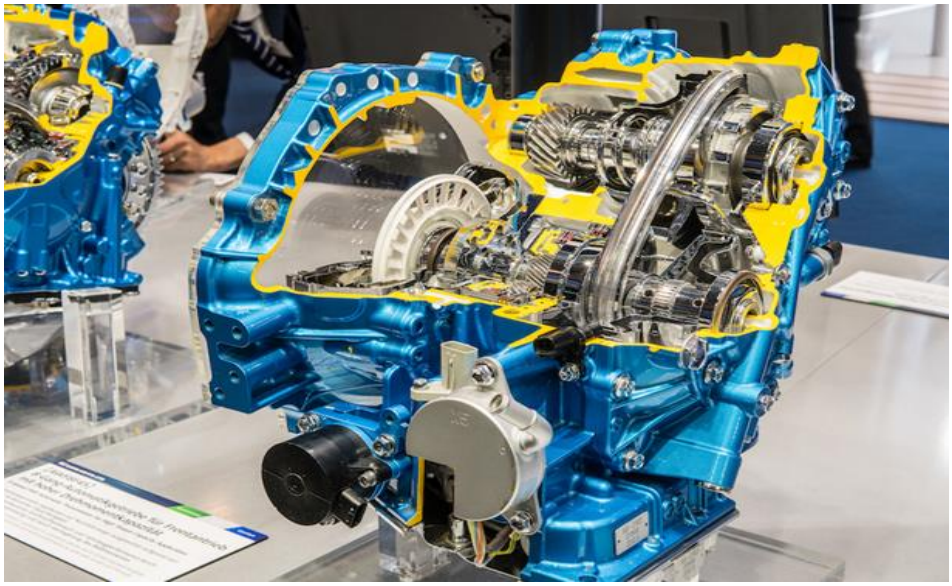
Automotive Mechanics

Level-III

Based on October, 2023 Curriculum Version-II



Module Title: Overhauling Clutch and Transmissions

Module code: EIS AUM3 M04 1023

Nominal duration: 70 Hours

Prepared by: Ministry of Labor and Skill

October 2023

የሥራና ክህሎት ሚኒስቴር
Ministry of Labor and Skills

Addis Ababa, Ethiopia

Table of Contents

Acknowledgment

Ministry of Labor and Skills wish to extend thanks and appreciation to the many representatives of TVT instructors and respective industry experts who donated their time and expertise to the development of this Teaching, Training and Learning Materials (TTLM).

Acronym

2WD	Two wheel drive
4WD-	Four Wheel drive
AWD	All wheel drive
CV	Constant Velocity
DMF	Dual-mass flywheel
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, clutch and transmission are among fundamental components of a vehicle that are providing power required to propel the vehicle. An automotive mechanic who is capable of servicing powertrain systems including clutch and transmission need to be competent enough in knowledge, skill and attitude required. Therefore, this module contains all essential instructional and operational information as well as self-check and lab tests to assist the trainee to prepare and conduct troubleshooting, repair and post repair test of transmission and clutch system functionality. In addition, 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 III occupational standard, particularly for the unit of competency: Overhaul clutch and transmissions

This module covers the units:

- Overview of clutch and transmission
- Applying OHS and environmental protection requirements
- Troubleshooting transmission and clutch faults
- Repairing Transmission and Clutch System
- Testing transmission and clutch system functionality

Learning Objectives of the Module

- Be familiar with different type clutches
- Determine gear ratio of different type gear trains
- Demonstrate transmission construction
- Diagnose clutch and transmission related faults
- Repair malfunctions associated with clutch and transmission
- Perform post repair tests for clutch and transmission proper functionality

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 ne: Introduction to Clutch and Transmission

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

- Introduction of powertrain
- Overview of Clutch System
- Basics of gear train
- Overview of Manual transmission and Transaxle
- Automatic Transmission

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:

- Understand purposes and types of transmission
- Grasp basics of gear train
- Be familiar with operation of clutch system
- Determine the gear ratio of different type gear trains
- Differentiate the layouts of transmission and transaxle
- Identify the internal and external components of clutch system
- Understand construction and operation of transfer case
- Grasp modern features of automatic transmission

1.1 Introduction to Powertrain

In Automotive professional competence area, the term powertrain shown in Figure 1.1 describes the main components that generate power and deliver it to the road surface to propel the vehicle. This includes the engine, clutch, transmission, drive shaft, final drive, differential, drive half axles and the drive wheels. However, the drivetrain excluding the engine serves two main functions such as transmits power from the engine to the drive wheels, and varies the speed and torque of the vehicle in wide operating range. The clutch is the first drivetrain component powered by the engine crankshaft. The clutch assembly that is located immediately after engine and before gearbox used to connect and disconnect the power flow between the engine and manual transmission or transaxle. The clutch system lets the driver to control power flow to the transmission.

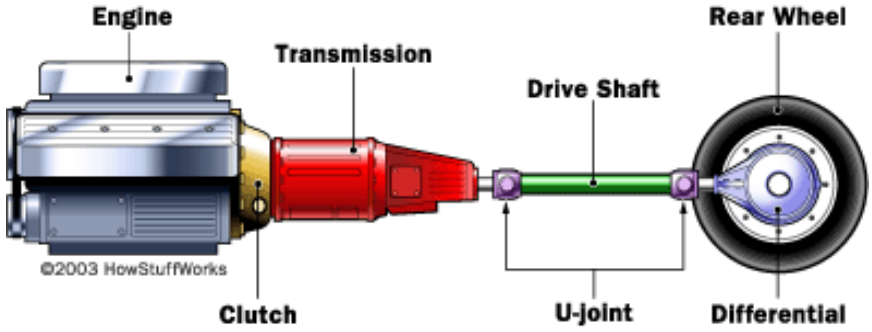


Figure 0.1 Typical powertrain of rear wheel drive vehicle

The transmission is an assembly of gears and shafts that is located after clutch and before the driveline or final drive in the direction of power flow. The transmission, while transmitting the engine power provides a means for changing the speed and torque of the engine before it reaches to the driving wheels best meet each particular driving situation. Manual transmissions require use of a clutch to engage and disengage the engine torque to the transmission input shaft as needed by the driver. A clutch used with manual transmissions/transaxles, mechanically connects the engine's flywheel to the transmission/transaxle input shaft. A special friction disc that is splined to the input shaft of the transmission accomplishes this. An automotive technician that is capable of overhauling clutch and transmission should have clear understanding of constructional and operational

features of different type clutch and transmission assemblies. This chapter provides essential information about the overview of clutch and transmission assemblies.

1.2 Overview of Clutch System

Clutch is a device to connect driving and driven shafts of a machine as shown in Figure 1.2, where the driven shaft can be disconnected almost instantaneously from the driving shaft as desired by the operator or driver.

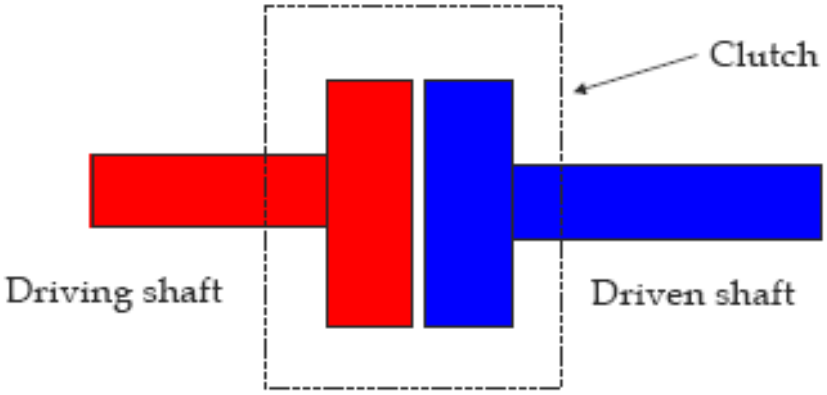


Figure 0.2: Basic layout of mechanical clutch coupling

1.2.1 Clutch Assembly

The clutch assembly is located between the transmission and engine where it provides a mechanical coupling between the engine's flywheel and the transmission's input shaft.

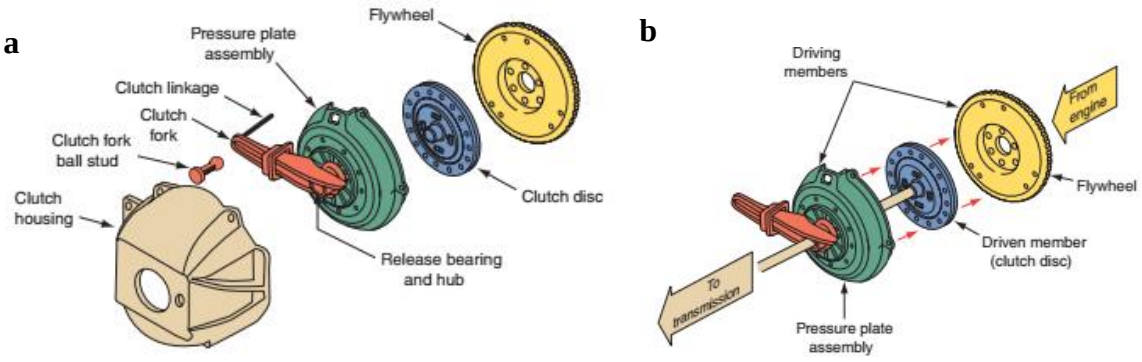


Figure 0.3: Major parts of the clutch assembly (a) and clutch operation and power flow during engaging (b)

Figure 1.3 (a) shows the components needed in clutch assembly such as the flywheel, clutch disc, pressure plate assembly, clutch release bearing (or throw-out bearing), and the clutch fork. The driver operates the clutch through a linkage that extends from the passenger compartment to the bell housing (also called the clutch housing) between the engine and the transmission. All manual transmissions require a clutch to engage or disengage the transmission. If the vehicle had no clutch and the engine was always connected to the transmission, the engine would stop every time the vehicle was brought to a stop. The clutch allows the engine to idle while the vehicle is stopped. It also allows for easy shifting between gears.

The basic principle of clutch operation is shown in Figure 1.3 (b). The pressure plate and flywheel are the drive or input members of the assembly. The clutch disc (plate), also called the friction disc, is the driven or output member and is connected to the transmission's input shaft.

- **Clutch Disengaging:-**When the clutch is depressed as shown in Figure 1.4, the clutch fork that 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.
- **Clutch Engaged:- w**hen the clutch is in the engaged position (clutch pedal up) as shown in Figure 1.5, the pressure on the throw out bearing is released and the force against the pressure plate spring(s), the spring exerts force on the clutch disc, holding (Clamping) it between the flywheel and the pressure plate.

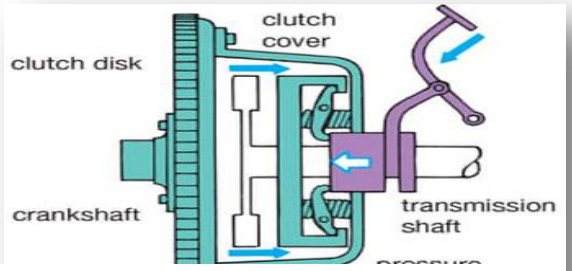


Figure 0.4: Operation of clutch during engaging

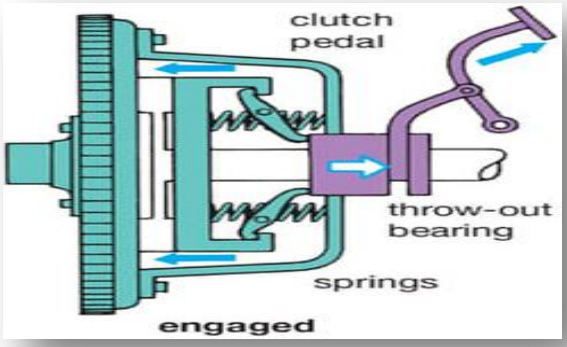
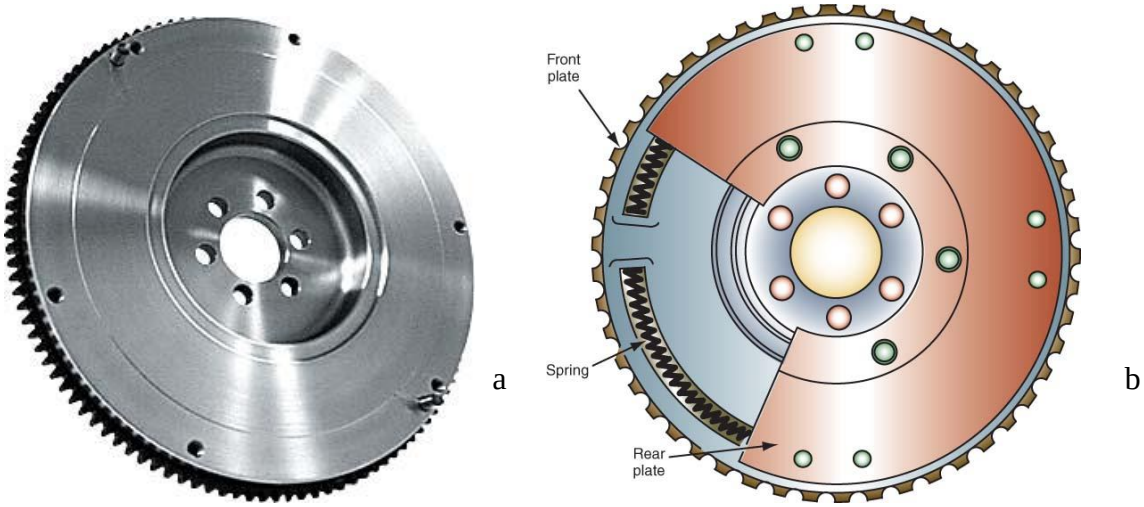


Figure 0.5: Operation of clutch during engaging

1.2.2 Components of the Clutch (Inside Assembly)

A. Flywheel

The flywheel shown in Figure 1.6 (a) is a fairly large wheel that is connected to the crankshaft. (Stores K.E during engine power stroke and release during idle strokes). It also provides some absorption of torsional vibration of the crankshaft and provides the inertia to rotate the crankshaft through the four strokes. It is normally made of nodular or gray cast iron, which has a high graphite content to lubricate the engagement of the clutch. Welded to or pressed onto the larger outside diameter of the flywheel is the starter ring gear allows for an excellent gear ratio, which provides for ample engine rotation during starting. A bore in the center of the flywheel and crankshaft holds the pilot bushing or bearing. This lubricated bearing, either a ball bearing or a bronze bushing, is used to support one end of the clutch shaft, which is also the transmission input shaft.



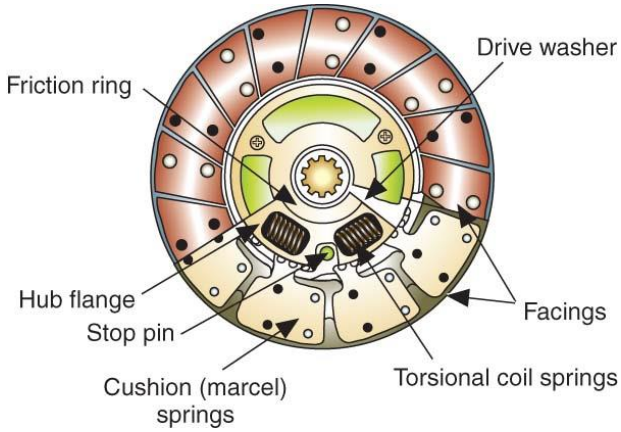
a b

Figure 0.6: A typical flywheel mounted to the rear of an engine's crankshaft (a) and dual-mass flywheel (b)

A few cars and light trucks use a dual-mass flywheel (DMF), where the flywheel hub and clutch mating area are two separate components as shown in Figure 1.6 (b). Springs are used to dampen engine and clutch engagement oscillations. These flywheels are used to reduce engine vibrations transmitted through the transmission, provide for smoother shifting, and reduce gear noise. Dual-mass flywheels can reduce the oscillations of the crankshaft before they move through the transmission (see Figure 1.6 (b)) by acting as a torsional damper.

B. Friction/Clutch Disc

The clutch disc (see Figure 1.7 (a)) is splined to the transmission's input shaft, receives the driving motion from the flywheel and pressure plate assembly, and transmits that motion to the transmission input shaft. The parts of a clutch disc are shown in Figure 1.7 (b). It consists of a splined hub and a round metal plate covered with friction material or disc lining or facing that is made of heat-resistant asbestos, cotton fibers, and copper wires woven or molded together. The clutch disc is designed to absorb such things as crankshaft vibration, abrupt clutch engagement, and driveline shock. Grooves are cut into the friction material to aid cooling and release of the clutch disc. Rivets are used to bond the friction material to both sides of the metal body of the disc. Torsion springs, to absorb the torsional vibration of the crankshaft and some of the vibration and shock produced by clutch engagement. Cushion spring, the steel disk is slightly twisted to make the engagement gradual as the disk flattens out



a b

Figure 0.7 Clutch disc (a) and parts of the clutch disc (b)

C. Pressure Plate Assembly

There are two types of pressure plate assembly such as with coil spring Diaphragm spring types. The main parts of a pressure plate assembly are:-

- With coil spring such as pressure plate cover, pressure springs(coil springs), pressure plate, release levers and eye bolt assembly as shown Figure 1.8.

- With Diaphragm type spring are a large round disc of spring steel which has a solid outer ring and individual tapered fingers and tapered fingers which serve as release levers as shown in Figure 1.9.

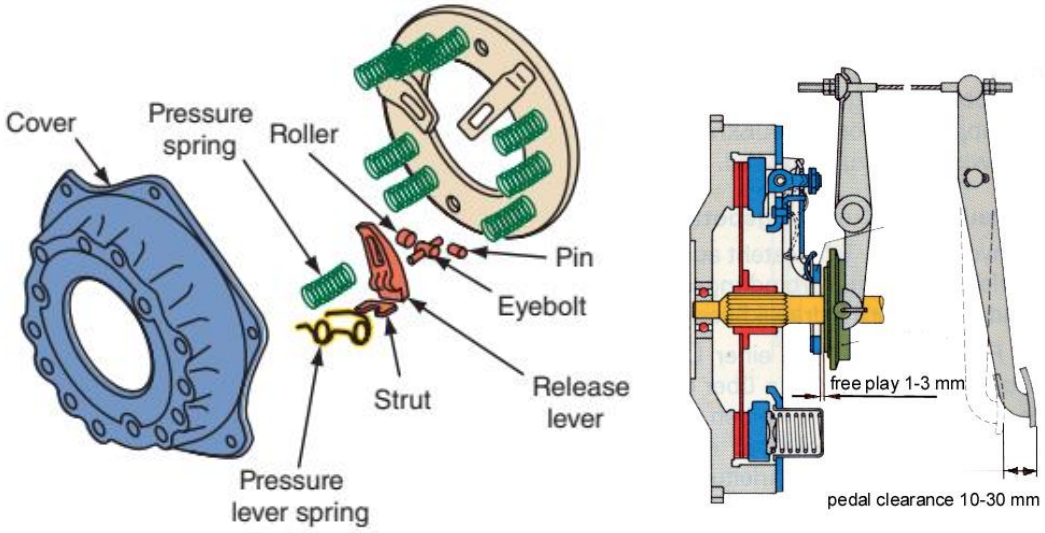


Figure 0.8: The main parts of pressure plate assembly with coil type spring

The diaphragm spring is held to the pressure plate by three retracting springs. A pivot ring is used as a pivot during the diaphragm spring action. Application of pressure at the inner section of the diaphragm will cause the outer rim to move away from the flywheel and draw the pressure plate away from the clutch disc, disengaging the clutch

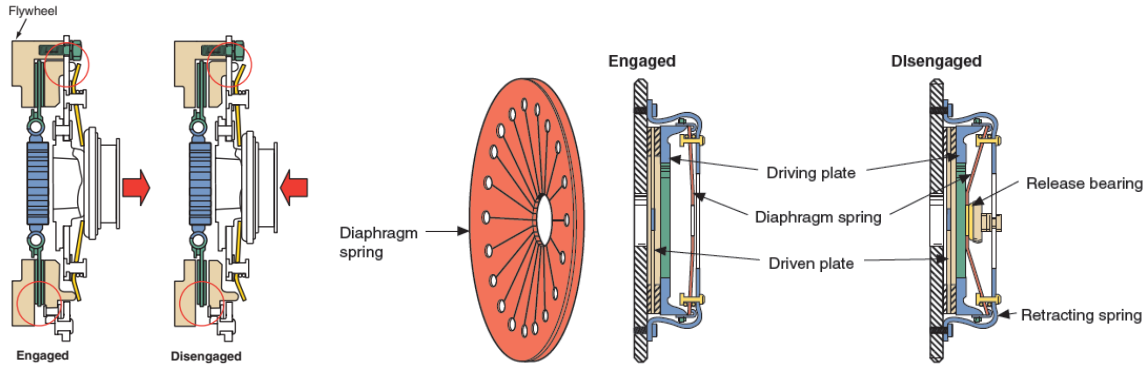


Figure 0.9: The action of diaphragm type pressure plate spring

D. Pilot Bearing or Bushing

Engine side of transmission input shaft supported by sealed pilot bearing or sintered bronze bushing. Some FWD transaxles may not use pilot bearing. Installed (pressed) into a machined bore in the end of the crankshaft or flywheel.

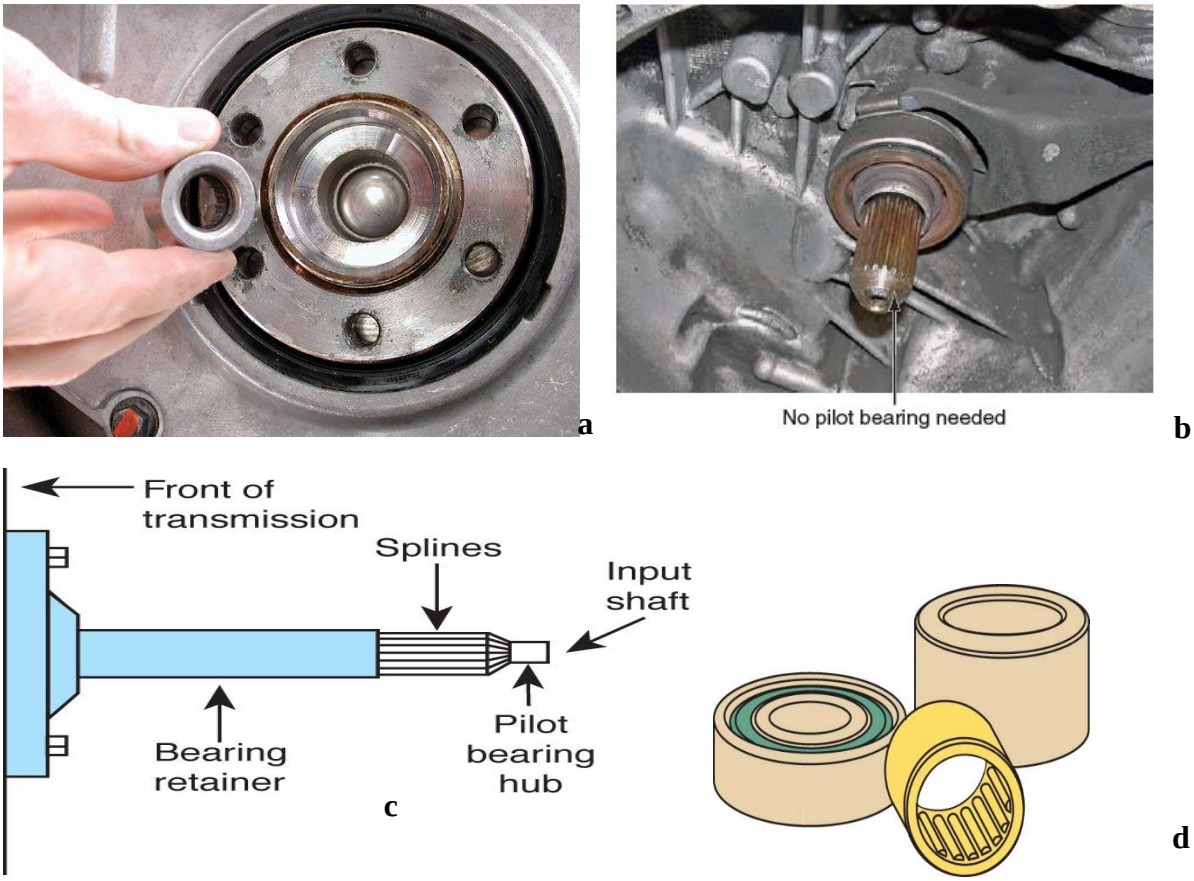


Figure 0.10: Hole for pilot bearing in crankshaft (a), transaxle without pilot bearing (b), components of drive shaft (c) and types of pilot bearings (d)

E. Clutch Fork and Release Bearing

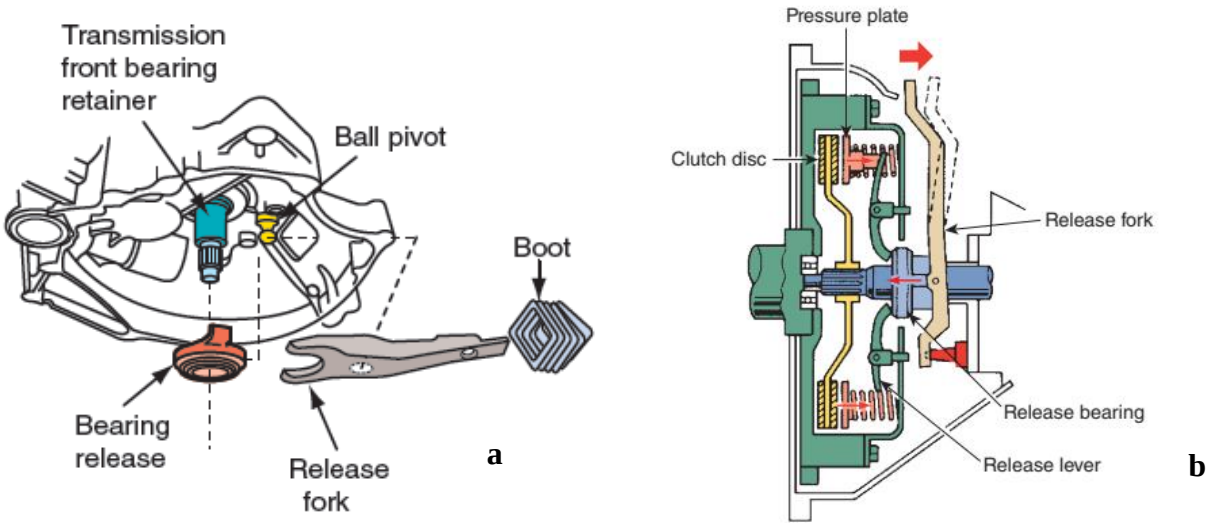


Figure 0.11: Components of clutch release mechanism (a) and action of clutch release (b)

Clutch fork is also called a clutch arm or release arm that transfers motion from the release mechanism to the release bearing and pressure plate. The clutch fork sticks through a square hole in the bell housing and mounts on a pivot. When the clutch fork is moved by the release mechanism, it pries on the release bearing to disengage the clutch.

