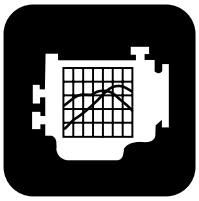
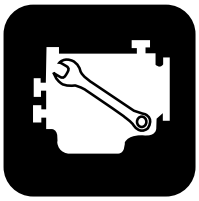


Engine Performance

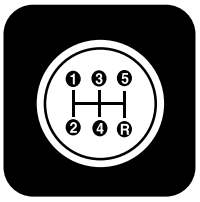


Engine Repair

Steering & Suspension

Electrical Systems

Climate Control

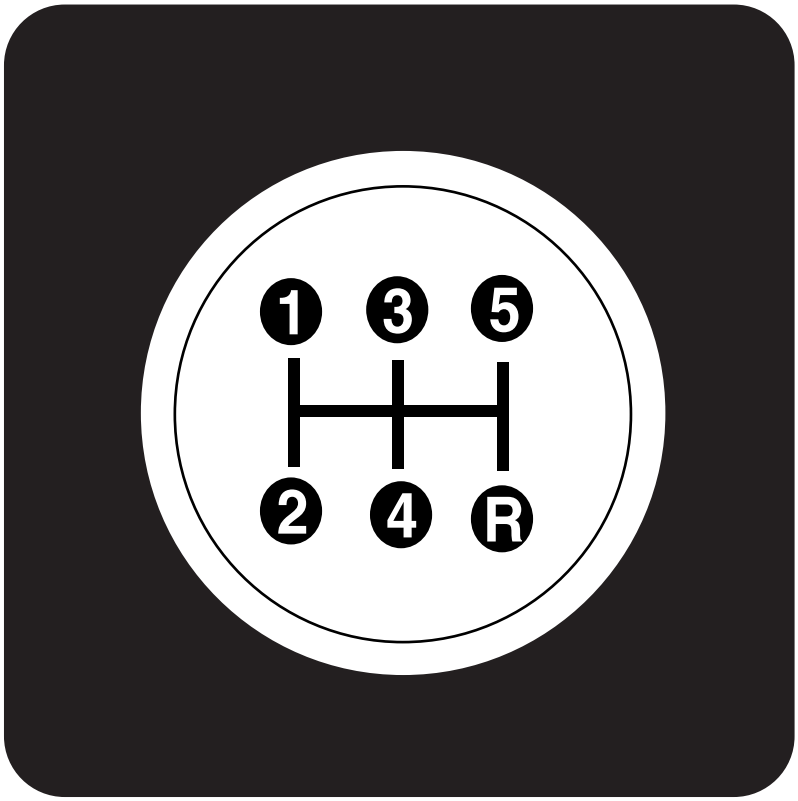


Manual Transmission

Automatic Transmission

Brakes

manual transmission and driveline



manual transmission & transaxle operation

self-study guide

COURSE CODE: 36S03S0
ORDER NUMBER: FCS-13042-VHS

STST

Service Technician Specialty Training

Ford Customer Service Division
Technical Training

Important Safety Notice

Appropriate service methods and proper repair procedures are essential for the safe, reliable operation of all motor vehicles, as well as the personal safety of the individual doing the work. This manual provides general directions for accomplishing service and repair work with tested, effective techniques. Following them will help assure reliability.

There are numerous variations in procedures, techniques, tools and parts for servicing vehicles, as well as in the skill of the individual doing the work. This manual cannot possibly anticipate all such variations and provide advice or cautions as to each. Accordingly, anyone who departs from instructions provided in this manual must first establish that he compromises neither his personal safety nor the vehicle integrity by his choice of methods, tools or parts.

As you read through the procedures, you will come across NOTES, CAUTIONS, and WARNINGS. Each one is there for a specific purpose. NOTES give you added information that will help you to complete a particular procedure. CAUTIONS are given to prevent you from making an error that could damage the vehicle. WARNINGS remind you to be especially careful in those areas where carelessness can cause personal injury. The following list contains some general WARNINGS that you should follow when you work on a vehicle.

