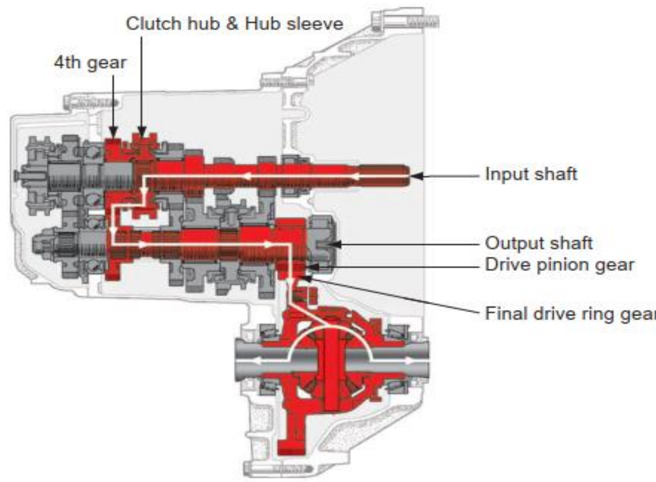


Figure 1-47 Power flow in fourth gear

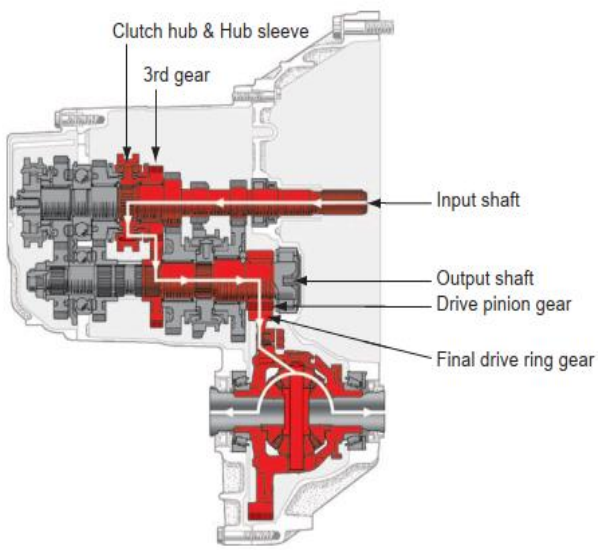


Figure 1-52 Power flow in fifth gear

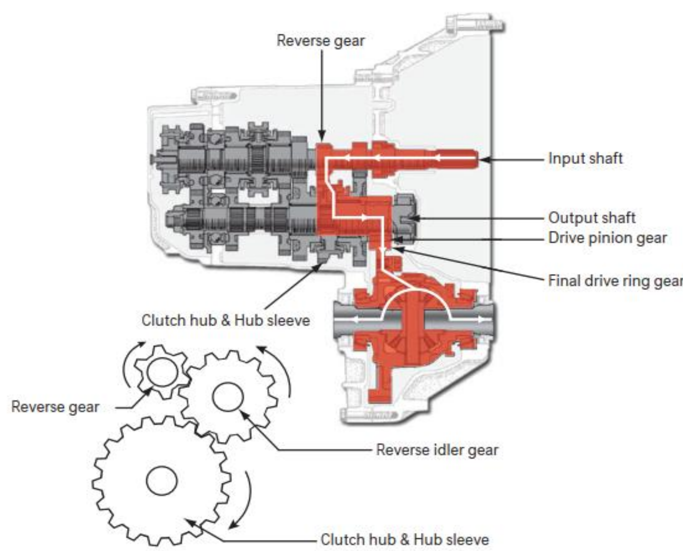


Figure 1-51 Power flow in Reverse gear

1.6 Synchromesh Mechanisms

The synchromesh mechanism is used to prevent "gear noise" and to make gear shifting smoother. This mechanism is called "synchromesh" because two gears which rotational speed is different are synchronized by friction force during gear shifting. Synchronizers are used in manual transmissions/transaxles to make shifting easier.

To synchronize means to make two or more events occur at the same time. To achieve a clash-free (no grinding sound) shift, the shift speed must match the speed of the rotating gears. The detents and interlocks hold the shift mechanism in position. The real ―shifting‖ in a synchromesh transmission takes place in the synchronizer assemblies, not the gears. Most synchronizer assemblies ride on the output shaft between two gears. Synchronizing Mechanism Duty:

1. Equalization of rotating speeds of two different gears, which shall be shifted.

2. Enable fast and silent shifting of gear- both is only possible if the two gears are at more or less the same speed

A. Different kinds of synchromesh unit

1. Synchromesh with internal synchronization (Borg Warner)

The gear-shift sleeve has at its internal side the shift dogs which slide at the synchromesh body (hub). Three inserts fit into the gaps at the hub. By the insert springs they are pressed outward against the shift dogs and keep the shift sleeve in central position.

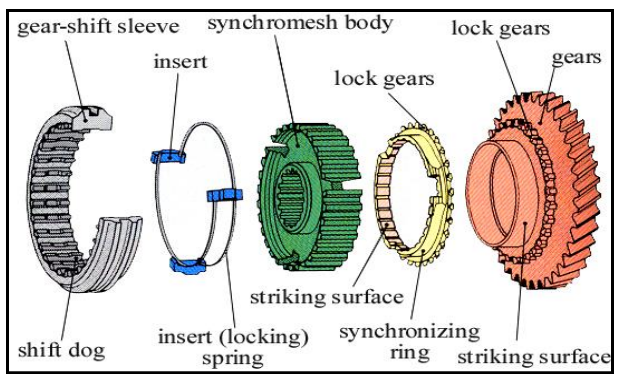
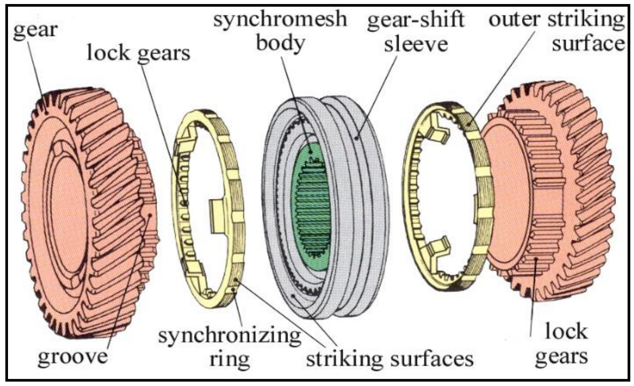


Figure 1-53 Synchromesh with internal

The hub is firmly fixed against rotation so that it cannot rotate on the shaft. The synchronizing ring has a striking (friction) surface at its inner diameter and locking gears at its circumference.

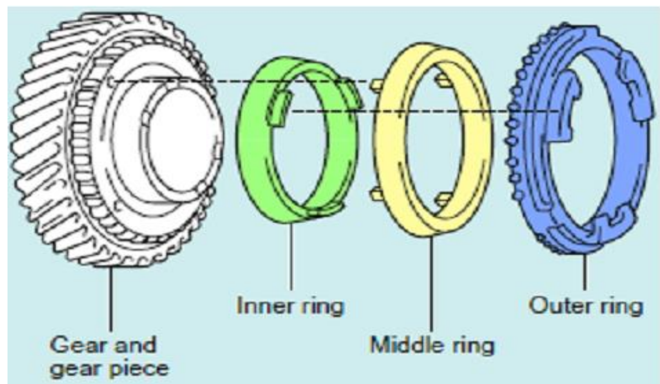
Three gaps limit the turn (rotation) of the ring in reference to the inserts (and therefore to the hub).The gear has at its synchronizing side a conical striking surface and after this it has its lock gears on which the shift dogs have to slide on in order to get a firm connection ready to transmit forces.

2. Synchromesh with external synchronization



The rings have their conical shape with the striking surface at their outer side whereas the lock gears are at the inner side. The corresponding striking surface is not at the gear but at the inner side of the gear shift sleeve. Three stops at the ring sit in the gap of the gear and limit the turn of the ring in reference to the gear.

3. Triple-/Double-cone type synchromesh mechanism



To increase the synchromesh capacity, recent models have adopted a triple- cone or double-cone synchromesh mechanism particularly for the 2nd and 3rd gears. The triple-cone synchromesh mechanism divides the synchronizer ring into an outer ring, middle ring, and inner ring.

When the shifting key pushes the outer ring, the outer ring and the middle ring form a single cone, then the middle ring and the inner ring become a single cone.

Furthermore, the inner ring and the gear piece become a single cone portion, so friction is generated by all three cone portions. Therefore, the capacity to absorb rotational speed differences between gears is large and the synchronizing process is completed smoothly).

B. Operation :(type Borg-Warner)

1. Neutral Position:

The inserts keep the gear-shift sleeve in its normal position in the middle of the synchromesh body (hub). No sliding force is applied. No connection between the shaft and the gear. Hub and gear can run on different speeds. Synchronizing ring runs with equal speed as hub and sleeve (and inserts with their springs). Insert is in released position in the gap on the ring.

2. Locked Position

By the force of the sifting fork (= drivers force) the sleeve moves towards the gear. Due to this, the inserts are pressed against the synchronizer ring, which again is pressed against the conical striking surface of the gear - friction occurs. The inserts are kept in their position below the center of the sleeve by the locking springs and due to their shape.

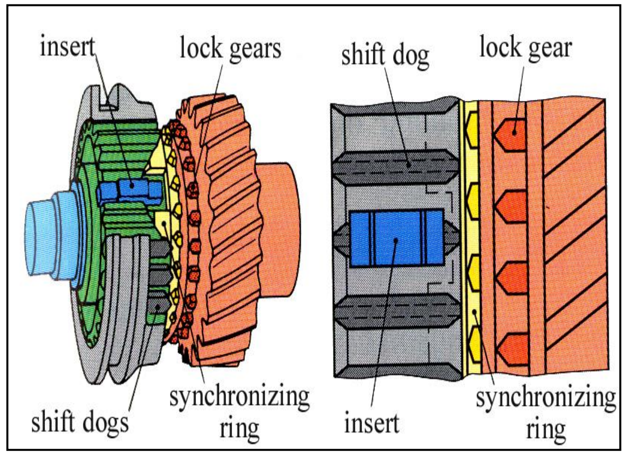


Figure 1-54 Locked Position

3. Gear Shifted

The friction torque results that the synch ring moves (distorts) towards the end of its gap till the inserts stop it. In this position it is kept (forced) as long as both gear and hub rotate with different speeds. It is not possible to move the sleeve further towards the gear since the lock gears of the synch ring and the shift dogs do not correspond - the lock gears of the synch ring block the shift dog. The friction force is higher than the sliding force applied by the driver.

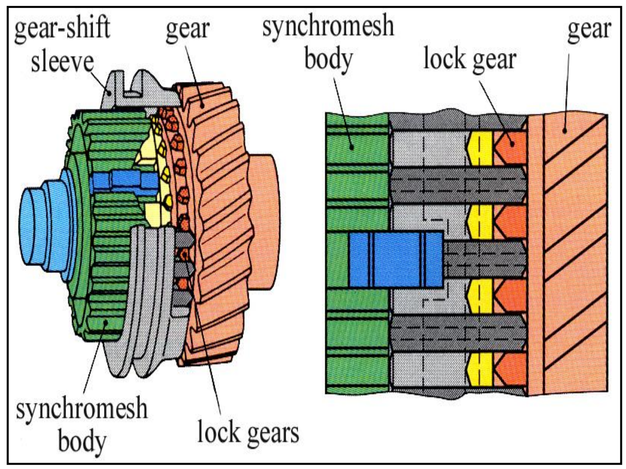


Figure 1-55 Gear Shifted

1.7 Transfer Case

As soon as gear and hub have the same speed (speed adaptation), no more sliding friction occurs between hub, synch ring and gear. The synch ring gets released due to the fact that the force that keeps it in locked position is decreased and is so overcome by the force of the driver. If at a car more than one axle shall be driven, a transfer case is required to be installed after the transmission in order to distribute the torque to front and rear axle(s).

It is differentiated between full-time 4WD and part-time 4WD. In part-time 4WD the rear axle is permanently driven whereas the front axle will be driven only when selected by the driver. The transfer case first of all is used to enable the shifting to a lower speed (and higher torque!) than the first gear of the transmission can provide. In cars equipped with part-time 4WD the transfer case moreover enables the driver to select between 2WD ("2H") and 4WD ("4H" or "4L"). Usually transfer cases are not or only partially synchronized (e.g. only the shifting from "2H" to "4H"), shifting can take place only when the car is stopped.

If it is a car with permanent 4WD the transfer case needs to have a differential ("central differential" or "transfer case differential") in order to compensate different speeds of front and rear axle. Some transfer cases have in addition a differential lock that can pause the speed compensation if required (for differential lock see also handout "differential").

1.7.1 Types of four-wheel drives

Because of the many names manufacturers give their drive systems, it is often difficult to clearly define the difference between 4WD and AWD. Both have the ability to send torque to all four wheels. To do this, these vehicles have a transfer case and a differential unit at the front and rear axles.

A transfer case splits the power from the transmission between the front and rear axles. For clarity, the primary difference between the two is that the transfer case in a 4WD vehicle offers two speed ratios in four-wheel drive: high and low. These systems are mostly found in pickups and large SUVs. An AWD vehicle does not offer this. AWD vehicles are smaller SUVs or passenger cars .

A. Four-Wheel-Drive Systems

Four-wheel-drive systems can have several names, including 4*4, and can be divided into separate types: part time and full time. These terms describe when power is sent to the four wheels. Both, however, have two-speed transfer cases. The transfer case is switched with a shifter or electrical switch. The high range could be called the normal range because the torque from the transmission is not altered by the transfer case. This gear selection is used to provide 4WD traction on roads covered with ice or packed snow. The low range provides extra torque at very low output speed. This allows drivers to slowly and smoothly climb very steep hills or pull heavy loads.

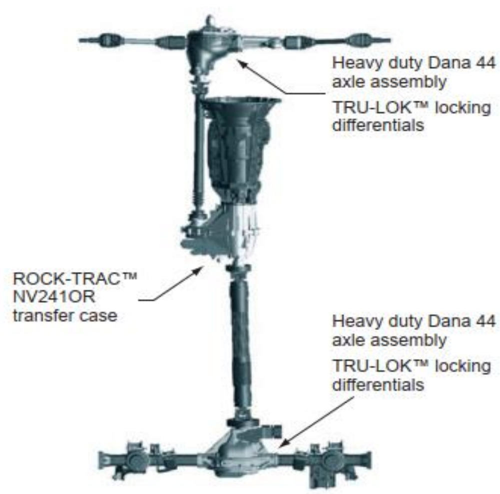


Figure 1-56 Part-Time 4WD

a. Part-Time 4WD

Part-time systems are often found on 4WD pickups and older SUVs. These vehicles are basically RWD vehicles fitted with a two-speed transfer case and axle connects/disconnects, normally called locking hubs. The transfer case in part-time systems does two things in response to the driver's commands: it engages/disengages 4WD and adjusts the overall gear ratio for the final drive. Normally, the system operates in 2WD until the driver selects 4WD.

A selector switch or shifter controls the transfer case so that power is directed to the axles as the driver desires. Normally, the driver can select 2WD, 4WD HI, 4WD LO. The shift control will either physically move a gear in the transfer case or activate an electrically operated solenoid or clutch pack to send torque to the front axle. In addition, most mechanical shifters offer a neutral position that is used as a stopping point before 4WD LO can be selected.

Figure 1-57 Selector switch

The transmission is connected directly to the transfer case. In turn, the transfer case is connected to the front and rear axle assemblies. Two drive shafts extend from the transfer case: One sends torque to the front axle and the other to the rear axle. When the system is operating in 4WD, all four wheels are powered by the engine. The front drive shaft is locked to the rear drive shaft; therefore, each axle receives half of the torque coming from the transmission and the axles rotate at the same speed.

With this split of torque, the tires need to slip on the surface when the vehicle makes a turn. This is one of the reasons 4WD in part-time systems should not be selected when the vehicle is traveling on dry surfaces. Four-wheel drives should only be selected during situations where the tires can easily slip, such as mud or other slippery surfaces. When operated on dry surfaces, the tires have a difficult time slipping and jerking in turns and excessive tire wear will result.

Part-time systems also have locking hubs, which can be manually or automatically controlled. The hubs are designed to stop the rotation of the front axles and differential when 4WD is not selected. This increases fuel economy and decreases the wear on those parts. Newer systems have automatic locking hubs that engage when the driver switches into 4WD. older vehicles had manual locking hubs that required the driver to turn a knob on the front wheels. Most manual or automatic hubs use a sliding collar that locks the front drive axles to the hub.

b. Full-Time 4WD

In a full-time 4WD system, all four wheels have power delivered to them all of the time. They do well off the road and can be used on all sur-faces, including dry pavement. These systems have a centers or inter-axle differential or viscous clutch that allows for a difference in speeds between the front and rear axles. These units decrease the amount of slip the wheels experience when the vehicle is turning a corner. The centers differential is located between the fronts and rear drive shafts and may be an integral part of the transfer case. Like all 4WD systems, the transfer case has a low- and high-speed range. However, the driver does not have the option of shifting into 2WD. Also, these systems have no need for locking hubs at the front wheels.

B. All-Wheel Drive

AWD systems are basically the same as 4WD systems, except there is no low gear option. Many AWD vehicles are based on FWD vehicles. They may not have a separate transfer case; rather, a viscous clutch, centers differential, or transfer clutch is used to transfer power from the transaxle to a rear driveline and rear axle assembly.

a) Full-Time AWD

These systems are very similar to the full-time 4WD and power the four wheels all of the time. They are not designed for heavy off-the-road driving; rather, they enhance a vehicle's stability and performance during normal driving conditions. The engine's torque is divided according to operating conditions. When the vehicle is moving straight on a level road, each wheel receives the same amount of torque. During a turn, the front wheels receive less torque; this prevents wheel slip.

Some AWD vehicles have an electromagnetic clutch in the transfer case. During normal driving, the AWD control module keeps the clutch working at a minimum level. This allows for a slight difference between speeds of the front and rear drive shafts, enabling the vehicle to negotiate turns. When the system detects wheel slippage, the control module fully activates the clutch to send more torque to the front or rear wheels. Wheel slip is monitored by inputs from wheel speed sensors that are available on the CAN bus.

Some systems allow the driver to select an operating mode that locks the front and rear drive shafts. This causes the drive shafts to rotate at the same speed and torque. This move is intended for very slippery conditions and should not be used on dry payment.

b) Automatic AWD

These systems operate in 2WD most of the time. Power to four wheels only occurs when the conditions dictate the need. These systems were designed to enhance vehicle stability and safety and are not intended for off-the-road usage. During normal driving, one axle receives all of the output from the transmission. When that axle experiences some slippage, the AWD control unit allows up to 50% of the torque to move to the other axle.