Release bearing allows the pressure plate's release mechanism to operate as crankshaft rotates. Slides on the front side of transmission bearing retainer that is lubricated and sealed at the factory. Self-centering release bearings used on FWD cars that do not use pilot bearing in the crankshaft. Specially designed release bearings found on vehicles that have pressure plates that pull to release

1.2.3 Components of the Clutch (Out-Side Assembly)

There are two types of clutch release mechanisms, distinguished by the way they are operated: the mechanically operated clutch using a cable linkage and the hydraulically operated clutch.

A. Mechanical Type Clutch

Here the movement of the clutch pedal is conveyed to the clutch body directly by mechanical release mechanism. The two types of mechanical release mechanisms are:- The clutch pedal is linked over levers and rods with the release fork ,and the link between the clutch pedal and release fork is made through a specially designed clutch control cable.

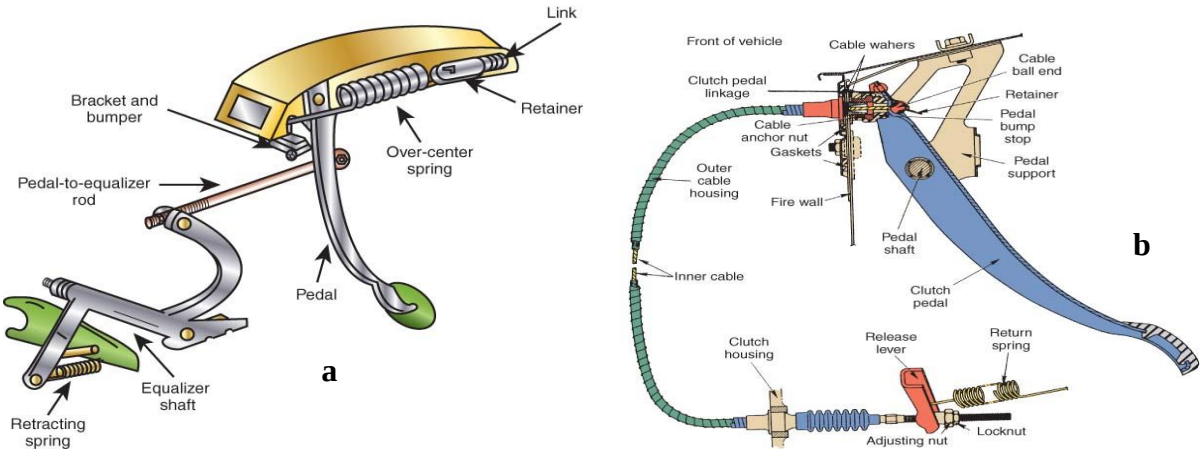


Figure 0.12: Mechanical clutch release mechanisms, lever type (a) and cable type (b)

B. Hydraulic Clutch

This mechanism consists of a clutch master cylinder and servo cylinder, which are connected hydraulically by a steel tube. Brake fluid is used in the system when the clutch pedal pressed, pressure is created in the master cylinder, which is, in turn, transmitted to the "slave" cylinder. The slave cylinder is attached to the throw-out fork by a small adjustable rod, so when pressure is exerted on the slave cylinder, it operates the fork.

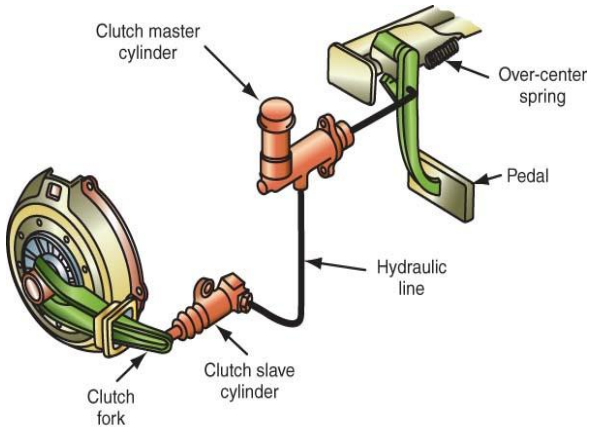


Figure 0.13: Hydraulic clutch system

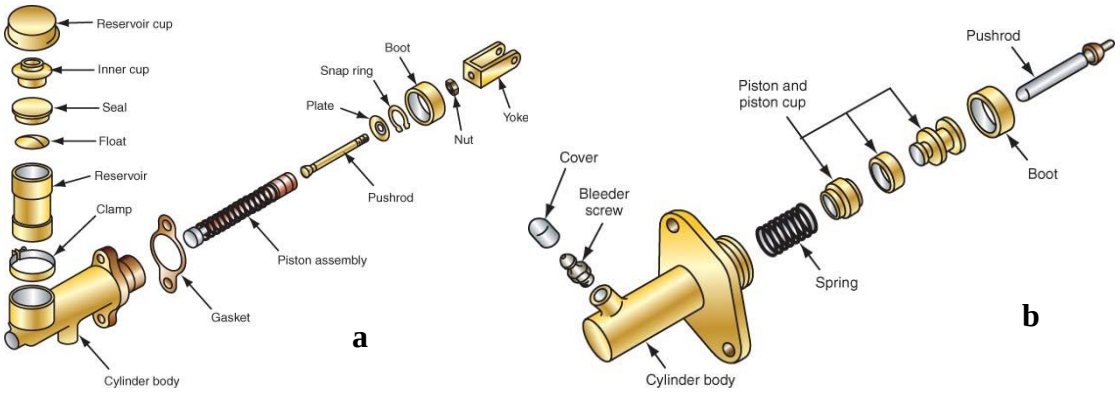


Figure 0.14: Parts inside the cylinders of clutch system master (a) and slave (b)

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. A gear train is two or more gear working together by meshing their teeth and turning each other in a system to generate power and speed. It reduces or increases speed and torque.

1.3.1 Types of Gear Train

A. Simple Gear Train

The most common of the gear train is the gear pair connecting parallel shafts. The teeth of this type can be spur or helical. Only one gear may rotate about a single axis.

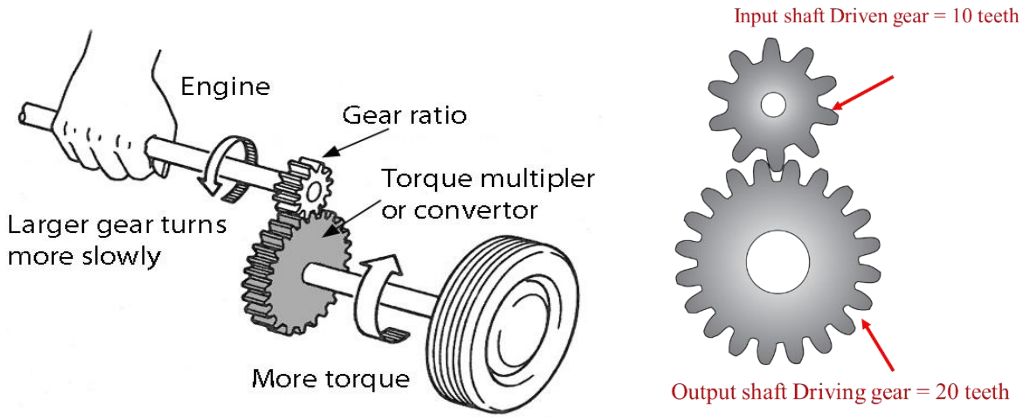


Figure 0.15: Drive mechanism of simple gear train

B. Compound Gear Train

For large velocities, compound arrangement is preferred so that wo or more gears may rotate about a single axis. Multiple simple gear trains in series, each set of gears generates an individual ratio.

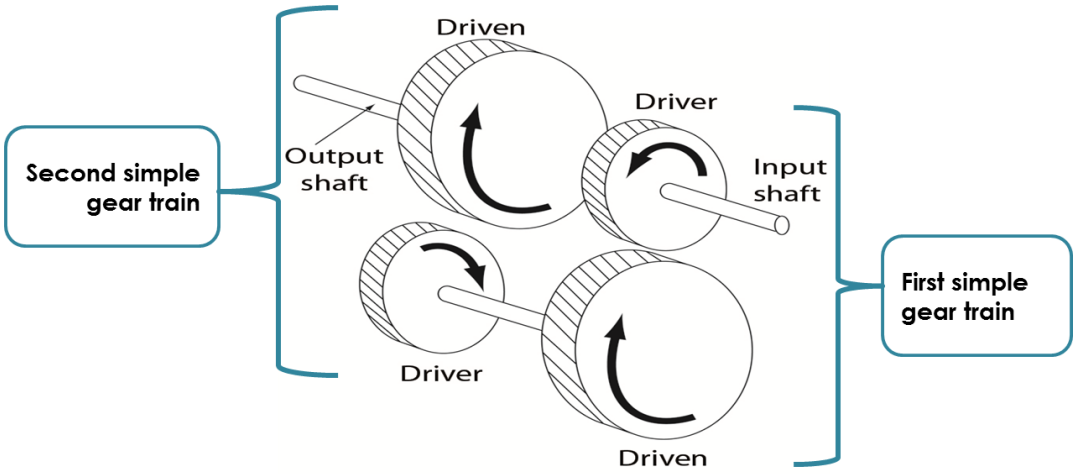


Figure 0.16: Drive mechanism of compound gear train

C. Planetary or Epicyclic Gear Train

In this gear system, the yellow gear (the sun) engages all three red gears (the planets) simultaneously. All three are attached to a plate (the planet carrier), and they engage the inside of the blue gear (the ring) instead of the outside.

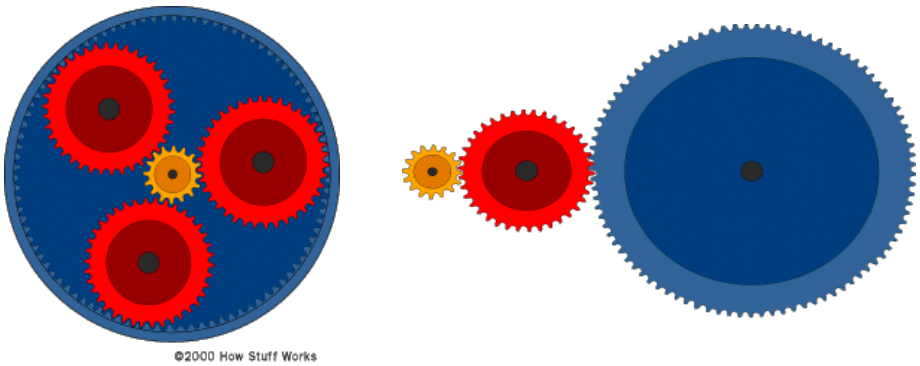


Figure 0.17: Drive mechanism of epicyclical gear train

1.3.2 Gear Ratios

For any gear, the pitch diameter is proportional to the number of teeth (N). The speeds of the gears are inversely related to the diameter. Torque is proportional to pitch diameter. Therefore, it is expressed as the number of rotations the drive gear must make in order to rotate the driven gear through one revolution. Gear ratio is the speed that the two gears turn in relation to each other.

$$\frac{T_{out}}{T_{in}} = \frac{D_{out}}{D_{in}} = \frac{N_{out}}{N_{in}} = \frac{\omega_{in}}{\omega_{out}} \quad (1)$$

Where T is torque, D is pitch diameter of gear, N is number of teeth and ω is angular speed

$$Gear\ Ratio = \frac{Number\ of\ teeth\ on\ output\ gear}{Number\ of\ teeth\ on\ input\ gear} \quad (2)$$

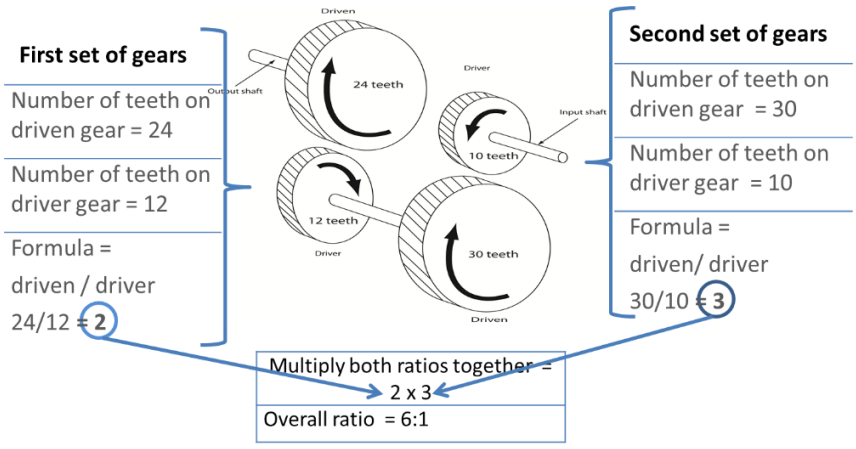


Figure 0.18: Determination of Gear Ratio for compound gear train

To obtain a gear ratio, divide the number of teeth on the driven gear by the number of teeth on the drive gear. The gear ratio of simple gear train given above is 20 teeth on output divided by ten teeth on input gears equal to 2:1.

Compound gear ratio of gear train shown in Figure 1.18 = $\frac{N_2}{N_1} \times \frac{N_4}{N_3}$

Where N_1, N_2, N_3, N_4, are number of teeth on 1st, 2nd, 3rd and 4th gears respectively starting from input gear. Similarly the gear ratio of planetary gear unit can be determined by using equation (2) based on input and output relation that may be either sun, ring or planet carrier. The desired drive members of planetary gear unit can be determined by using equations

$$N_C = N_R + N_S \quad (3)$$

$$N_R = N_S + 2N_P \quad (4)$$

Where N is number of teeth, the subscripts C, P, R and S are the carrier, planet/pinion, ring and sun gears respectively. The Gear ratios of automotive transmission and driveline ma fall into one of the three categories:

- **Direct Drive** - 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.
- **Gear Reduction** -This type of gear arrangement, where the rotation and torque of the input shaft is transmitted to the output shaft, the speed of the rotation decreases and the torque increases
- **Overdrive** - The opposite of a gear reduction is called Overdrive and occurs when a driven gear turns faster than its drive gear.
- **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.

1.4 Overview of manual Transmission/Transaxle

1.4.1 Purposes of Automotive Transmission

Transmission, Gearbox, or Transaxle is an assembly of gears and shafts to transmit the rotation and torque of the engine to the driveline or final drive.

- **Functions of Transmission**
  - To provide a means to vary the torque ratio by set of gears between the engine and the road wheels as required. That is to provide the high torque at the time of starting, hill climbing, accelerating and pulling a load since high tractive effort is needed
  - It permits engine crankshaft to rotate at high speed, while the wheels turn at slower speeds and Vehicle speed can be changed keeping engine speed same with certain limit

- To provide a neutral position so that the engine and road wheel are disconnected even with the clutch is in engaged position
- To provide a means of reverse the car by reversing the direction of rotation of the drive

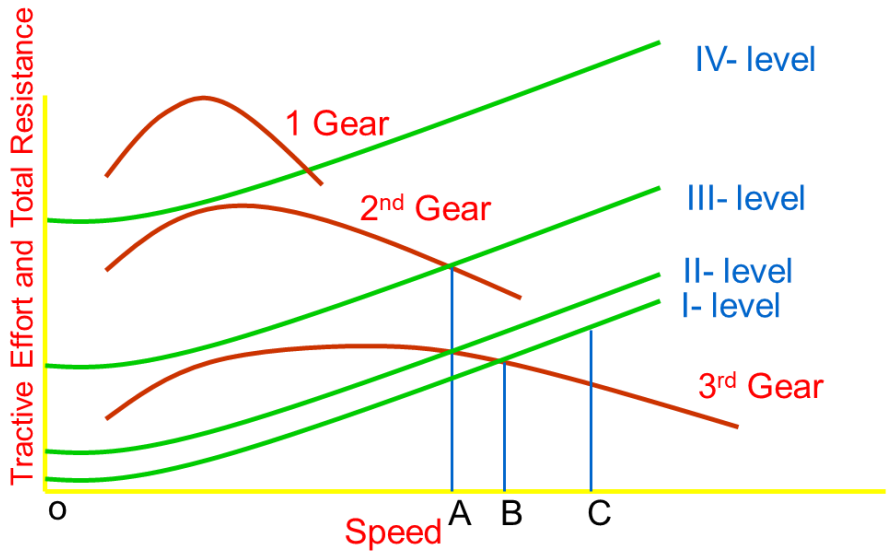


Figure 0.19: Relation between vehicle road resistance and required gear in wide speed operation

- **Necessity of Transmission**
  - To vary the torque to overcome the various resistance acting against the vehicle motion at various speeds
  - To vary the tractive effort of the vehicle available at various speeds in order to overcome the various resistance
  - to start the vehicle from rest, with the engine running continuously
  - To Stop the vehicle by disconnecting the drive when appropriate transmission is installed to every vehicle to meet its demand.

Total resistance consists of wind resistance, gradient Resistance and rolling Resistance

1.4.2 Types of 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.

A. Sliding Mesh Gearbox

The simplest type of Gearbox that has two or more shafts mounted in parallel or in line, with sliding spur gears arranged to mesh with each other and provide a change in speed or direction

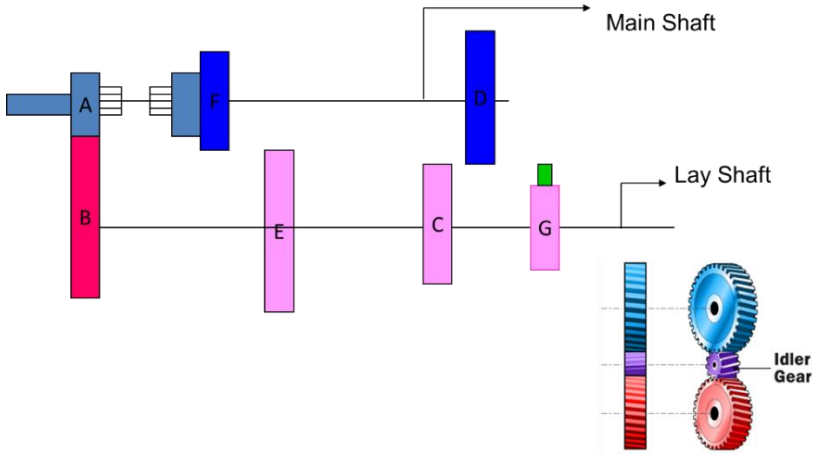


Figure 0.20: Sliding mesh type gearbox

The limitations Sliding Mesh Gearbox are:-

- Low mechanical efficiency
- The noise level is high
- The driver required considerable skill in changing the gear

B. Constant Mesh- Dog Clutch Gearbox

It is also known as the collar shift transmission. In this type, all the gears are in constant mesh with the corresponding gears on the lay shaft

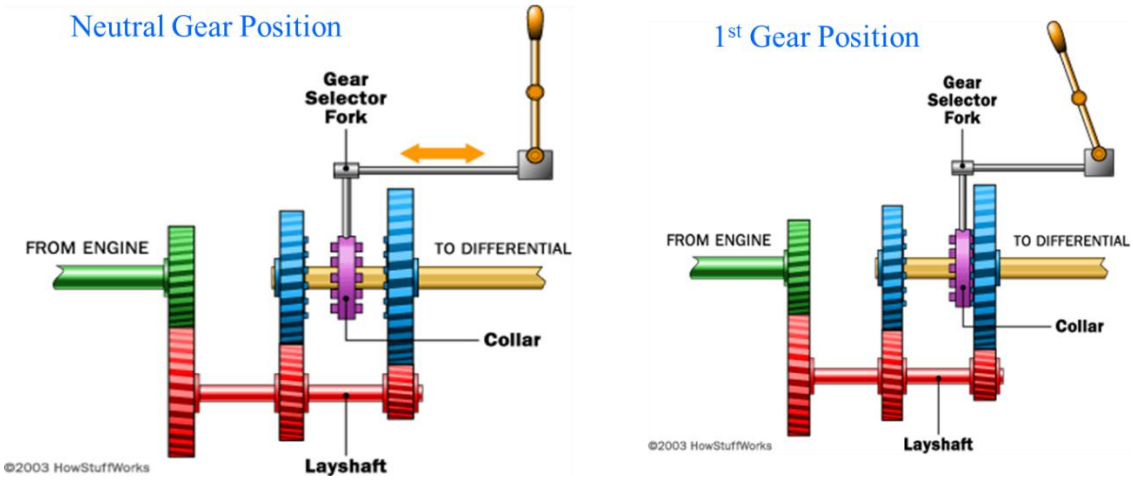


Figure 0.21: Constant mesh dog-clutch type gearbox

C. Constant Mesh- Synchromesh Gearbox

Manual transmissions in modern passenger cars use synchronizers to eliminate the need for double clutching. A synchro's purpose is-

- To allow the collar and the gear to make frictional contact before the dog teeth make contact.
- To lets the collar and the gear synchronize their speeds before the teeth need to engage
- To lock the main shaft gear to the main shaft

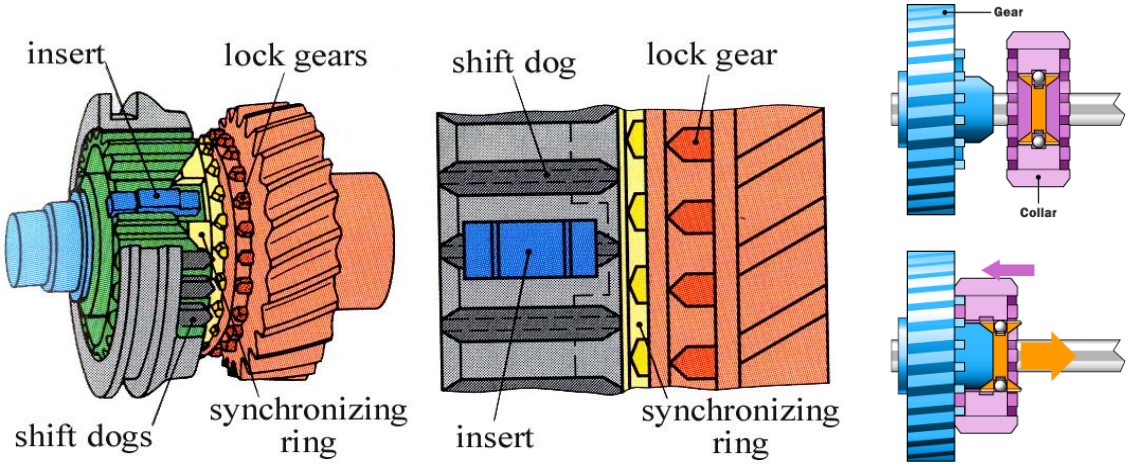


Figure 0.22: Constant mesh synchromesh type gearbox

The cone on the blue gear fits into the cone-shaped area in the collar, (bronze cone) and friction between the cone and the collar synchronize the collar and the gear. The outer portion of the collar then slides so that the dogteeth can engage the gear.

Advantages of synchromesh gear box are:- it simplifies the operation of changing gears without the occurrence of clashes b/n the gear tooth & consequent damages and avoid double clutching.

1.4.3 Major Components of Manual Transmission

- Transmission Case (20)
- Extension Housing (21)
- Transmission Shafts including input shaft or clutch shaft (1), countershaft, or cluster gear shaft (12), reverse idler shaft (14), main shaft or the output shaft (5)
- Transmission Gears including input gear, countershaft gears (11), main shaft gears (4, 6, 7, 8), and the reverse idler gear(13)
- Shift Linkage and Levers

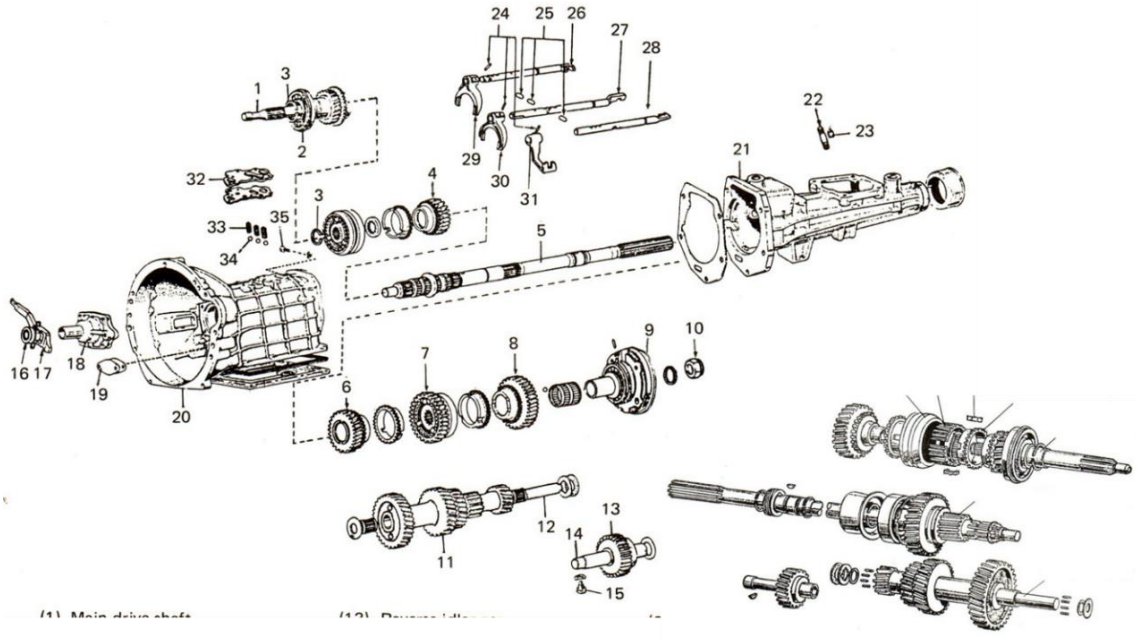


Figure 0.23: Exploded view of components of manual transmission

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. In five-speed transmission there are six gear sets that provide five forward speeds and one reverse speed. It provides reduction ratios in (first, second, and third), direct drive (fourth), and an overdriven ratio (fifth).