- Always wear safety glasses for eye protection.
- Use safety stands whenever a procedure requires you to be under the vehicle.
- Be sure that the ignition switch is always in the OFF position, unless otherwise required by the procedure.
- Set the parking brake when working on the vehicle. If you have an automatic transmission, set it in PARK unless instructed otherwise for a specific service operation. If you have a manual transmission it should be in REVERSE (engine OFF) or NEUTRAL (engine ON) unless instructed otherwise for a specific service operation.
- Operate the engine only in a well-ventilated area to avoid the danger of carbon monoxide.
- Keep yourself and your clothing away from moving parts when the engine is running, especially the fan and belts.
- To prevent serious burns, avoid contact with hot metal parts such as the radiator, exhaust manifold, tail pipe, catalytic converter and muffler.
- Do not smoke while working on the vehicle.
- To avoid injury, always remove rings, watches, loose hanging jewelry, and loose clothing before beginning to work on a vehicle. Tie long hair securely behind your head.
- Keep hands and other objects clear of the radiator fan blades. Electric cooling fans can start to operate at any time by an increase in underhood temperatures, even though the ignition is in the OFF position. Therefore, care should be taken to ensure that the electric cooling fan is completely disconnected when working under the hood.

The recommedations and suggestions contained in this manual are made to assist the dealer in improving his dealership parts and/or service department operations. These recommendations and suggestions do not supersede or override the provisions of the Warranty and Policy Manual, and in any cases where there may be a conflict, the provisions of the Warranty and Policy Manual shall govern.

The descriptions, testing procedures, and specifications in this handbook were in effect at the time the handbook was approved for printing. Ford Motor Company reserves the right to discontinue models at any time, or change specifications, design, or testing procedures without notice and without incurring obligation. Any reference to brand names in this manual is intended merely as an example of the types of tools, lubricants, materials, etc. recommended for use. Equivalents, if available, may be used. The right is reserved to make changes at any time without notice.

WARNING: MANY BRAKE LININGS CONTAIN ASBESTOS FIBERS. WHEN WORKING ON BRAKE COMPONENTS, AVOID BREATHING THE DUST. BREATHING THE ASBESTOS DUST CAN CAUSE ASBESTOSIS AND CANCER.

Breathing asbestos dust is harmful to your health.

Dust and dirt present on car wheel brake and clutch assemblies may contain asbestos fibers that are hazardous to your health when made airborne by cleaning with compressed air or by dry brushing.

Wheel brake assemblies and clutch facings should be cleaned using a vacuum cleaner recommended for use with asbestos fibers. Dust and dirt should be disposed of in a manner that prevents dust exposure, such as sealed bags. The bag must be llabeled per OSHA instructions and the trash hauler notified as to the contents of the bag.

If a vacuum bag suitable for asbestos is not available, cleaning should be done wet. If dust generation is still possible, technicians should wear government approved toxic dust purifying respirators.

OSHA requires areas where asbestos dust generation is possible to be isolated and posted with warning signs. Only technicians concerned with performing brake or clutch service should be present in the area.

Produced and Coordinated by
Technical Support Operations
Ford Customer Service Division

January 2000

Customer Expectations

Customer Expectations: Service

1. Make it convenient to have my vehicle serviced at your dealership.
2. The Service Advisor should demonstrate a genuine concern for my service needs.
3. Fix it right the first time.
4. Complete servicing my vehicle in a timely and professional manner.
5. Provide me with a clear and thorough explanation of the service performed.
6. Call me within a reasonable amount of time after my service visit to ensure that I'm completely satisfied.
7. Be responsive to questions or concerns I bring to your attention.

Expectation 3

"Fix It Right the First Time, on Time."

Both service advisors and technicians are important players when it comes to Expectation#3.

Why

Customers tell us "Fixing It Right the First Time, on Time" is one of the reasons they would decide to return to a dealer to buy a vehicle and get their vehicles serviced.

Technician Training

It is our goal to help the technician acquire all of the skills and knowledge necessary to "Fix it Right the First Time, on Time." We refer to this as "competency."

Technician's Role

Acquire the skills and knowledge for competency in your specialty via:

STST

- Self Study
- Fordstar Broadcasts
- Ford Multimedia Training (FMT)
- Instructor Led

New Model

- Self Study
- FordStar Broadcasts
- Instructor Led

The Benefits

The successful implementation of expectations means:

- Satisfied customers
- Repeat vehicle sales
- Repeat service sales
- Recognition that Ford and Lincoln/Mercury technicians are "the Best in the Business"

TABLE OF CONTENTS

TABLE OF CONTENTS

NOTES

INTRODUCTION

The Manual Transmission and Transaxle Operation self-study is the third course of the Manual Transmission and Driveline Curriculum. Since this course sets the building blocks for the other manual transmission and transaxle courses, it is important that it be completed first. It is also important that all prerequisite courses be completed prior to taking this self-study, as this will lead to a better understanding of the material presented in this course.