This power split can be accomplished hydraulically, mechanically, or electrically, depending on the system. As soon as the axle that was slipping is no longer slipping, all torque is sent to that axle. Under normal conditions one axle gets 100% of the torque—meaning you are driving in 2WD.

1.8 Final drive

The drive line in the rear wheel drive vehicles must be able to transfer driving torques from the transmission output shaft to the differential under all operating conditions. It should do this smoothly and without any appreciable loss of torque.

The drive line on the front wheel drive vehicles must be able to transfer driving torque from the transaxle output shot to the front wheels. They must operate at varying angles and provide a means for shaft length changes to allow for vertical suspension (wheel) and engine movement.

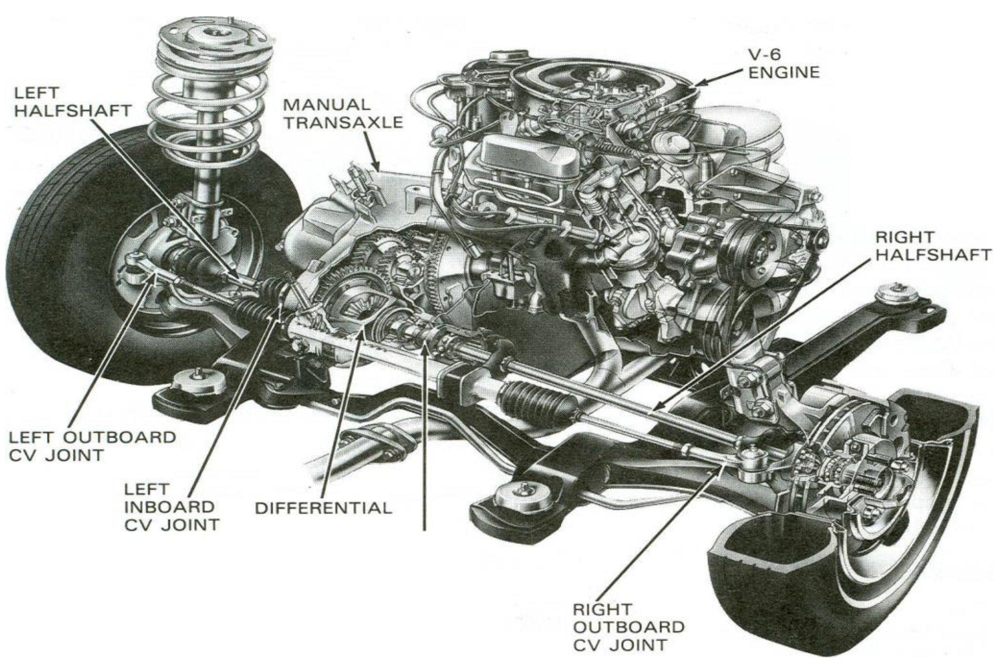


Figure 1-58 Final drive layout

1.8.1 Components of drive lines

1. **Universal joint**

Universal joints called U-joints are located at both ends of the drive shaft. They transmit power at an angle. When the axle moves up or down, the universal joint allows the changes in angle at the ends of the drive shaft to take place.

To link two independent units, such as the gear box and final drive, a universal joint must be fitted to each end of the propeller shaft. The universal joints enable the propeller shaft to rotate smoothly and to transmit the engines torque, even though the axis of the engine and gear box, proper shaft and final drive des not form a straight line. The sliding joint allows for minor variations in length.

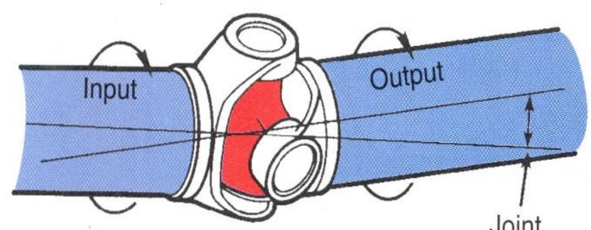


Figure 1-59 Universal joint

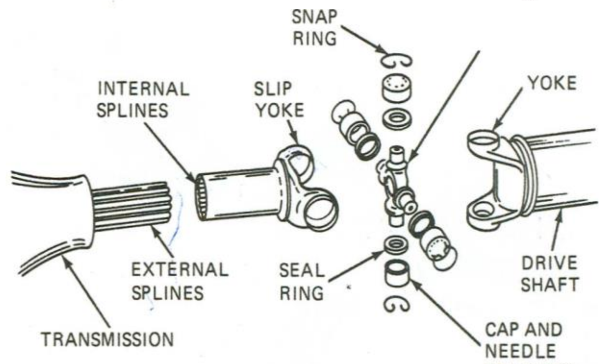


Figure 1-60 Exploded view of UJ

2. **Propeller shaft**

In general, propeller shafts is a components fitted to vehicles that have a conventional in-line layout. In this layout the engine and gear box are in line with the longitudinal axis of the vehicle and generally at the front, with the final drive located at the rear. The propeller shaft is commonly of tubular steel construction. Slide shafts are sometimes used, but this is rare.

1. Tubular shafts have a number of advantages over the slie version:
2. A tubular propellers shafts weights less than a slid shaft this helps to improve fuel economy.
3. A tubular shaft is less likely than a slide shaft to go out of balance when subjected to centrifugal forces because it has a smaller mass
4. A tubular shaft is considerable stronger than the equivalent solid propeller shaft of similar mass, and is much less likely to beud or ship when spinning at speed.
5. Constant velocity joint

Front wheel service vehicles of either transverse or inline layout use similar shafts but with constant velocity (VC) joints. ACV joint can transmit the available torque through varying angles without any noticeable difference in the speeds of the two shafts. This results in the vehicles having an acceptable steering lock, but without the vibration associated with other designs of coupling.

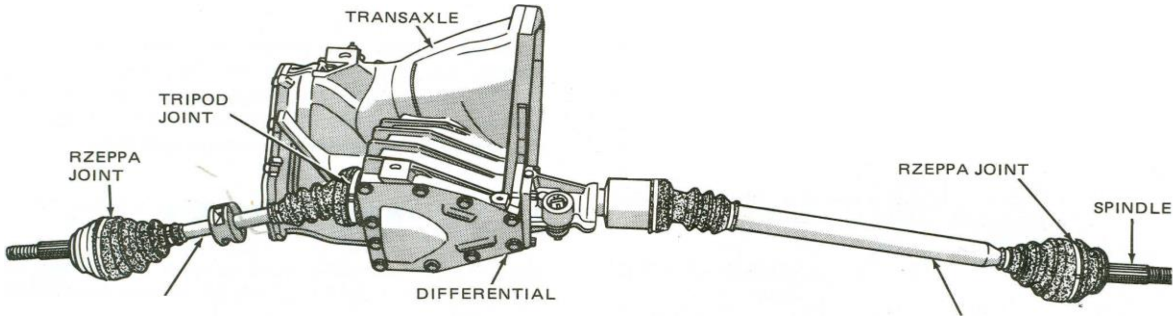


Figure 1-61 Equal-length drive shafts

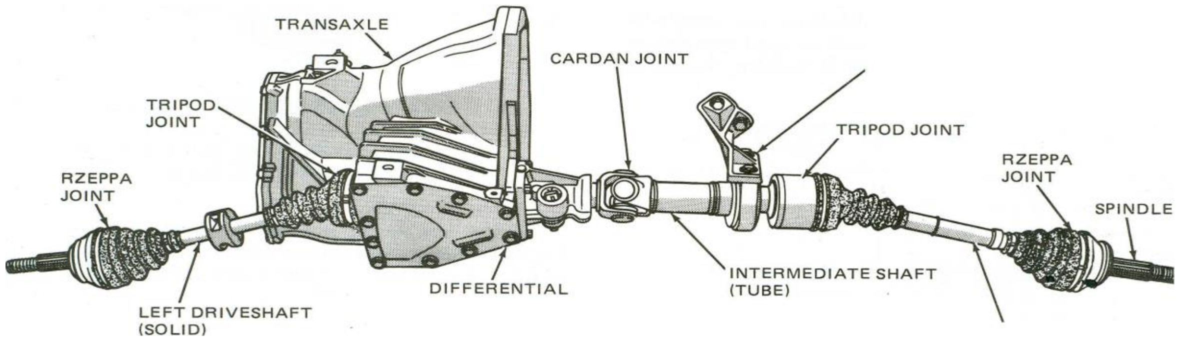


Figure 1-62 Unequal-length drive shafts

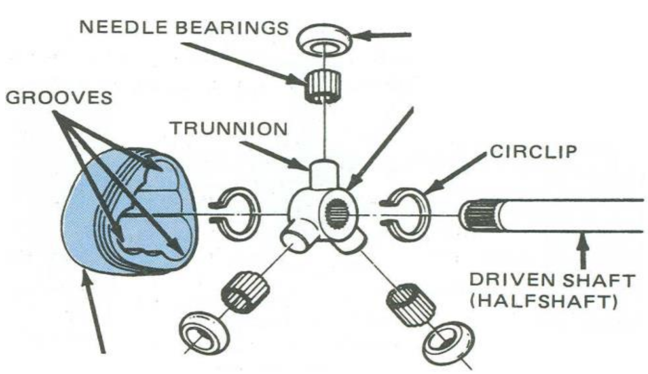


Figure 1-64 Tripod CV joint construction

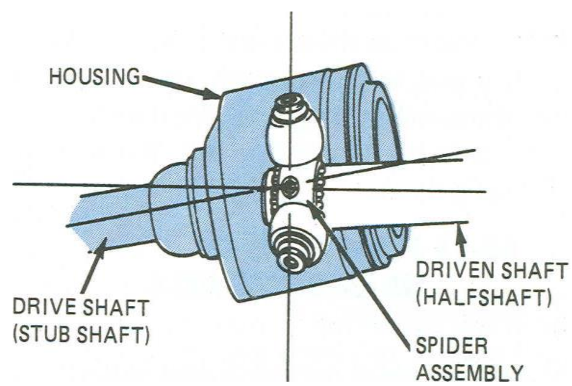


Figure 1-63 Tripod CV joint operation

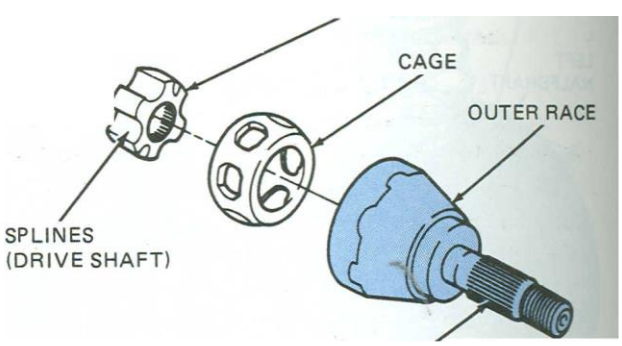


Figure 1-65 Rzappa CV joint construction

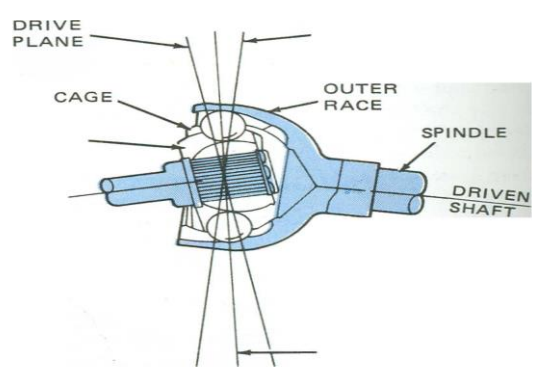


Figure 1-66 Rzappa CV joint operation

1.9 Differential

The differential is a device or gear assembly between two shafts that permits the shafts to turn at different speeds while continuing to transmit torque. It is used in drive axles to allow different rates of wheels rotation on curves. In a rear-wheel drive (RWD) vehicle, the rear wheels receive power from the engine, and the differential is located in the rear axle.

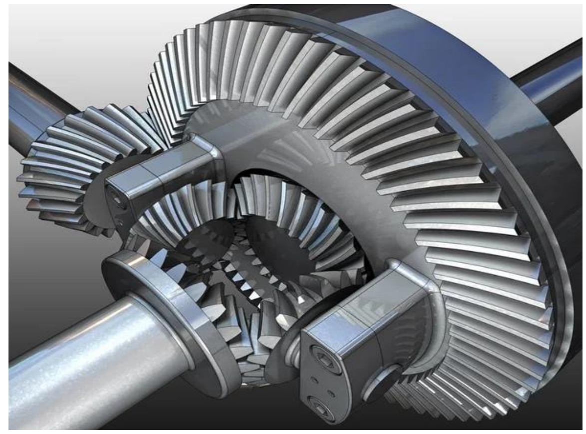


Figure 1-67 Differential

Metal shafts connect it to each of the rear wheels, and to the engine via the transmission. The differential in a front-wheel drive (FWD) vehicle is contained in the transaxle, which transfers engine power to the metal shafts leading to each of the front wheels.

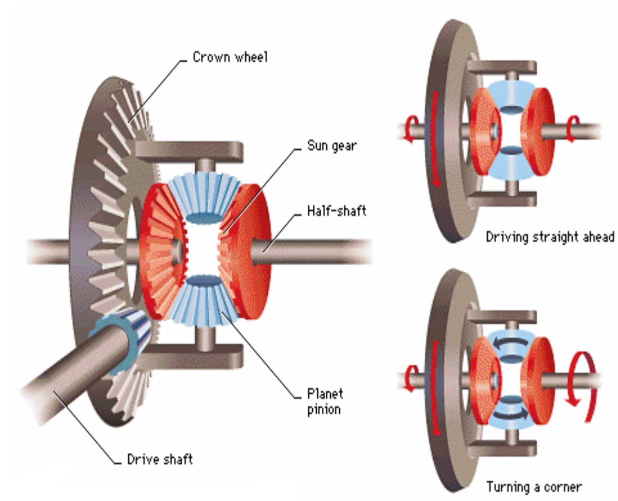


Figure 1-68 Differential operation

The gears of a differential allow a car's powered wheels to rotate at different speeds as the car turns around corners.

The car's drive shaft rotates the crown wheel, which in turn rotates the half shafts leading to the wheels. When the car is traveling straight ahead, the planet pinions do not spin, so the crown wheel rotates both wheels at the same rate.

Differentials are used in the following:

- The rear-drive axle of front engine, rear wheel drive vehicles;
- The transaxles of front engine, front-wheel-drive and rear-engine, rear wheel drive vehicles;
- The front-drive axle and rear drive axle of four wheel drive vehicles; and
- The transfer case of some four-wheel drive vehicles

1.9.1 Differential Fluids

For lubrication fluid, a very heavy oil, must be used in rear axle housings. Special hypoid oils are used in the differential case. Even another type of fluid, or oil must be used in a positraction type differential.

Figure 1-69 Differential Fluids

The oil is circulated by the ring gear, and flung all over all the parts. Special troughs, or gullies are used to bring the oil back to certain spots, like the ring and pinion area and the piston bearings. The fluid is kept in with gaskets and oil seals. The bottom of the housing has a drain plug, and another filler plug is located part way up the housing. The housing must never be filled above this plug.

1.9.2 Types of Differentials

A. Open Differentials

This type of diff is the most basic and only allows for variations of individual wheel speed or slip but that’s it. In optimal road conditions, it allows the outside wheel to rotate faster than the inside wheel. The problem is when road conditions are not ideal such as on wet pavement, ice, snow, or gravel. With an open diff, the engine torque still transfers even if the wheel has zero traction so that slipping tire will simply spin and not go anywhere. Open differentials are found in most vehicles on the road today so generally speaking, the cost to repair the differential is less that other diff types (if same axle).


Figure 1-70 Open Differentials

B. Limited Slip Differentials

A Limited Slip Differential (also known as a LSD) attempts to address the problems of an Open Differential. A Limited Slip Differential is very similar to an Open Differential, but it adds a spring pack and a set of clutches. Some of these have a cone clutch that is similar to the synchronizers in a manual transmission.


Figure 1-71 Limited Slip Differentials

The spring pack pushes the side gears against the clutches, which are attached to the cage. Both side gears spin with the cage when both wheels are moving at the same speed, and the clutches aren't really needed - the only time the clutches step in is when something happens to make one wheel spin faster than the other, as in a turn.

The clutches fight this behavior, wanting both wheels to go the same speed. If one wheel wants to spin faster than the other, it must first overpower the clutch. The stiffness of the springs combined with the friction of the clutch determines how much torque it takes to overpower it.

C. Locking Differentials

The locking differential is useful for serious off-road vehicles and for drag racing. This type of differential has the same parts as an open differential, but adds an electric, pneumatic or hydraulic mechanism to lock the two output pinions together.

Figure 1-72 Locking Differentials

This mechanism is usually activated manually by switch, and when activated, both wheels will spin at the same speed. If one wheel ends up off the ground, the other wheel won't know or care. Both wheels will continue to spin at the same speed as if nothing had changed. This maximizes the amount of forward motion, regardless of wheel slippage - perfect for drag racing.

There are several types of locking differentials. An ARB Air Locker is a unique differential because it acts like an open differential until an on-board air compressor is activated by a switch. The air pressure is used to lock the differential. This allows a very high breakaway torque for racing but no compromises for daily driving.

A Detroit Locker, popular on muscle cars and some off-road trucks, is a ratcheting type of locking differential. It is very strong and will almost always provide equal torque application to each axle, but it is noticeable when cornering.

Finally there is the spool, which solidly connects the left and right axles with no slipping allowed. It is used for drag-racing applications only, since it maximizes forward acceleration, but makes the vehicle very difficult to turn and is very hard on the axles.

D. Torsen Differentials

The Torsen differential is a purely mechanical device; it has no electronics, clutches or viscous fluids. The Torsen (from Torque Sensing) works as an open differential when the amount of torque going to each wheel is equal. As soon as one wheel starts to lose traction, the difference in torque causes the gears in the Torsen differential to bind together. The design of the gears in the differential determines the torque bias ratio. For instance, if a particular Torsen differential is designed with a 5:1 bias ratio, it is capable of applying up to five times more torque to the wheel that has good traction.