- **In First Gear-** Torque flows through the transmission in gear reduction at the first gear ratio

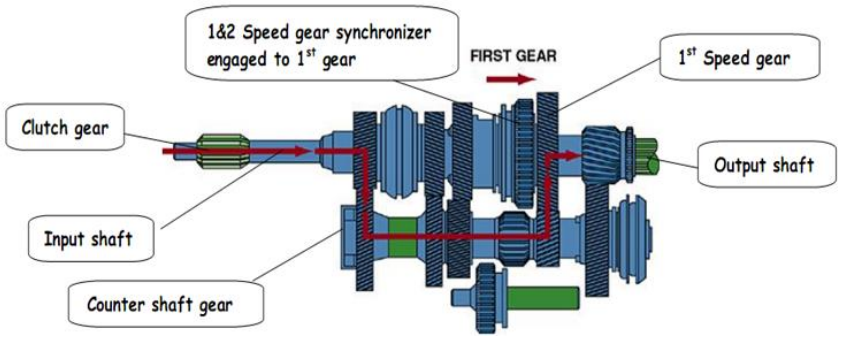


Figure 0.24: Power flow in first gear of five-speed transmission

- **In Second Gear-** Torque flows through the transmission in gear reduction at the second gear ratio.

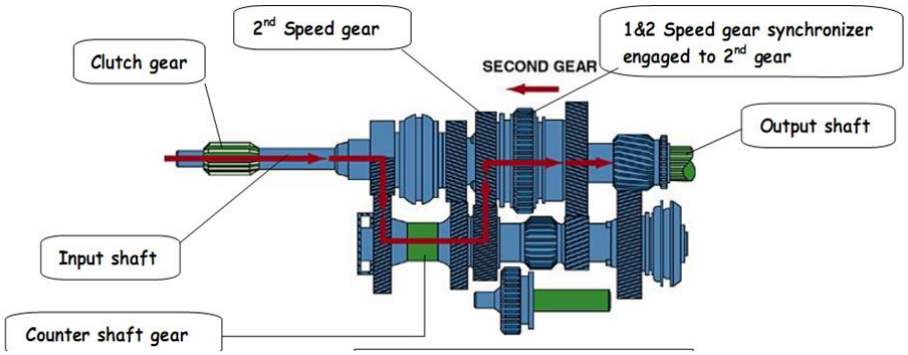


Figure 0.25: Power flow in second gear of five-speed transmission

- **In Third Gear-** Torque flows through the transmission in gear reduction at the third gear ratio.

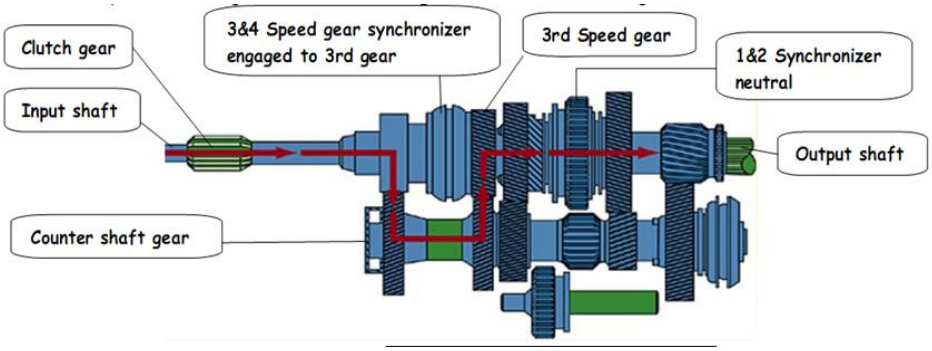


Figure 0.26: Power flow in third gear of five-speed transmission

- **In Fourth Gear-**The synchronizer assembly locks the input shaft drive gear to the output shaft. 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.

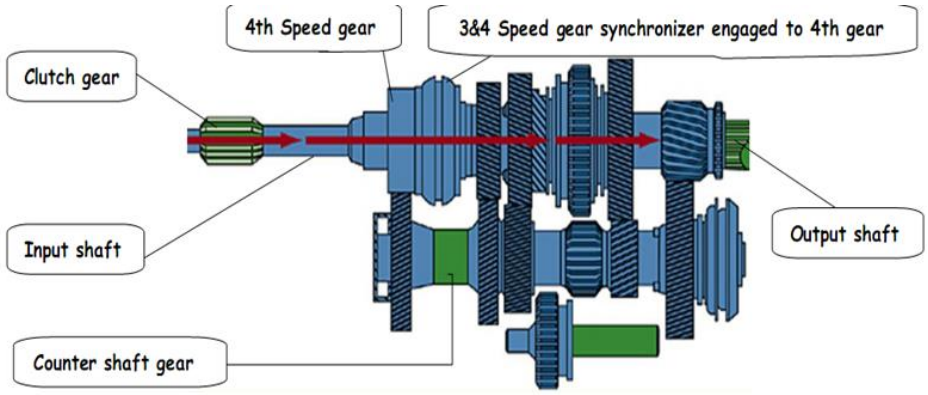


Figure 0.27: Power flow in fourth gear of five-speed transmission

- **In Fifth Gear-**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.

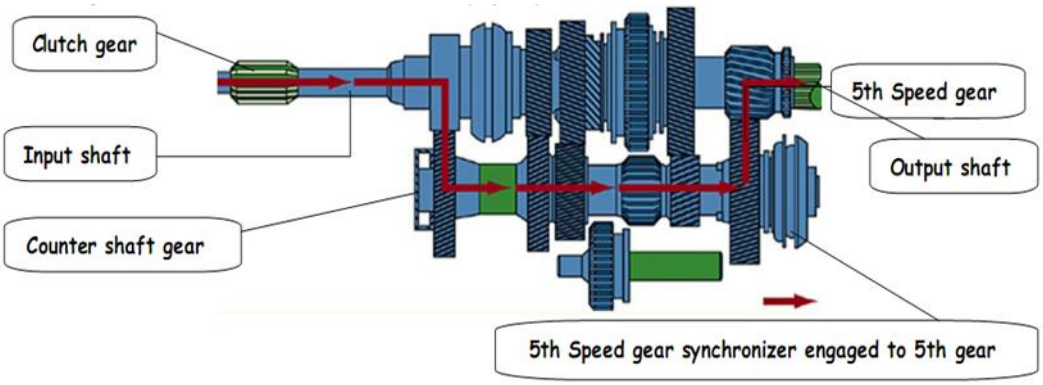


Figure 0.28: Power flow in fifth gear of five-speed transmission

- **In Reverse with Sliding Gear Designs-** The shift linkage slides the reverse idler gear on its shaft until it engages the reverse gears on the countershaft and output shaft gear. This design uses spur gears for reverse, because the gear teeth must move into and out of mesh. On some gearboxes, the sliding gear splines to the output shaft.
- **In Reverse with Constant-Mesh Gear Design-** 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.

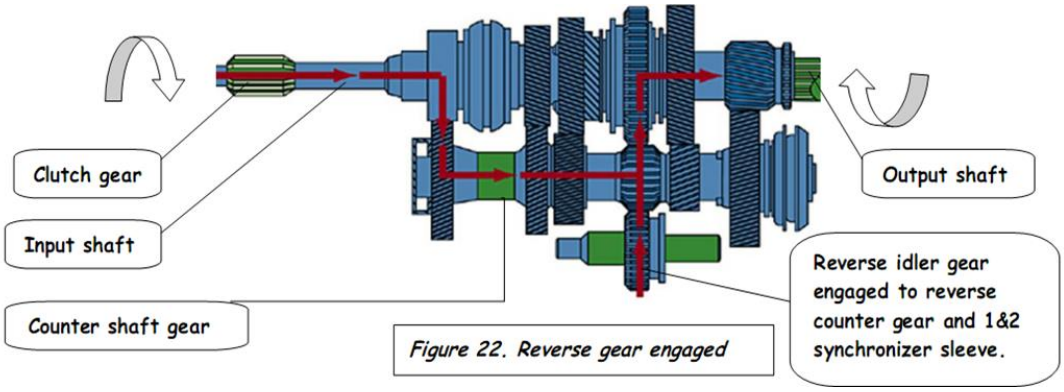


Figure 0.29: Power flow in reverse gear of five-speed transmission

1.4.5 Manual Transaxle

A transaxle is a transmission and differential combination in a single assembly. Transaxles are used in front-wheel (FF) or (RR) drive vehicles. A transaxle allows the wheels next to the engine to propel the vehicle. A manually shifted transaxle includes an input shaft, an output shaft, and a differential assembly all in one case. 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.

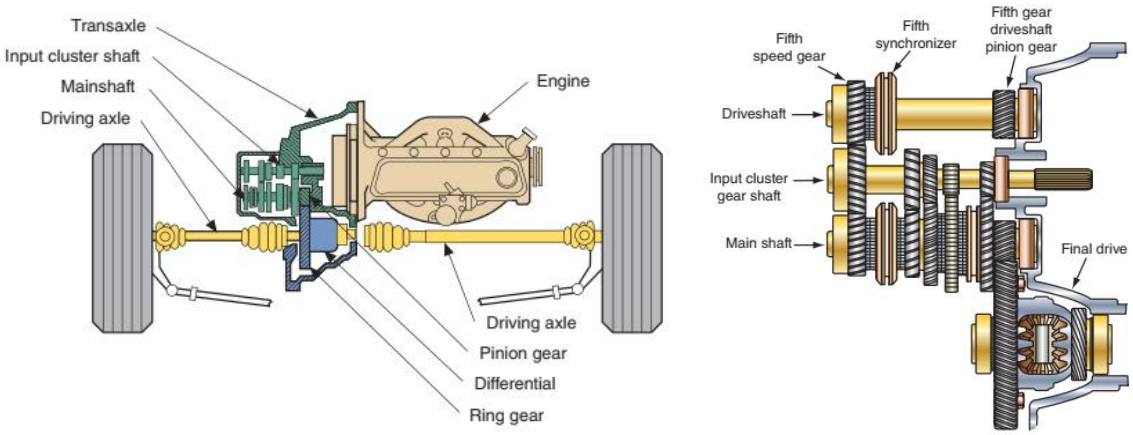
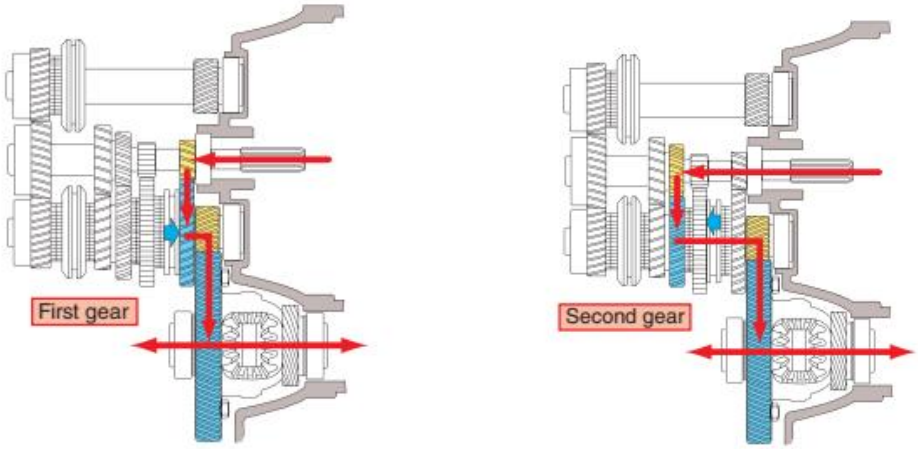


Figure 0.30: Sectional view of manual transaxle components



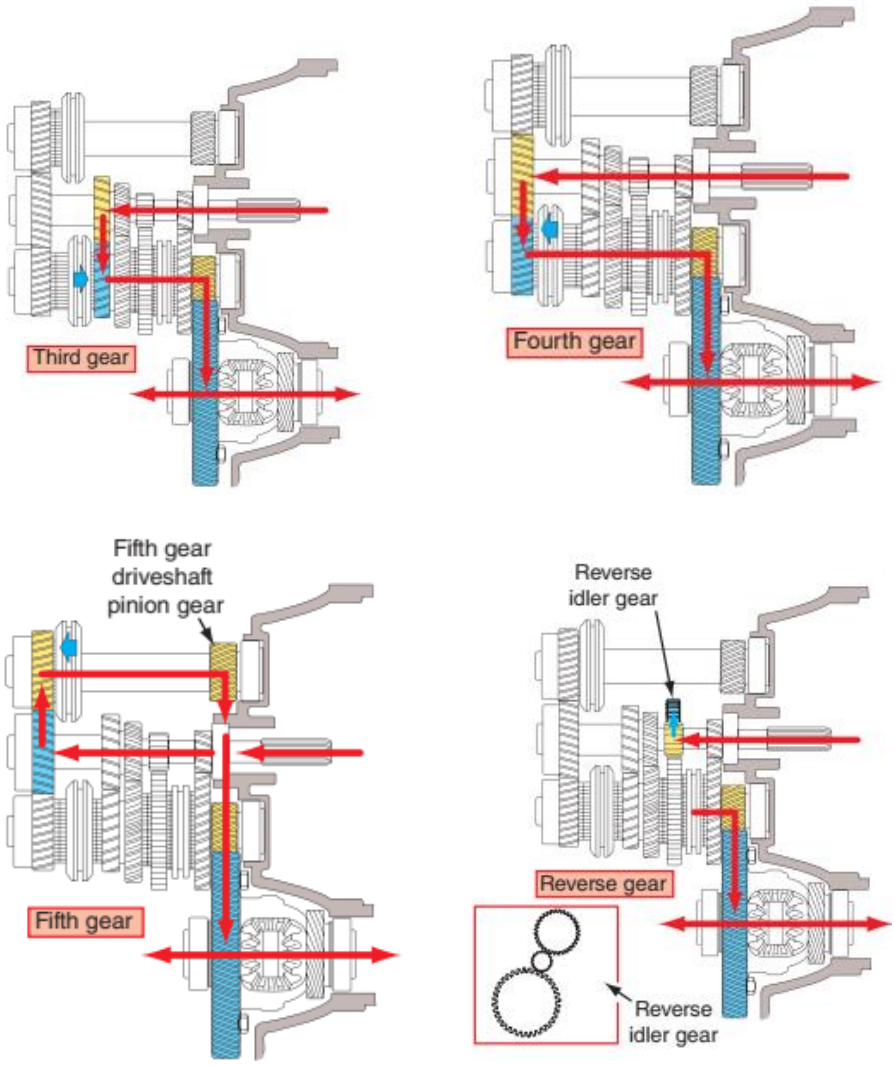


Figure 0.31: Power flow of typical five-speed transaxle

Most transaxles use speed gears and synchronizers on both the input and output shafts. The differential assembly, also called a final drive assembly, attaches to the output shaft and splits the torque to both front drive axles. Most transversely mounted transaxles are supported by bearings in the housing, and these units do not need a pilot

Vehicle manufacturers claim that a transaxle and front-wheel drive has several advantages over a vehicle with rear-wheel drive

- Improved efficiency and reduced drive train weight
- Improved traction on slippery surfaces because of increased weight on the drive wheels

- Increased passenger compartment space (no hump in floorboard for rear drive shaft)
- Less un-sprung weight (weight that must move with suspension action), thereby providing a smoother ride
- Quieter operation since engine and drive train noise is centrally located in the engine compartment
- Improved safety because of the increased mass in front of the passengers

1.4.6 Transfer Case

If a car's 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.

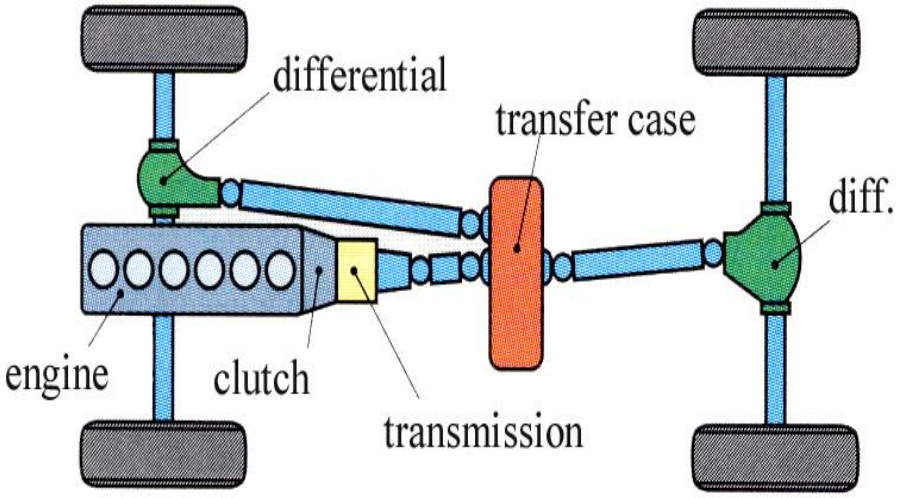


Figure 0.32: Layout of 4WD powertrain with transfer case

Transfer cases are used in off-road vehicles to divide engine torque between the front and rear driving axles. The transfer case also allows the front driving axle to be disengaged, which is necessary to prevent undue /excessive/ drive line component wear during highway use.

Another purpose of the transfer case is to move the drive shaft for the front driving axle off to the side so that it can clear the engine. This arrangement is necessary to allow adequate

ground clearance and to allow the body of the vehicle to remain at a practical height (see the above figure).

The transfer case first 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").

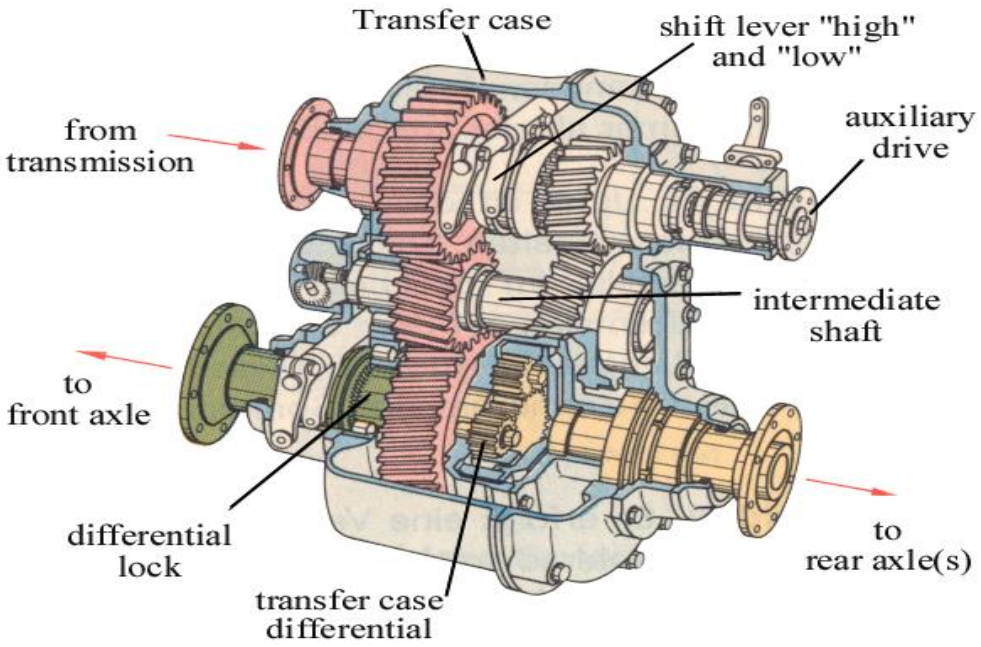


Figure 0.33: Internal construction of transfer case

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.

A conventional transfer case is constructed similar to a transmission, in that it uses shift forks, splines, gears, shims, bearings, and other components found in manual and automatic transmissions.

1.5 Automatic Transmission

The ubiquitous automatic is by far the most common transmission on the road today. Like the manual transmission is designed to Mach the load requirements of the vehicle to the power & speed range of the engine. The conventional clutch and Manual Synchromesh gearbox by a torque converter and a compound epicyclical gear train.

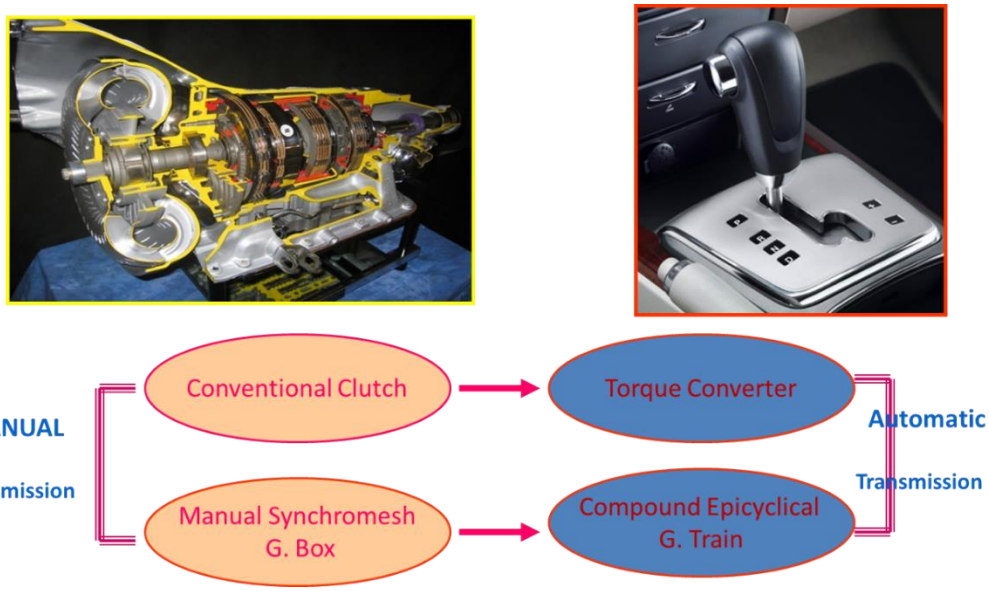


Figure 0.34: Comparison of automatic and manual transmission based on construction

Gear shifting of Automatic transmission depends on

- Throttle Position
- Vehicle Speed
- Position of the Shift Lever

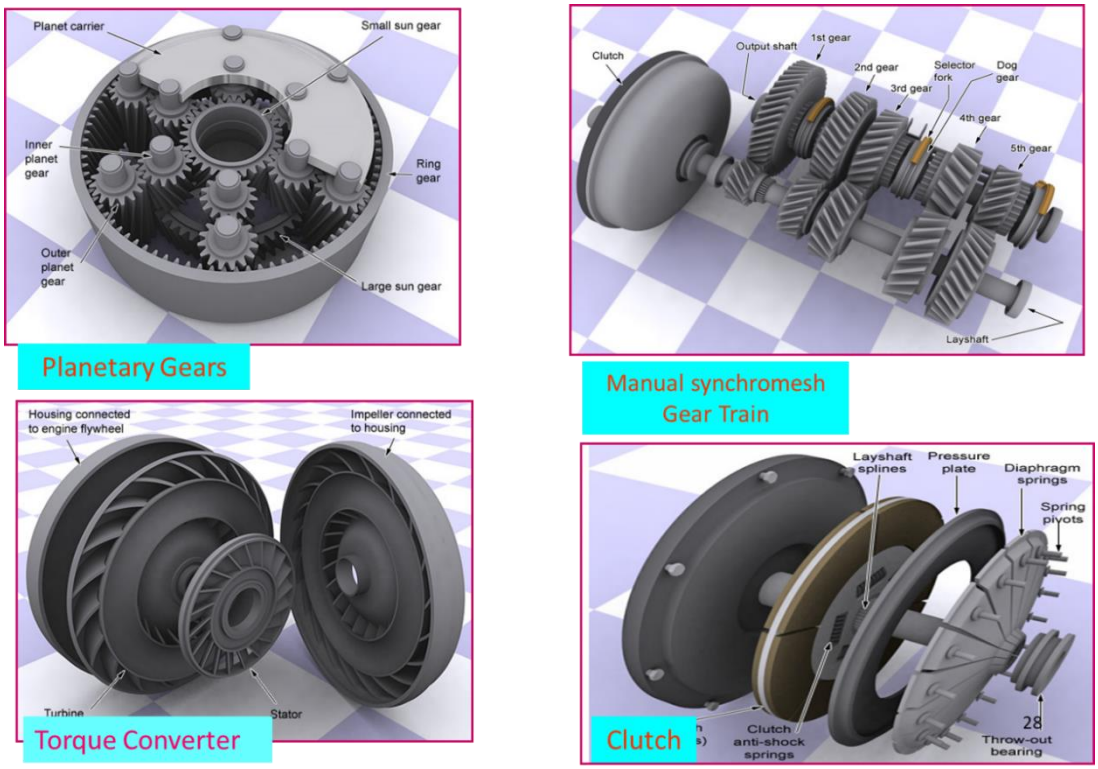


Figure 0.35: Components of automatic and manual transmission

The advantages of AT compared with Manual Transmission

- Free acceleration without interruption
- Reduces driver fatigue by eliminating Clutch operation & Constant Shifting Gears
- Automatically & Smoothly shift gears at speeds appropriate to the driving conditions
- Prevents the engine & drive line from becoming overloaded, because it connect them hydraulically via torque converter rather than mechanically

1.5.1 Automatic Transmission Drive Arrangements

A. Rear Wheel Drive

The transmission is usually mounted to the back of the engine. Power flow on this system is simple and straight forward going from the engine, through the torque converter, then through the transmission and drive shaft until it reaches the final drive where it is split and sent to the two rear wheels. Example Alpha Romeo Alfeta in early 70's.