This course has two main goals. The first goal is to introduce you to the manual transmissions and transaxles used on Ford Motor Company vehicles. The second goal is to provide an understanding of the Symptom-to-System-to-Component-to-Cause diagnostic process. As you learn new information, try to relate the new knowledge to manual transmission and transaxle systems as a whole. Think about the cause-and-effect relationships between the subsystems and components. Understanding the cause-and-effect relationships will help you in diagnosis. Some of the topics that will be covered in this course include the following:

- Clutch System Components
- Clutch System Operation
- Clutch System Diagnosis
- Clutch System Service

- Manual Transmission Powerflow
- Manual Transmission Components
- Manual Transmission Operation
- Manual Transmission Diagnosis
- Manual Transmission Service

- Manual Transaxle Powerflow
- Manual Transaxle Components
- Manual Transaxle Operation
- Manual Transaxle Diagnosis
- Manual Transaxle Service

- Front Wheel Drive Halfshaft Components
- Front Wheel Drive Halfshaft Operation
- Front Wheel Drive Halfshaft Diagnosis
- Front Wheel Drive Halfshaft Service

CURRICULUM DESCRIPTION

MANUAL TRANSMISSION AND DRIVELINE CURRICULUM

Each course found in the Manual Transmission and Driveline Curriculum is one of the following types:

- Self-Study - This type of course is a self-paced program. The technician is responsible for learning the material on his or her own. The training material consists of a reference book and an accompanying videotape. The videotape is designed to support the material in the reference book and should not be used on its own.

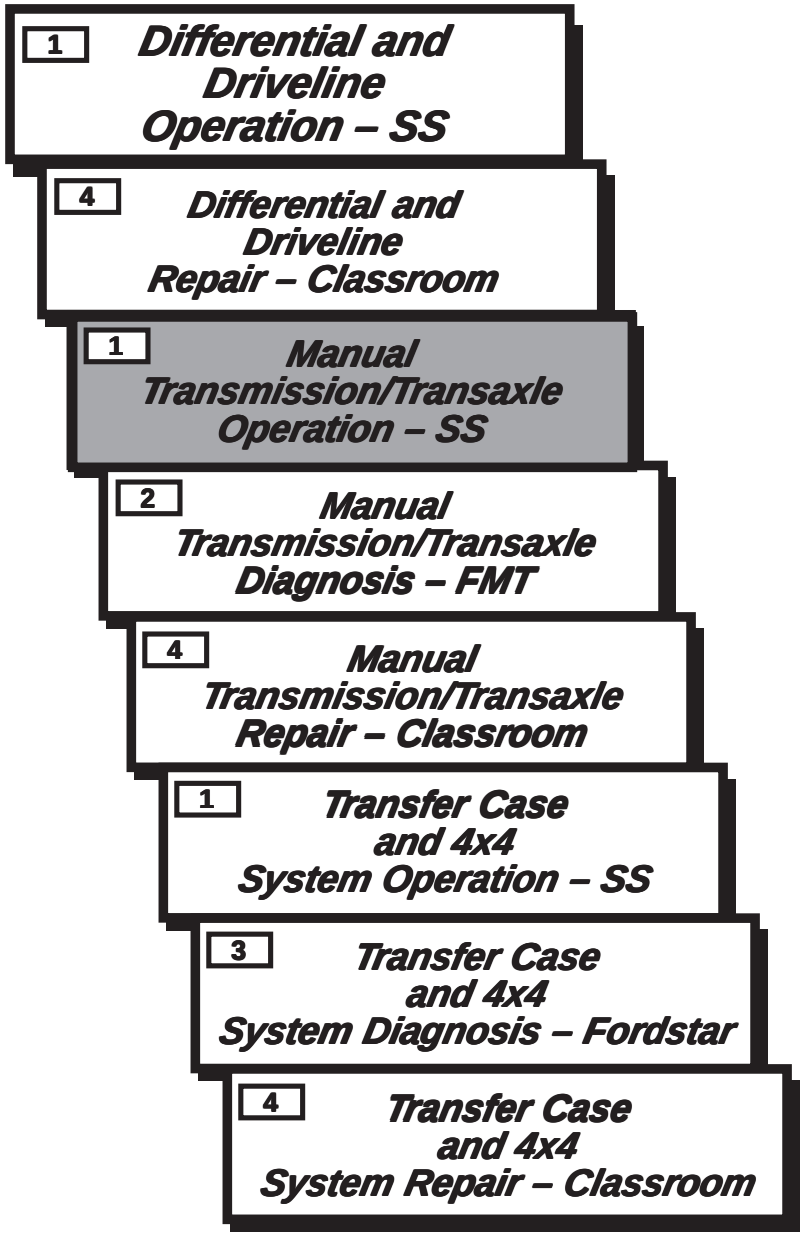
- Ford Multimedia Training (FMT) - This type of course is also self-paced. The multimedia course allows the technician to interact with the training materials. The multimedia course allows the technician to utilize the knowledge attained in the self-study course. The FMT concentrates on relationships, such as the cause- and -effect relationships between symptoms and components.