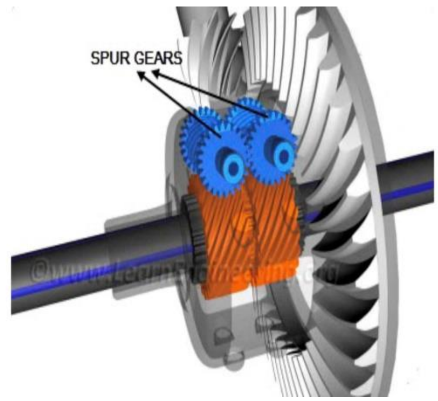


Figure 1-73 Torsen Differentials

E. Vicious Coupling Differentials

The viscous coupling is often found in all-wheel-drive vehicles. It is commonly used to link the back wheels to the front wheels so that when one set of wheels starts to slip, torque will be transferred to the other set. The viscous coupling has two sets of plates inside a sealed housing that is filled with a thick fluid, as shown in below. One set of plates is connected to each output shaft. Under normal conditions, both sets of plates and the viscous fluid spin at the same speed. When one set of wheels tries to spin faster, perhaps because it is slipping, the set of plates corresponding to those wheels spins faster than the other.

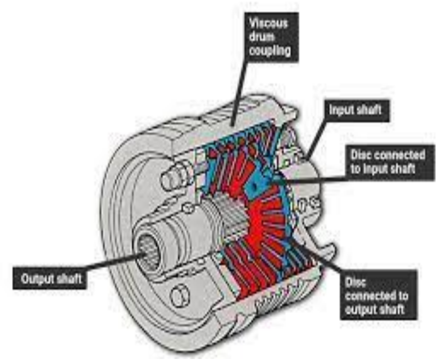


Figure 1-74 Vicious Coupling Differentials

F. Positraction Differentials

A positraction differential is a special traction differential. Its purpose is to improve the way your differential performs under adverse conditions. When one wheel starts to slip, these differentials transfer the torque to the wheel that is not slipping. The car can then continue to go forward.

There are several different kinds of positraction differentials, but all of them are based on a friction device to provide resistance to normal differential operation.

Figure 1-75 Positraction Differentials

A positraction differential provides better traction, which is handy when roads are slippery. It also lends itself to fast acceleration.

1.10 Axle shafts

The purpose of an axle shaft is to transfer driving torque from the differential assembly to the vehicle's driving wheels. There are two types of axles: dead and live or drive. A dead axle does not drive a vehicle.

It merely supports the vehicle load and provides a mounting place for the wheels. The rear axle of a FWD vehicle is a dead axle, as are the axles used on trailers.

A live axle is one that drives the vehicle. Drive axles transfer torque from the differential to each driving wheel. Depending on the design, rear axles can also help carry the weight of the vehicle or even act as part of the suspension.

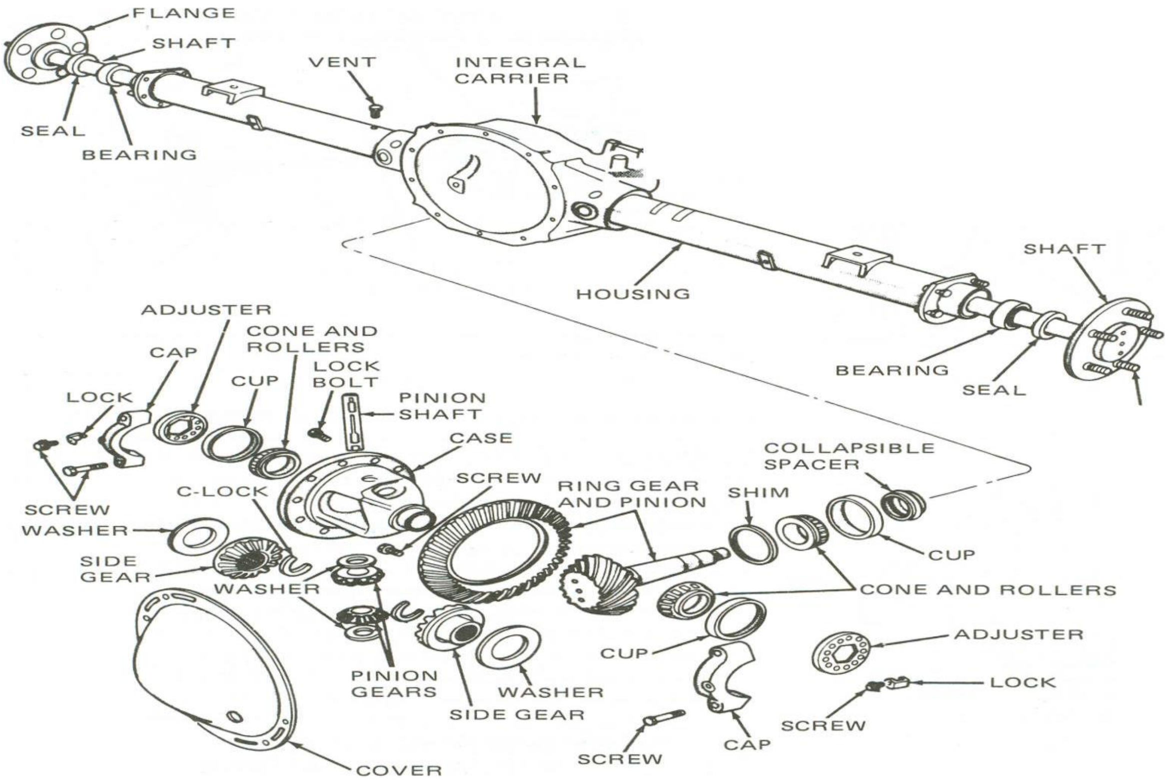


Figure 1-76 Disassembled view of rear axle

Three types of driving axles are commonly used: semi floating, three-quarter floating, and full-floating. All three use axle shafts that are splined to the differential side gears. At the wheel ends, the axles can be attached in any one of a number of ways. This attachment defines the type of axle it is and the manner in which the shafts are supported by bearings.

A. Semi floating Axle Shafts

Semi floating axles help to support the weight of the vehicle. Most RWD vehicles have semi floating axles. The axles are supported by bearings located in the axle housing. An axle shaft bearing supports the vehicle's weight and reduces rotational friction. The inner ends of the axle shafts are splined to the axle side gears. The axle shafts transmit only driving torque and are not acted upon by other forces. Therefore, the axle shafts are said to be floating.

The driving wheels are bolted to the outer ends of the axle shafts. The outer axle bearings are located between the axle shaft and axle housing. This type of axle has a bearing pressed into the end of the axle housing. This bearing supports the axle shaft. The axle shaft is held in place with either a bearing retainer belted to a flange on the end of the axle housing or by a C-shaped washer that fits into grooves machined in the splined end of the shaft. A flange on the wheel end of the shaft is used to attach the wheel.

When semi floating axles are used to drive the vehicle, the axle shafts push on the shaft bearings as they rotate. This places a driving force on the axle housing, springs, and vehicle chassis, moving the vehicle forward. The axle shaft faces the bending stresses associated with turning corners and curves, skidding, and bent or wobbling wheels, as well as the weight of the vehicle. In the semi floating axle arrangement with a C-shaped washer-type retainer, if the axle shaft breaks, the driving wheel comes away from or out of the axle housing.

B. Three-Quarter Floating Axle

The wheel bearing on a three-quarter floating axle is on the outside of the axle housing instead of inside the housing as in the semi floating axle. The wheel hubs are bolted to the end of the axle shaft and are supported by the bearing. In this arrangement, the axle shaft only supports 25% of the vehicle's weight. The weight is transferred through the wheel hub and bearing to the axle housing. Three-quarter floating axles are found on older vehicles and some trucks.

C. Full-Floating Axle Shafts

Most medium- and heavy-duty vehicles use a full-floating axle shaft. This design is similar to the three-quarter floating axle except that two bearings rather than one are used to support the wheel hub. These are slid over the outside of the axle housing and carry all of the stresses caused by torque loading and turning. The wheel hubs are bolted to flanges on the outer end of each axle shaft.

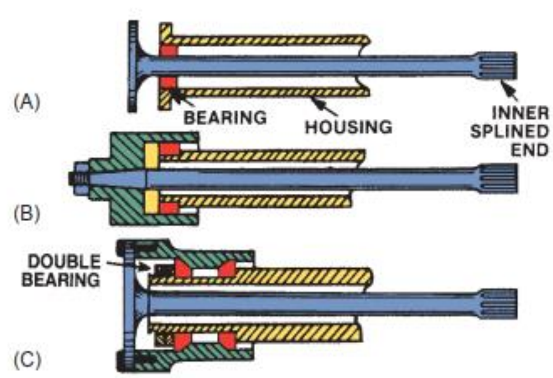


Figure 1-77 Types of rear axle shaft

In operation, the axle shaft transmits only the driving torque. The driving torque from the axle shaft rotates the axle flange, wheel hub, and rear driving wheel. The wheel hub forces its bearings against the axle housing to move the vehicle.

The stresses caused by turning, skidding, and bent or wobbling wheels are taken by the axle housing through the wheel bearings.

If a full-floating axle shaft should break, it can be removed from the axle housing. Because the rear wheels rotate around the rear axle housing the dis-abled vehicle can be towed to a service area for replacement of the axle shaft.

1.11 Wheel Bearing and Hub Assembly

Wheel bearings allow the wheel and tire assembly to turn freely around the spindle, in the steering knuckle, or in the bearing support. Wheel bearings are lubricated with heavy, high-temperature grease. This allows the bearing to operate with very little friction and wear.

The two basic wheel-bearing configurations are tapered roller or ball bearing types. The basic parts of a wheel bearing are as follows:

- ✓ Outer race (cup or cone pressed into the hub, steering knuckle, or bearing support).
- ✓ Balls or rollers (anti-friction elements that fit between the inner and outer races).
- ✓ Inner race (cup or cone that rests on the spindle or drive axle shaft).

There are two types of wheel bearing and hub assemblies: non-driving and driving. For example, the front wheels on a rear-wheel drive vehicle are non-driving.

A. Non-driving Wheel Assembly

The components of a non-driving wheel bearing and hub assembly include the following:
Spindle (a stationary shaft extending outward from the steering knuckle or suspension system to which the following components are attached). Wheel bearings (normally tapered roller bearings mounted on the spindle and in the wheel hub). Hub (outer housing that holds the brake disc, or drum, wheel, grease, and wheel bearing).
Grease wheel (a seal that prevents loss of lubricant from the inner end of the spindle and hub). Safety washer (a flat washer that keeps the outer wheel bearing from rubbing on and possibly turning the adjusting nut). Spindle adjusting nut (a nut threaded on the end of the spindle for adjusting the wheel bearing). Nut locks (a thin, slotted nut that fits over the main spindle nut).

Dust cap (a metal cap that fits over the outer end of the hub to keep grease in and dirt out of the bearings). Since a non-driving wheel bearing and hub assembly does NOT transfer driving power, the spindle is stationary. The spindle simply extends outward and provides a mounting surface for the wheel bearings, hub, and wheel. With the vehicle moving, the wheel and hub spin on the wheel bearings and spindle. The hub simply freewheels.

1.11.1 Driving Wheel Assembly

The components of a driving wheel bearing and hub assembly (Figure 2-9) includes the following: Outer drive axle (a stub axle shaft that extends through the wheel bearings and is splined to the hub). Wheel bearings (either ball or roller type bearings that allow the drive axle to turn in the steering knuckle or bearing support).

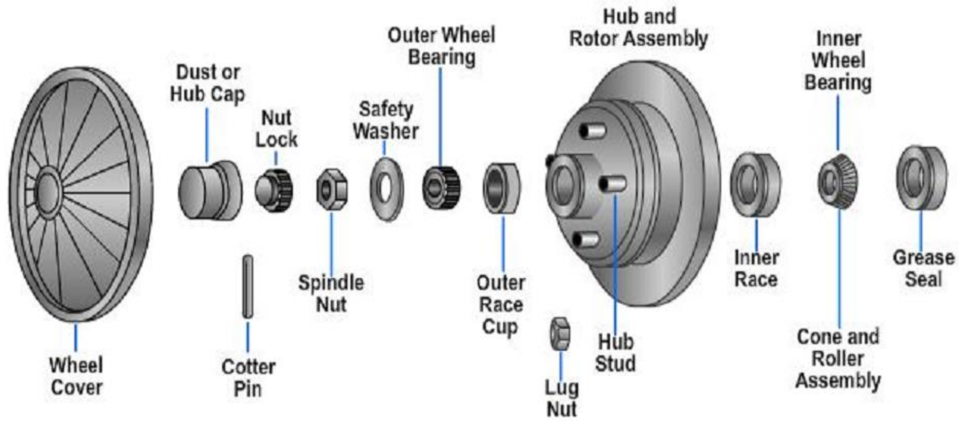


Figure 1-78 View of a non-driving wheel bearing and hub assembly

Steering knuckle or bearing support (a suspension or steering component that holds the wheel bearings, axle stub, and hub). Drive hub (a mounting place for the wheel which transfers driving power from the stub axle to the wheel). Axle washer (a special washer that fits between the hub and locknut).

Hub or axle locknut (a special nut that screws onto the end of the drive axle stub shaft to secure the hub and other parts of the assembly). Grease seal (prevents lubricant loss between the inside of the axle and the steering knuckle and bearing support).

The driving wheel bearing and hub assembly has bearings mounted in a stationary steering knuckle or bearing support. The drive axle fits through the centers of the Bearings. The hub is splined to the axle shaft. Instead of a stationary spindle, the axle Shaft spins inside the stationary support. With the hub splined to the axle shaft, power is transferred to the wheels.

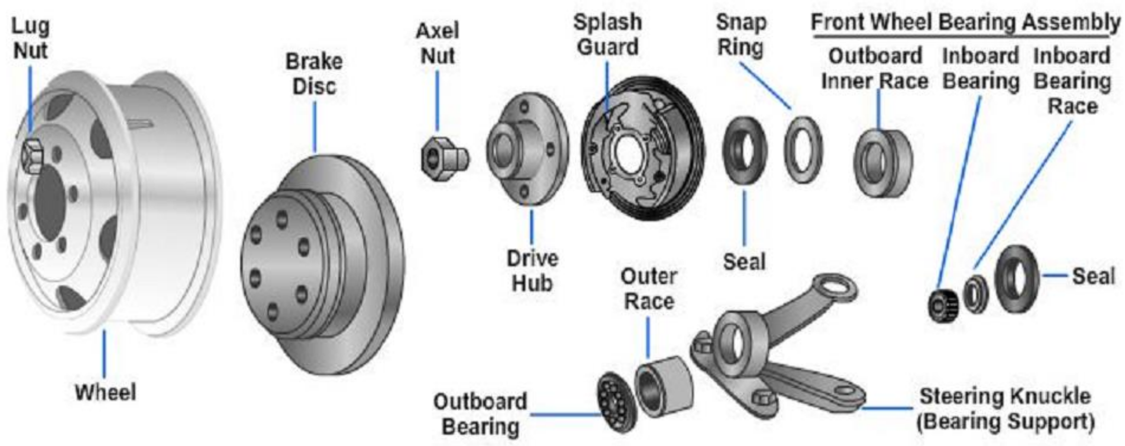


Figure 1-79 View of a driving wheel bearing and hub assembly

1.11.2 Bearing Lubrication - Grease

Grease should be replaced every 12,000 miles or 12 months. Prior to repacking bearings, all old grease should be removed from the wheel hub cavity and bearings. Bearings should be packed by machine if possible. If a machine is unavailable, packing by hand method is acceptable. The method to pack bearing cones is as follows:

1. Place a quantity of grease onto the palm of your hand.

2. Press a section of the widest end of bearing into the outer edge of the grease pile closest to the thumb forcing grease into the interior of the bearing between two adjacent rollers.

3. Repeat this while rotating the bearing from roller to roller.

4. Continue this process until you have the entire bearing completely filled with grease.

5. Before reinstalling, apply a light coat of grease onto the bearing cup mating surface.

Self-check-1
Instruction: Select the best answer

1. Technician A says, in a gear set, speed reduction means torque. Technician B says speed increase means torque reduction. Who is right?

   a. A only B. B. Only C. Both A and B D. Neither A nor B

2. A synchronizer does all the following except:

   a) Prevents gear clash during shifting
   b) Uses friction to make the gear synchronizer ring rotate at the same speed
   c) Locks a gear to the shaft
   d) Attaches directly to the shift rail

3. When the gear ratio through the transmission is 1:1, the transmission is in

   A. overdrive b. direct drive c. underdrive d. neutral

4. Power leaves the transmission section of a manual transaxle through a

   A. pinion gear b. ring gear c. cluster gear d. counter gear

5. Technician A says when a five-speed manual transaxle is in fifth gear, the first-second and third-fourth synchronizer sleeves are in neutral. Technician B says the fifth synchronizer is disengaged. Who is right?

   a. A only B. B. Only C. Both A and B D. Neither A nor B

6. The purpose of an interlock device is to

   a) lock the transmission to prevent theft
   b) complete the electric circuit to the starting motor
   c) Prevent locking two gears to the output shaft at the same time
   d) interlock the shift lever to prevent shifting

7. To shift into a gear, the first movement of the gearshift lever

   a. moves the synchronizer
   b. selects the synchronizer
   c. meshes the gears
   d. moves the synchronizer sleeve

8. Shift linkage enclosed within the transmission or transaxle case is called

   a. external linkage
   b. floor shift
   c. column shift
   d. internal linkage

9. Another name for clutch shaft:

a) Input shaft
b) Output shaft
c) Disk shaft
d) Pressure plate shaft

10. A mechanism in the power train that engage and disengage the engine power to the transmission:

a) Clutch
b) Transmission
c) Propeller shaft
d) Differential

11. A protective cover that houses the clutch pressure plate assembly:

a. Clutch fork
b. Clutch disk
c. Clutch pressure plate
d. Clutch housing

12. A mechanism that carries the movement of the clutch pedal to the release bearing:

a) Clutch fork
b) Clutch linkage
c) Throw-out bearing
d) Clutch housing

13. It disengage the pressure plate from the friction lining causing the clutch plate to disengage with the flywheel:

a) Clutch fork
b) Clutch linkage
c) Throw-out bearing
d) Clutch linkage

14. The mechanism that holds the throw-out bearing or release bearing and is pivoted at the hub:

a) Clutch pressure plate
b) Clutch disk
c) Clutch fork
d) Clutch linkage

15. A series of coil springs/fingers or diaphragm and smooth pressure plate which presses flywheel against the clutch disk or drive plate:

a) Clutch pressure plate
b) Clutch disk
c) Clutch fork
d) Throw-out bearing

Unit Two: Remove and inspect power train drive line assemblies

This unit to provide you the necessary information regarding the following content coverage and topics:

- Inspection of power train and drive line assemblies
- Inspection of mounting points and fittings
- Remove power train and drive line assemblies
- Report inspection findings

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Inspecting of power train and drive line assemblies
- Inspecting of mounting points and fittings
- Removing power train and drive line assemblies
- Reporting inspection findings

2.1 Inspecting power train and drive line assemblies

2.1.1 Drive shaft Diagnosis Inspecting

Drive shaft problems can result in noise or vibration from worn or rusted U-joints (universal joints), a worn slip yoke, or a bad centers support bearing. Worn U-joints can cause squeaking or grinding sounds.