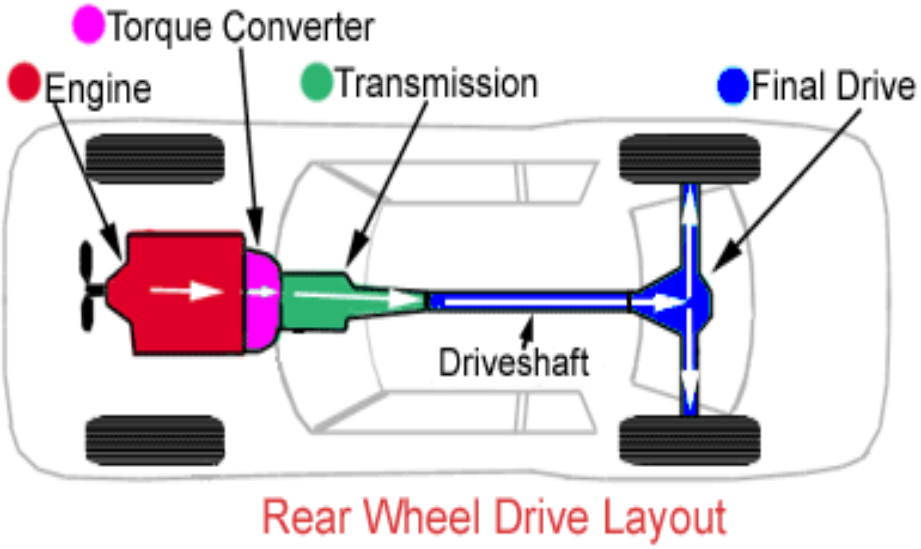


Figure 0.36: Layout of RWD with automatic transmission

B. Front Wheel Drive

On a front wheel drive car, the transmission is usually combined with the final drive to form what is called a transaxle.

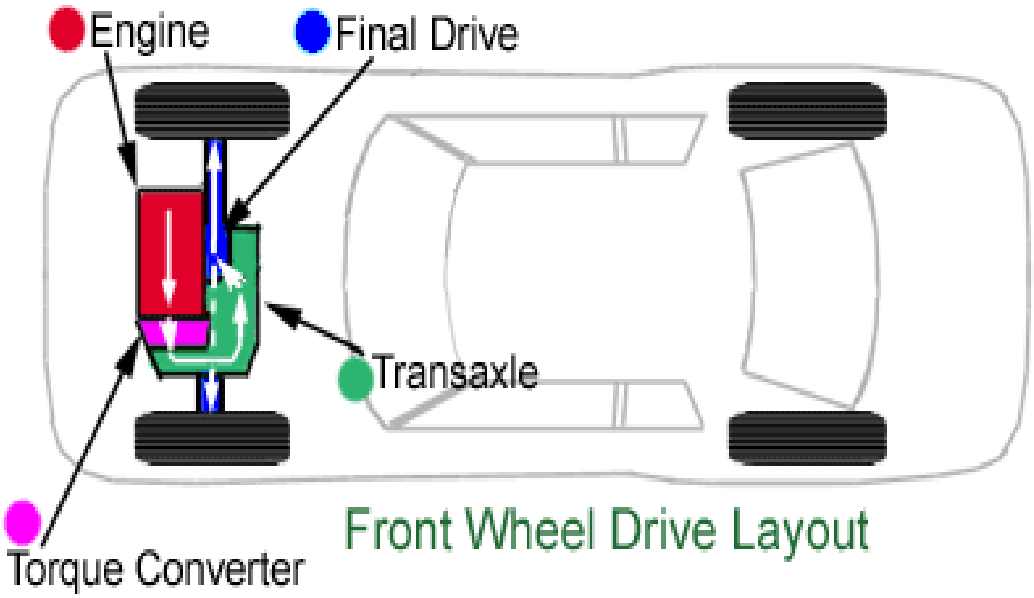


Figure 0.37: Layout of front transaxle with automatic transmission

1.5.2 Major Components of AT

- Planetary Gear Sets
- Hydraulic System
  - Oil Pump
  - Valve Body
  - Clutches
  - Band
- Seals and Gaskets
- Torque Converter
- Governor

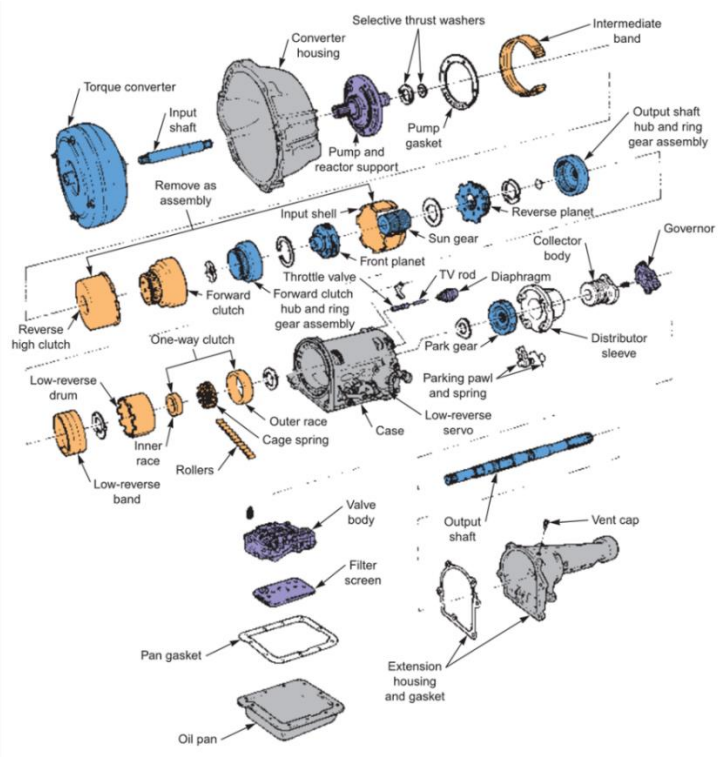


Figure 0.38: Exploded view of the components of automatic transmission

A. Torque Converter:

Provides a smooth and automatic take-up of the drive and at the same time multiplies the output torque from the engine.

Roles of Torque Converter

- Multiplying the torque generated by the engine
- Serving as Automatic Clutch, which transmits (or does not transmit) the engine torque to the transmission
- Absorbing the torsional vibration of the engine and drive train
- Serving as a fly wheel to smooth out engine rotation
- Driving the oil pump of the hydraulic control system

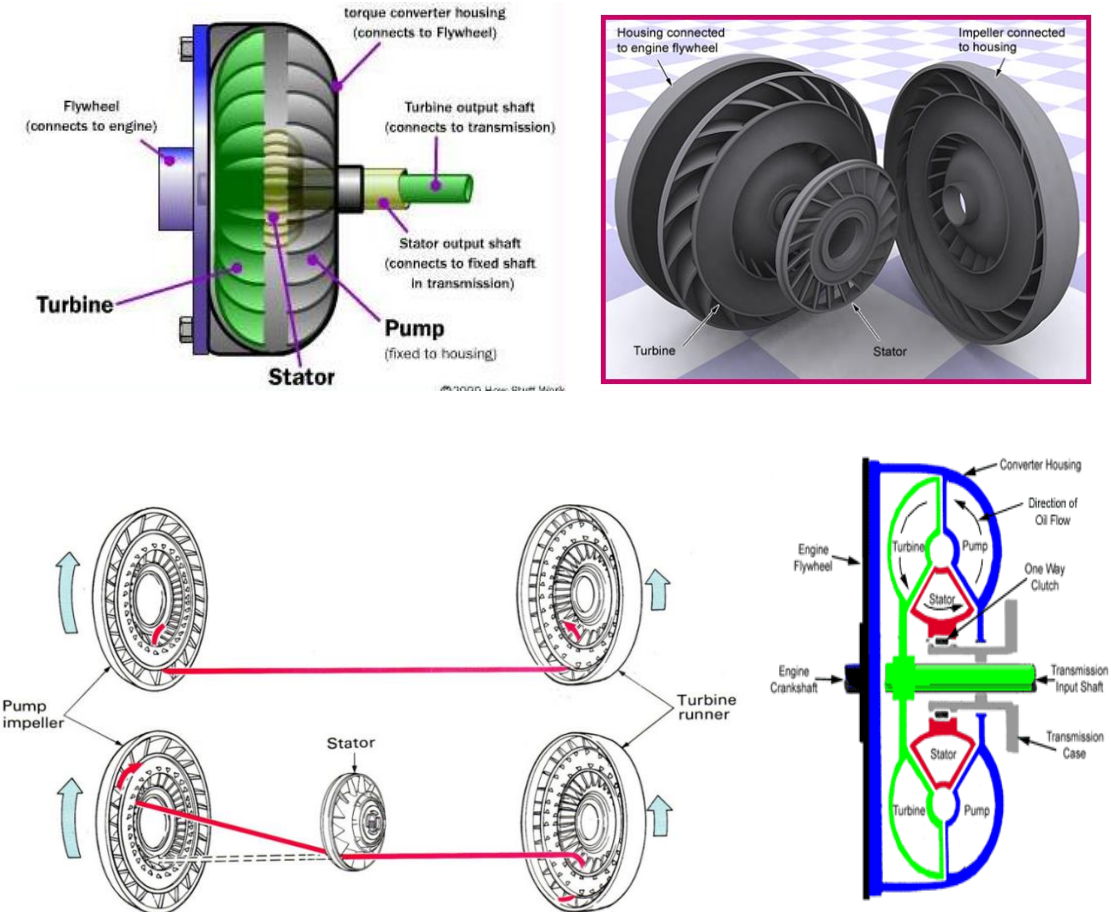


Figure 0.39: Components of torque converter and process of torque multiplication

B. Planetary Gear Unit

Changes the transmission output rpm and/or the direction of the output rotation and transmits it to the final drive unit. It consists of

- The planetary gears (which changes the output rpm)
- Clutches & Brakes (which are operated by hydraulic pressure to control the operation of the PGs
- Shafts (for transmitting the engine power
- Bearings (for facilitating the smooth rotation of each shaft

The rolls of Planetary Gear Unit

- Providing several gear ratios to obtain proper torque & rotational speed in accordance with the driving conditions & drivers desires

- Providing the reverse gears for reverse traveling
- Providing a neutral gear potion to allow the engine to idle which the vehicle is stopped.

Planetary gear unit consists of

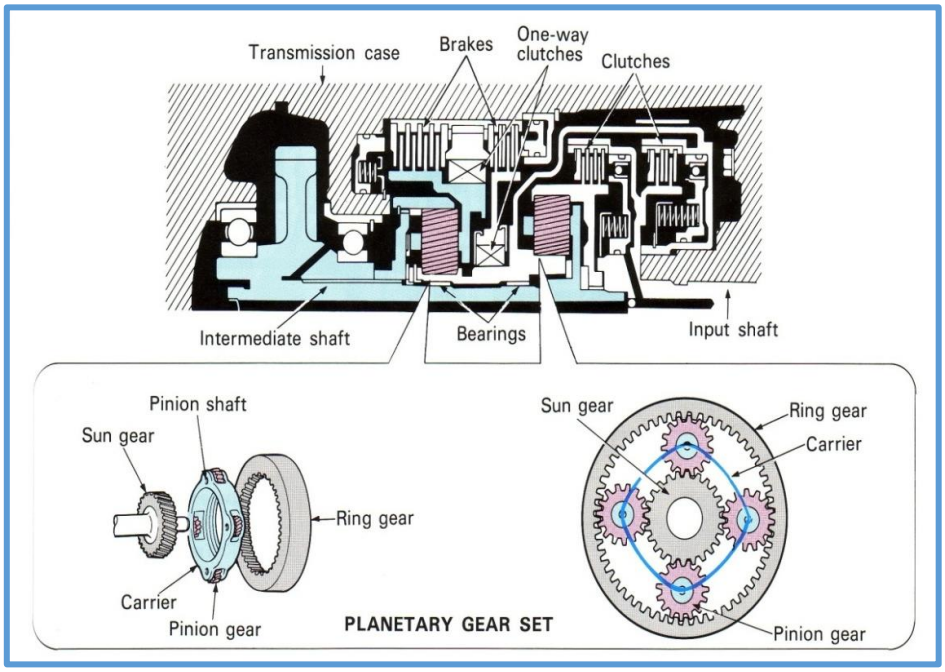


Figure 0.40: Internal construction of planetary gear unit

Table 0-1 Speed torque and direction of rotation for different input output drive relation

No	**Sun Gear**	**Carrier**	**Ring Gear**	**Speed**	**Torque**	**Direction**
1	Input	Output	Held	Maximum reduction	Increase	Same as input
2	Held	Output	Input	Minimum reduction	Increase	Same as input
3	Output	Input	Held	Maximum increase	Reduction	Same as input
4	Held	Input	Output	Minimum increase	Reduction	Same as input
5	Input	Held	Output	Reduction	Increase	Reverse of input
6	Output	Held	Input	Increase	Reduction	Reverse of input
When any two members are held together, speed and direction are the same as input. Direct 1:1 drive						
When no member is held or locked together, output cannot occur. The result is a neutral condition.						

- **Planetary Gear Set**- is a serious of interconnecting gears consisting of a
  - Sun Gear

- Several Planetary pinion Gear
- A Ring gear
- The Carrier connecting the pinion gears to the ring gear

In planetary gear design, it is possible to get different gear ratios forward & reverse

Laws of simple planetary gear operation

- **Brakes-**hold one of the planetary gear components (sun gear, ring gear, or carrier) immovable in order to obtain the necessary gear ratio. It is operated by Hydraulic pressure.

There are two types of brakes

- Wet multiple-disc brake- in this type of brake, the plates, which are fitted to the transmission case, and the discs, which rotate integrally with each planetary gear set
- Band type brake- in this type of brake, a brake band encircles the brake drum, which is integrated with one of the planetary gear components

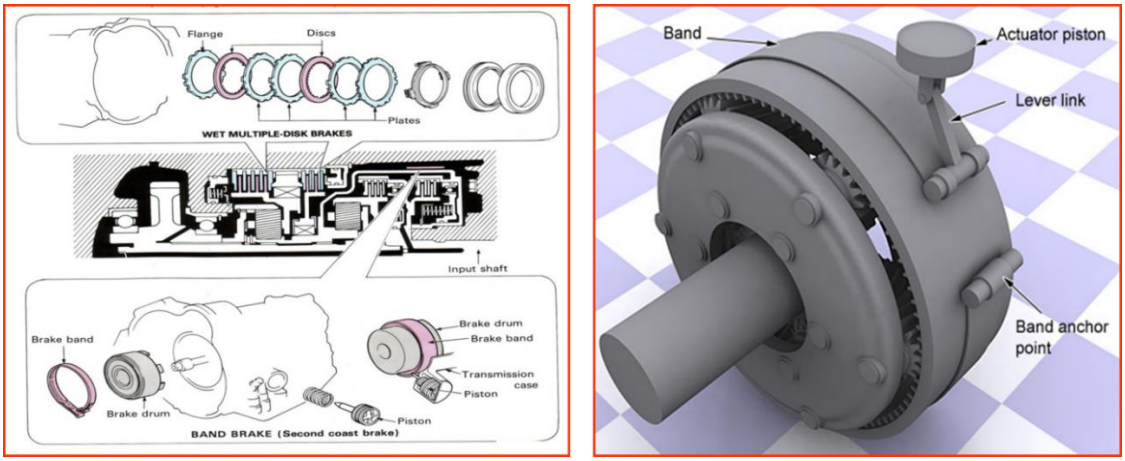


Figure 0.41: Band brakes and multi-disc

- **Clutches and one-way clutches**- the clutches connect the torque converter to the planetary gears to transmit engine torque to the intermediate shaft, and they disconnect the converter from the planetary gears to stop the transmission of torque. Wet multiple-disc clutches consisting of several alternately arranged discs and plates. Hydraulic pressure is used to connect and disconnect the clutches.

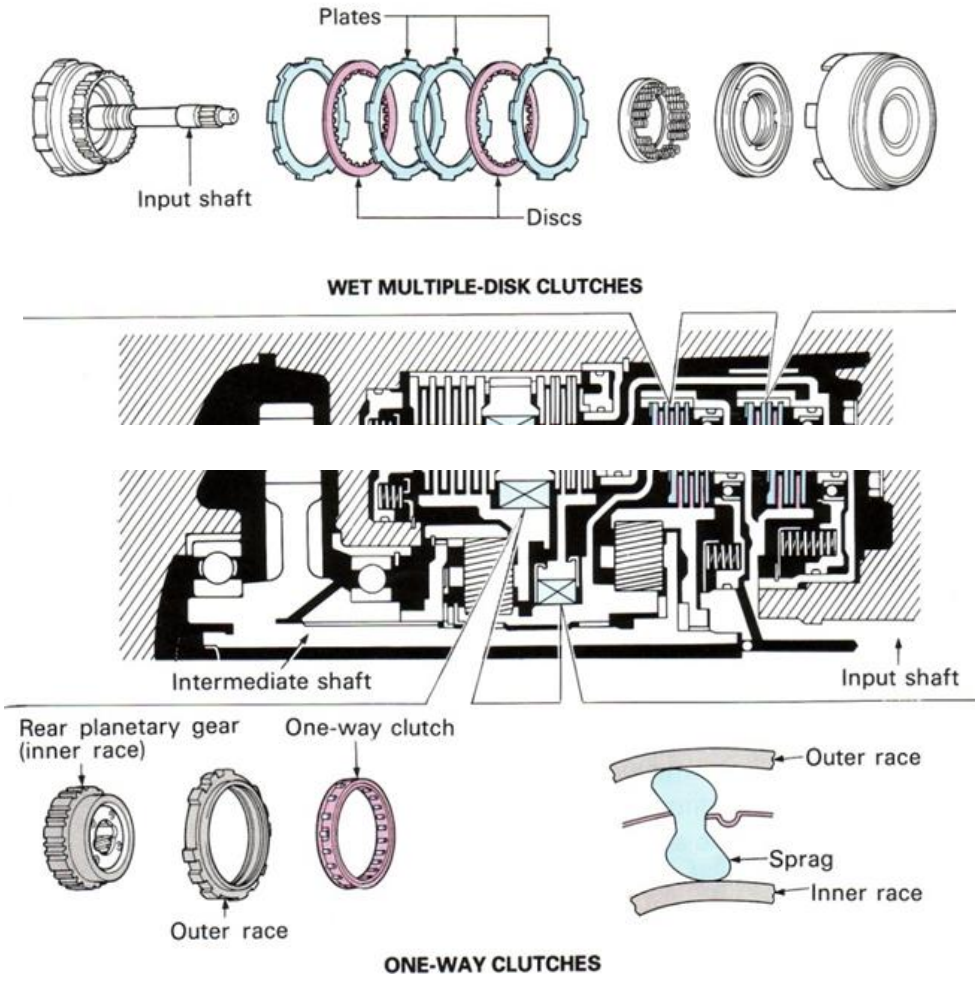


Figure 0.42: Wet multiple disc and one way clutches

- **Difference between Clutches & Brakes**

Clutches are integrated with two different planetary gear components for example, input shaft and sun gears, overdrive sun gear and overdrive planetary carrier, etc are therefore always revolving with them. Their function is to bring the rotational speeds of the two components up or down to the same speed, and to cause them to rotate in the same direction

Brakes do not move - they are fixed to the transmission case and serve only to halt the rotation of the planetary gear unit components

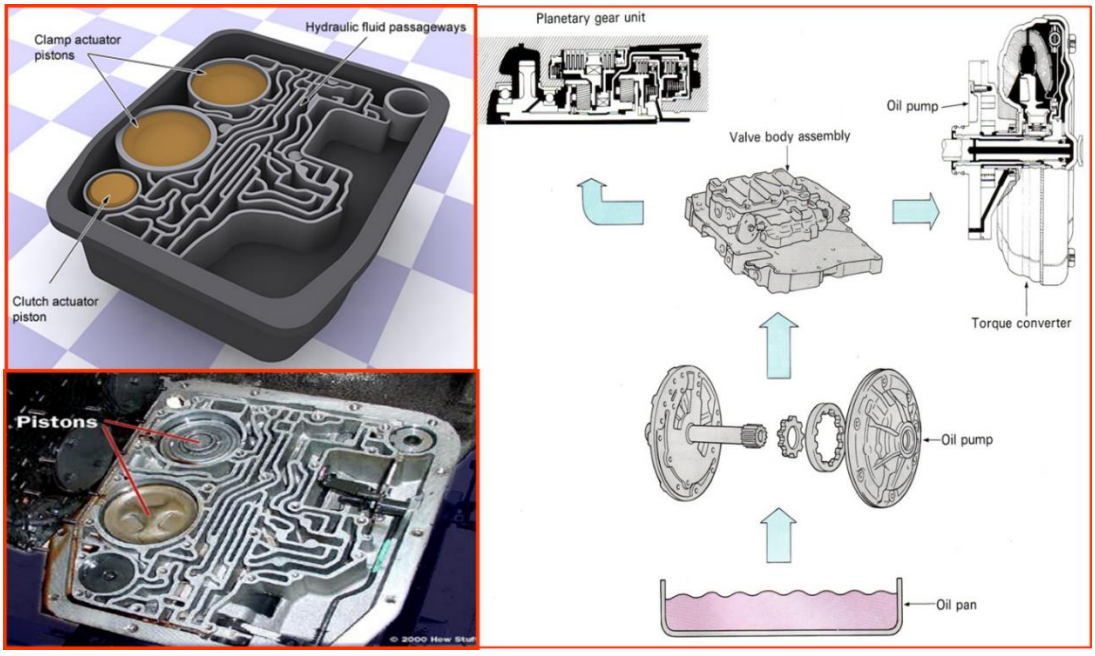
C. Hydraulic Control System

The hydraulic control system consists of

- Oil pan, which acts as the fluid reservoir;

- Oil pump, which generates the hydraulic pressure
- Various valves having various functions
- Fluid passages and tubes, which deliver the transmission fluid to the clutches, brakes

Most valves in the hydraulic control system are housed in the valve body assembly under the planetary gears



- Roles the hydraulic system:
  - The hydraulic system enables an automatic transmission to operate automatically.
  - Supply pressurized fluid to the torque converter for proper operation.
  - Regulate the hydraulic pressure generated by the oil pump.
  - Convert the engine load and vehicle speed into hydraulic "signals".
  - Applying hydraulic pressure to the clutches and brakes.
  - Lubricates the moving parts in the transmission with fluid.
  - Circulates the transmission fluid through a cooler.
  - Operates hydraulic valves in the transmission to control the shifting of gears.
- Transmission hydraulic pressures
  - Mainline Pressure

- Throttle Pressure
- Governor Pressure
- Converter and lubrication pressures

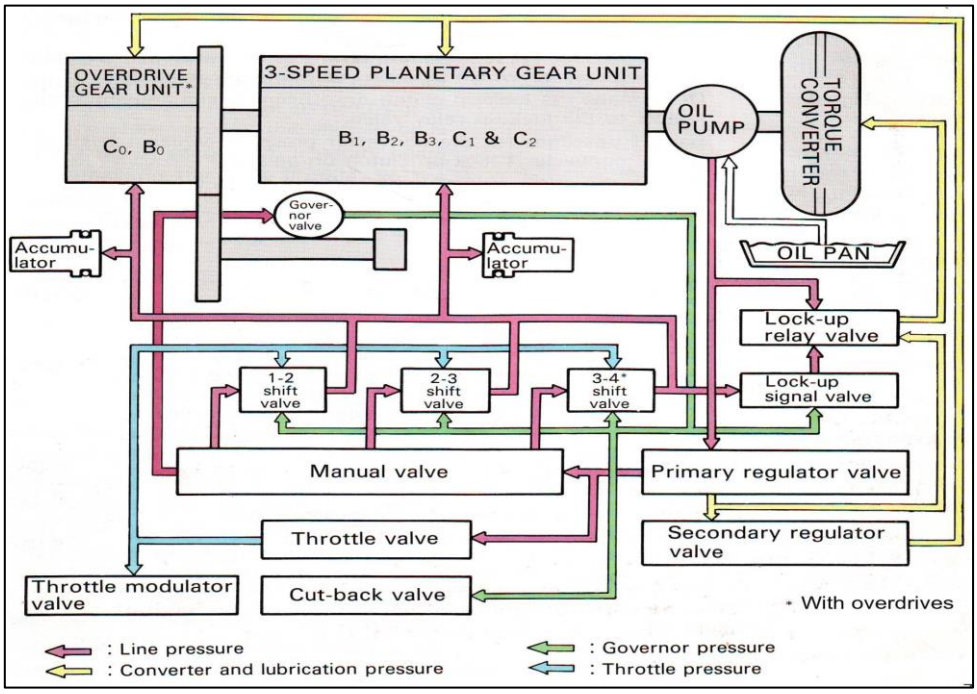


Figure 0.43: Layout of hydraulic system of automatic transmission including pressure lines

D. Manual Linkages

The automatic transmission up-shifts and down-shifts automatically. However, two linkages allowing manual operation by the driver are connected to the automatic transmission.

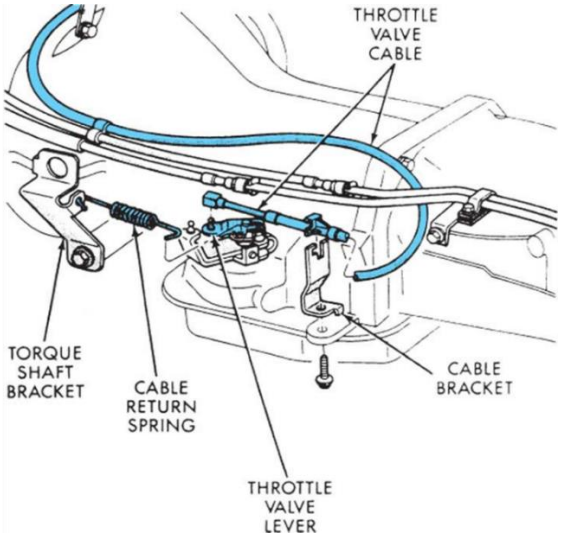


Figure 0.44: Automatic transmission shift lever and manual control mechanism

These linkages are

- The selector lever and cable,
- The accelerator pedal and throttle cable

The shift selector lever corresponds to the gearshift lever of the manual transmission. It is connected to the transmission via a cable or linkage.

The driver can select the driving modes such as Forward, Reverse, Neutral, Parking. In almost all automatic transmissions, the forward mode consists of three ranges:

- "D" (Drive),
- "2" (second)
- "L" (low)

For safety, the engine can be started only when the shift selector lever is at the "N" (neutral) or "P" (park) position; that is, when the transmission cannot transmit power from the engine to the drive train.

When the accelerator pedal is depressed a little, transmission up- and downshifting occur at relatively low vehicle speeds. When the accelerator pedal is depressed further, shifting occurs at relatively high speeds. The accelerator and throttle cables must be adjusted correctly to the specified lengths because correctly-timed transmission shifting requires conversion of the amount of accelerator pedal depression into the correct engine throttle valve opening angle, and correct transmission of that valve opening angle to the transmission.