- Distance Learning (FORDSTAR) - This type of course is an instructor-led, interactive type. It is presented over the Fordstar Distance Learning Network. The instructor can present information to, relate questions to, and interact with the technicians. Demonstrations and video presentations are used to introduce material.

- Classroom - The classroom course allows for practical, real-world application of skills and knowledge learned in the other courses.

There are eight courses in the Manual Transmission and Driveline Curriculum. Please refer to the Manual Transmission and Driveline Curriculum Path that follows.

MANUAL TRANSMISSION AND DRIVELINE CURRICULUM PATH



Legend

- 1 = *Self Study (SS)*
- 2 = *Ford Multimedia Training (FMT)*
- 3 = *Fordstar*
- 4 = *Instructor Led – Classroom*

Prerequisites

- Basic Electrical Part 1 – (Self Study)
- Basic Electrical Part 2 – (FMT)
- Basic Electrical Part 3 – (Classroom)
- Electronics Part 1 – (Self Study)
- Electronics Part 2 – (FMT)
- Electronics Part 3 – (Classroom)
- Automotive Measuring Tools – (FMT)
- Networks + Multiplexing Part 2
- Noise, Vibration & Harshness

Course Codes

These courses may be found in the STARS planner using the following course codes:

Engine Performance

- Differential and Driveline System Operation - Self-Study ..... Course code: 36SO1SO
- Differential and Driveline System Diagnosis - Classroom ..... Course code: 36SO2TO
- Manual Transmission/Transaxle System Operation - Self-Study .....Course code: 36SO3SO
- Manual Transmission/Transaxle System Diagnosis - FMT ..... Course code: 36SO4MO
- Manual Transmission/Transaxle System Repair - Classroom ..... Course code: 36SO5TO
- Transfer Case and 4x4 System Operation - Self-Study ..... Course code: 36SO6SO
- Transfer Case and 4x4 System Diagnosis - FORDSTAR ..... Course code: 36SO7FO
- Transfer Case and 4x4 System Repair - Classroom ..... Course code: 36SO8TO

COURSE PURPOSE

Technician Course Objectives

Upon completion of this course, you will be able to:

- Explain the purpose and function of manual transmission and transaxle systems
- Describe the purpose and function of a clutch system
- Identify the purpose and function of front wheel drive halfshafts
- Describe manual transmission and transaxle components
- Explain manual transmission and transaxle powerflow
- Identify basic diagnostic process
- Describe common symptoms of manual transmission, manual transaxle, clutch, and halfshaft concerns
- Explain common manual transmission, manual transaxle, clutch, and halfshaft service procedures

INTRODUCTION

Why Training?

1. Customers bring vehicles to the dealership because they want the best service possible. They believe that no other technician besides you, a Ford trained technician, could know their vehicle better.

2. Customers expect a dealership to "Fix It Right The First Time, On Time."

3. Customers understand that they get what they pay for. Therefore, they are willing to pay the extra money at the dealership for your professional services.

So, how do you live up to the customer's expectations? The answer is continuous training. Training allows you to gain efficiency. Efficiency makes you an asset to the customer, the dealer, and yourself. Training promotes job security and allows you to learn the "latest and greatest" technology and service procedures.