Sometimes a car will have a clunking sound when changing from acceleration to deceleration. This can be due to worn slip yoke splines or a bad extension housing bushing. It can also be because of problems in the differential or a much worn U-joint. Sometimes leaf springs can be loose at the differential allowing the housing to wind up.

A ringing sound is sometimes a complaint. This often results from a bad clutch disc damper. Replacing the clutch disc usually solves the problem. If the car has an automatic transmission, the problem can be due to a bad lock-up converter.

A worn centers support bearing can cause a whining sound that varies with vehicle speed. The noise is constant in pitch, rather than changing or intermittent like U-joint noise. A U-joint noise changes pitch because of the changing angle of the U-joint.

For example, Drive Shaft Balance: Dive shafts are a possible source of vibration. In high gear, the drive shaft spins at engine rpm. If the shaft is bent or a universal joint is worn, a vibration can occur.

Some drive shafts are built in two pieces with rubber dampening rings inside of them. Another drive shaft style has a damper like a crankshaft vibration damper mounted on its outside. This absorbs torsional vibration.

A. Universal Joint Inspection

When a universal joint begins to fail, a squeaking sound is often noticed just when the car begins to go forward. The most common cause of U-joint failure is when its grease dries out. This often happens because the seal on the U-joint has failed allowing moisture in.

A vibration can also occur when a U-joint starts to fail. With a worn U-joint, a sharp, one-time click sound often occurs when the vehicle direction is changed from forward to reverse or when the vehicle first takes off.

Universal Joint Disassembly

The procedure described here is for single cross and yoke (cardan) universal joints. If the U-joint has any snap rings, remove them. Some snap rings are on the inside of the yoke. Other are on the outside. When the snap ring is on the outside, a sturdy pair of pliers can be used.

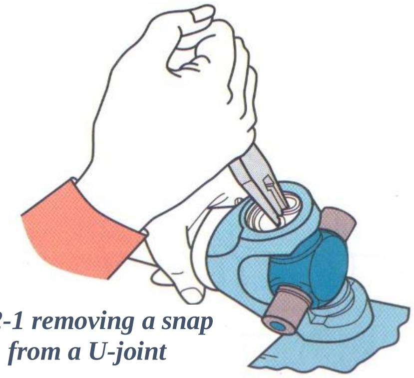


Figure 2-1 removing a snap ring from a U-joint

Note: Smaller needle nose pliers can become damaged because they are not sturdy enough.

Sometimes snap rings are on the inside. A punch or a special tool can be used to remove them. If the U-joint is retained by plastic resin, follow the manufacturer’s service manual instructions. A small tube of resin is usually used

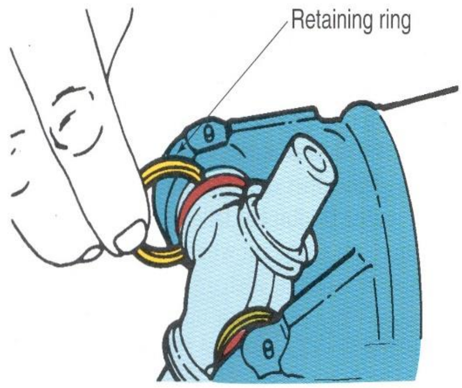


Figure 2-2 Sometimes snap rings go on the inside of the yoke.

Universal Joint Inspection

One problem caused during installation in a vise is that drive shaft yoke ears commonly become sprung inward. This results in brinelling. Brinelling is when small indentations wear into the bearing surface. Brinelling is often the result of a faulty U-joint installation. The joint should always fell loose and relaxed (not binding up) after a correct installation.

Figure 2-3 Brinelling of the trunnion

A. CV Joint Inspection

To inspect the outer CV joint, cut off the boot clamps (Fig. 2-25A) and remove the boot. Rub some of the grease from the CV joint between your fingers (Fig. 2-25B). If the grease feels gritty, the joint probably is damaged.

Wipe away the grease and remove the CV joint from the half shaft. Most are retained by a snap ring or circlip. Force up one side of the cage and inner race, and remove each ball. Then pivot the cage and inner race so the cage windows align with the lands of the outer race. Lift out the cage and inner race. The Rzeppa outer CV joint completely disassembled.

Inspect the cage for cracks and pitting. This allows excess ball movement and causes a clicking sound during turns. Check the inner and outer races for excess wear in the grooves caused by the balls moving back and forth. Shiny areas in the grooves and cage windows are normal. Replace the CV joint only if a part is broken, cracked, severely pitted, or damaged.

A).Cutting boot clamp

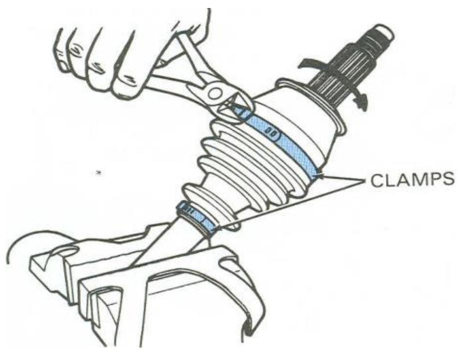


Figure 2-4 Cutting boot clamp

B).Checking grease for grit

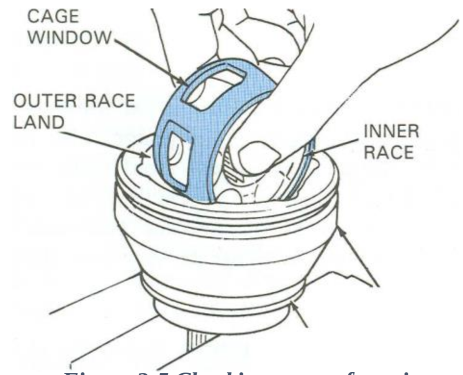


Figure 2-5 Checking grease for grit

C).Tilting cage and inner race

Figure 2-6 Tilting cage and inner race

D) lifting out cage and inner race

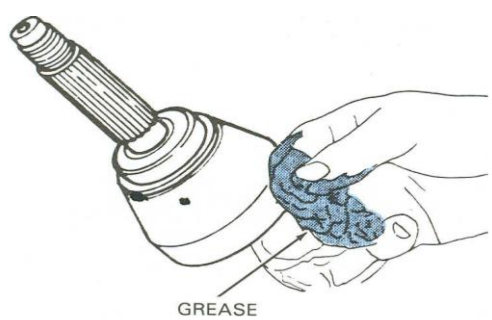


Figure 2-7 Lifting out cage and inner race

B. Differential and Axle Diagnosis and Service

Before removing a final drive unit for service, make sure it needs to be serviced. Typically, problems with the differential and drive axles are first noticed as a leak or noise. As the problem worsens, vibrations or a clunking noise might be felt during certain operating conditions. Diagnosis of the problem should begin with a road test in which the vehicle is taken through the different modes of operation

- ✓ **Inspection before Disassembly Integral Carrier**

The differential case assembly and drive pinion should be inspected before they are removed from the carrier casting. These inspections help to find the cause of the trouble and to determine the correction needed. Drain lubricant and remove cover, then proceed as follows:

1. Wipe the lubricant from the internal working parts and visually inspect the parts for wear and/or damage.
2. Rotate the gears to see if there is any roughness to indicate defective bearings or gears.
3. Check the ring gear teeth for signs of scoring, abnormal wear, or nicks and chips.
4. Set up a dial indicator and check ring gear backlash and ring gear blackface run out.
5. Do not check for gear tooth contact pattern. A contact pattern is not an acceptable guide to check

- ✓ **Inspection after Disassembly of Carrier**

Replace all parts that do not pass inspection. Thoroughly clean all parts. Synthetic seals must not be cleaned, soaked, or washed in cleaning solvents. Always use clean solvent when cleaning bearings. Oil the bearings immediately after cleaning to prevent rusting. Inspect the parts for defects. Clean the inside of the carrier before rebuilding it. When a scored gear set is replaced, the axle housing should be washed thoroughly and steam cleaned. This can only be done effectively if the axle shafts and shaft seals are removed from the housing. Inspect individual parts as outlined below.

- ✓ **Gears**

Examine the pinion and ring gear teeth for scoring or excessive wear. Extreme care must be taken not to damage the pilot bearing surface of the pinion. Worn gears cannot be rebuilt to correct a noisy condition. Gear scoring is the result of excessive shock loading or the use of an incorrect lubricant.

- ✓ **Carrier housing**

Make sure that the differential bearing bores are smooth and the threads are not damaged. Remove any nicks or burrs from the mounting surfaces of the carrier housing.

- ✓ **Differential case**

Make sure that the hubs where the bearings mould are smooth. Carefully examine the differential case bearing shoulders, which may have been damaged when the bearings were removed. The bearing assemblies will fail if they do not seat firmly against the shoulders. Check the fit (free rotation) of the differential side gears in their counter bores. Be sure that the mating surfaces of

Road Test

Does the noise change under different driving conditions? There are several driving conditions to be aware of when listening for noises or feeling for vibration. The following is the terminology you need to become familiar with:

•**Drive** – under acceleration, power is on the convex side of the gear tooth.

•**Cruise -** the car is maintaining its speed.

•**Coast** – deceleration, power is on the concave side of the gear tooth.

•**Float** – car speed is slowly dropping.

Noise that resembles a howl or whine can be due to adjustment of the ring and pinion or due to bearings that are worn. Incorrect differential gear adjustment can result in a howl that occurs only under drive or only under coast conditions. Worn bearings will make a constant sound that changes in relation to road speed. Clunking noises can be due to damaged gears or bearings. When a gear is badly damaged, a shudder can sometimes be felt along with the noise.

Noise that happens only during a turn is probably due to a problem with the spider gears. They can become damaged when a wheel is allowed to spin in a puddle and then gets traction. The differential pinions are very small gears. They cannot withstand the punishment of a heavy load that the large ring and pinion can. Remember that the pinion gears (spiders) are only turning during a turn. When they come to an abrupt halt, they can easily lose teeth. Damaged side gears are usually on the side that received the stress.

Other problems related to the spider gears include:

- Pinion gears too tight on the shaft
- Side gears too tight or too loose in the differential case
- Excessive backlash between the spider gears. The two parts of the case are smooth and free from nicks or burrs.

2.2 Inspecting mounting points and fittings

2.2.1 Inspecting Yoke End Fittings

Inspecting Yoke End Fittings (Includes Slip Yoke, Yoke Shaft, Tube Yoke and End Fitting Yoke)

• Take hold of the end fitting with both hands. Try to move it vertically and horizontally to feel any looseness. NOTE: If oil is evident coming from the transmission, it may be hot and officers should exercise caution.

• Check all input and output end fittings (yokes at each end of driveshaft) for looseness or play. Ensure that all the mounting hardware (nuts bolts, etc.) are not loosen by hand pressure, broken or missing.

• Inspect the yoke end for cracks.

• Attempt to move the slip joint yoke shaft by hand. Check to see if there is any movement. Movement indicates wear in the splines of the slip joint.

• Attempt to rotate the universal joint ends in opposing directions. With hand pressure only, determine if there is any independent rotational movement between the opposing yoke ends.

• Verify all bearing cup assembly caps are in place.

• With hand pressure, ensure the universal joint bolts are

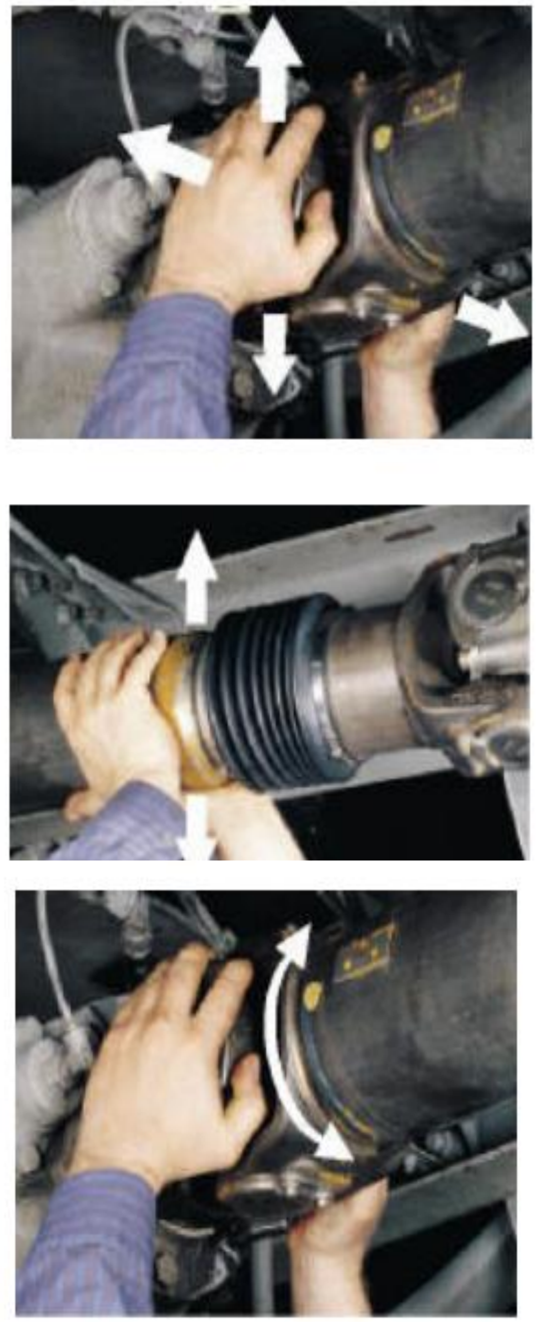


Figure 2-8 Inspection of Yoke End Fittings

2.2.2 Inspecting Centers Bearing (Carrier Bearing)

• Inspect the centers bearing bracket, bracket bolts and mounting hardware and ensure they are not loosen or broken.

• Inspect the centers bearing bracket for cracks.

With hand pressure only, push up and pull down on the driveshaft to check for movement in the centers bearing carrier. Movement of shaft in the centers bearing carrier is not a violation until the out-of-service criteria is met.

2.2.3 Inspecting the Driveshaft Tube

• Inspect the driveshaft tube for cracks.

• Inspect for any obvious cracked welds at the driveshaft tube end.

• Ensure the driveshaft tube has no obvious twists.

Figure 2-9 Inspection of Driveshaft Tube

2.2.4 Inspecting Powertrain Mounts

Engines and transmissions are suspended on rubber isolating mounts that absorb vibration and powertrain noise.

Most vehicles have three different mounts: two engine mounts and one transmission mount. The engine mounts can be tested by brake torqueing the engine forward and backward. If a mount is broken, the engine will lift and visibly separate from the mount. To test the transmission mount, use proper lifting equipment to raise the vehicle and attempt to lift the extension housing. If the mount is separated, the extension housing will lift from the mount.

Figure 2-10 Powertrain Mounts

Some drivelines have adjustable mounts to compensate for variations in drivelines. An angle gauge can be used to measure the angle of the drive shaft. Consult proper service information for the correct procedure. Front-wheel-drive mounts not only suspend the engine and transaxle but also locate the assembly left to right and absorb the torque wrap-up of the engine from front to back.

The suspension mounts are located on the left and right of the engine and transaxle. They have slotted mounting holes, which allow for minor adjustments in position. The ability to adjust position allows for equal distribution of half the shaft length from side to side. If adjusted improperly, the CV-joints will undergo undue compression or extension, which will cause them to fail prematurely.

The front-to-back engine mount is sometimes called a torque strut because it absorbs the forward and backward movement of the engine and transaxle during acceleration and deceleration. This forward and backward movement of the engine is called torque wrap-up.

Front-wheel-drive transaxle and engine mounts can be inspected in much the same way as rear-wheel drive transmission mounts. When the weight of the assembly is lifted from the mount, look for looseness or separation of the rubber from the metal. If the rubber bushing is loose on the mount bolt of the torque strut, the strut is defective.

An additional check can be made by brake torqueing the engine forward and backward. This will force the engine back and forth against the strut. If the bushing is bad, there will be a noticeable cling or thumping in the mount.

Procedures for centering front-wheel-drive mounts vary, depending on the manufacturer. On some vehicles, the drive shaft hub nuts must be loosened and the CV-joints bottomed. Then the amount of shaft thread that extends from the hub is measured, and the mounts are adjusted until they are equal.

Other vehicles require different centering procedures. All centering procedures are designed to achieve sufficient length clearance to allow for changes in suspension geometry. Consult proper service information for the correct procedure.

2.3 Removing power train and drive line assemblies

2.3.1 Removing propeller shaft from the vehicle

There are two methods of attachment of the rear of the drive shaft to the differential pinion hanged or end yoke.

1. Raise the vehicle on a hoist mark the relationship of the shaft to the pinion hanged and disconnect the rear universal joint by removing the straps or V-bolts. If the searing cups are loose, tape them together to prevent dropping and loss of bearing rollers.
2. Withdraw the propeller shaft slip yoke from the transmission by moving the shaft rear ward, passing it under the axle housing. Do not allow the drive shaft to drop or allow the Universal joints to bend to an extreme angle, as this might fracture the joint internally support the propeller shaft during removal.

Warning: Do not pound on the original propeller shaft yoke cars, as injection joints may fracture.