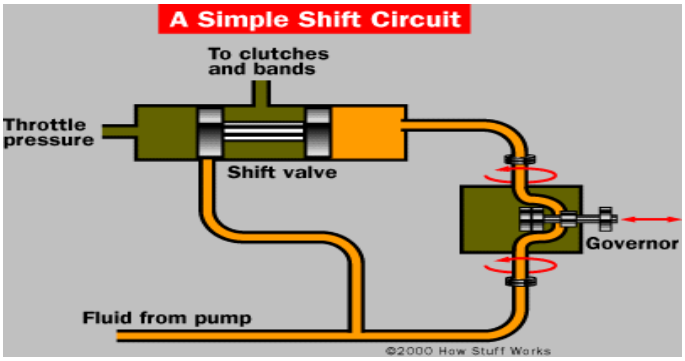


Figure 0.45: A simple shift circuit based on throttle and governor pressure

The accelerator pedal is connected to the throttle valve of the carburetor (to the throttle body in an EFI engine) by the accelerator cable. The degree of accelerator pedal depression that is, the throttle valve opening is correctly transmitted to the transmission by this cable. The automatic transmission up-shift and down-shift speeds depend on the engine load (the throttle valve opening), and the driver can vary these by controlling the amount of accelerator pedal depression.

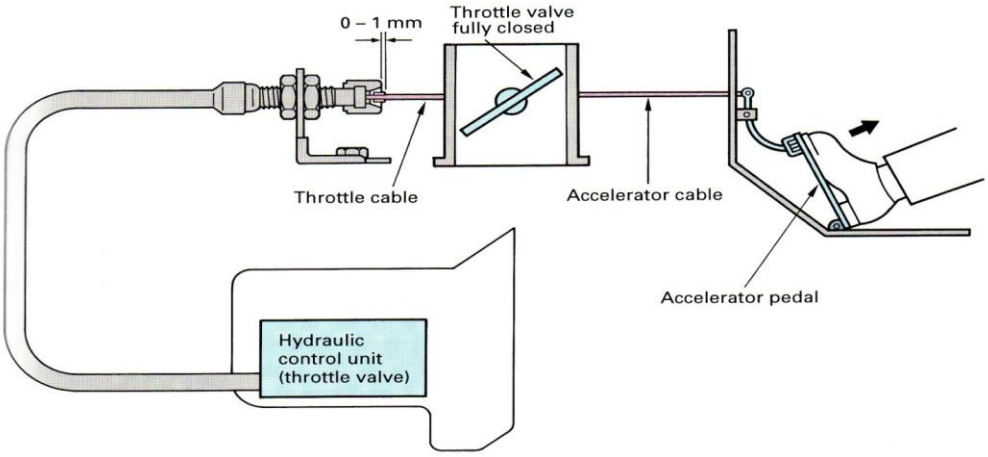


Figure 0.46: coordinated system for throttle valve and governor control

1.5.3 Automatic Transmission-Power Flow Model

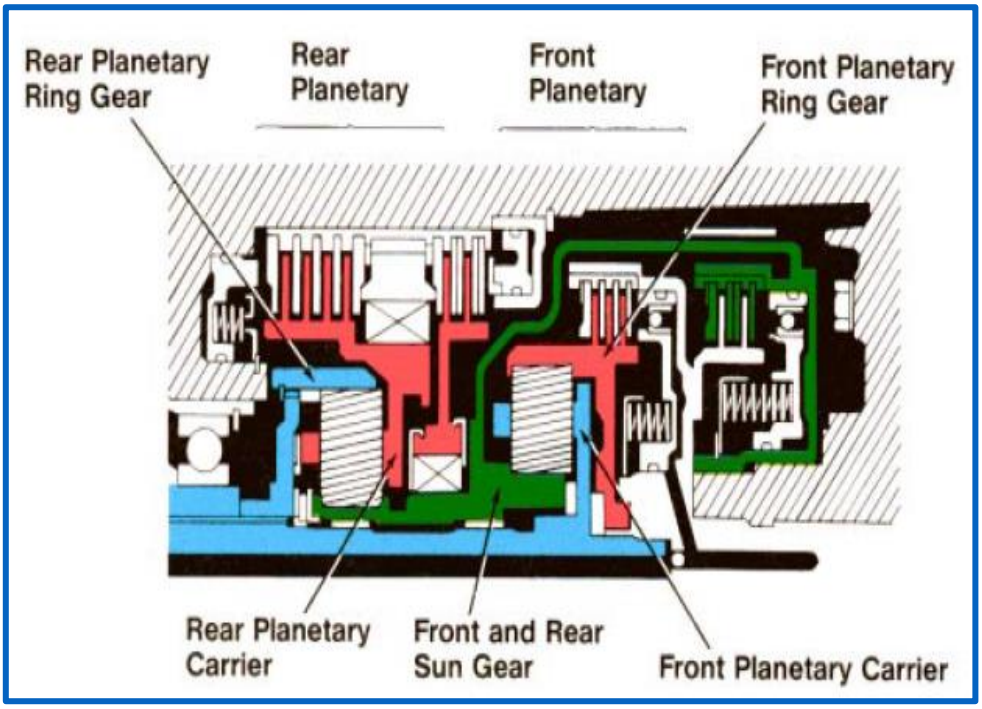


Figure 0.47: Sectional view of planetary gear unit

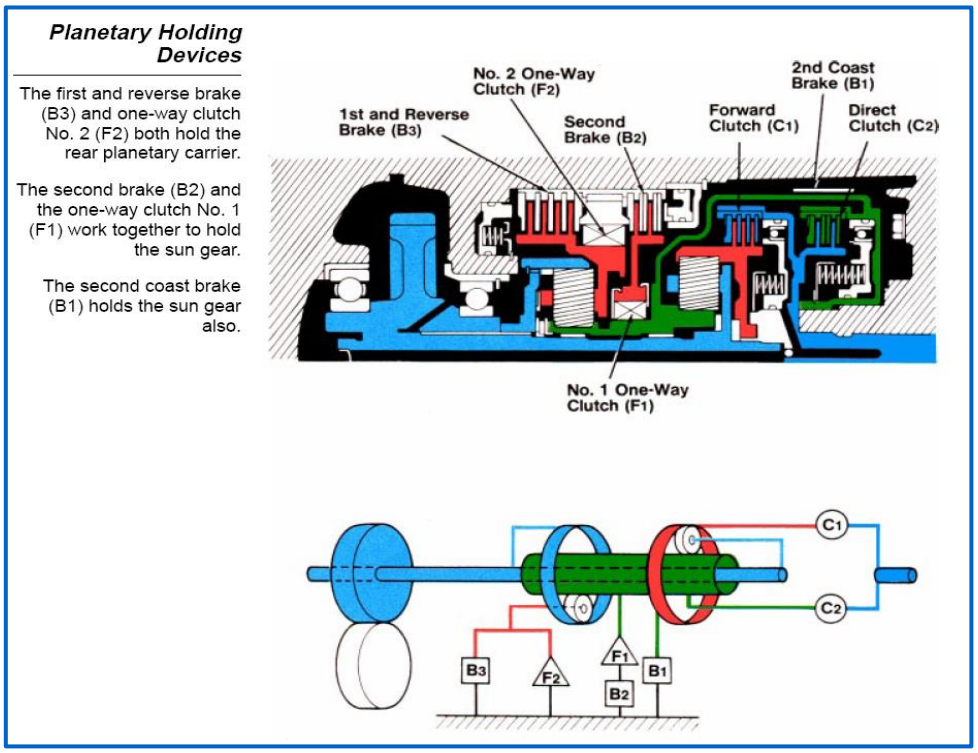


Figure 0.48: Sectional view of planetary holding devices

HOLDING DEVICE		FUNCTION
C_1	Forward Clutch	Connects input shaft and front planetary ring gear.
C_2	Direct Clutch	Connects input shaft and front and rear planetary sun gear.
B_1	2nd Coast Brake	Prevents front and rear planetary sun gear from turning either clockwise or counterclockwise.
B_2	2nd Brake	Prevents outer race of F1i from turning either clockwise or counterclockwise, thus preventing front and rear planetary sun gear from turning counterclockwise.
B_3	1 st and Reverse Brake	Prevents rear planetary carrier from turning either clockwise or counterclockwise.
F_1	No. 1 One-Way Clutch	When B2 is operating, prevents front and rear planetary sun gear from turning counterclockwise.
F_2	No. 2 One-Way Clutch	Prevents rear planetary carrier from turning counterclockwise.

Figure 0.49: Common holding devices with in automatic transmission and their functions

Table 0-2: The relation between the positions of shift lever and gear range with operation of holding and connecting devices

Shift Lever Position	Gear Position	C_0	C_1	C_2	B_0	B_1	B_2	B_3	F_0	F_1	F_2
P	Parking										
R	Reverse										
N	Neutral										
D	1st										
	2nd										
	3rd										
	O/D										
2	1st										
	2nd										
	3rd										
L	1st										
	2nd*										

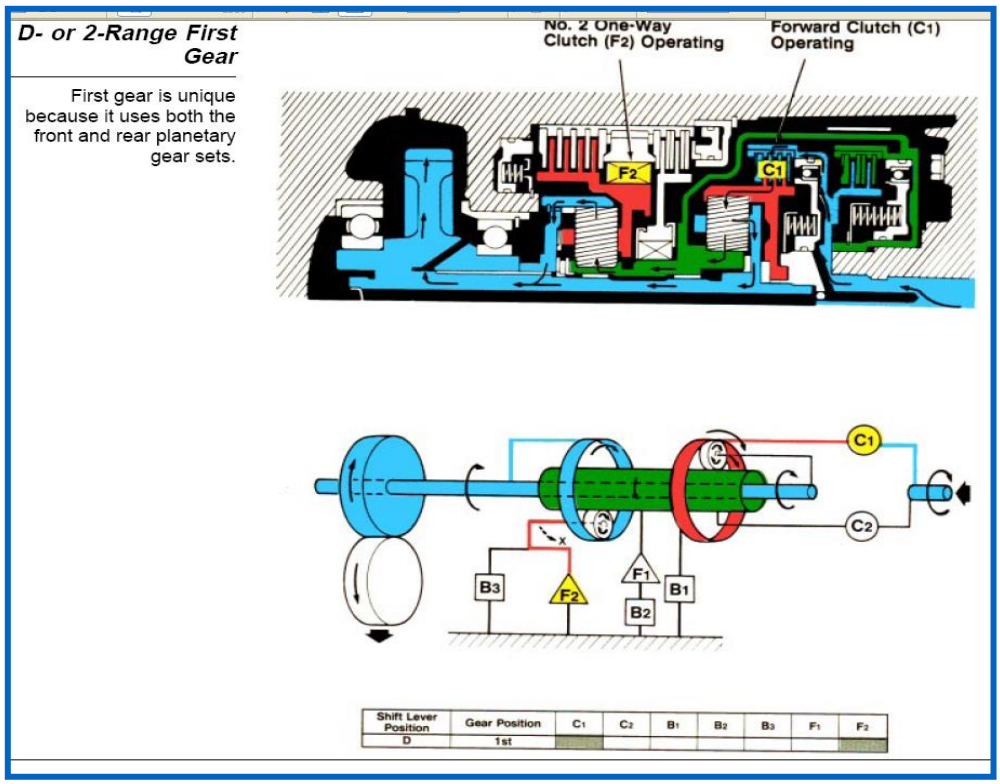


Figure 0.50: Power flow through Simpson Planetary Gear Set D or 2- Range 1st Gear

- Power flow through Simpson Planetary Gear Set D or 2- Range 1st Gear
  - 1st gear is unique because it uses both front and rear planetary gear sets
  - The forward clutch (C1) is applied in all forward gears & drives the ring gear of the front planetary gear set.
  - When the ring gear rotates CW, it causes the pinion to rotate CW since the sun gear is not held to the case.
  - The sun gear rotates in CCW direction
  - The front Planetary carrier which is connected to the out put shaft rotates, but more slowly than the ring gear, so for practical purpose, it is locked un to the case by the one way clutch No.2 (F2) Turning torque is transferred to the rear planetary by the sun gear which is turning CCW.

Self-check-1.1

Part I: Short answer questions

Directions: Write the correct short answer for questions listed below

1. Name three types of clutch linkages.
2. The number of gear teeth per unit of measurement of the gear's diameter (such as teeth/inch) is known as gear ___.
3. The surface of the pressure plate contacts the___.
4. The pressure plate moves away from the flywheel when the clutch pedal is ___.
5. What component keeps the stator assembly from rotating when driven in one direction and permits rotation when turned in the opposite direction?
6. What determines whether a conventional transmission or a transaxle is used?
7. What determines the timing of the shifts in an automatic transmission?
8. When a transmission is described as having two planetary gear sets in tandem, what does this mean?

Part II: True false questions

Directions: Write TRUE for correct statement and FALSE for wrong statement.

1. Some manufacturers recommend the use of heavy oil in the transaxle; others may recommend the use of automatic transmission fluid in the transaxle.
2. Bearing noise increases under load and is usually described as a growl that gets louder with speed.
3. The pressure plate moves away from the flywheel when the clutch pedal is released.
4. The Ravigneaux gearset has one sun gear, two sets of planet gears, and two ring gears.
5. A reverse idler gear changes the direction of torque flow to the opposite direction of engine rotation.
6. A set of gears can be configured or used in three different ways.
7. In most transmissions and transaxles, there is one synchronizer assembly for each speed gear.

8. The cone on a synchronizer's blocking ring serves as a cone-clutch assembly while changing gears

Part III: Multiple Choice questions

Directions: Choose the correct answer from the given alternatives.

1. The clutch, or friction, disc is connected to the___.
    A. Engine crankshaft
    B. Transmission input shaft
    C. Transmission output shaft
    D. Transmission countershaft
2. Torsional coil springs in the clutch disc ___.
    A. cushion the driven disc engagement rear to front
    B. are the mechanical force holding the pressure plate against the driven disc and flywheel
    C. absorb the torque forces
    D. are located between the friction rings
3. The surface of the pressure plate contacts the ___.
    A. transmission main shaft
    B. throw-out bearing
    C. clutch disc
    D. flywheel
4. Which of the following gear ratios indicates an overdrive condition?
    A. 2.15:1
    B. 1:1
    C. 0.85:1
    D. None of the above
5. Which type of gear develops gear whine at high rotational speeds?

A. Spur gear
B. Helical gear
C. Both a and b
D. Neither a nor b

6. When an idler gear is placed between the driving and driven gears, the driven gear:
   A. rotates the opposite direction as the drive gear
   B. rotates the same direction as the drive gear
   C. reduces the torque transfer from the drive gear to the driven gear
   D. none of the above
7. 4. The component used to ensure that the main shaft (output shaft) and main (speed) gear locked to it are rotating at the same speed is known as a ___.
   A. synchronizer
   B. shift detent
   C. shift fork
   D. transfer c
8. In a transaxle, the pinion gear on the pinion shaft meshes with the ___.
   A. reverse idler gear
   B. ring gear
   C. countershaft drive gear
   D. input gear
9. Which of the following gear ratios provides the highest torque multiplication?
   A. 0.85:1
   B. 2.67:1
   C. 5.23:1
   D. 0.50:
10. 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

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

A. Overdrive

B. Direct drive

C. Underdrive

D. Neutral

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

A. Pinion gear

B. Ring gear

C. Cluster gear

D. Counter gear

13. 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

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

A. external linkage

B. floor shift

C. column shift

D. internal linkage

15. Another name for clutch shaft:

A. Input shaft

B. Output shaft

C. Disk shaft

D. Pressure plate shaft

16. 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

A. Clutch housing

17. 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

18. 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

19. 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

20. 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 bearin

Unit Two: Inspecting Common Faults of Clutch and Transmission

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

- Techniques of troubleshooting
- Inspecting Common Faults of Clutch System
- Inspecting Common Faults of Manual Transmission
- Inspecting Common Faults of Automatic Transmission

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:

- Be familiar with common faults of clutch and transmission
- Interpret techniques of troubleshooting
- Accurately pinpoint the common faults of clutch system
- Perform transmission tests precisely
- Analyze the fault based on test results
- Verify the repaired systems functionality

1.6 Techniques of Troubleshooting

1.6.1 The Six-Step Approach

It is a way to organize your efforts, keeping you on-track while you are troubleshooting the problem. The Six- steps of Troubleshooting plan can be explained in either of the following manner. However, both steps have equivalent logical approach to conduct diagnostic process.

A. Verify the complaint

This is a method for gathering information stated by the customer (driver). Sometimes you will be able to discover other things that the driver does not realize. Therefore, you should attempt to understand what the customer complaint is and pay attention to the vehicle's operation at driving conditions. Because gathering information will simplify your task. This is the first step in any diagnostic process. When you are handed a repair order with a customer's complaint on it, there are three things that you must do:

- You must be able to identify the problem the customer noted
- You must determine if it is a problem or not
- If there is a problem, determine if it is intermittent or continuous

B. Define the problem

Now that you have verified that there is a problem, you need to examine the problem symptoms more thoroughly. The related symptoms check is an operational check
The major goal of this check is to determine:

- How much of the system is affected.
- Find clues to the location of the problem by operating other systems related or connected to the problem area

If any part of the failed system works, it is extremely important to determine exactly which parts are working and which parts are not. This step will save you from making unnecessary checks to parts of the system that are OK. In this step, you can define the problem and know what happens and when it happens.

C. Analyze the symptoms

At this point, you need to stop, and put all of this information together to define:

- Exactly which components/circuits are affected (both the customer's complaint and any related symptoms)
- What kind of problem you need to look for (open, short-to-ground, high resistance, if it is electrical problem)
- When it occurs (what operating conditions: key ON, driver's door open, etc.)
- In this step the problem system will be isolated which involves knowing which system can cause the problem.

D. Isolate the system

This is a kind of test to determine the exact problem. To do this:

- First identify the possible causes for the problem
- Find possible problem areas and determine where to begin making tests
- Then conduct test to pinpoint the problem
- Before identifying the exact problem (pinpoint) each suspected system is tested.
- If a fault is obtained in the system, detailed tests should be conducted to determine the exact problem.
- If no faults are found in the suspected parts (systems), others should be tested. At this point, you need to stop, and put all of this information together to define:

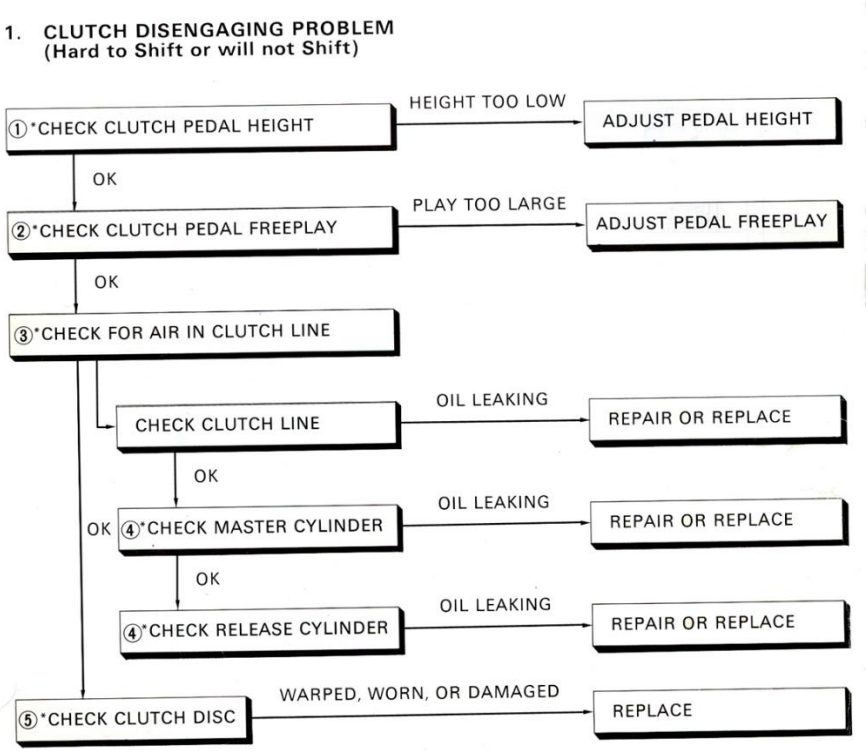
E. Correct the trouble

Correcting the trouble is probably the most straightforward step in the diagnostic process. Once the problems have been identified, they must be corrected. Here you have to follow the proper procedure when replacing any component and when making an adjustment.

F. Verify the repair

After making the repair, you must always verify that the problem was actually fixed. With the repairs and adjustments made, for example run the engine and bring it to the same condition that the problem occurred in before.

1.6.2 Branching diagnostic procedures



In diagnostic techniques used to pinpoint the most common faults of clutch and transmission system, it is expected to-

- Gather all possible information
  - Obtain the customer's explanation of the concern
  - Look up service history
- Listen for unusual noises and isolate them
  - Noise when clutch is first engaged: due to problem with friction lining
  - Noise only happens when foot is resting lightly on pedal: release bearing is probably at fault
- Road test the vehicle to verify customer concern
  - Pay close attention to the clutch during all phases of operation
- Go to Service manual for more information

1.7 Inspecting Common Faults of the Clutch

1.7.1 Clutch slippage

The engine over speeds without generating any increase in torque to the driving wheels in a condition. It occurs when the clutch disc is not gripped firmly between the flywheel and the pressure plate. Instead, the clutch disc slips between these driving members. It is partial engagement and partial disengagement. Slippage can occur during initial acceleration or subsequent shifts. A slipping clutch is associated with the following symptoms:

- The vehicle speed does not increase in accordance with that of the engine during sudden acceleration.
- A burning smell from the clutch.
- Reduced engine output when driving uphill.

Clutch slippage could be checked with the parking brake applied, by disengaging the clutch, shifting the transmission into third gear, and increasing the engine speed to about 2,000 rpm. Thereafter slowly releasing the clutch pedal until the clutch engages. In doing so the engine should stall immediately. If it does not stall within a few seconds, the clutch is slipping. Check the clutch linkage for binding and broken or bent parts. If no linkage problems are found, the transmission and the clutch assembly must be removed and overhauled.

Clutch slippage can be caused due to an oil-soaked or worn disc facing, warped pressure plate, weak or broken diaphragm spring, or the release bearing contacting and applying pressure to the release levers.

1.7.2 Clutch Dragging and Binding

E. Clutch Dragging

If the clutch disc is not completely released when the clutch pedal is fully depressed, clutch drag occurs. Clutch drag causes gear clash, especially when shifting into reverse. It can also cause hard starting and vehicle movement during starting since engine attempts to turn the transmission input shaft.

To check for clutch drag; start the engine, depress the clutch pedal completely, and shift the transmission into first gear. As the clutch pedal is depressed shift the transmission into neutral and wait 5 seconds before attempting to shift smoothly into reverse. It should take no

more than 5 seconds for the clutch disc, input shaft, and transmission gears to come to a complete stop after disengagement. This period, called the clutch spin down time, and should not be mistaken for clutch drag.

If the shift into reverse causes gear clash, raise the vehicle safely and check the clutch linkage for binding, broken, or bent parts.

F. Clutch Binding

If there is binding clutch problem, Pedal is hard to depress: due to binding linkage or cables (Clutch pedal does not operate smoothly). If no problems are found in the linkage, the transmission and clutch assembly must be removed so that the clutch parts can be examined. A binding or seized pilot bushing or bearing can also cause clutch drag Clutch drag can occur as a result of a warped disc or pressure plate, a loose disc facing, a defective release lever, or incorrect clutch pedal adjustment that results in excessive pedal play. A cracked or broken firewall around the clutch master cylinder or cable guide can also cause the clutch to bind or drag. Binding can result when the spline in the clutch disc hub or on the transmission input shaft are damaged or when there are problems with the release levers.

- Symptom: If the clutch cannot be disengaged, gear shifting becomes sluggish and/or the gears clash.
- Dragging is caused by: Warped disc or Pressure plate, Loose disc facing and too much clutch pedal free travel

1.7.3 Clutch Grabbing or Chatter

Even when the operator slowly releases the clutch pedal, intermittent vibrations sometimes accompany Clutch engagement (with vehicle stationary) and the vehicle sometimes jumps before the clutch is completely engaged. In either case, a smooth start is prevented. A shaking or shuddering that is felt in the vehicle as the clutch is engaged is known as clutch chatter. It usually occurs when the pressure plate first contacts the clutch disc and stops when the clutch is fully engaged.

Vibrations that are too low to be noticed during starting may become more noticeable when the car is started on an uphill or when loaded condition.

- To check for clutch chatter; start the engine, depress the clutch completely, and shift the transmission into first gear.

Increase engine speed to about 1,500 rpm, then slowly release the clutch pedal and check for chatter as the pedal begins to engage. Do not release the pedal completely, or the vehicle might jump and cause serious injury. As soon as the clutch is partially engaged, depress the clutch pedal immediately and reduce engine speed to prevent damage of clutch

- Usually clutch chatter is caused by liquid leaking onto the clutch and contaminating its friction surfaces. This results in a mirror like shine on the pressure plate or a glazed clutch facing.

Oil and clutch hydraulic fluid leaks can occur at the engine rear main bearing, transmission input shaft , clutch slave cylinder, and hydraulic line. Other causes of clutch chatter may include broken engine or transmission mount, loose bell housing bolt and damaged clutch linkage.

- During disassembly, check for a warped pressure plate or flywheel, hot spots on the flywheel, a burned or glazed disc facing, and worn input shaft splines.

If an oil-soaked clutch disc causes the chattering and no other parts are damaged, then the disc alone needs to be replaced. However, the cause of the oil leak must also be found and corrected. Clutch chatter can also be caused by broken or weak torsional coil springs in the clutch disc and by the failure to resurface the flywheel when a new clutch disc and/or pressure plate is installed. It is highly recommended that the flywheel be resurfaced every time a new clutch disc or pressure plate is installed.

1.7.4 Pulsating Clutch Pedal and vibration

- Pedal pulsations are a rapid up and down movement of the clutch pedal as the clutch engages or disengages.

A pulsating clutch pedal is caused by the run out (wobble or vibration) of one of the rotating members of the clutch assembly. To check for pedal pulsation; start the engine, depress the clutch pedal slowly until the clutch just begins to disengage, and then stop briefly. Resume depressing the clutch pedal slowly until the pedal is depressed to a full stop. A series of slight movements can be felt on the clutch pedal.

- Pulsating is caused by: Bent, or warped release levers, Misalignment of the transmission and engine, Warped pressure plate, disc, or flywheel.
- Clutch vibrations; unlike pedal pulsations, can be felt throughout the vehicle, and they occur at any clutch pedal position. These vibrations usually occur at normal engine operating speeds (more than 1,500 rpm).
- Possible sources of vibration that should be checked
  - Check the engine mounts and the crankshaft damper pulley.
  - Look for any indication engine parts rubbing against the body or frame.
  - Accessories can also be a source of vibration. To check them, remove the drive belts one at a time.
  - Set the transmission in neutral, and securely set the emergency brake.
  - Start the engine and check for vibrations.
  - Do not run the engine for more than 1 minute with the belts removed.
  - If the source of vibration is not discovered through these checks, the clutch parts should be examined. Be sure to check for loose flywheel bolts, excessive flywheel run out, and pressure plate cover balance problems.

1.7.5 Clutch Noises

Most clutch noises are caused by bad bearings or bushings including-

- Unlubricated clutch release mechanism.
  - An operator reports hearing a scraping, clunking, or squeaking sound when the clutch pedal is moved up or down. This is a good sign of a worn or un lubricated clutch release mechanism.
- Misalignment is a common cause of clutch problems.
- To diagnose, determine whether the noise changes with the clutch engaged or disengaged.
  - Clutch disengaged only
    - ✓ These noises are usually caused by a bad throw-out bearing or pressure plate release lever
    - ✓ Pilot bearing

- Clutch engaged only
  - ✓ Input shaft bearing or pilot bearing
  - ✓ Internal transmission component (other)
- In neutral only: that disappear when the clutch pedal is pushed, are caused by problems inside the transmission.

- To find unusual sound or noise:
  - Put stoppers under the wheels.
  - Depress the clutch pedal, and start the engine.
  - Release the clutch pedal, with the shift lever in the neutral position.
  - Depress the clutch pedal again completely.
  - Repeatedly depress and release the pedal, both quickly and slowly, to check for unusual sounds from the clutch.

1.8 Inspecting Common Faults of Transmission

To begin diagnosis, gather as much information as possible. Determine in which gears the transmission acts up: first, second, third, fourth, or in all forward gears when shifting. Does it happen at specific speeds? This information will assist you in determining which parts are faulty.

1.8.1 Most Common Transmission Faults

Most Transmission problems fall in to one of these categories

- Leak: fluid escapes from the transmission
- Hard shift: requires an abnormally high amount of force to shift into gear.
- Shift block out: will not shift into one or more gears
- Locked in to gear: will not shift out of a gear
- Jumps Out Gear: will shift into neutral on its own
- Clash/Grinding during Shift: gear clash/grinding noise and vibration occur as shift is made
- Noisy in neutral: a grinding, growling noise while in neutral
- Noisy in one gear: a grinding, growling bearing noise or rough growling, buzzing gear noise in only one gears.

- Noisy in all gears: same as above but in all gears
- Noisy in all reduction gear : same as above, but quiet in the 1:1 gear range

One example of troubleshooting chart is given below.

Problem	Possible Cause	Remedy
Gear clash when shifting from one gear to another	1. Clutch adjustment incorrect	1. Adjust the clutch.
	2. Clutch linkage or cable binding	2. Lubricate or repair as necessary.
	3. Clutch housing misalignment	3. Check runout at the rear face of the clutch housing. Correct runout.
	4. Lubricant level low or incorrect lubricant	4. Drain and refill the transmission/transaxle and check for lubricant leaks if the level was low. Repair as necessary.
	5. Gearshift components or synchronizer blocking rings worn or damaged	5. Remove, disassemble, and inspect the transmission/transaxle. Replace worn or damaged components as necessary.
Clicking noise in any one gear range	1. Damaged teeth on input or intermediate shaft gears (transaxles) or damaged teeth on the countergear, cluster gear assembly, or output shaft gears (transmissions)	1. Remove, disassemble, and inspect the unit. Replace worn or damaged components as necessary.
Does not shift into one gear	1. Gearshift internal linkage or shift rail assembly worn, damaged, or incorrectly assembled	1. Remove, disassemble, and inspect the transmission/transaxle cover assembly. Repair or replace components as necessary.
	2. Shift rail detent plunger worn, spring broken, or plug loose	2. Tighten the plug or replace worn or damaged components as necessary.
	3. Gearshift lever worn or damaged	3. Replace the gearshift lever.
	4. Synchronizer sleeves or hubs damaged or worn	4. Remove, disassemble, and inspect the unit. Replace worn or damaged components.

DEC MV-6721 By Tatek Mamo (PhD Scholar)

Locked in one gear—cannot be shifted out of that gear	1. Shift rails worn or broken, shifter fork bent, setscrew loose, center detent plug missing or worn	1. Inspect and replace worn or damaged parts.
	2. Broken gear teeth on countershaft gear input shaft, or reverse idler gear	2. Inspect and replace the damaged part.
	3. Gearshift lever broken or worn, shift mechanism in cover incorrectly assembled or broken, worn or damaged gear train components	3. Disassemble the transmission/transaxle. Replace the damaged parts of the assembly correctly.
Slips out of gear	1. Clutch housing misaligned	1. Check runout at the rear face of the clutch housing.
	2. Gearshift offset lever nylon insert worn or lever attachment nut loose	2. Remove the gearshift lever and check for loose offset lever nut or worn insert. Repair or replace as necessary.
	3. Gearshift mechanisms, shift forks, shift rail, detent plugs, springs, or shift cover worn or damaged	3. Remove, disassemble, and inspect the transmission cover assembly. Replace worn or damaged components as necessary.
	4. Clutch shaft or roller bearings worn or damaged	4. Replace the clutch shaft or roller bearings as necessary.
	5. Gear teeth worn or tapered, synchronizer assemblies worn or damaged, excessive end play caused by worn thrust washers or output shaft gears	5. Remove, disassemble, and inspect the transmission/transaxle. Replace worn or damaged components as necessary.
	6. Pilot bushing worn	6. Replace the pilot bushing.
Vehicle moving—rough growling noise isolated in transmission/transaxle and heard in all gears	1. Intermediate shaft front or rear bearings worn or damaged (transaxle) or output shaft rear bearing worn or damaged (transmission)	1. Remove, disassemble, and inspect the transmission/transaxle. Replace damaged components as necessary.

Problem	Possible Cause	Remedy
Rough growling noise when engine operating with transmission/transaxle in neutral	1. Input shaft front or rear bearings worn or damaged (transaxle) or input shaft bearing, countergear, or countershaft bearings worn or damaged (transmission)	1. Remove, disassemble, and inspect the transmission/transaxle. Replace damaged components as necessary.
Vehicle moving—rough growling noise in transmission—noise heard in all gears except direct drive	1. Output shaft pilot roller bearings	1. Remove, disassemble, and inspect the transmission. Replace damaged components as needed.
Transmission/transaxle shifts hard	1. Clutch adjustment incorrect	1. Adjust the clutch.
	2. Clutch linkage binding	2. Lubricate or repair as necessary.
	3. Shift rail binding	3. Check for mispositioned roll pin, loose cover bolts, worn shift rail bores, worn shift rail, distorted oil seal, or extension housing not aligned with the case. Repair as necessary.
	4. Internal bind in transmission/transaxle caused by shift forks, selector plates, or synchronizer assemblies	4. Remove, disassemble, and inspect the unit. Replace worn or damaged components as necessary.
	5. Clutch housing misalignment	5. Check runout at the rear of the clutch housing. Correct runout.
	6. Incorrect lubricant	6. Drain and refill.

1.8.2 Inspection of Manual Gearbox

When properly operated and maintained, a manual transmission/transaxle normally lasts the life of the vehicle without a major breakdown. Maintaining good internal lubrication is the key to long transmission/transaxle life. If the amount of oil falls below minimum levels, or if the oil becomes too dirty, problems result.

A. Transmission Visual inspection

- **Lubricant check**

The transmission/transaxle gear oil level should be checked at the intervals specified in the service manual. Normally, these range from every (12,000 to 48,000 km). For service convenience, many units are now designed with a dipstick and filler tube accessible from beneath the hood. Check the oil with the engine off and the vehicle resting in a level position. If the engine has been running, wait 2 to 3 minutes before checking the gear oil level.

Some vehicles have no dipstick. Instead, the vehicle must be placed on a lift, and the oil level checked through the fill plug opening on the side of the unit. Clean the area around the plug before loosening and removing it. Normally, lubricant should be level with, or not more than, 1⁄2 inch (12.7 mm) below the fill hole.

- **The under hood Visual checks for**
  - Clutch master cylinder fluid level or mechanical linkage
  - Broken or damaged engine motor mounts
  - Transmission and bell housing bolt tightness
- **The under vehicle visual checks for**
  - Damage to the transmission case, mounts and support.
  - Worn or bent shift linkage
  - Loose or missing transmission mounting bolts
  - Fluid leaks from the transmission.

B. Transmission in Vehicle test

- **Engine-off Shift Test**

The engine–off shift test, also called a static shift test. Measures the amount of effort it takes to move the synchronizer or gear, fork, and shift rail past the neutral detent and into mesh with the other detent engaged. On transmissions with exterior linkage, you can disconnect the shift rod and make the shift using a torque wrench and a socket on the shift lever bolt. This enables you to measure the actual amount of torque needed to make a shift. To make an engine- off shift test:

- Depress the cultch pedal
- Shift transmission in to a gear to align the parts and then shift back to neutral.
- Shift back in to the same gear, carefully noting the amount of effort required.
- Repeat this check on the remaining gears, noting any shift that requires a greater amount of effort.

- **Engine Running Shift Test**

The engine running test, also called a dynamic shift test, is almost a repeat of the engine–off check except that it checks for cultch drag as well as transmission problems. To make an engine running shift test:

- Check clutch pedal free play.
- Apply the parking brake securely, and start the engine.
- Let the engine idle in neutral, and note any unusual noises.
- Depress the clutch, and shift into first gear. Note and compare the effort required to do this during the engine-off test: a greater effort indicates a dragging cultch. Also note any unusual noises as the shift occurs.
- Release the parking brake and engage the clutch to cause the vehicle to move slightly while you check for unusual noise or movement.
- Repeat this process for the remaining gears.

- **Road Test**

If the customer's problem has not been located by the previous checks, the vehicle should be driven on the road. During the road test, the technician checks the quality of the up shifts and downshifts between gears, listens for any unusual noises in each gear, and feels for any unusual movements or vibrations as he or she accelerates or decelerates in each gear. Before conducting road, test:

- ✓ Check clutch pedal free play.
- ✓ Check transmission before testing (drive for about 20 minutes)

➢ With vehicle stationary, engine idling, clutch depressed, and in neutral:

- ✓ Release clutch and listen for noise, depress pedal; repeat 10 times, noting any noises.
- ✓ Release clutch, depress pedal, wait 3 seconds, and shift in to reverse, then first, and then back to reverse. Repeat, but wait 20 seconds. Note any differences in noise or shifting ability.
- ✓ Note pedal movement, position point at which clutch engages, and any noises.
- ✓ Shift into reverse, release pedal and while backing up carefully increase engine speed to 2,500rpm, and note any noises.

➢ Drive a vehicle on road with little traffic:

- ✓ Start in first, accelerate, and up shift at 4,000 rpm (1-2, 2-3,3-4 &4-5) depending on speed limits and driving conditions. Note shift quality and any noises.
- ✓ Decelerate and downshifting in each gear at about 3,000 rpm. Note shifts quality and any noises.
- ✓ Drive in fourth gear at speed limit or 60mph (96.56km/h), accelerate (if speed limit allows), and shift to fifth gear.
- ✓ Drive in fifth gear for a moment, and downshift to fourth gear.
- ✓ Repeat six times and not any problems

1.9 Inspecting Common Faults of Automatic Transmission

1.9.1 Basic Diagnostics

Automatic transmission problems are commonly caused by-

- Poor engine performance
- Problems in the hydraulic system
- Abuse resulting in overheating
- Mechanical malfunctions
- Electronic failures and
- Improper adjustments.

Engine performance can affect torque converter clutch operation. If the engine is running too poorly to maintain a constant speed, the converter clutch will engage and disengage at higher speeds. The customer complaint may be that the vehicle vibrates. If the vehicle has an engine performance problem, the cause should be found and corrected before any conclusions on the transmission are made.

A quick way to identify if the engine is causing shifting problems is to connect a vacuum gauge to the engine and take a reading while the engine is running. The gauge should be connected to intake manifold vacuum. A normal vacuum gauge reading is steady at about 17 in. Hg (431.8 mm Hg). The rougher the engine runs, the more the gauge readings will fluctuate.

1.9.2 Transmission Noise and Vibration Diagnosis

The entire driveline should be checked before assuming the noise is transmission related. Faulty bearings, damaged gears, worn or damaged clutches and bands, a bad oil pump, contaminated fluid, or improper fluid levels can cause abnormal transmission noises and vibrations.

- An unbalanced torque converter assembly, a poorly mounted torque converter, or a faulty output shaft causes most vibration problems.
- If the vibration changes with a change in engine speed, the cause of the problem is most probably the torque converter.
- If the vibration changes with vehicle speed, the cause is probably the output shaft or the driveline connected to it.
- If a noise is engine speed related and is present in all gears, including park and neutral, the most probable source of the noise is the oil pump.
- An engine related noise that is present in all gears except park and neutral, could be caused by those parts that rotate in all gears, such as the drive chain, the input shaft, and the torque converter.
- Noises that only occur in a particular gear must be related to those components responsible for providing that gear, such as a brake or clutch.

Problem	Probable cause(s)
Ratcheting noise	The return spring for the parking pawl is damaged, weak, or misassembled
Engine speed sensitive whine	Torque converter is faulty Faulty pump
Popping noise	Pump cavitation—bubbles in the ATF Damaged fluid filter or filter seal
Buzz or high-frequency rattle whine or growl	Cooling system problem Stretched drive chain Broken teeth on drive and/or driven sprockets Nicked or scored drive and/or driven sprocket bearing surfaces Pitted or damaged bearing surfaces
Final drive hum	Worn final drive gear assembly Worn or pitted differential gears Damaged or worn differential gear thrust washers
Noise in forward gears	Worn or damaged final drive gears
Noise in specific gears	Worn or damaged components pertaining to that gear
Vibration	Torque converter is out of balance Torque converter is faulty Misaligned transmission or engine Output shaft bushing is worn or damaged Input shaft is out of balance The input shaft bushing is worn or damaged

1.9.3 Visual Inspection

Diagnosis of transmission problems should continue with conducting a thorough visual inspection, checking the various linkage adjustments, retrieving all DTCs (if any), and checking basic engine operation. Also, check the voltage of the battery as improper voltage can affect the performance of the transmission

- **Fluid Leaks**

Check all drivetrain parts for looseness and leaks. If the transmission fluid was low or there was no fluid, raise the vehicle and carefully inspect the transmission for signs of leakage.

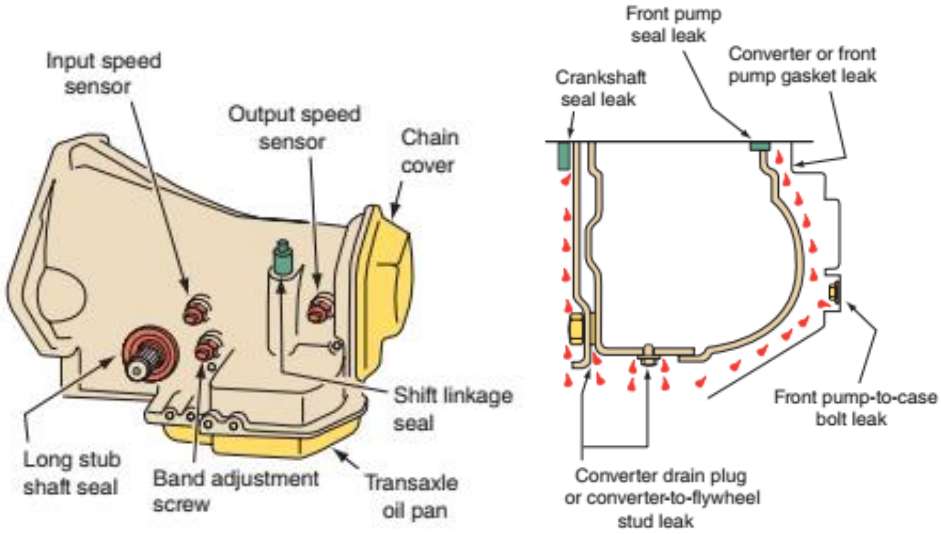


Figure 0.1 Possible sources of fluid leaks on this transaxle (left) and by determining the direction of fluid travel, the cause of a fluid leak around the torque converter can be identified (right)

Defective gaskets or seals often cause leaks. Common sources of leaks are the oil pan seal, rear cover and final drive cover (on transaxles), extension housing, speedometer gear assembly, and electrical switches mounted into the housing. The housing may have a porosity problem, allowing fluid to seep through the metal. Case porosity may be repaired with an epoxy sealer.

- **ATF Level Check**
  - The fluid level in the automatic transmission should be inspected by means of the dipstick after the transmission has been warmed up to ordinary operating temperature, approximately 158°F to 176°F or 70^0C-80^0C.
  - The fluid level is proper if it is in the hot range between hot maximum and hot minimum.
  - The cool level found on the dip stick should be used as a reference only when the transmission is cold. The correct fluid level can only be found when the fluid is hot
  - If the fluid level is too low, the oil pump will draw in air, causing air to mix with the fluid. Aerated fluid lowers the hydraulic pressure in the hydraulic control system, causing slippage and resulting in damage to clutches and

bands

- If the fluid level is excessive, planetary gears and other rotating components agitate the fluid, aerating it and causing similar symptoms as too little fluid. In addition, aerated fluid will rise in the case and may leak from the breather plug at the top of the transmission or through the dipstick tube

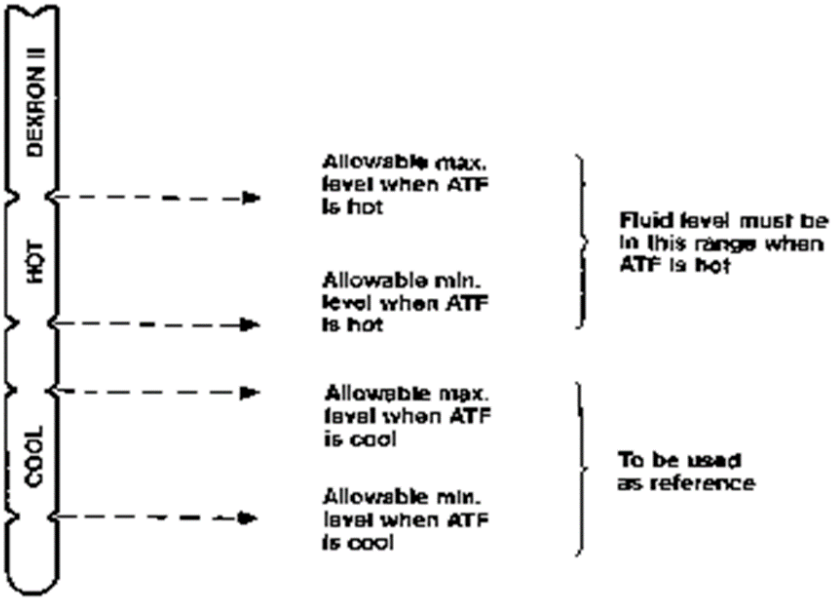


Figure 0.2: Typical dipstick used for Automatic transmission

- **ATF Condition Check**

- If the fluid is dark reddish brown or brown-black and smells burnt, this may indicate that the fluid has not been changed at proper intervals.
- Removing the pan may reveal large amounts of sediment, indicating a failed multi-plate clutch or brake. Flakes indicate a massive internal failure.
- If the fluid is milky colored, coolant is mixed with the ATF.
- In some cases, water may enter the transmission case through the breather cap or dip stick tube due to flooding or driving in adverse weather conditions with a filler tube that has not been capped with the dip stick.

Figure 0.3: Condition of automatic transmission fluid

- Aerated fluid can be caused by low fluid level or high fluid level.
- Small bubbles will cover the dip stick as an indication of this condition. it will cause oxidation and varnish buildup
- Air is whipped into the fluid and heat will cause the fluid to oxidize. Varnish build-up will cause the valves in the valve body to stick.

- Transmission fluid should last 100,000 miles if the operating temperature remains no higher than 175°F.
- For every 20 degrees of temperature increase, the projected service life of the fluid is cut in half.
- For example, if operating temperature is allowed to remain at 195°F, the service life of the fluid would be 50,000 miles.
- To get a better indication of fluid condition, place a sample of the fluid on a white paper towel.
- If any of the conditions listed below are found in the fluid sample, the transmission should be rebuilt or replaced with a remanufactured unit:
  - ✓ Residue or flaky particles of metal or friction material.
  - ✓ Heavily varnished fluid which is no longer clear.
  - ✓ Milky appearing fluid caused by engine coolant entering transmission.

- **Parking Pawl Inspection**
  - Any time you have the oil pan off, you should inspect all of the exposed parts,

especially the parking pawl assembly.

- This component is typically not hydraulically activated; rather, the gearshift linkage moves the pawl into position to lock the output shaft of the transmission.
- Check the pawl assembly for excessive wear and other damage. Also, check to see how firmly the pawl is in place when the gear selector is shifted into the PARK mode.
- If the pawl can be moved out easily, it should be repaired or replaced.

- **Torque Converter Testing**

G. Bench Testing

- In order to bench test the converter, the stator one-way clutch must lock in one direction and freewheel in the other.
- Two special service tools are used to perform the test: the stator stopper and the one-way clutch test tool handle.
- Since the one-way clutch is subject to greater load while in the vehicle (while on the bench is only subject to the load you can place by hand), final determination is made when it is in the vehicle
- Place the converter on its side and use the stator stopper which locks the stator to the converter case while the test tool handle is turned clockwise and then counterclockwise

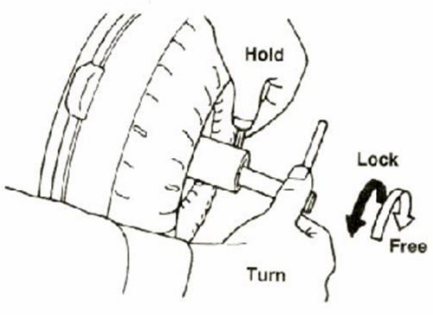


Figure 0.4: Torque converter bench test

H. Stall Testing

- The term stall is the condition where the impeller moves but the turbine does not.

- The greatest amount of stall happens when the pump impeller is driven at the maximum speed possible without moving the turbine. The engine speed at which this occurs is called the torque converter stall speed.
- Before stall testing a torque converter, consider the customer complaint and your test drive symptoms.
- The symptoms like poor top end performance or poor acceleration may already point to the torque converter as the problem.
- A road test of the vehicle's acceleration and forced downshift will indicate a slipping stator if acceleration is poor. Poor top end performance will indicate a stator which does not freewheel.

- **Stall test procedures**

The engine and transmission should both be at operating temperature and the ATF level should be at the proper level before stall test is executed.

1. Connect a tachometer to the engine and position it so that it can be easily read from the driver's seat.
2. Set the parking brake and place blocks in front of the vehicle's non-driving tires.
3. With the engine running, press and hold the brake pedal.
4. Then move the gear selector to the drive position and accelerate to wide open throttle and read the maximum engine rpm.
5. Hold the throttle down for 2 seconds then note the tachometer reading and immediately let off the throttle pedal and allow the engine to idle.
6. Compare the measured stall speed to specifications.
    - When engine rpm falls within the specifications, it verifies several items:
    - The one-way clutch in the torque converter stator is holding.
    - Holding devices (clutches, brakes, and one-way clutches) used in first and reverse gears are holding properly.
    - If the holding devices hold properly, the transmission oil pressure must be adequate.
    - Engine is in a proper state of tune.

- A lower than specified stall speed indicates converter problems and higher than normal readings indicates slippage in the transmission.

- **Inspect and Adjust the Throttle Cable**
  - To inspect the throttle cable adjustment, the engine should be off.
  - Depress the accelerator pedal completely, and make sure that the throttle valve is at the maximum open position.

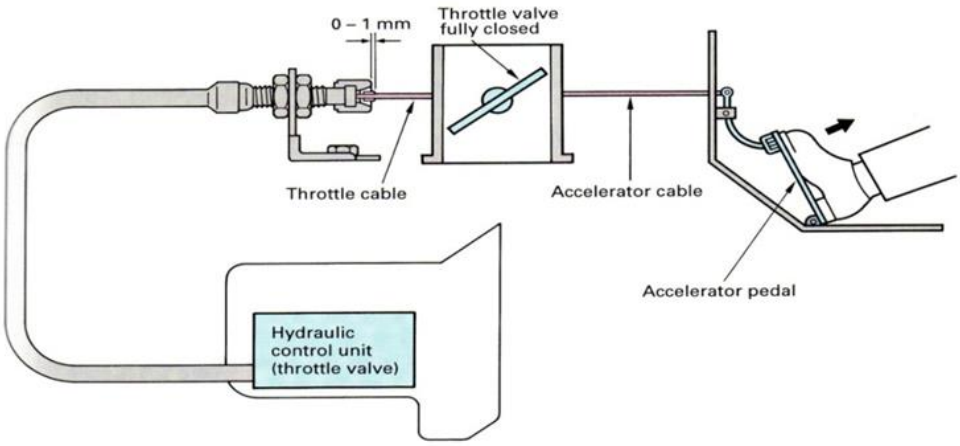


Figure 0.5: AT throttle cable adjustment

  - If the throttle valve is not fully open, adjust as needed.
  - With the throttle, fully open, check the throttle cable stopper at the boot end and ensure that there is no more than 1 mm between the end of the stopper and the end of the boot.
  - If adjustment is required, make the adjustment with the throttle depressed.
  - Loosen the locking nuts on the cable housing and reposition the cable housing and boot as needed until the specification is reached.