2.4 Removing the CV joint and front drive axle

1. In some cases it may be necessary to remove the right-side shaft first before the left shaft can be removed, or the other way around depending on the design on some models, either shaft may be removed without being affected by the other.
2. Remove the service hub nut

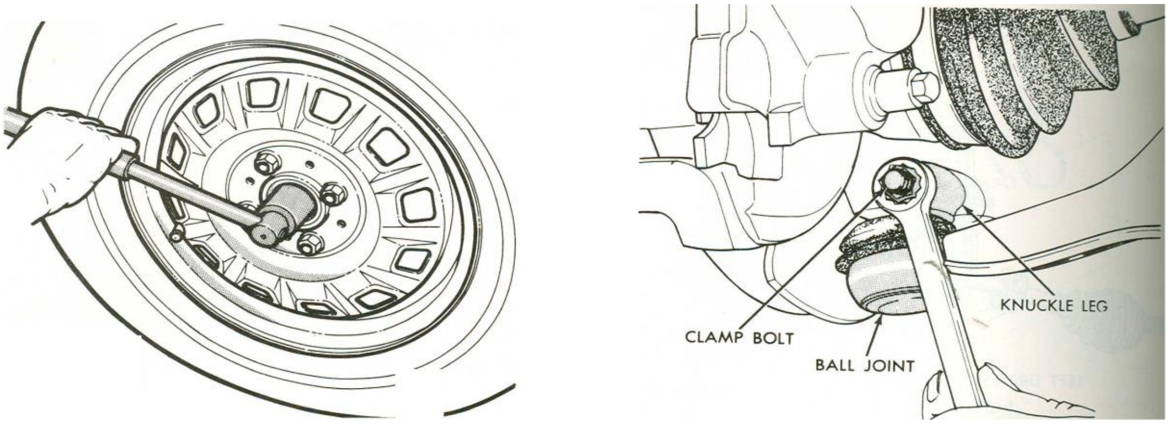


Figure 2-11Loosening hub nut (left) and disconnecting control arm (right) from steering knuckle prior to drive axle removal

3. Separate the steering knuckle from the suspension arm.
   - Support the drive axle with wire audtie to some part of the vehicle.
   - Slide the wheel hub and steering knuckle assembly from the outer stub shaft.
4. Disconnect the inner end of the drive axle from the transaxle depending on the design.

(A) Separating ball joint from steering knuckle

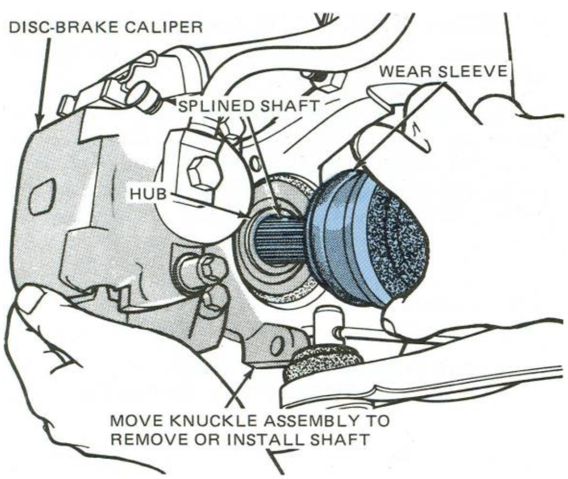


Figure 2-13 Separating ball joint from steering

(b) Separating outer cv-joint shaft from hub

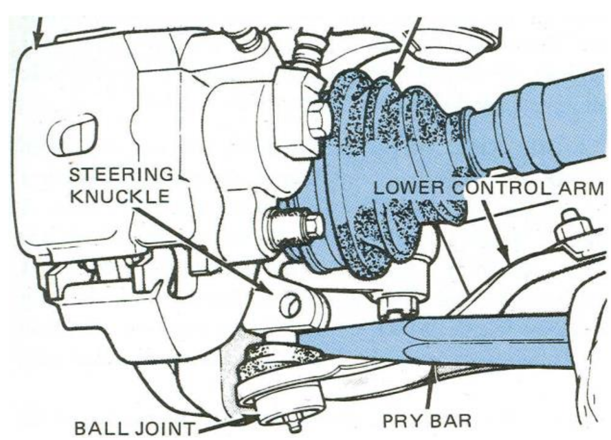


Figure 2-12 Separating outer cv-joint shaft from hub

C) Removing inner cv-joints from transaxle **(d handling inner cv-joints assembly**

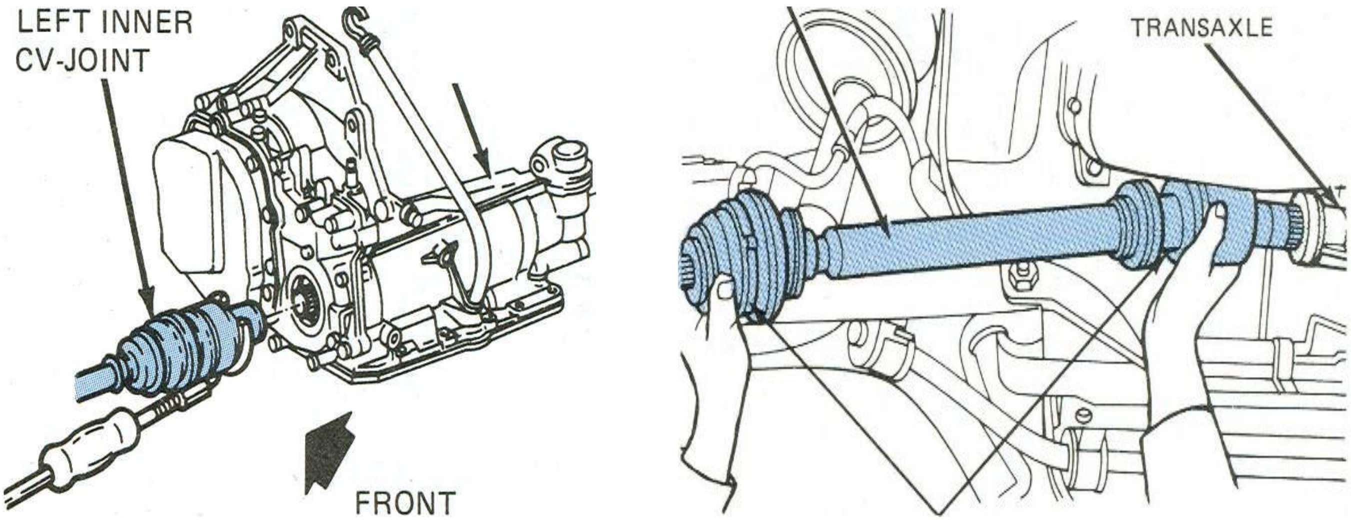


Figure 2-15 Removing half shaft assembly with CV joints from vehicle,

Unit Three: Service power train drive line assemblies

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Manual Transaxle Troubles
- Fluids and lubricants
- Clutch system servicing

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Troubleshooting Manual Transaxle
- Changing fluids and lubricants
- Servicing clutch system

3.1 Manual Transaxle Troubles

Two types of manual-transmission and transaxle troubles are noise and improper operation. The cause of either of these may be internal or external. Three general types of noise may come from a manual transmission or transaxle. The type of noise provides information about what is taking place inside the case to make that noise.

The sound of a periodic clunk indicates broken gear teeth. A growl or whine indicates a defective bearing or worn teeth. A defective bearing usually produces a rough growl or grating noise rather than a whine, which is more typical of gear noise. Gear clash during shifting often indicates a worn defective synchronizer.

3.2 Manual-Transmission Trouble Diagnosis

1. Manual Transmission Troubles

A complaint of "transmission trouble may actually be a defective clutch. Check the clutch first. If the trouble is in the external shift linkage, the linkage may need lubricating and adjusting or a defective cable replaced.

Table 1 Three types of manual-transmission noise and their causes.

Noise	Cause
Periodic clunk	Broken teeth
Growl or whine	Defective bearing or worn teeth
Gear clash	Defective synchronizer

Caution: Never go under a vehicle unless you are wearing eye protection-safety glasses or safety goggles. If the vehicle is raised on a lift, lock the lift. If the vehicle is raised on a jack, be sure the vehicle is properly supported on safety stands before going under it.

2. Hard Shifting into Gear

Difficulty in shifting into gear may be caused by improperly adjusted linkage between the gearshift lever and the transmission. This greatly increases the force required to "shift gears". Hard shifting also results if the linkage is bent, jammed or rusted and in need of lubrication. Other causes include a bent shift fork, a worn or defective synchronizer, a twisted main shaft and an improperly adjusted clutch.

3. **Transmission Sticks in Gear**

Conditions that cause difficulty shifting into gear can also cause the transmission to stick in gear. These include improper shift-linkage adjustment and the linkage failing to move freely. Other causes include improper clutch-linkage adjustment and any condition that prevents the clutch from disengaging.

The transmission may stick in gear if the interlock device fails to operate properly and if a synchronizer sleeve does not slide freely on the hub splines. Lack of lubricant in the transmission or use of the wrong lubricant may also cause the transmission to stick in gear.

4. **Transmission Jumps Out of Gear**

Improperly adjusted shift linkage may cause the transmission to slip or jump out of gear. Binding or an excessively stiff boot on the gearshift lever may pull it back to neutral from any gear position. To check the boot, squeeze it. If the boot is too stiff, replace it.

Worn splines in the synchronizer sleeve or worn external teeth on the gear may cause the transmission to jump out of gear. Both the sleeve and the external teeth often wear at the same time. When this condition is found, replace both the sleeve and the gear.

Sometimes the transmission begins jumping out of gear immediately after the clutch or transmission has been serviced or replaced. Check for misalignment between the transmission and the engine. A pulsating clutch pedal may indicate clutch-housing misalignment. If the clutch housing is out of line, then so is the transmission.

5. **Gear Clash When Shifting**

A worn or defective synchronizer will cause gear clash during shifting. This may be due to a broken synchronizer spring or a worn cone surface on a synchronizer ring. Gear clash also occurs if the clutch does not fully disengage and if a gear sticks on the main shaft.

Gear clash may occur if a sudden shift is made to first or to reverse before the gears stop moving. Some transmissions do not have a synchronizer on first or reverse.

To shift into either of these positions without gear clash, the driver must wait until the gears stop turning ("spin down"). Then the shift lever can be moved and the gears will mesh without clashing.

A worn or dry pilot bearing or bushing may drag around the input shaft even after the clutch is disengaged. This cause gear clash when shifting as will incorrect lubricant in the transmission.

6. **Transmission Noisy in Gear**

Noise while the transmission is in gear could result from any condition. The noise could also be due to a defective friction disc in the clutch or a defective engine vibration damper. Other causes include a worn or dry rear bearing on the transmission output shaft, a loose gear on the output shaft and worn or damaged gear teeth, synchronizers, or speedometer gears. Transmission troubles may cause several types of **noise.**

A whining or growling noise may be either steady or intermittent. It can be due to worn, chipped, rough or cracked gears. As the gears continue to wear, the noise may take on a grinding sound. It will be the loudest in the gear position that throws the greatest load on the worn gears.

Bearing trouble often causes a hissing noise that develops into a bumping or thudding sound as the bearing wears. Metallic rattles may be caused by worn or loose parts in the shift linkage, or by gears loose on the shaft splines. Sometimes noise from defective cushions springs in the clutch friction disc or from the engine vibration damper carry into the transmission. Typically, this noise is heard only at certain engine speeds.

While diagnosing transmission noise, listen carefully to determine in which gear position the noise is loudest. This information helps pinpoint the worn or defective parts.

7. **Transmission Noisy in Neutral**

Noise heard with the transmission in neutral and the clutch engaged may be caused by transmission misalignment with the engine. It may also be caused by a defect in any of the parts that are rotating. Possible causes include a worn or dry bearing, a worn gear, a worn or bent counter gear, or excessive counter gear endplay.

8. **Transmission Noisy in Reverse**

Noise in reverse is probably due to a damaged or worn reverse idler gear or bushing, reverse gear on the main shaft or counter gear. A damaged shift mechanism will also cause noise in reverse

9. **No Power through Transmission**

If no power flows through the transmission when it is in gear and the clutch engaged, the clutch may be slipping. Internal transmission causes include teeth stripped from gears, a broken shift fork or linkage part, splines shared off and a broken gear or shaft.

10. Transmission Oil Leaks

Various places lubricant may leak from a manual transmission. If the lubricant in the transmission is not the correct type, it may foam excessively. The foam will completely fill the case and then begin to leak out. To prevent foaming, fill the transmission with the specified lubricant to the proper level. An overfilled transmission, a loose drain plug or fill or fill plug, and a cracked transmission case or extension housing will also leak oil.

3.3 Checking fluids and Lubricant

Sometimes, problems such as noise and hard shifting are caused by insufficient or incorrect lubricant. If the customer is lucky, the problem might be corrected by repairing any leaks and refilling with approved lubricant before substantial damage has been done. Leaks can occur due to gasket failure, oil seal failure, loosen or missing case bolts, or case damage. The lubricant level on most transmissions should reach the bottom of the fill hole when at operating temperature. You should be able to easily reach it with a finger. Make sure the piece you remove is indeed the fill plug and not transmission hardware before removing it.

The oils seals are normally lip seals found in the front bearing retainer and the rear of the extension housing. When these seals leak, you should check or replace the shaft bushing or bearing, too. A bad bushing or bearing allows too much lateral movement of the shaft, which is often what caused the seal to leak in the first place. The extension housing bushing and seal can usually be replaced without removing the transmission.

3.3.1 Check and refill transmission/transaxle fluids

Most manual transmission/transaxles have an access port located in the side of the case that is at the correct height for the fluid level. To check the fluid level:

- ✓ The vehicle must be raised in the level position
- ✓ The technician must locate and identify the access port, remove the access port, and determine if the fluid level is at or near the access port opening
- ✓ If fluid level is low, the technician must first determine the correct fluid specified for refilling the transmission/transaxle
- ✓ Then, using a fluid pump, fluid is added through the access port until it reaches the bottom of the opening (do not overfill)

- ✓ Re-install the access port plug and clean away any remaining fluid residue from the outside of the transmission/transaxle

3.3.2 Diagnosing and Correcting for Fluid Loss

How to diagnose fluid loss and fluid condition concerns and determine necessary action to correct the condition

A visual inspection is used to identify the cause of manual transmission/transaxle fluid loss. The inspection should include fluid leaks at each seal and gasket area and at the clutch housing. Fluid leaking from the clutch housing could be caused by a fluid leak from the transmission input shaft seal (not visible without removing the transmission). If the input shaft seal fails, transmission/transaxle fluid can flow into the clutch housing where it leaks through the opening to the outside of the clutch housing.

Note: *Fluid leaking from the clutch housing must be analyzed to determine the source. Engine oil and clutch release fluid as well as transmission/transaxle fluid are all possible sources of fluid leakage from the clutch housing. Check transmission/transaxle case and extension housing(s) for leaks that may be caused by cracks or damage to these components.*

Check transmission/transaxle fluid condition:

- ✓ Remove a small amount of fluid and place in a clean container
- ✓ Inspect the fluid for water contamination
    - If the fluid is milky or foamy, water may have entered the transmission/transaxle
    - If the fluid appears to be burned, the transmission may have been driven with low fluid level or have been abused by the driver
- ✓ Inspect the fluid for metal particles
    - Fine brass colored particles are normally the result of synchronizer wear
    - Small silver metal particles can be caused by gear wear
    - Chunks of metal are signs of gear damage
- ✓ Based on the type and amount of material in the fluid, the technician must determine the necessary action to correct the condition

- ✓ Contaminated fluid must be drained and replaced, but if the transmission/transaxle has symptoms that indicate that damage has occurred, changing the fluid may not correct the condition
- ✓ A small amount of brass or silver particles in the fluid may be normal and if the vehicle has no symptoms of transmission/transaxle problems, draining and replacing the fluid is the only service required
- ✓ If metal chunks or a large amount of brass or metal particles are found in the fluid or if the vehicle has symptoms of transmission /transaxle problems, the transmission/transaxle will need to be removed and repaired or replaced

3.3.3 Draining and Refilling

Review service information to determine the correct procedure and correct fluid type for vehicle being serviced.

Common procedures for draining and refilling the transmission/transaxle and final drive normally include:

- ✓ Remove the drain plug (not all units have drain plugs; use service information to determine how to remove the old fluid) and catch the old fluid as it drains
- ✓ When all of the fluid has drained out, reinstall the drain plug and tighten to correct specifications
- ✓ Remove the fill port, access plug and using a fluid pump, refill the transmission/transaxle to the correct level
- ✓ Reinstall the access port plug and tighten to correct specifications

Many transaxles have separate compartments for the transmission fluid and differential fluid. In these types it is necessary to:

- ✓ Drain the fluid from the differential (through a drain plug or removing a cover)
- ✓ Once all of the fluid has drained out, reinstall the drain plug or cove
- ✓ Use service information to identify the correct fluid type and the location of the differential fill access port plug
- ✓ Remove the fill plug and use a fluid pump to refill the differential to the correct level
- ✓ Reinstall the full plug and tighten to the correct specifications

3.4 Clutch Service

Clutch services can range from adjustments and service of the release mechanism and other accessible components to replacement of the clutch assembly.

3.4.1 Clutch Adjustment

We have discussed the need for proper clutch adjustment. Some systems have partially or fully self-adjusting mechanisms and some of these have constant-contact release bearings. Others require periodic adjustment of the pedal free travel as routine maintenance. Refer to the service information for the vehicle for adjustment methods and specifications.

- ✓ **Mechanical Linkage** - The adjustment for mechanical linkages is usually found on the pushrod that actuates the clutch fork. The rod will have a threaded portion with an adjustment nut to lengthen or shorten the working part of the rod. The rod is shortened to increase free travel. A locknut (jam nut) is tightened against the adjustment nut to retain the adjustment. Two wrenches are usually needed to loosen and tighten the nuts.

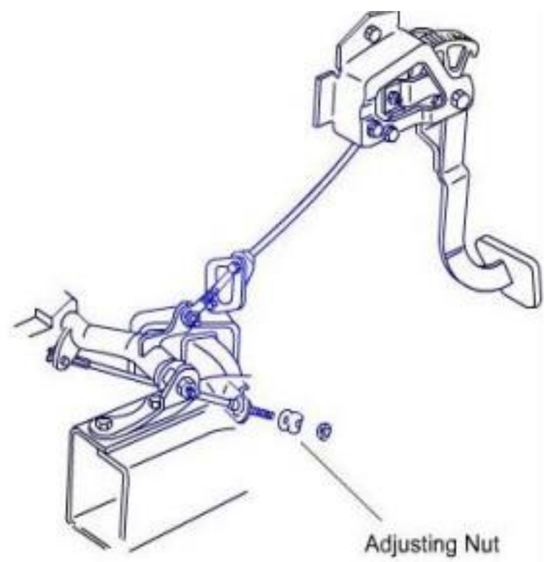


Figure 3.4-1 Mechanical Linkage Adjustment

- ✓ **Cable** - The clutch cable is also usually adjusted with a nut. The nut lengthens or shortens the cable housing.
- ✓ **Hydraulic Systems** - There is usually an adjusting nut on the fork pushrod, but sometimes it is located on the clutch master cylinder pushrod.

3.4.2 Bleeding the Hydraulic clutch System

Just as with a brake system, any time the hydraulic system is opened, the system must be bled to remove air. When filling the master cylinder reservoir, always use fresh hydraulic fluid from a sealed container. Do not re-use fluid that has been bled from the system. Keep in mind that brake fluid will damage painted surfaces and some plastics.