- **Troubleshooting Abnormal Line Pressure**

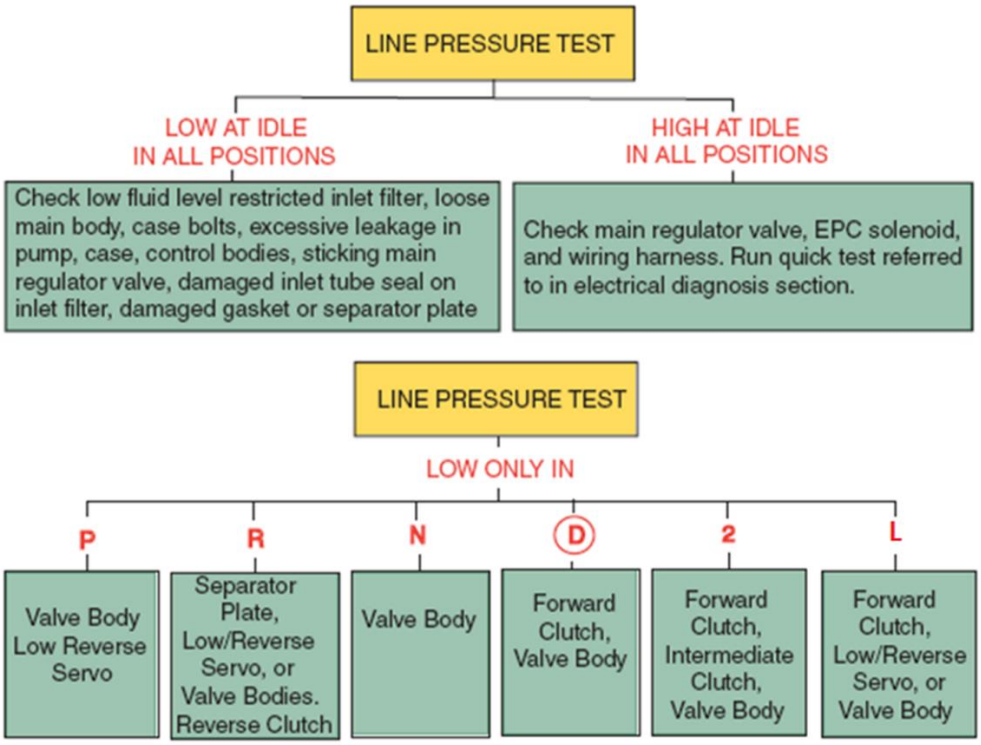


Figure 0.6: Troubleshooting chart for automatic transmission line pressure fault

- **Pressure Tests**
  - A pressure test measures the fluid pressure of the different transmission circuits in the various operating gears.
  - The number of hydraulic circuits that can be tested will vary between different makes and models.
  - Most transmissions are equipped with pressure taps, which allow the pressure test equipment to be connected to the hydraulic circuits.
  - Pressure taps on a typical transaxle case.

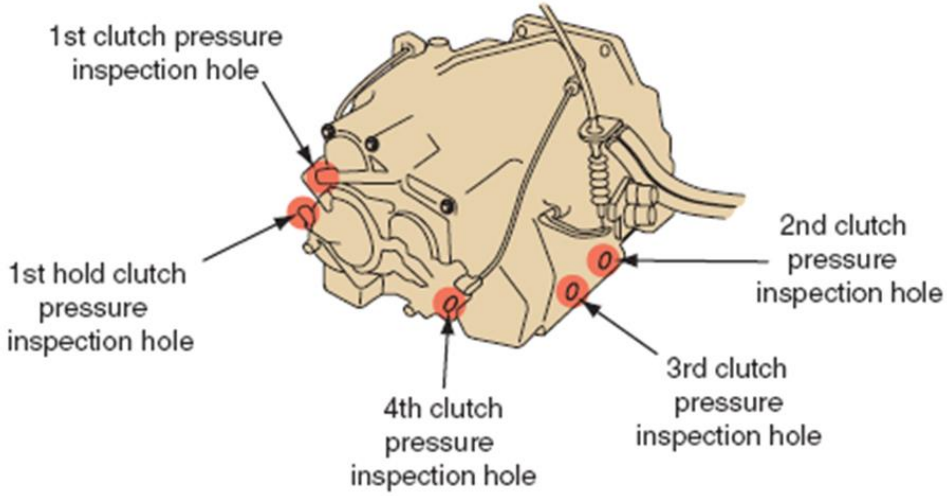


Figure 0.7: Pressure testing points for each line

Self-check-2.1

Part I: Short answer questions

Directions: Write the correct short answer for questions listed below

1. List five checks that should be made during the visual inspection of the parts of a transmission/transaxle.
2. List three causes of noise that are not transmission related but may appear to be.
3. List five common sources for transmission fluid leaks. List at least five items that are typically removed when removing a transaxle.
4. What is checked during a stall test?
5. If a transmission does not have a dipstick, how do you check the level of the fluid?

Part II: True false questions

Directions: Write TRUE for correct statement and FALSE for wrong statement.

1. Bearing noise increases under load and is usually described as a growl that gets louder with speed.
2. A reverse idler gear changes the direction of torque flow to the opposite direction of engine rotation.

3. The cone on a synchronizer's blocking ring serves as a cone-clutch assembly while changing gears
4. If the clutch fluid reservoir is low, the entire system should be checked for fluid leaks.
5. In manual transmission, using thicker lubricants than the specified can lead to hard shifting.
6. The vent in an automatic transmission housing is designed to allow fluid to escape when there is excessive pressure in the system.

Part III: Multiple Choice questions

Directions: Choose the correct answer from the given alternatives.

1. A rough, growling noise that is heard from a transaxle while it is in neutral with the engine running, the vehicle stationary, and the clutch engaged is a likely indication that there is a problem in the ___.
   A. Transaxle input shaft bearings
   B. Transaxle main (intermediate) shaft bearings
   C. First/second synchronizer assembly
   D. Pinion and ring gear interaction
2. A clicking noise during transmission/transaxle operation may be an indication of ___.
   A. Worn main shaft (input shaft) bearings
   B. Faulty synchronizer operation
   C. Failed oil seals
   D. Worn, broken, or chipped gear teeth
3. Which of the following is probably not the cause of a vibrating clutch?
   A. Excessive crankshaft end play
   B. Out-of-balance pressure plate assembly
   C. Excessive flywheel runout
   D. Loose flywheel bolts
4. Insufficient clutch pedal clearance results in ___.
   A. gear clashing while shifting transmission
   B. a noisy front transmission bearing

C. premature release bearing failure

D. premature pilot bearing failure

5. Before making a clutch adjustment, it is necessary to ___.

   A. measure clutch pedal free travel

   B. lubricate the clutch linkage

   C. check the hydraulic fluid level

   D. place the transmission in reverse

6. Which of the following would not cause clutch binding?

   A. A warped clutch disc

   B. Improper pedal adjustment

   C. An oil-soaked clutch disc

   D. A cracked fire wall

1. Technician A says that an oil-soaked clutch disc can cause clutch chatter. Technician B says that clutch chatter can be caused by loose bell housing bolts. Who is correct?

   A. Technician A only

   B. Technician B only

   C. Both A and B

   D. Neither A nor B

Operation Sheet 2.1

Operation Title: Visual inspection of the transmission

Instruction:

- Keep your working area safe
- Refer to your vehicle's service manual to obtain the manufacturer's specifications

Purpose: To check the condition of transmission as part of regular or routine maintenance

Required Tools and Equipment: Cotton cloth, hand tools, note book

Precautions: Before making a test make sure the vehicle is parked I safe level ground or properly hoisted

Quality Criteria: - Check properly all conditions

Procedures:

Perform the following checks to inspect the transmission/transaxle visually

1. Check for lubricant leaks at all gaskets and seals.
2. Check the case body for signs of porosity that show up as leakage or seepage of lubricant.
3. Push up and down on the unit. Watch the transmission mounts to see if the rubber separates from the metal plate. If the case moves up but not down, the mounts require replacement.
4. Move the clutch and shift linkages around and check for loose or missing components. Cable linkages should have no kinks or sharp bends, and all movement should be smooth.
5. Transaxle drive axle boots should be checked for cracks, deformation, or damage.
6. The constant velocity joints on transaxle drive axles should be thoroughly inspected.

Unit Three: Repairing Transmission and Clutch System

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

- Servicing Clutch and Manual Transmission
- Overhauling Clutch
- Overhauling Manual Transmission
- Conducting post repair test

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:

- Access and interpret repairing information correctly from manufacturer's specifications
- Replicate techniques of clutch and transmission service
- Demonstrate transmission overhauling
- Practice clutch services
- Install clutch precisely
- Grasp overhauling procedures of transmission
- Rectify the repaired clutch and transmission

3.1 Repairing Clutch systems

3.1.1 Clutch service

Gather as much information as you can on the operation of the clutch. Use this information, your knowledge of clutch principles, and a service manual troubleshooting chart to determine which components are faulty. Clutch servicing includes on vehicle inspection and adjustment.

A. Clutch Linkage Adjustment

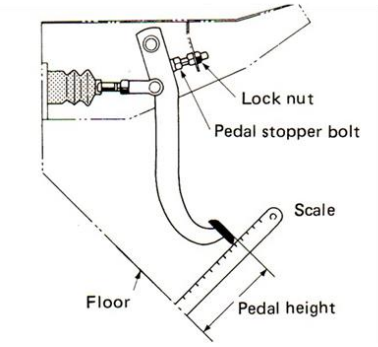
Except for systems with self-adjusting mechanisms, the release bearing should not touch the pressure plate release levers when the clutch is engaged (pedal up). Clearance between these parts prevents premature clutch plate, pressure plate, and release bearing wear. As the clutch disc wears and becomes thinner, this clearance is reduced. Clearance can be ensured by adjusting the clutch linkage so the pedal has a specified amount of play, or free travel. Free travel is the distance a clutch pedal moves when depressed before the release bearing contacts the clutch release lever or pressure plate.

Clutch adjustments are made to compensate for wear of the clutch disc lining and linkage between the clutch pedal and the clutch release lever. This involves setting the correct amount of free play in the release mechanism.

- Too much free play causes the clutch to drag during clutch disengagement.
- Too little free play causes clutch slippage

A clutch adjustment may be required to maintain the correct pedal height and free travel.

Pedal height: adjust the height by turning the pedal stopper bolt to the specification indicated on the manual.



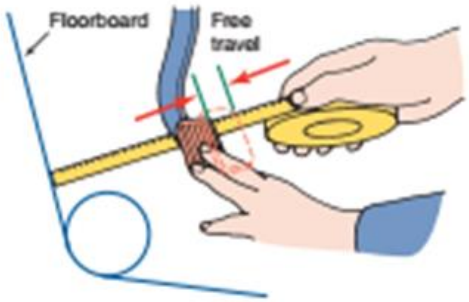


Figure 0.1: Clutch pedal height and free play adjustment

- Pedal free play
  - With Clutch cable type: Typically the clutch cable will have an adjusting nut. When the nut is turned, the length of the cable housing increases or decreases.
  - With hydraulic Clutch type: The hydraulically operated clutch shown in figure is adjusted by changing the length of the master or slave (refer manufacturers manual) cylinder pushrod.

B. Check Clutch Fluid Level

The fluid for a hydraulic clutch system is checked by looking at the fluid's level in the master cylinder's reservoir. Most reservoirs have a mark to indicate the proper level. If there are no marks, check the service information. If the level is low check for fluid leaks, Worn out piston seals, Air in the system and Corrosion buildup. Internal hydraulic system problems; the result of dirty or aging internal rubber sealing parts are Master and slave cylinder can develop leaks

Hydraulic clutch systems need to be bleed just like brake systems when air enters the system.

- The slave cylinder will have a bleeder screw
- All air must be removed for proper operation
- Use of a pressure or vacuum bleeder can greatly reduce time.

C. External Clutch Linkage Lubrication

- External clutch linkage should be lubricated at regular intervals, such as during a chassis lubrication.
- Refer to the vehicle's service manual to determine the proper lubricant. Many clutch linkages use the same chassis grease used for suspension parts and U-joints.
- Lubricate all the sliding surfaces and pivot points in the clutch linkage. The linkage should move freely after lubrication.

3.1.2 Overhauling clutch assembly

A. Remove clutch from the vehicle

- Remove a Transmission or Transaxle

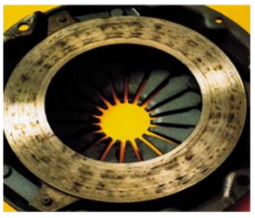
- Follow instructions in service manual
- In rear-wheel-drive cars, mark and remove: Driveshaft, Vehicle speed sensor, Cross member and transmission.
- Front-wheel-drive cars, remove: Half shafts and Transaxle

Major steps

- Remove fasteners between housing and engine
- Mark parts before disassembly
- Use an aligning arbor to hold the disc while removing clutch cover
- Inspect part for damage
- Clean parts with hot soapy water, parts cleaner, or alcohol

B. Inspect clutch components after disassembling

Check the friction disc, bell housing, flywheel, and pressure plate for signs of oil leakage. Check the friction disc defects for signs of the causes of problems. Identify and repair the cause before installing new parts. Typical signs of defect and the corresponding causes are presented in the following figure.



Heavy chatter marks oil or grease onto the clutch facing.

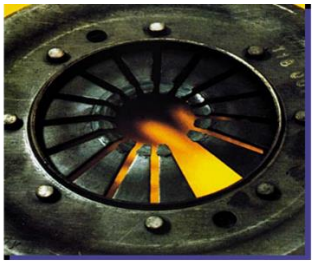
Hot spots of clutch slip or oil onto the clutch facing.

Friction material worn down to the rivets.

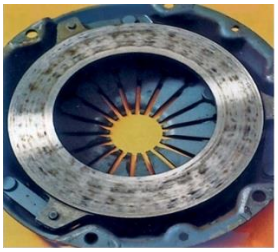
Deep scoring in the friction material on the flywheel side flywheel was not resurfaced or replaced during a previous repair

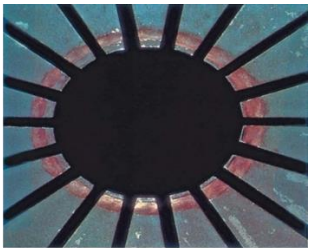
A broken cushion segment caused by a missing or defective pilot bearing.

A destroyed torsional damper by driving at too low an engine speed



A worn down or broken diaphragm by a faulty release bearing or a linkage problem





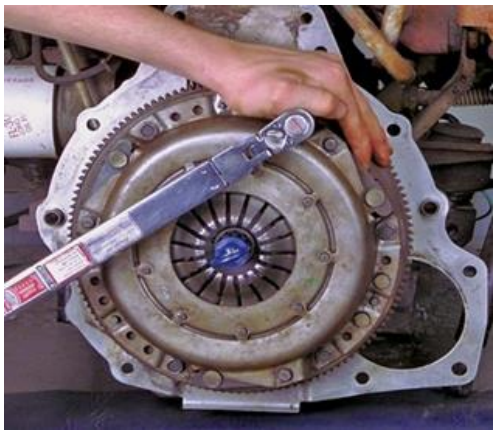
It should be checked for hot spots, scoring, finger wear, and bent or broken fingers.

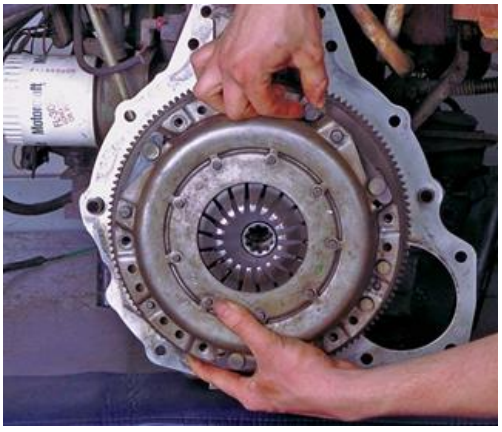
Figure 0.2: Indications of different faults on disassembled parts of clutch

C. Servicing the Inside Clutch Assembly

1 Attaching bolts of pressure plate must be loosened in a staggered (zigzag) sequence.

2 Torque the pressure plate and flywheel to manufacturer's specifications in a staggered sequence.





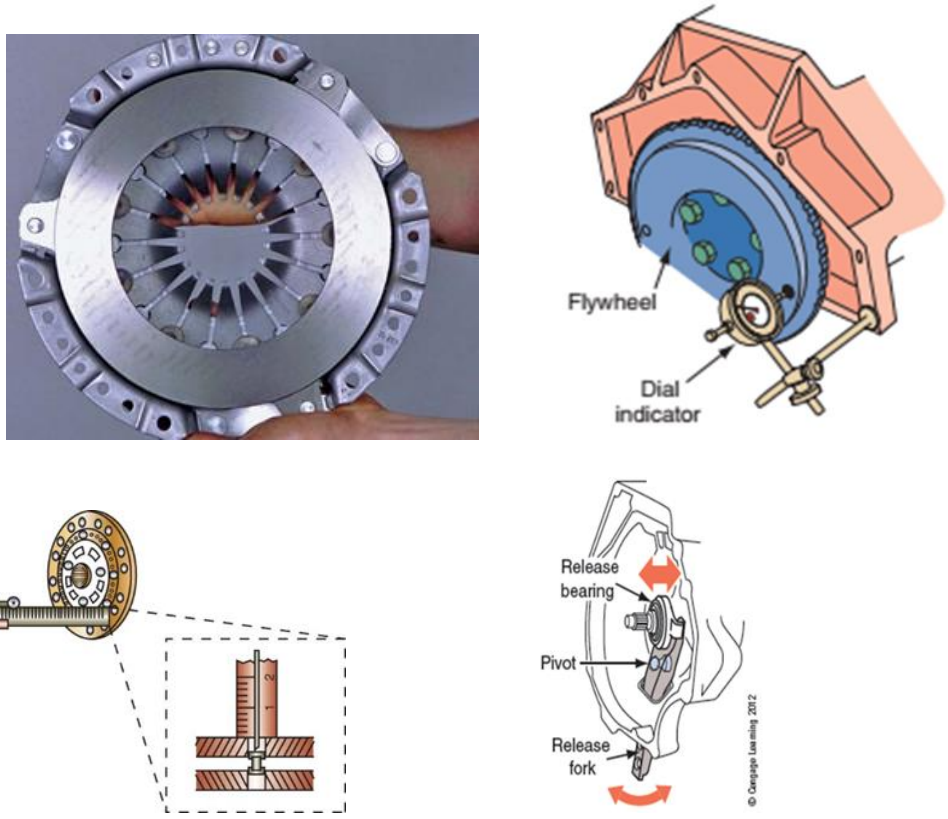


Figure 0.3 Services of clutch internal assembly

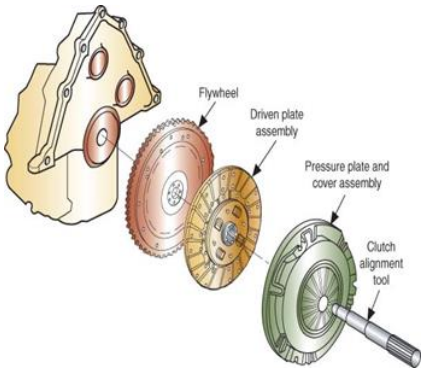
3 Inspect rivet depth .If the clutch is removed from a vehicle with more than 50,000 miles, it should be replaced. All clutch disc mating surfaces must be free of dirt and grease.

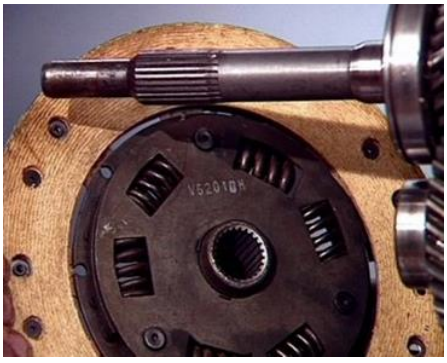
4 Flywheel Inspection-Check the flywheel for signs of glazing, overheating, or excessive wear. Discoloration of the surface may indicate glazing or overheating of the flywheel. Replace if any grooves or shows signs of uneven wear or any evidence of cracks. Check the teeth on the flywheel's ring gear; if there is damage, the ring gear or flywheel should be replaced. Warpage occurs with overheating and can cause clutch chatter and vibrations. The flatness of the flywheel can be checked with a straightedge and a feeler. Check run out also.

If the system uses a pilot bearing it should be replaced with the disc/pressure plate. A removal tool is usually necessary Release bearing sometimes fails and usually replaced on a preventative maintenance basis. Sometimes release fork is reused. Check front bearing retainer. Lubricate release mechanism contacts

3.1.3 Clutch Installation

- Use of a clutch alignment tool is essential
- The alignment tool centers the clutch disc before the pressure plate is tightened.
- The splines on the input shaft must be lightly greased.
- Always test-fit a new clutch disc on the input shaft prior to installation
- All metal to metal friction points must be lightly greased including:
  - ✓ Bearing retainer
  - ✓ Throw-out bearing
  - ✓ Fork pivots
  - ✓ Linkage pivots
  - ✓ Input shaft
- Important considerations
  - ✓ Be sure to clean your hands
  - ✓ Thin film of grease is applied to input shaft splines
  - ✓ Install disc in the right direction
  - ✓ Tighten all clutch cover screws
  - ✓ Use a jack to lift transmission into place
  - ✓ Perform adjustments and fluid level checks
  - ✓ Test-drive





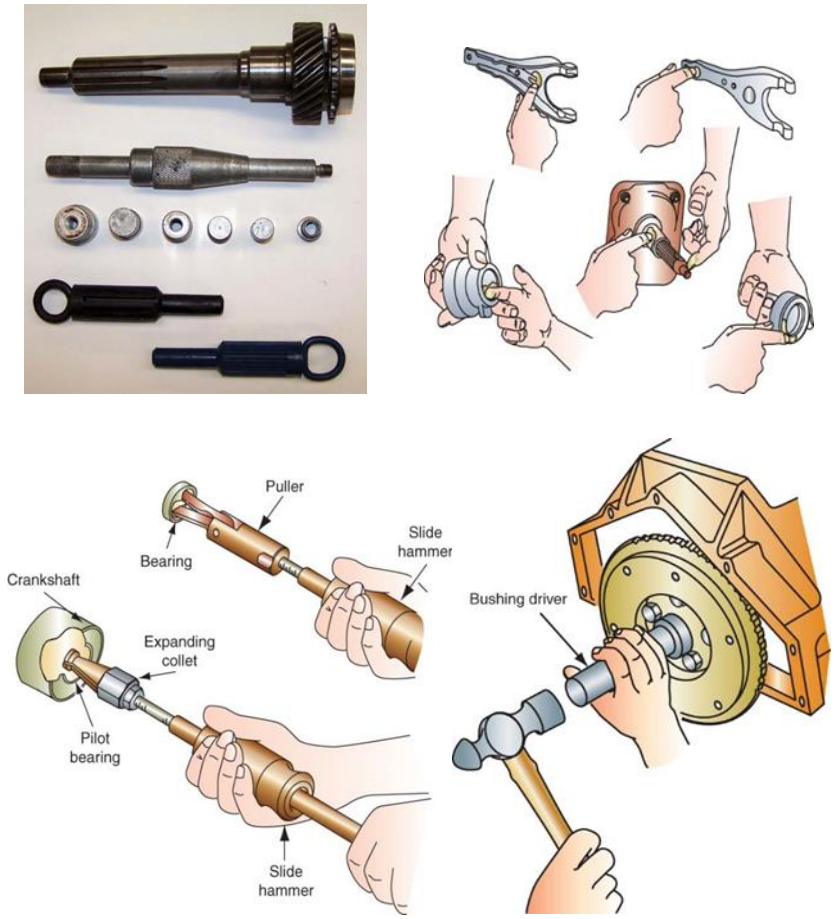


Figure 0.4: Clutch installation sequence

3.2 Repairing Transmission

3.2.1 Transmission in Vehicle Service

If possible, service and repair operations are done with the transmission in the vehicle. It includes:

- A periodic check of the lubricant level
- Visual inspection for leaks and other abnormal conditions.
- Change Fluid (lubricant)
- Back-Up Light Switch Service
- Rear oil seal and bushing replacement

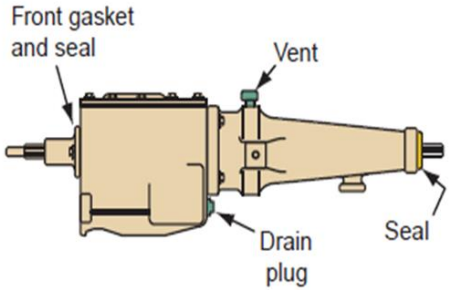


Figure 0.5 Common sources of oil leakage

- Linkage adjustment
- Mount replacement
- Speedometer Drive Gear Service

A. Change Fluid (lubricant)

- Follow manufacturer's recommend intervals of fluid replacement.
- When the vehicle is operated under severe conditions, such as in high heat or dusty road conditions, the fluid may need to be periodically changed.
- To change the transmission fluid, drive the vehicle to warm the fluid, raise the vehicle on a hoist. Park car on level so that all of the fluid can drain out.
- Wipe the area around the plug and remove it. Catch the fluid in a catch pan positioned below the hole.
- Let the transmission drain completely, because the fluid is normally very thick and it takes some time to drain it all out.
- Inspect the drained fluid for gold color metallic and other particles. The gold color particles come from the brass blocking rings of the synchronizers
- Be careful to pull the shavings out, not push them in.
- Large amounts of metal particles indicate severe problems. To remove Metal shavings insert a small magnet into the drain hole and Sweep it around the inside to remove all metal particles, but for brass shavings, insert a small brush or rag because brass is not magnetic.
- Before refilling the transmission, reinstall the drain plug with a new washer or a sealer . Remove the filler plug, which is normally located above the drain plug and refill recommended type oil
- Normally the case should be filled until the oil just starts to run out the filler hole or until it is at the bottom of the bore.
- Reinstall the plug with a new washer and check the transmission housing vent to make sure it is not blocked with dirt. If the case is not properly vented, the fluid can easily break down and the pressure buildup can cause leaks.
- Make sure you fill the transmission with the correct type and amount of fluid. Too much or too little fluid can destroy a transmission

B. Rear Oil Seal and Bushing Replacement

Procedures for the replacement of the rear oil seal and bushing on a transmission vary little with each car model. Typically, to replace the rear bushing and seal, follow these steps:

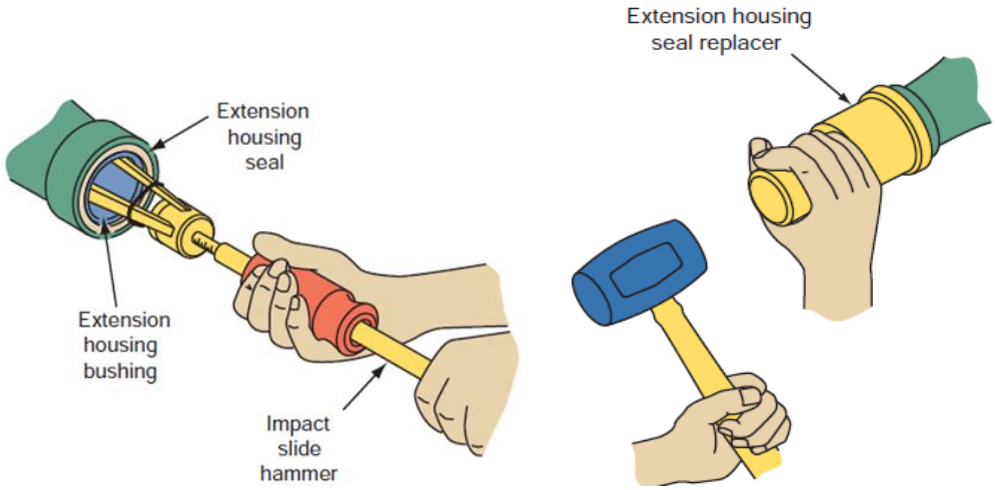


Figure 0.6: Removing the extension housing's seal and bushing and Drive the new seal in place with a hammer and seal driver.

STEP 1: Remove the drive shaft.

STEP 2: Remove the old seal from the extension housing.

STEP 3: Insert the appropriate puller tool into the extension housing until it grips the front side of the bushing.

STEP 4: Pull the bushing from the housing

STEP 5: Drive a new bushing into the extension housing.

STEP 6: Lubricate the lip of the seal, and then install the new seal in the extension housing

STEP 7: Install the drive shaft.

C. Linkage Adjustment

- Transmissions with internal linkage have no provision for adjustments. However, external linkages, both floor and column mounted, can be adjusted.

- Linkages are adjusted at the factory, but worn parts may make adjustments necessary. Also, after a transmission has been disassembled, the shift lever and other controls may need adjustment.
- Only externally controlled gearshift levers and linkages can be adjusted.
- To begin the adjustment procedure, raise the car and support it on jack stands. Then follow the procedure given in your service manual.

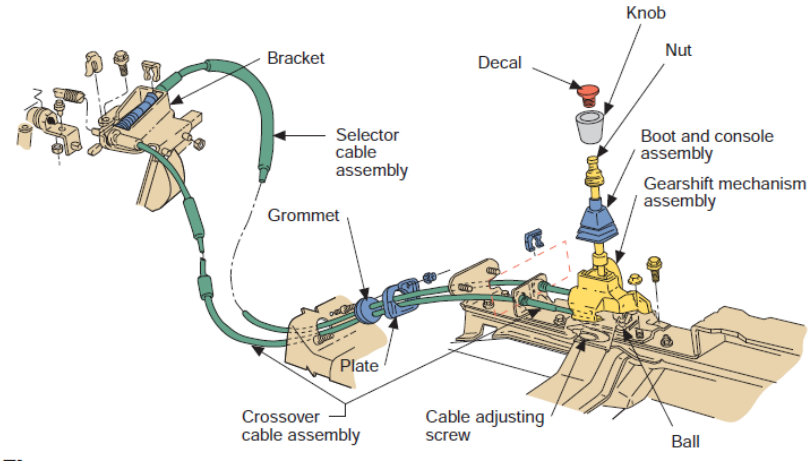


Figure 0.7: Adjustment for cable type shift linkage

D. Back-Up Light Switch Service

- To replace the back-up light switch, disconnect the electrical lead to switch.
- Put the transmission into reverse gear and remove the switch. Never shift the transmission until a new switch has been installed.
- To prevent fluid leaks, wrap the threads of a new backup light switch with Teflon tape in a clockwise direction before installing it.
- Tighten switch to the correct torque and reconnect the electrical wire to it.

E. Speedometer Drive Gear Service

- Begin to remove the speedometer cable retainer and drive gear by cleaning off the top of the speedometer cable retainer.
- Then remove the hold down screw that keeps the retainer in its bore. Carefully pull up on the speedometer cable, pulling the speedometer retainer and drive gear assembly from its bore. Unscrew the speedometer cable from the retainer.

- To reinstall the retainer, lightly grease the O-ring on the retainer and gently tap the retainer and gear assembly into its bore while lining the groove in the retainer with the screw hole in the side of the clutch housing case.
- Install the hold down screw and tighten it in place.

3.2.2 Transmission Overhauling

The overhauling operations for most transmissions are very similar. These include:

- Transmission removal from a vehicle
- Disassembly of the unit
- Gear inspection
- Bearing inspection
- Adjusting bearing clearance as the unit is reassembled.
- Assembling the unit
- Installing transmission on the vehicle
- Filling lubricant and rod testing

The exact procedure for doing each of these will vary depending on the make. It is highly recommended that the service manual procedure be followed along with the clearances and torque specification.

A. Transmission Removal

- The exact operation varies somewhat between vehicle models, so it is highly recommended that a service manual covering the particular vehicle model be used when you remove and replace a transmission.
- The basic removal procedures are as follows:
  1. Unscrew the transmission drain plug and drain the oil.
  2. Remove the drive shaft & cover end of the output shaft with plastic.
  3. Disconnect the transmission linkage at the transmission.
  4. Unbolt and remove the speedometer cable from the extension housing.
  5. Remove all electrical wires leading to switches on the transmission.
  6. Remove any cross members or supports if necessary.
  7. Support the transmission and engine with jacks.

8. The service manual recommends depending upon what, remove the transmission to clutch cover bolts or the bolts going into the engine from the clutch cover.
9. Slide the transmission straight back

B. Transmission Disassembly

- Before disassembly, remove the inspection cover. This will allow you to observe transmission action. Shift the transmission into each gear and at the same time, rotate the input shaft while inspecting the conditions of the gears and synchronizers.

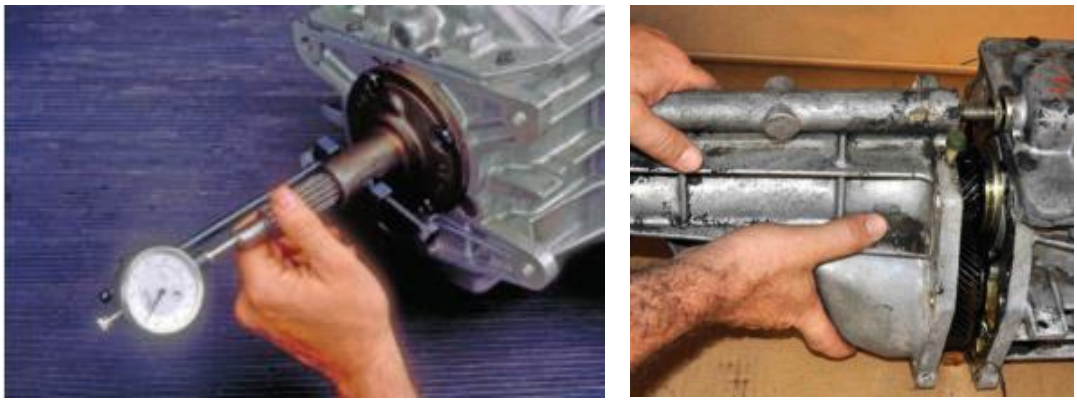


Figure 0.8: Use of a dial indicator to measure the endplay of the shafts before disassembling the unit (left) and sliding the extension housing off the output shaft (right)

- The basic disassembly procedures are as follows:
  1. Unbolt and remove the rear extension housing. It may be necessary to tap the housing off with a soft face mallet or bronze hammer.
  2. Unbolt and remove the front extension housing and any snap rings.
  3. Carefully pry the input shaft and gear forward far to free the main shaft.
  4. Using a brass drift pin, push the reverse idler shaft and countershaft out of the transmission case.
  5. Remove the input shaft and output shaft assemblies. Slide the output shaft and gears out of the back of the transmission as a unit. Be careful not to damage any of the gears.

- Remove the bell housing from the transmission case, extension housing, and the side or top cover.
- The seal and bushing should be removed from the extension housing (tail shaft) prior to cleaning.
- With the housing and cover removed, the gears, synchronizers, and shafts are exposed and the shift forks can be removed.

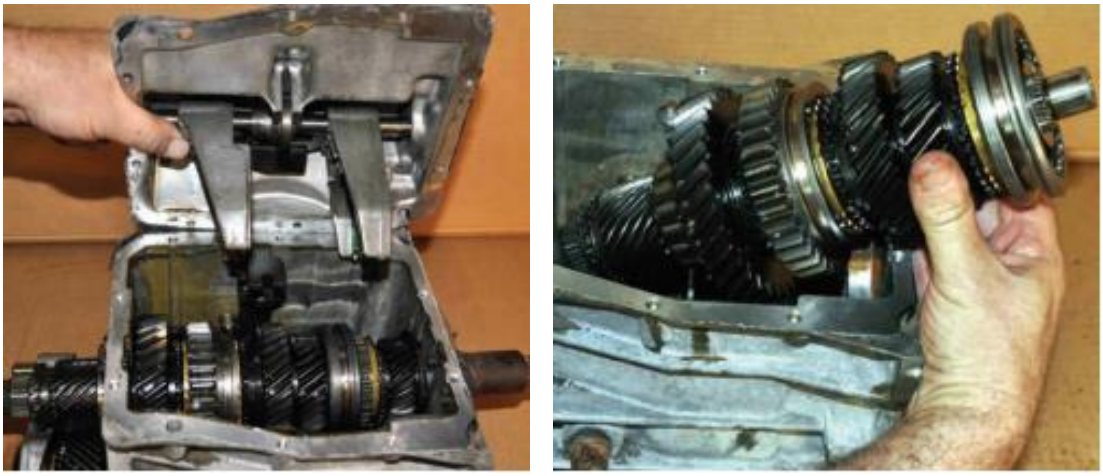


Figure 0.9 Remove the top cover and the shift linkage and Lift the output shaft from the case and then

- Each transmission design has its own specific service procedures. Always refer to the appropriate service information prior to overhauling a transmission or transaxle.
- In some cases, the countershaft must be removed before the input and main shaft. In other cases, the main shaft is removed with the extension housing.
- It may be removed through the shift cover opening. To avoid difficulty in disassembly, follow the recommended sequence.
- A gear puller or hydraulic press is often needed to remove gears and synchronizer assemblies from transmission/transaxle pinion shafts.

C. Gear and Inspection

- In some cases, gear damage is quite obvious and easy to locate. There is no need to clean up some of the unusable gears.

- A close inspection is necessary to determine if there is a problem with the teeth or thrust or bearing surfaces.
- Each of the gears, along with their clutching teeth and their inner bore, should be inspected for wear or damage.
- Close inspection of a gear tooth will often show a smooth metallic sheen with a duller, cleaner area; this indicates the gear's contact pattern with its mating gear.

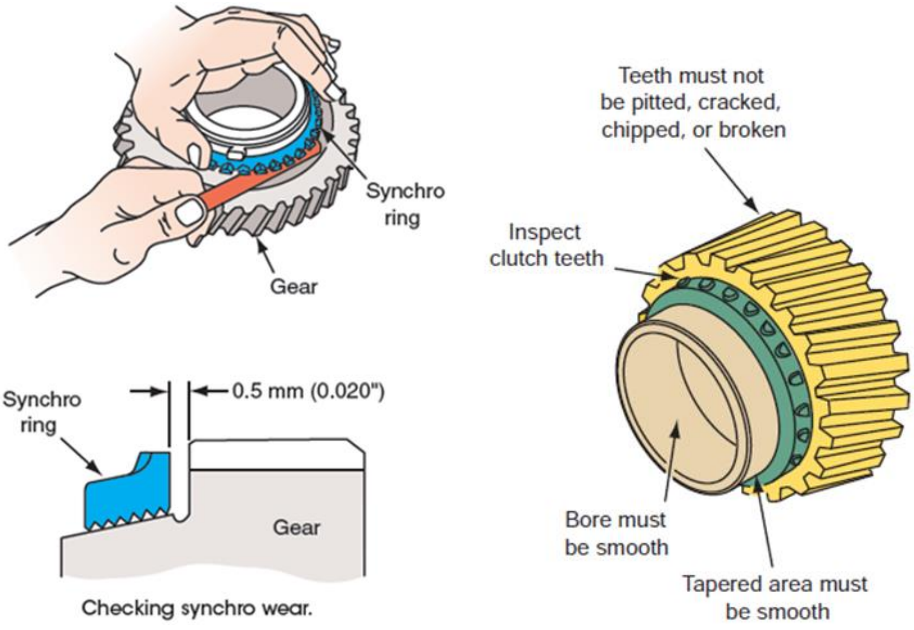


Figure 0.10: Checking gear teeth and synchronizer wear

- Many gear teeth will also show underlying machine marks from when the gear was originally made; these marks are normal.
- Inspect brass blocker rings if they are to be reused
- Inside surface should have sharp edges
- Push blocker ring against polished tapered surface on gear that it rides on
- Should grab against chrome surface

D. Inspecting Synchronizer Assembly

- Synchronizer assemblies are disassembled for cleaning, inspection, and occasionally for de- burring the ends of the splines in the sleeve.

- As mentioned earlier, the sleeve and hub are factory matched so that index marks need to be placed on them before disassembly.
- To disassemble a synchronizer assembly, simply remove the energizer springs and slide the sleeve off the hub. Now inserts will either fall or slide out of their grooves.
- Scribe line on outside to reassemble synchronizer in same position. Some are marked from factory. Look for wear of gears and shift sleeves.
- Check the synchronizer sleeves for free movement on their hubs

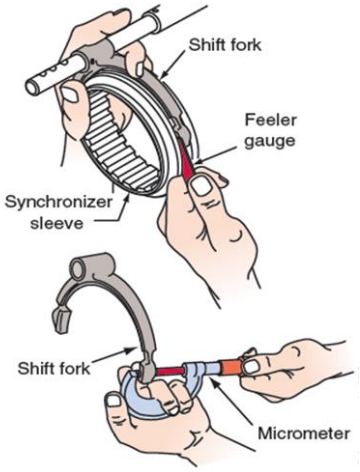


Figure 0.11: Synchronizer mechanism and shift hub check

E. Bearing and shaft Inspection and Servicing

- Immediately after cleaning, an antifriction (ball, roller, or needle) bearing should be dipped in a clean, light weight lubricant and covered to keep it clean and dust free.
- Inspection of a bearing is normally done by sight, feel, and sound.
- Visual inspection of a worn bearing can reveal a broken cage or pitted, spelled raceways.
- Use a press and support inside of bearing with bearing separator
- Reassembling: apply pressure on inside of bearing only

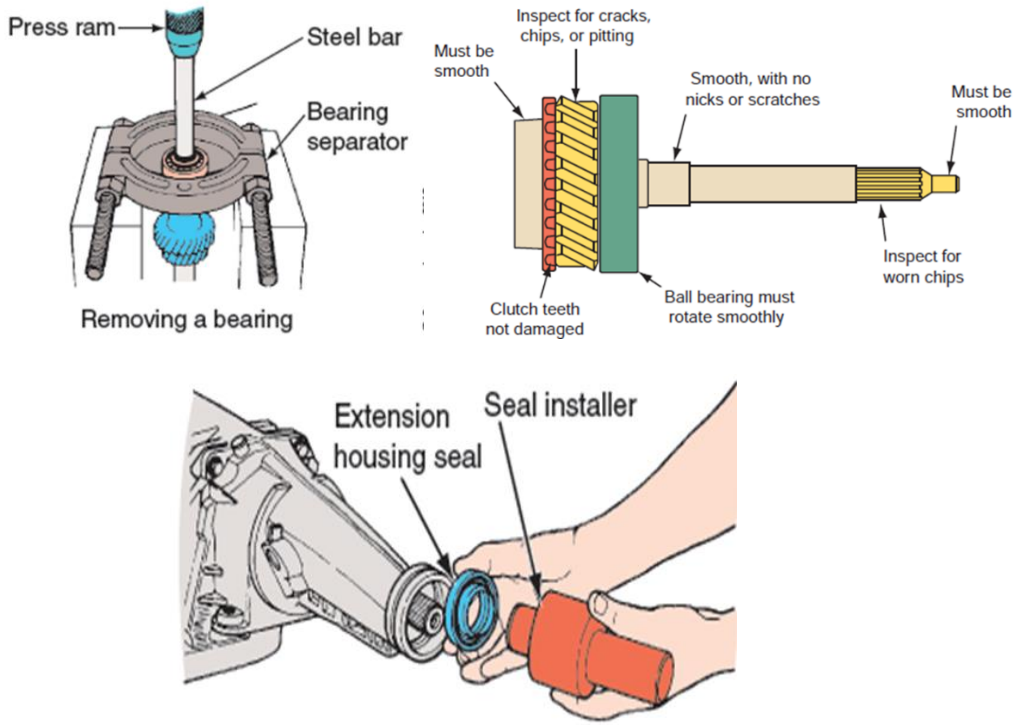


Figure 0.12: Removing bearings seals and shaft inspection

- Shaft splines may be twisted from abusive driving. Twisted spline prevents drive shaft slip yoke from sliding in and out of transmission.
- Inspect drive gear for vehicle speed sensor or speedometer, located on the output shaft. A special puller is available to pull these gears

F. Reassemble the Transmission

- Before assembling, locate and assemble any new replacement parts. Gear is replaced with corresponding gear. Using an old gear with a new gear can result in unacceptable gear noise
- Reassemble the synchronizers. Lightly oil the parts of the synchronizer.
- Assemble the synchronizer assemblies, being careful to align the index marks made during disassembly.
- Install the synchronizer assemblies onto the main shaft.
- Reassemble the shafts and gears

- Install synchro hub
- Lubricate parts liberally
- Check end play of assembled parts
- Adjust clearance by changing thickness of snap ring

Figure 0.13: Check thrust clearances between gears and synchronizer assembly

- Install a new transmission gasket set. Gaskets are not reusable. Gasket working fine previously could leak after reassembly
- Complete the Transmission Reassembly
- Install shift mechanism. Replace extension housing bushing & seal.
- Use a seal installer to replace the seal without distorting it
- Be sure clutch fork is properly seated on its pivot
- Align transmission with engine. Shake transmission while rotating it back and forth
- Install bolts in transmission and torque to specifications
- Add the correct Lubricant into transmission: SAE 80W-90 (GL-4) gear lubrication or STF (synchromesh transmission fluid).
- Test Drive after servicing transmission. Be sure shifts are smooth in all gears
- Check outside of transmission for leaks after returning to shop

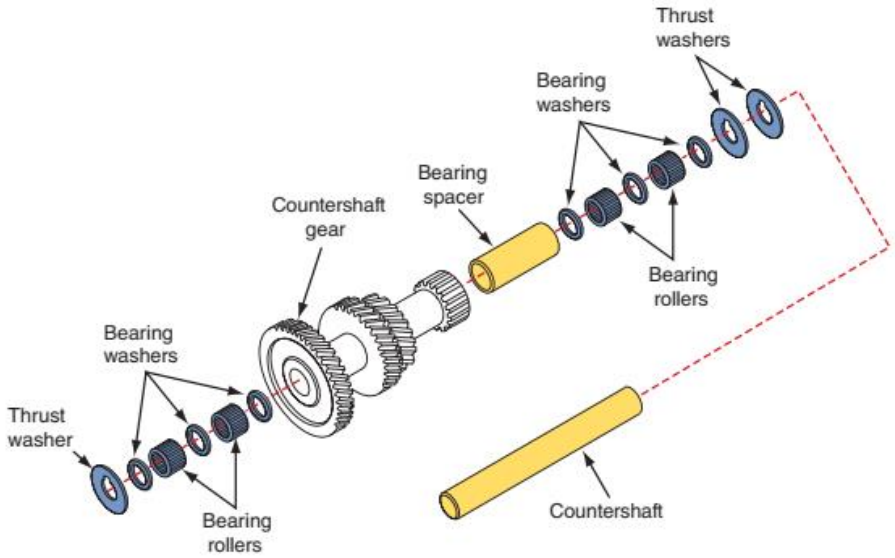


Figure 0.14: Exploded parts connected to counter shaft of manual transmission

Self-check-3

Part I: Short answer questions

Directions: Write the correct short answer for questions listed below

1 After draining gear oil from a transaxle, the technician notices that the oil has shiny, metallic particles in it. What does this indicate?

2 What tool is often required to remove gears and synchronizer assemblies from the main shaft?

3 When removing or installing bearings, where should the force be applied?

4 List five common sources for transmission fluid leaks. List at least five items that are typically removed when removing a transaxle.

5 List five reasons for replacing a torque converter.

6 Explain how a plugged fluid cooler can cause a vehicle to stall when reverse is selected.

Part II: True false questions

Directions: Write TRUE for correct statement and FALSE for wrong statement.

1. Some manufacturers recommend the use of heavy oil in the transaxle; others may recommend the use of automatic transmission fluid in the transaxle.
2. The pressure plate moves away from the flywheel when the clutch pedal is released.
3. A reverse idler gear changes the direction of torque flow to the opposite direction of engine rotation.
4. A set of gears can be configured or used in three different ways.
5. In most transmissions and transaxles, there is one synchronizer assembly for each speed gear.
6. The cone on a synchronizer's blocking ring serves as a cone-clutch assembly while changing gears

Part III: Multiple Choice questions

Directions: Choose the correct answer from the given alternatives.

1. Insufficient clutch pedal clearance results in ___.

A. gear clashing while shifting transmission
B. a noisy front transmission bearing
C. premature release bearing failure
D. premature pilot bearing failure

2. Before making a clutch adjustment, it is necessary to ___.
   A. measure clutch pedal free travel
   B. lubricate the clutch linkage
   C. check the hydraulic fluid level
   D. place the transmission in reverse
3. Technician A says that double-cone synchronizers have friction material on both sides of the synchronizer rings. Technician B says that multiple-cone synchronizers are used with larger engines and require a larger transmission housing. Who is correct?

   A. Technician A only
   B. Technician B only
   C. Both A and B
   D. Neither A nor B
4. 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. B. Only
   C. Both A and B
   D. Neither A nor B
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

Operation Sheet 3.1

Operation Title: Installing and aligning a Clutch Disc

Instruction:

- Keep your working area safe
- Refer to your vehicle's service manual to obtain the manufacturer's specifications

Purpose: To replace the clutch

Required Tools and Equipment: Cotton cloth, hand tools, clutch-aligning tool

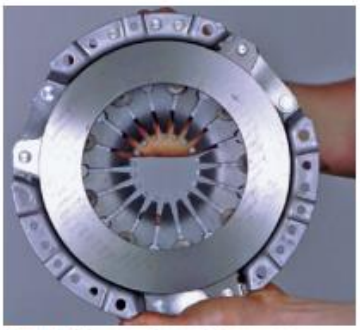
Precautions: Clutch Service Safety Precautions

Procedures:

Perform the following tasks following as presented in photo sequence

P31-1 The removal and replacement of a clutch assembly can be completed while the engine is in or out of the car. The clutch assembly is mounted to the flywheel that is mounted to the rear of the crankshaft.

P31-2 Before disass
make sure alignment
on the pressure plate



P31-4 The surface of the pressure plate should be inspected for signs of burning, grooving, warpage, and cracks. Any faults normally indicate that the plate should be replaced.

P31-5 The surface of
also be carefully inspe
flywheel surface can b
remove any defects. A
of the flywheel. The pi
ing should also be insp

P31-7 Install the pressure plate according to the alignment marks made during disassembly. Then install the clutch alignment tool through the hub of the disc and the pilot bearing to center the disc on the flywheel.

P31-8 Install the att
do not tighten.

Operation Sheet 3.2

Operation Title: Replacing a Concentric Slave Cylinder

Instruction:

- Keep your working area safe
- Refer to your vehicle's service manual to obtain the manufacturer's specifications

Purpose: To replace a concentric slave Cylinder

Required Tools and Equipment: Cotton cloth, hand tools,

Precautions: Clutch Service Safety Precautions

Procedures:

Perform the tasks following the steps

STEP 1 Carefully clean the hydraulic tube coupling and disconnect it with the appropriate quick disconnect tool.

STEP 2 Remove the transmission.

STEP 3 Remove the concentric slave cylinder mounting bolts and remove the cylinder from the transmission.

STEP 4 Clean the transmission's input shaft.

STEP 5 Inspect the shaft for damage and excessive wear.

STEP 6 Install the new slave cylinder. Make sure it is installed flat against its mounting surface inside the transmission.

STEP 7 Tighten the slave cylinder is mounting bolts to specifications.

STEP 8 Reinstall the transmission.

STEP 9 Bleed the hydraulic system

LAP-Test

Direction: Perform the following tasks correctly. Time allotted 30minutes for each task and 3:30hrs for the lap test

- ✓ Task-1: Inspection 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 Inspection
- ✓ Task-6: Testing Automatic transmission
- ✓ Task-7: Report the findings

Reference

- ✓ *Jack Erjavec, Automotive Technology: a systems approach, 5 t h Edition, 2010 Delmar, Cengage Learning*

- ✓ *James D. Haldeman, Automotive technology Principles, Diagnosis, and Service fourth edition*
- ✓ *Crouse, W.H. and Anglin D.L, Auto motive mechanics 10th edition*
- ✓ *R.K Rajput, Automobile Engineering*
- ✓ *Prof. Dr.-Ing. Konrad Reif, Brakes, Brake Control and Driver Assistance Systems*
- ✓ *David A. Crolla , Automotive Engineering*
- ✓ *Nunney, M. J.Rutledge, 2007, Light and Heavy Vehicle Technology 4th ed.*

Participants of this Module (training material) preparation

No	Name	Qualification	Field of Study	Organization/ Institution	Mobile number	E-mail
1)	Amanuel Abdeta	MSc.	Automotive Technology	Ambo PTC	0911799468	Amanuelloko@gmail.com
2)	Biruk Tilahun	BSc.	Automotive Technology	General Wingate PTC	0913789176	biruktilahun1@gmail.com
3)	Fiseha Manyazewal	MSc.	Automotive Technology	Debrebirhan PTC	0910406732	Natifish76@gmail.com
4)	Sisay Legese	MSc.	Automotive Technology	Athlete Kenenisa PTC	0910407622	alemsisay647@gmail.com
5)	Tatek Mamo	PhD	Automotive Engineering	Ethiopian Defense University College of Engineering	0911841121	mimibaba928@gmail.com /tatek.mamo@astu.edu.et