There are several methods of bleeding the hydraulic system. Professional bleeder machines that use pressure or vacuum can be used. The master cylinder should be bench bled before installation. The system can also be manually bled using an assistant. When manually bleeding the system, the fluid level in the master cylinder must be checked often. The assistant begins the procedure by depressing the clutch pedal to build up fluid pressure.

The assistant then continues to hold a steady pressure on the pedal while the other technician opens the bleeder valve and observes as fluid and air bubbles are expelled. The pedal will go to the floor and the assistant will continue to hold steady pressure on the pedal until the other technician closes the bleeder valve. This process is repeated until all the air has been expelled.

Removing all of the air from some hydraulic clutch systems can be tricky. Gravity bleeding can be effective. Below is a procedure for gravity bleeding a system.

1. Clean dirt and grease from the cap to ensure no foreign substances enter the system.

2. Remove cap and diaphragm and fill reservoir to the top with approved fluid only.

3. Fully loosen bleeder screw in the slave cylinder body.

4. Fluid will now begin to move from the master cylinder down the tube to the slave cylinder. It is important for efficient gravity fill that the reservoir is kept full at all times.

5. Bubbles will appear at the bleeder screw outlet. This means that air is being expelled. When the slave cylinder is full, a steady stream of fluid will come from the slave cylinder bleeder. At this point, tighten bleeder screw.

6. Assemble diaphragm and cap to the reservoir.

7. The hydraulic system should now be fully bled and should release the clutch. Check vehicle by starting, pushing clutch pedal to the floor and selecting reverse gear. There should be no grating of gears; if there is, the hydraulic system still contains air. If this is the case, repeat bleed procedure.

3.4.3 Clutch trouble shooting chart

Table 2 Clutch trouble shooting

Complaint	Possible causes	Check or correction
1. Clutch slips while engaging	a. Binding or incorrectly adjusted linkage b. Broken engine mount c. Internal damage or out of adjustment	• Lubricate, adjust; check for broken return spring • Replace • Remove clutch for service
2. Clutch chatters or grabs when engaging	a. Binding linkage b. Broken engine mount c. Misaligned clutch housing d. Internal problems: disk hub binding on shaft; grease or oil on facing; loose facing	• Lubricate, adjust • Replace • Realign or replace • Free disk hub on shaft; replace disk, pressure-plate assembly
3. Clutch spins or drags when disengaged	a. Linkage out of adjustment b. Broken engine mount c. Internal problems: worn facing; weak springs; oil or grease on facings; incorrect lever adjustment	• Readjust • Replace • Replace disk, pressure-plate assembly; adjust levers.
4. Clutch noises	a. Worn disk hub or shaft b. Misalignment c. Worn throw-out bearings d. Worn pilot bearing in crankshaft e. Linkage pilots need lubrication f. Release levers rubbing g. Worn out or weak retracting springs (diaphragm)	• Replace • Align transmission and clutch with engine • Replace • Replace • Lubricate • Adjust • Replace
5. Clutch pedal pulsation	a. Misalignment b. Flywheel not seated or warped c. Release levers out of adjustment d. Warped disk or pressure plate	• Align transmission and clutch with engine • Seat flywheel on flange or replace • Adjust • Replace
6. Rapid friction-disk-facing wear	a. Driver abuse b. Crack in flywheel or pressure-plate faces c. Internal problems: weak spring; oil on facing; release lever out of adjustment d. Linkage binding or out of adjustment	• Avoid riding clutch, speed shifts, popping clutch • Replace • Replace parts; adjust levers • Lubricate; adjust
7. Clutch pedal stiff	a. Binding in linkage b. Pedal shaft binding on floor-board seal c. Over-centers s spring out of adjustment or broken	• Lubricate, adjust • Free up seat, lubricate • Adjust, replace
8. Hydraulic-clutch troubles	a. Gear clashing, trouble shifting into and out of mesh.	• Hydraulic clutches can have any of the troubles listed in the chart. Also, if the hydraulic system is not working, gear clash and shifting troubles will result.

Operation Sheet-1

Operation Title: Manual Transmission Parts

Purpose: Every learner should identify Manual Transmission Parts

Instruction:

- Safe working area
- Properly operated tools and equipment
- Appropriate working cloths fit with the body

Required tools and equipment: Thickness gauge, combination wrench, hammer, compressor, wire brush, screw driver, vise grips, wrench, hex or Allen key, socket wrench

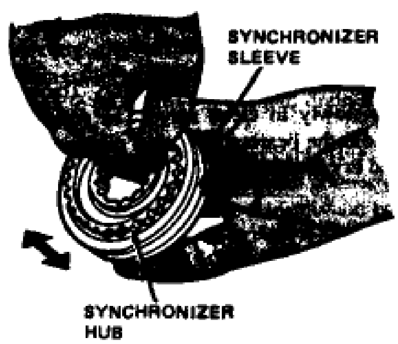
Consumable Materials: Water, first aid kit, waste bin,

Precautions:

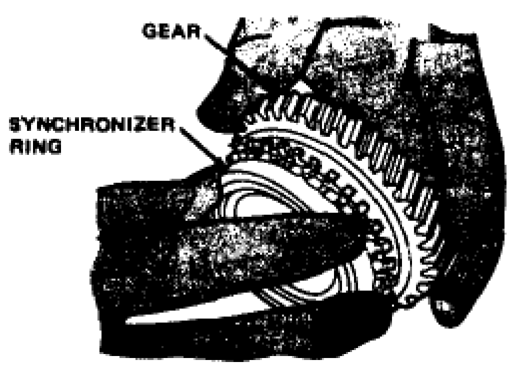
- Wearing proper clothes, eye glass, glove
- Make working area hazard free

Inspecting Manual Transmission Parts

1. Inspect the transmission case for cracks and worn or damaged bearing bores and threads.
2. Check the front and back of the case for nicks or burrs that could cause misalignment with the flywheel housing or extension housing.
3. Remove all burrs with a fine file.
4. Check the condition of the shift levers, shift rails, forks, shafts and gears.
5. Replace the counter gear and any other gear if teeth are worn, broken, chipped or damaged.
6. Replace the counter gear shaft if it is worn, bent or scored. In some transmissions, the bushings in the reverse gear and reverse-idler gear are not serviced separately.
7. Replace the reverse-idler gear if the bushing is worn. The new gear has a new bushing in it.
8. Check each synchronizer sleeve for the movement on its hub.
9. Look for worn or damaged splines.
10. Inspect the teeth on each synchronizer ring.

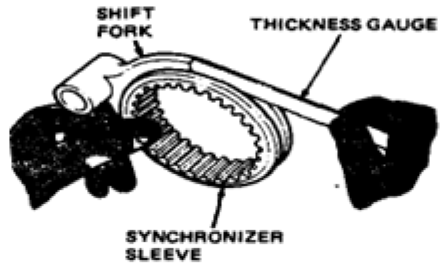


(A) CHECKING HUB AND SLEEVE



(B) CHECKING RING WEAR

11. Replace the synchronizer ring if it has chipped or worn teeth or marks on the gear face.
12. Check the amount of synchronizer-ring wear by placing the ring on its gear case.
13. With a thickness gauge, measure the clearance between the side faces. A typical specification is to replace the synchronizer ring or gear if the clearance is less than 0.031 inch (0.8 mm).
14. Inspect the shaft fork and groove in the synchronizer sleeve for wear or damage.
15. Position the shift fork in the synchronizer sleeve.
16. Measure the clearance between the fork and the groove with a thickness gauge. A typical specification is that the clearance is less than 0.031 inch (0.8 mm).



MEASURING SLEEVE-TO-FORK CLEARANCE

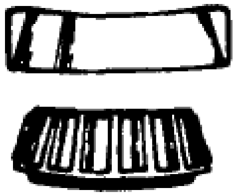
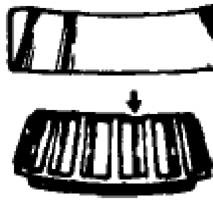
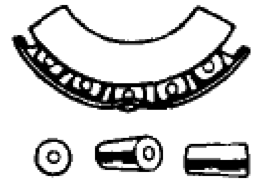
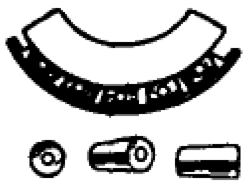
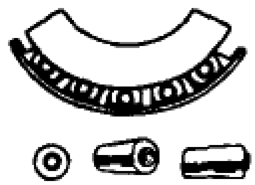
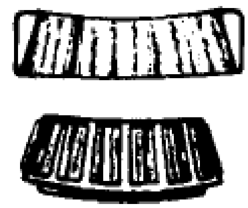
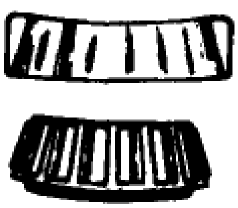
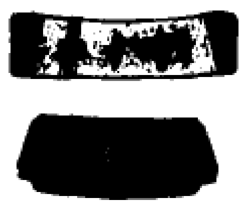
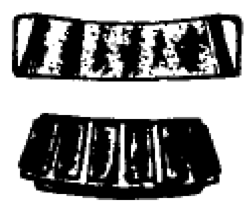
Inspecting Ball and Roller Bearings

To inspect a bearing, first clean it as described above. Metal particles clinging to the bearing indicate it has become magnetized. Use a demagnetizer to remove the magnetism or replace the bearing.

There are various types of roller-bearing failure and the recommended service procedure. The below shows various ball-bearing failures. In addition, inspect for damage or cracks around the snap-ring groove. Also, replace the bearing if the ball cage is cracked or deformed. Replace any bearing that is broken, worn or rough.

1. If the bearing has no visible damage, give the bearing a spin test.
2. Lubricate the bearing races lightly with clean oil.
3. Turn the bearing back and forth slowly to coat the races and balls.
4. Hold the bearing vertically by the inner race. Some vertical movement between the inner and outer races is acceptable.
5. Spin the outer ring several times by hand, not with compressed air.
6. If you notice roughness or vibration or if the outer ring stops abruptly, re-clean the bearing.
7. Then lubricate it and spin it again. Roughness is usually caused by particles or dirt in the bearing.
8. Discard the bearing if it is still rough after cleaning and lubricating three times.
9. Hold the bearing horizontally by the inner race with the snap-ring groove up.
10. Spin the outer race several times by hand.

11. Discard the bearing if it is still rough after cleaning and lubricating three times.

 **GOOD BEARING**	 **BENT CAGE** Cage Damage Due To Improper Handling Or Tool Damage. Replace Bearing.	 **BENT CAGE** Cage Damage Due To Improper Handling Or Tool Damage. Replace Bearing.
 **BALLING** Metal Shears On Roller Ends Due To Overheat, Lubricant Problem Or Overload. Replace Bearing – Check Seals And Check For Proper Lubrication.	 **CRACKED INNER RACE** Race Cracked Due To Improper Fit, Cocking Or Poor Bearing Seats	 **ETCHING** Bearing Surfaces Appear Gray Or Grayish Black In Color With Related Etching Away Of Material Usually At Roller Spacing. Replace Bearing - Check Seals And Check For Proper Lubrication.
 **BRINELLING** Surface Indentation In Races Caused By Rollers Either Under Impact Loading Or Vibration While The Bearing Is Not Rotating. Replace Bearing If Rough Or Noisy.	 **HEAT DISCOLORATION** Heat Discoloration Is Dark Blue Resulting From Overload Or No Lubricant (Yellow Or Brown Color Is Normal. Excessive Heat Can Cause Softening Of Races And Rollers To Check For Loss Of Temper On Races Or Rollers A Simple File Test May Be Made. A File Drawn Over A Hard Part Will Glide Readily With No Metal Cutting. Replace Bearing If Over Heating Damage Is Indicated. Check Seals And Other Parts.	 **FATIGUE SPALLING** Flaking Of Surface Metal Resulting From Fatigue. Replace Bearing – Clean All Related Parts.

Operation title: Inspecting Ball and Roller Bearings

To inspect a bearing, first clean it as described above. Metal particles clinging to the bearing indicate it has become magnetized. Use a demagnetizer to remove the magnetism or replace the bearing.

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15. Hold the bearing vertically by the inner race. Some vertical movement between the inner and outer races is acceptable.
16. Spin the outer ring several times by hand, not with compressed air.
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19. Discard the bearing if it is still rough after cleaning and lubricating three times.
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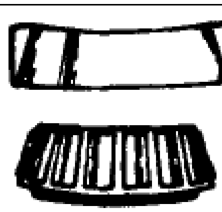
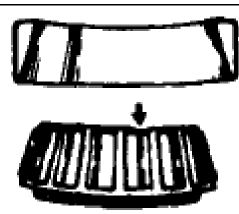
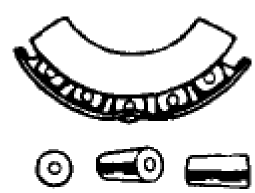
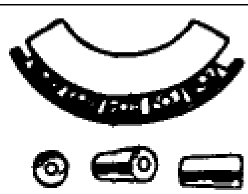
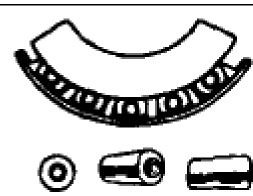
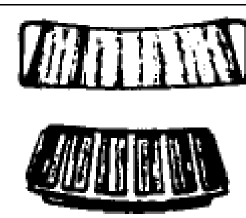
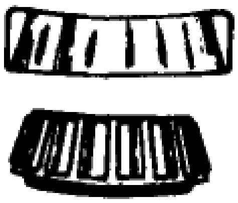
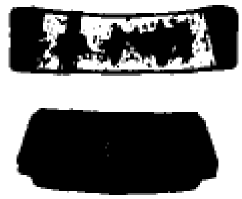
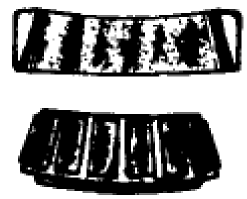
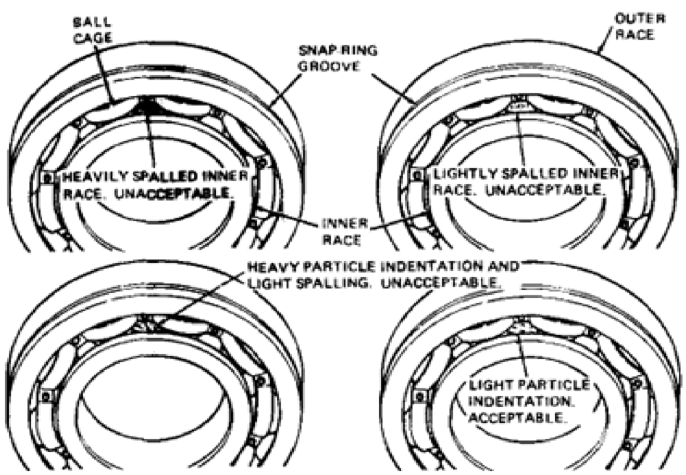
 **GOOD BEARING**	 **BENT CAGE** Cage Damage Due To Improper Handling Or Tool Damage. Replace Bearing.	 **BENT CAGE** Cage Damage Due To Improper Handling Or Tool Damage. Replace Bearing.
 **BALLING**	 **CRACKED INNER RACE**	

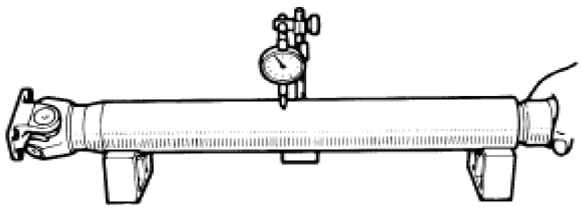
	Metal Shears On Roller Ends Due To Overheat, Lubricant Problem Or Overload. Replace Bearing – Check Seals And Check For Proper Lubrication.	Race Cracked Due To Improper Fit, Cocking Or Poor Bearing Seats	**ETCHING** Bearing Surfaces Appear Gray Or Grayish Black In Color With Related Etching Away Of Material Usually At Roller Spacing. Replace Bearing **-** Check Seals And Check For Proper Lubrication.
	 **BRINELLING** Surface Indentation In Races Caused By Rollers Either Under Impact Loading Or Vibration While The Bearing Is Not Rotating. Replace Bearing If Rough Or Noisy.	 **HEAT DISCOLORATION** Heat Discoloration Is Dark Blue Resulting From Overload Or No Lubricant (Yellow Or Brown Color Is Normal. Excessive Heat Can Cause Softening Of Races And Rollers To Check For Loss Of Temper On Races Or Rollers A Simple File Test May Be Made. A File Drawn Over A Hard Part Will Glide Readily With No Metal Cutting. Replace Bearing If Over Heating Damage Is Indicated. Check Seals And Other Parts.	 **FATIGUE SPALLING** Flaking Of Surface Metal Resulting From Fatigue. Replace Bearing – Clean All Related Parts.

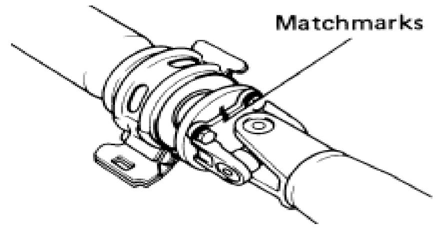


Propeller Shaft Inspection & Service

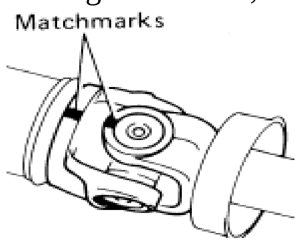
PROCEDURE:

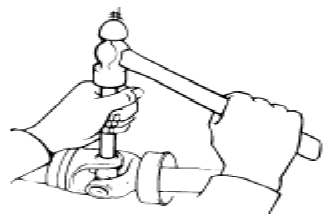
1. Inspect propeller shaft & intermediate shafts runout. If runout is greater than maximum, replace the shaft.
   Maximum runout: 0.8 mm (0.031 in.)   Actual Reading: ______________
2. Disassembly, separate propeller shaft and intermediate shaft. Place a match mark on both flanges. Remove four bolts, washers and nuts.

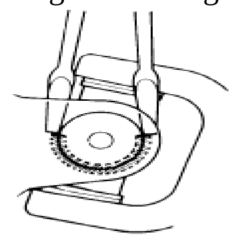




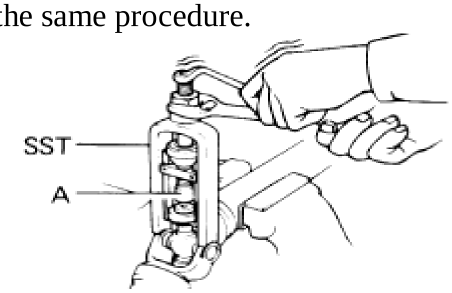
3. Replace spider bearing, place match mark on shaft and flange or yoke, remove snap rings, slightly tap in the bearing outer races, use two screwdrivers remove the four snap rings from the grooves.

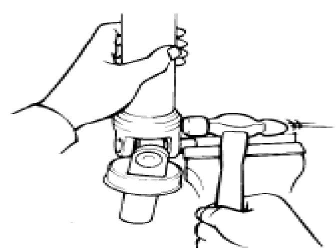




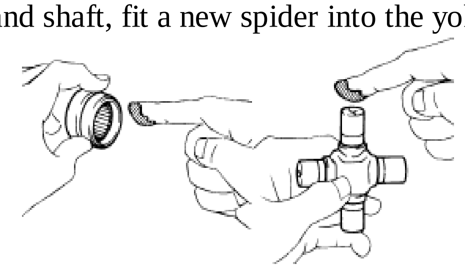


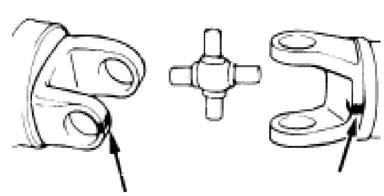
4. Remove spider bearing, using SST push out the bearing from the propeller shaft, clamp the bearing outer race in a vise and tap off the propeller shaft with a hammer, remove the bearing on opposite side in the same procedure.



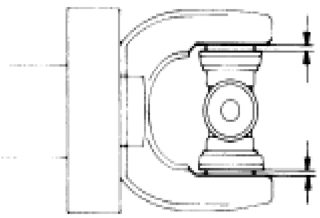


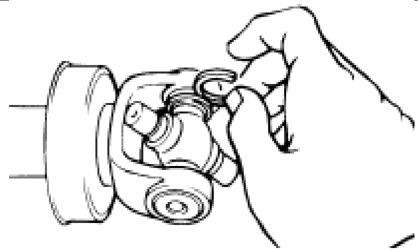
5. Install spider bearing, apply MP grease to the spider and bearings, align the match mark on the yoke and shaft, fit a new spider into the yoke, using SST install new bearings on the spider.





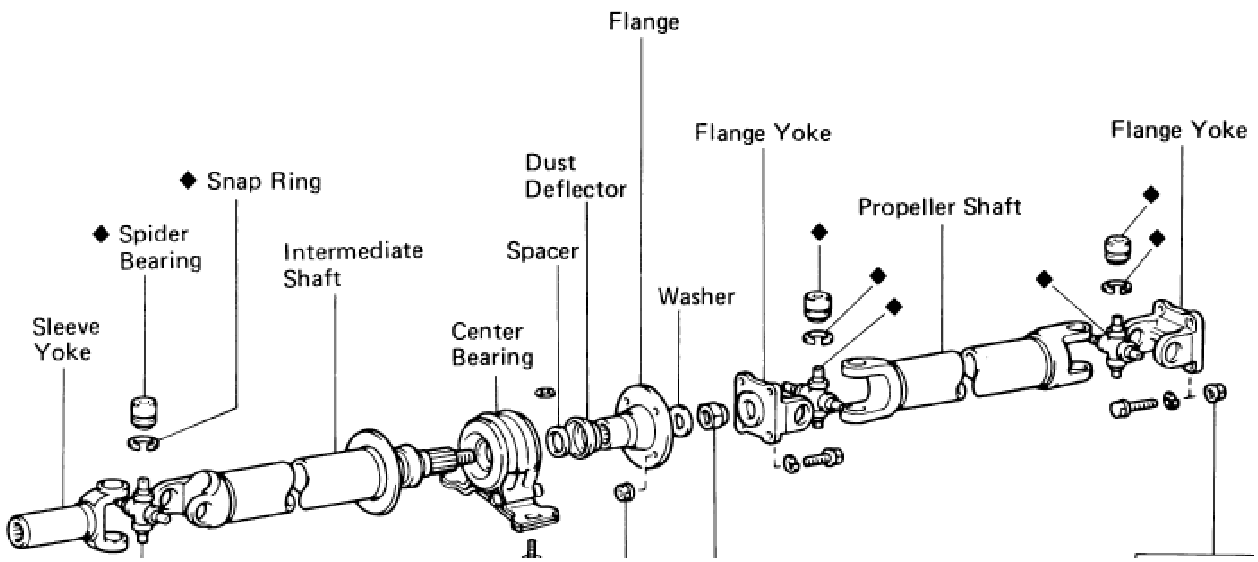
6. Using SST, adjust both bearings so that the snap ring grooves are at maximum and equal widths, install two snap rings of equal thickness which will allow **0 – 0.05 mm (0 – 0.0020 in.)** axial play. Do not re use snap rings.





Mark	Color	Thickness mm (in.)
1	–	2.100 – 2.150 (0.0827 – 0.0846)
2	–	2.150 – 2.200 (0.0846 – 0.0866)
3	–	2.200 – 2.250 (0.0866 – 0.0886)
–	Brown	2.250 – 2.300 (0.0886 – 0.0906)
–	Blue	2.300 – 2.350 (0.0906 – 0.0925)
6	–	2.350 – 2.400 (0.0925 – 0.0945)
7	–	2.400 – 2.450 (0.0945 – 0.0965)
8	–	2.450 – 2.500 (0.0965 – 0.0984)

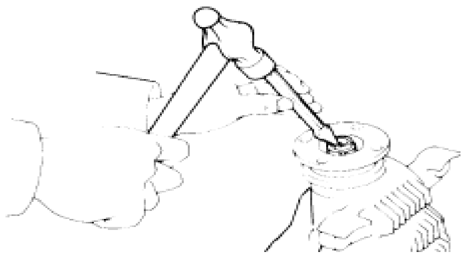
Propeller shaft components

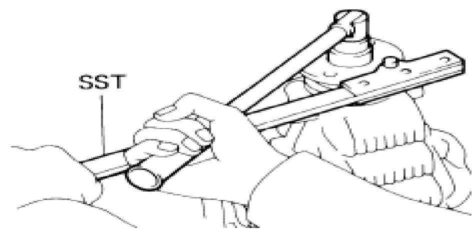


Differential Inspection & Service

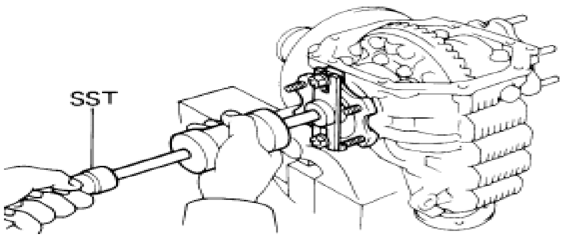
Disassembly

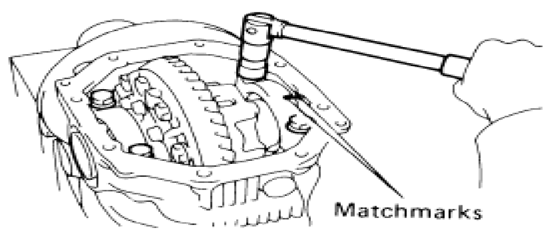
1. Disassembly, using hammer & chisel loosen the stake part of nut, using SST hold the flange and remove the nut, remove the companion flange.



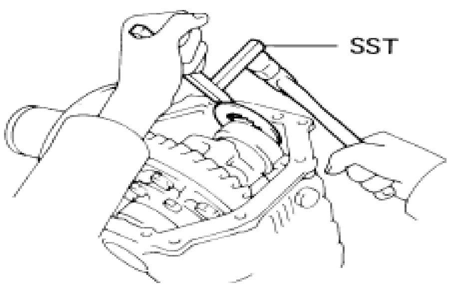


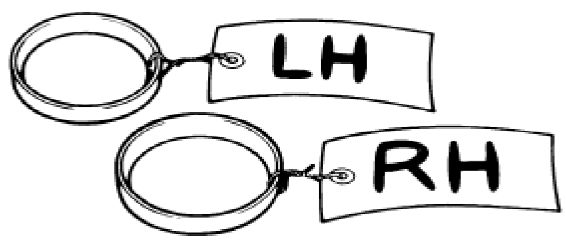
2. Using SST, pull out the side gear shaft from the differential, remove differential case, place match marks on the bearing cap and differential carrier, remove the two bearing caps.



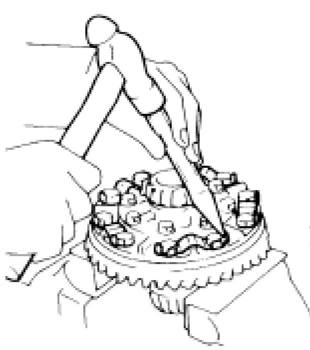


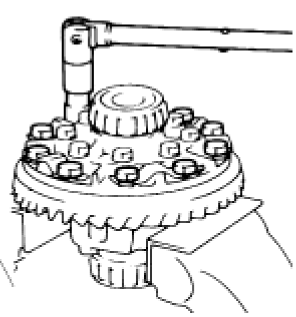
3. Remove the two side bearing preload adjusting plate, remove the differential case and bearing outer race from the carrier, tag the bearing outer races to show the location for reassembly.





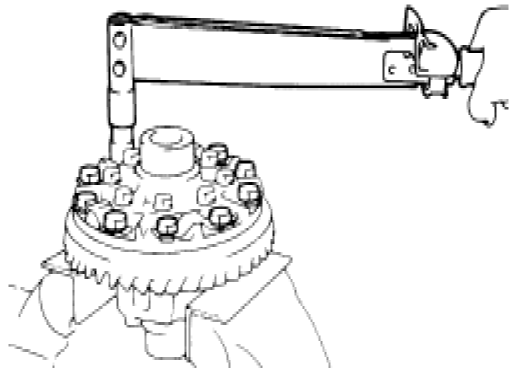
4. Remove the ring gear set bolts and lock plate, place match mark on the ring gear and differential case, using hammer tap on the ring gear to separate from differential case, disassemble the differential case.

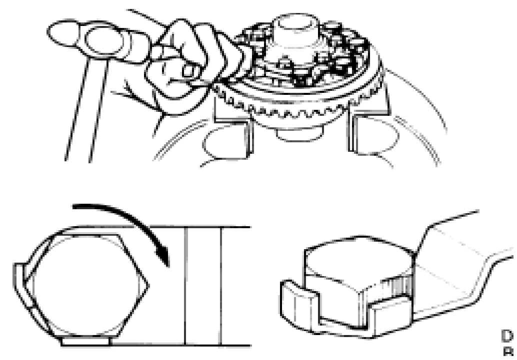




Reassembly & Inspection

5. Assemble the differential case, install the ring gear, align the match marks, coat set blots with gear oil and tighten uniformly.

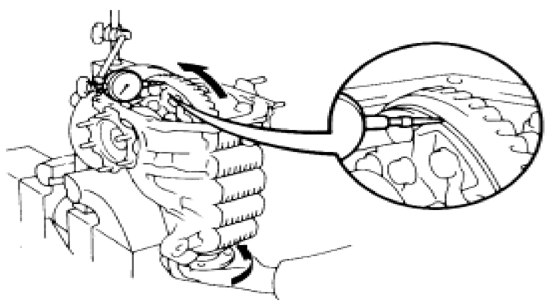


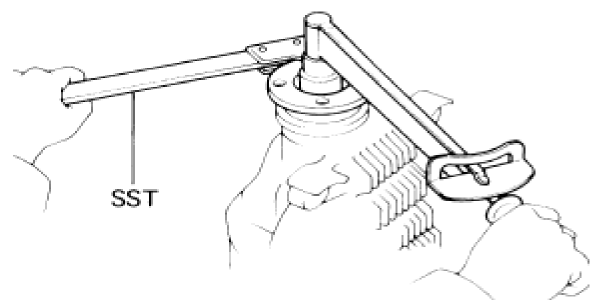


6. Inspect ring gear runout, **maximum runout: 0.1 mm (0.004 in.),** adjust the drive pinion preload by tightening the companion flange, using torque wrench, measure the preload.

   New bearing: 10 – 16 kg-cm (8.7 – 13.9 in.-lb, 1.0 – 1.6 N.m)

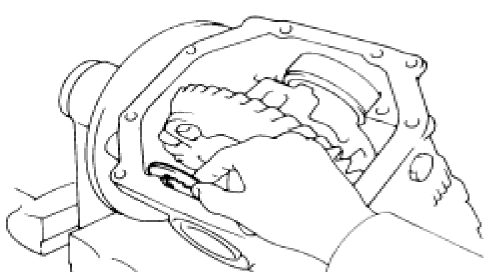
   Reused bearing: 5 – 8 kg-cm (4.3 – 6.9 in.-lb, 0.5 – 0.8 N.m)

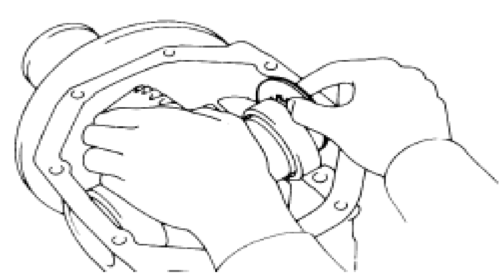




7. Adjust ring gear backlash, install only the plate washer on the ring gear back side, select a ring gear back plate washer using back lash as reference.

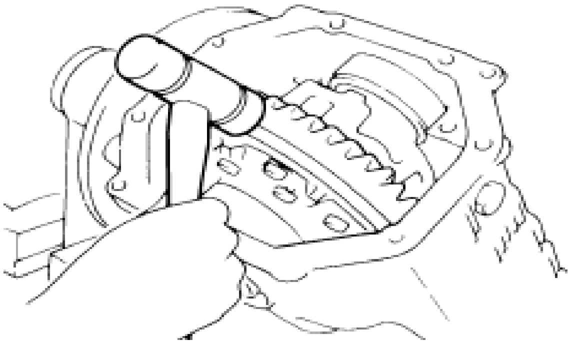
   Back lash (reference): 0.10 mm (0.0039 in).

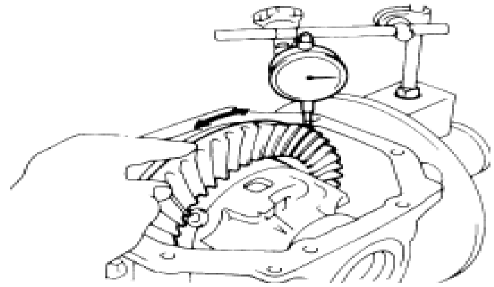




8. Using hammer snug down the washer and bearing by tapping the ring gear, using dial indicator measure the ring gear backlash.

   Backlash: 0.13 – 0.18 mm (0.0051 – 0.0071 in).

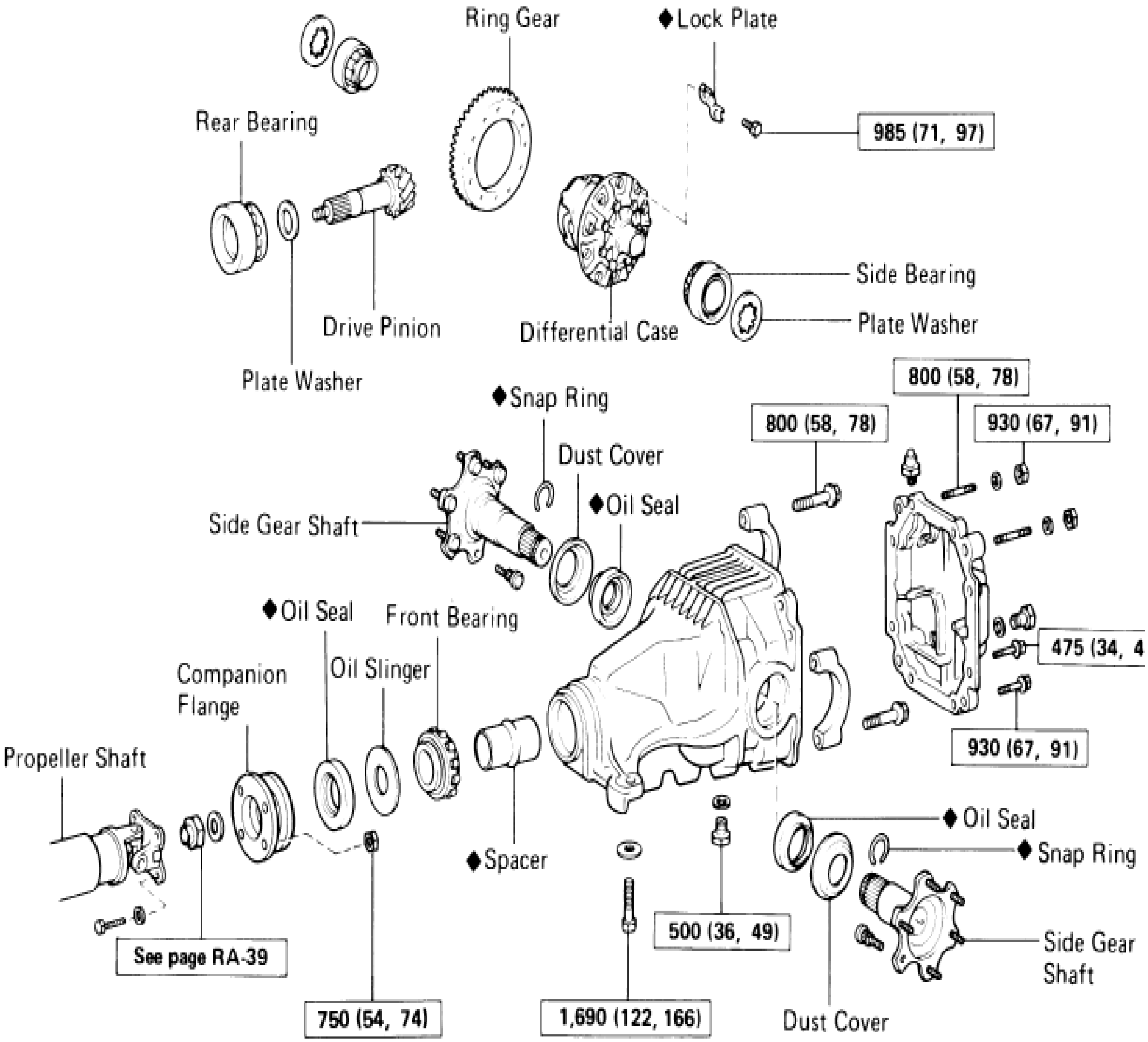




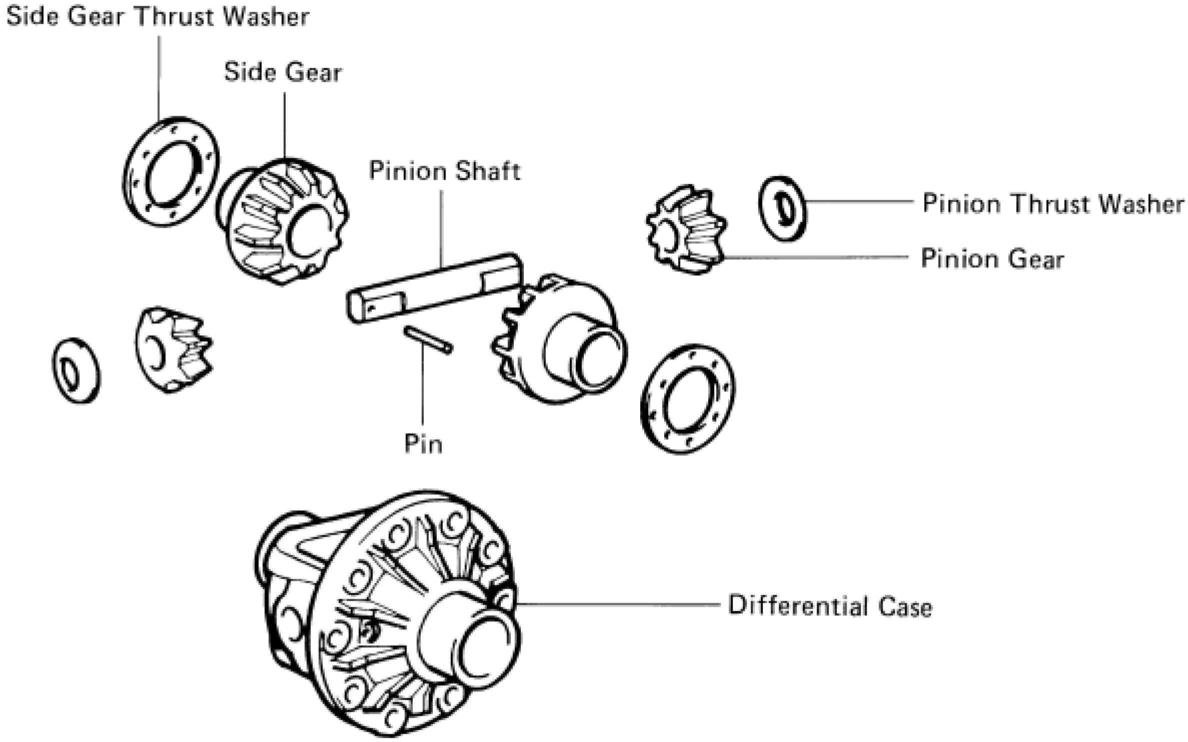
Washer thickness

Thickness		mm (in.)
2.57 – 2.59 (0.1012 – 0.1020)	2.90 – 2.92 (0.1142 – 0.1150)	3.23 – 3.25 (0.1272 – 0.1280)
2.60 – 2.62 (0.1024 – 0.1031)	2.93 – 2.95 (0.1154 – 0.1161)	3.26 – 3.28 (0.1283 – 0.1291)
2.63 – 2.65 (0.1035 – 0.1043)	2.96 – 2.98 (0.1165 – 0.1173)	3.29 – 3.31 (0.1295 – 0.1303)
2.66 – 2.68 (0.1047 – 0.1055)	2.99 – 3.01 (0.1177 – 0.1185)	3.32 – 3.34 (0.1307 – 0.1315)
2.69 – 2.71 (0.1059 – 0.1067)	3.02 – 3.04 (0.1189 – 0.1197)	3.35 – 3.37 (0.1319 – 0.1327)
2.72 – 2.74 (0.1071 – 0.1079)	3.05 – 3.07 (0.1201 – 0.1209)	3.38 – 3.40 (0.1331 – 0.1339)
2.75 – 2.77 (0.1083 – 0.1091)	3.08 – 3.10 (0.1213 – 0.1220)	3.41 – 3.43 (0.1343 – 0.1350)
2.78 – 2.80 (0.1094 – 0.1102)	3.11 – 3.13 (0.1224 – 0.1232)	3.44 – 3.46 (0.1354 – 0.1362)
2.81 – 2.83 (0.1106 – 0.1114)	3.14 – 3.16 (0.1236 – 0.1244)	3.47 – 3.49 (0.1366 – 0.1374)
2.84 – 2.86 (0.1118 – 0.1126)	3.17 – 3.19 (0.1248 – 0.1256)	
2.87 – 2.89 (0.1130 – 0.1138)	3.20 – 3.22 (0.1260 – 0.1268)	

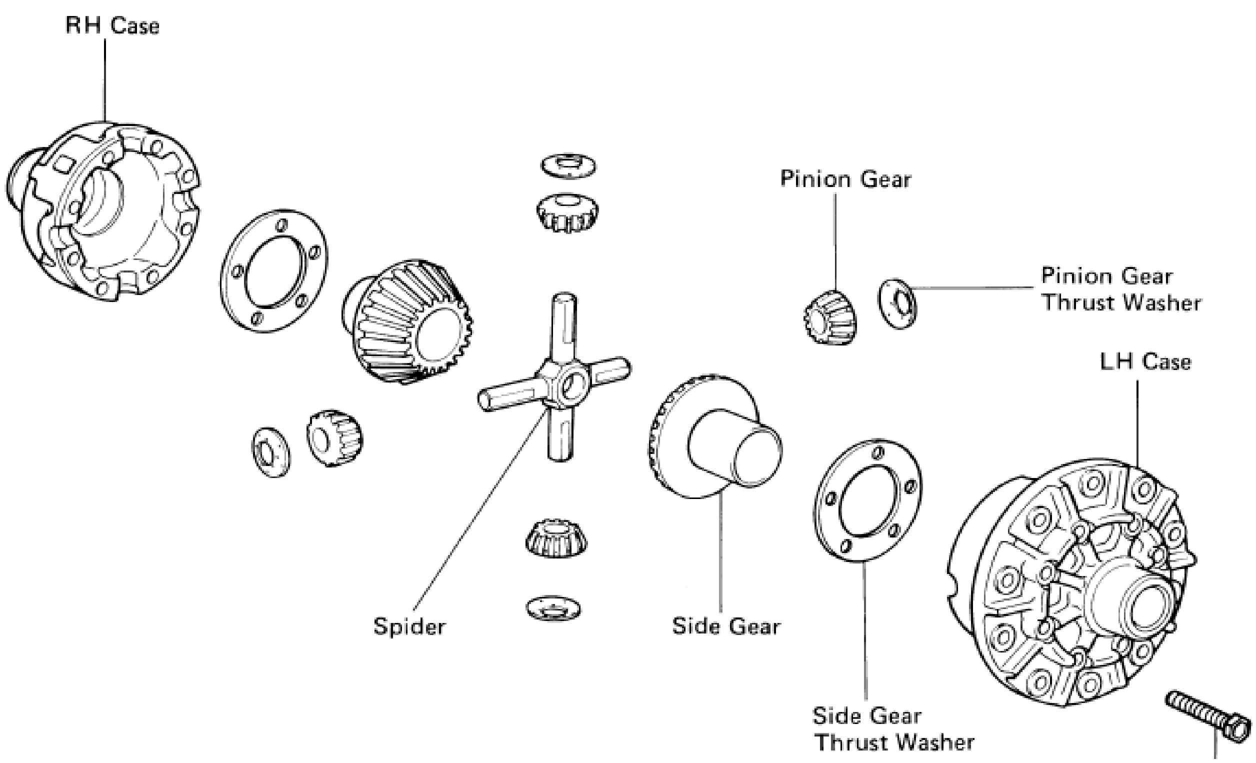
Differential components

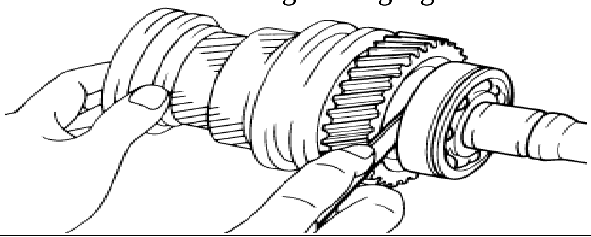


Differential case (conventional 2 pinion type)



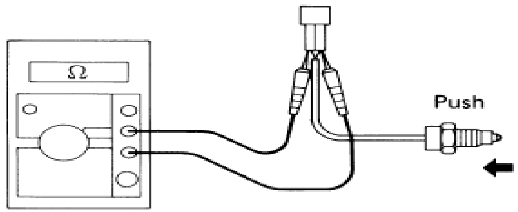
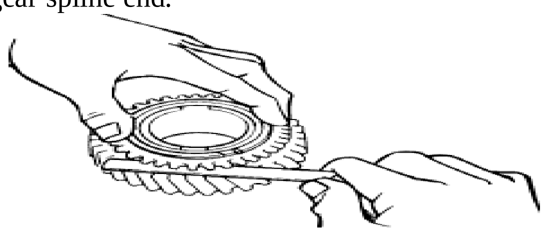
Differential case (conventional 4 pinion type)



<table>
<tr><th>ACTIVITY</th><th>SPICIFICATION</th><th>ACTUAL READING</th><th>REMARKS / RECOMMENDATION</th></tr>
<tr><td>1. Inspection of output assembly: Measure each gear thrust clearance using feeler gauge.
</td><td>Standard clearance:
0.10 – 0.25 mm (0.0039 – 0.0098 in.)
Maximum clearance:
0.30 mm (0.0118 in.)</td><td>1st gear:

2nd gear:

3rd gear:

4th gear:</td><td></td></tr>
<tr><td>2. Inspect back-up light switch, check that there is continuity between terminals.
</td><td><table><tr><th>Switch Position</th><th>Specified</th></tr><tr><td>Push</td><td>Continuity</td></tr><tr><td>Free</td><td>No continuity</td></tr></table></td><td></td><td></td></tr>
<tr><td>3. Inspection of shaft assembly: turn the ring and push it in to check the braking action. Measure the clearance between the synchronizer ring back and the gear spline end.

4. Measure each gear oil clearance using dial indicator.</td><td>Standard clearance:
0.7 – 1.7 mm (0.028 – 0.067 in.)
Minimum clearance:
0.5 mm (0.020 in.)
If clearance is less than limit replace the synchronizer ring.

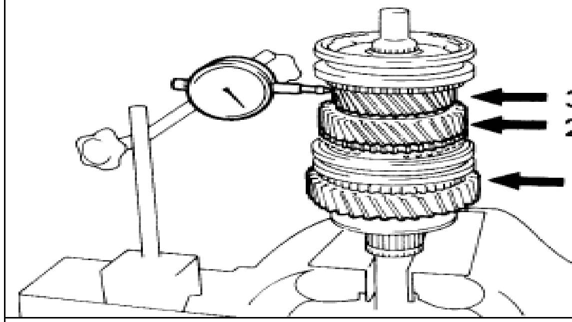
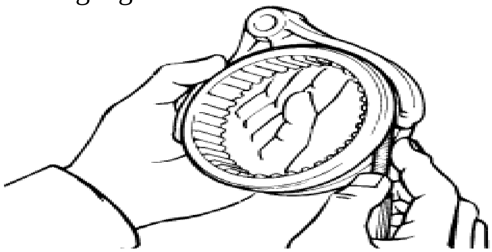
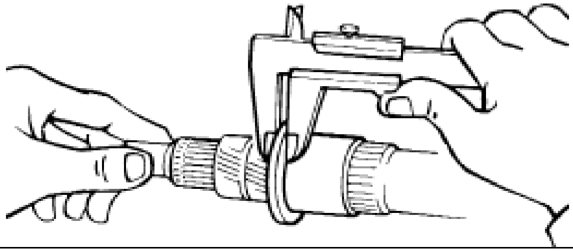
Standard clearance:
1st and 2nd gear 0.009 – 0.060 mm
(0.0004 – 0.0024 in)
3rd gear 0.060 – 0.103 mm
(0.0024 – 0.0041)
Maximum clearance:
1st and 2nd gear 0.15 mm (0.0059 in.)
3rd gear 0.20 mm (0.0079 in.)
If clearance exceeds the limit, replace the gear, shaft or needle bearing.</td><td>1st & 2nd gear synchronizer:

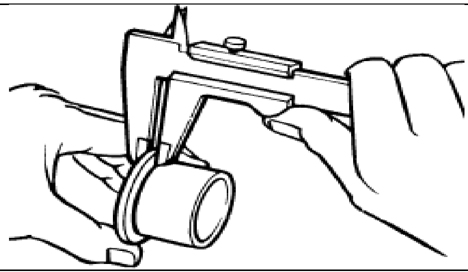
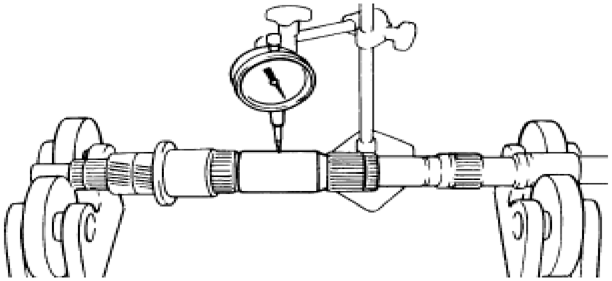
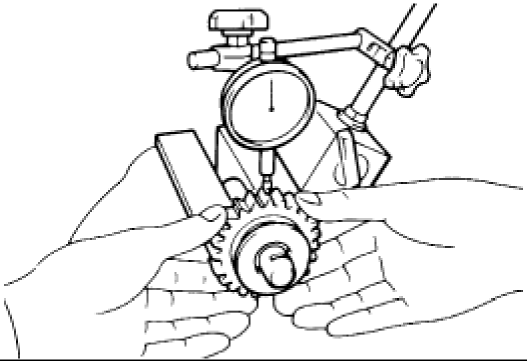
3rd & 4th gear synchronizer:

1st gear:

2nd gear:

3rd gear:</td><td></td></tr>
</table>

		4th gear:	
5. Measure clearance of shift fork and hub sleeves, using feeler gauge. 	**Maximum clearance:** 1.0 mm (0.039) If clearance exceeds the limit, replace the shift fork or hub sleeve.	1st & 2nd gear sleeve: 3rd & 4th gear sleeve:	
6. Measure the output shaft flange thickness using caliper. 	**Minimum thickness:** 5.60 mm (0.2205 in.)		
7. Measure the inner race flange thickness using caliper.	**Minimum thickness:** 4.76 mm (0.1874 in.)		

			
8. Check the shaft runout using dial indicator. 	**Maximum runout:** 0.06 mm (0.0024 in.)		
9. Measure reverse idler gear oil clearance using dial indicator. 	**Standard clearance:** 0.041 – 0.074 mm (0.0016 – 0.0029 in) **Maximum clearance:** 0.194 mm (0.0076 in.)		

LAP-TEST

- ✓ Task-1: Inspection & Service of Transmission/Trans axle
- ✓ Task-2: Bleed hydraulic clutch system
- ✓ Task-3: Inspecting mounting points and fittings
- ✓ Task-4: Checking fluids and Lubricant
- ✓ Task-5: Drive shaft Diagnosis Inspecting
- ✓ Task-6: Dismantle universal joints in to sub
- ✓ Task-7: Report the findings

Unit Four: Service power train drive line assemblies

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:
• Inspect tools and equipment • Clean tools and equipment • Lubricate tools and equipment • Store tools and equipment This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to: • Inspecting tools and equipment • Cleaning tools and equipment • Lubricating tools and equipment • Storing tools and equipment

4.1 Inspect Tools and equipment

If you are in the habit of using a power tool every day, it can be easy to fail to notice when that tool's performance gradually drops over time. That's why it is important to at least semi-regularly take a moment and inspect your most-used tools, paying close attention to signs of wear and performance issues. Run a few basic operations with a tool, paying close attention to warning signs like weaker than normal power levels, any sort of burning smell, and strange buzzes and noises coming from inside the tool. Any of these is a pretty strong indicator that there's something off with your tool and it may require some extra attention.

4.2 Clean Tools and equipment

It might seem like overkill at first, but be sure that each of your power tools gets cleaned every time you finish using it. Cleaning methods will vary from tool to tool, but most of the time everyday cleaning can be as simple as wiping dirt and dust from the casing. Something as simple as a good wipe down will keep particles from building up and getting into your tool's internal mechanisms. Tighter areas like filters can be kept dust free with a few blasts from a can of compressed air.

4.3 Lubricate Tools and equipment

Lubrication is an often neglected maintenance step that can really drag down tool performance, causing issues like chafing that can cause parts to quickly deteriorate. Most likely, each of your tools will have a section in their owner's manual explaining proper lubrication practices. Follow the recommended steps to ensure that your power tools remain the well-oiled machines they are meant to be.

4.4 Store Tools and equipment

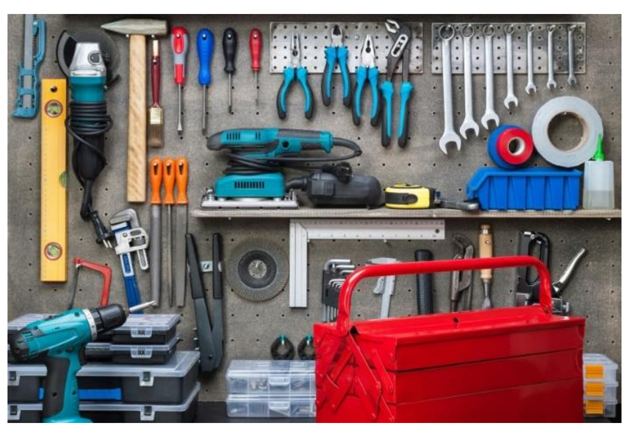


Figure 4-1 properly stored tools and equipment

Always store tools in a dry, climate-controlled environment. Moist and dirty environments can cause hand tools to rust and dull, and storing power tools in damp areas can degrade electrical components and cause parts to corrode over time. While fitting power tools back into their cases can be a pain, the case will go a long way towards protecting its tool from the environment. If you need the extra space, consider gutting your tool cases.

Self-check-2

Instruction: Short answer

1) How do we Inspect tools and equipment?
2) How can cultivate the habit of cleaning?
3) What the best practices for lubricate tools and equipment?
4) What are the storing tools and equipment?

Reference

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- *R.K Rajput, Automobile Engineering*
- *Prof. Dr.-Ing. Konrad Reif, Brakes, Brake Control and Driver Assistance Systems*
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