COURSE DESCRIPTION AND FORMAT

Course Description for Self-Study Learners

This Student Reference Book is designed for use as part of a self-study training course, which means you can allow yourself as much time as you need to learn the information in each section. A videotape has been developed to accompany this book. The videotape provides information that can best be presented through visual means.

Lesson Review Questions are provided throughout this book to help evaluate your individual learning needs. Answers to the Lesson Review Questions are provided to help you determine your strengths and weaknesses. If you have difficulty answering certain questions, review the material until you feel confident that you understand the information.

Take as much time as you need to master the material. You may not answer the questions 100% correctly the first time around. With study, you will quickly master those areas with which you may have difficulty.

Evaluation Strategy

The final evaluation questions for this self-study course are on the Manual Transmission/ Transaxle System Diagnosis FMT CD-ROM. You must pass this test before you can begin the FMT course.

NOTES

LESSON 1: OVERVIEW

LESSON OBJECTIVES

OBJECTIVES

- Identify key principles that are commonly used when describing transmission operation.
- Describe the function of the clutch.
- Explain the function of the manual transmission.
- Identify the function of the manual transaxle.
- Describe the function of the halfshafts.

CONTENTS

LESSON 1: OVERVIEW

INTRODUCTION

The internal combustion engine develops power within a very narrow range of rpm. In fact, most automotive engines only develop power between 1,000 and 5,000 rpm. Another limitation of most automotive engines is that they generally develop less than 500 foot pounds of torque. Since it takes 1 pound of torque to move 1 pound of weight, the standard automotive engine couldn't move even a small vehicle.

These engine limitations are overcome using transmissions. The transmission maintains engine operating rpm within the narrow rpm range where power is developed, and multiplies the engine's torque to allow vehicle operation. This is done using gears in different combinations to provide gear ratios.

Transmissions can be shifted either automatically using electronic and hydraulic controls, or they can be shifted manually by the driver.

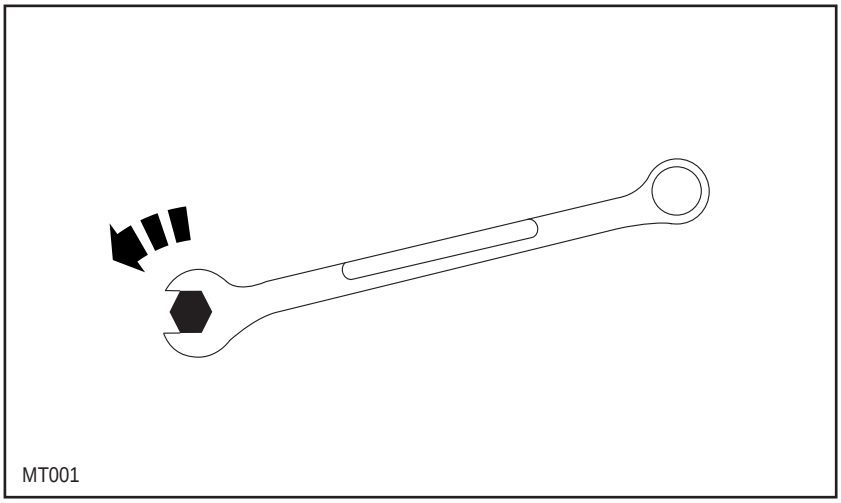
This self-study course will describe the theory, operation, diagnosis, and service of manual transmissions and transaxles that are used on Ford cars and light trucks.

Before we can begin a discussion of manual transmission operation, there are some basic concepts that must be understood.

TORQUE

Several basic terms are used in nearly all discussions of transmissions. One of these terms is torque. When the burning of fuel takes place in the engine's cylinder, the pistons and connecting rods force the crankshaft to turn. This rotary force is called torque. One of the main purposes of the driveline is to multiply the torque developed by the engine.

Torque, in simple terms, is turning or twisting effort. When a technician uses a wrench to tighten a bolt, torque is applied to the bolt. When the bolt is tight, the technician may not be able to turn it any more, but even though the bolt does not turn, the technician is applying torque. Torque, then, is a force that produces, or tries to produce, rotation.



Wrench Creating Torque

POWER

The term power is often confused with torque. Power is the rate or speed of doing work. Power adds the idea of time. The more quickly work is done, the more power is involved.

For example, when a horse is connected to a plow and is plowing a field it would take that single horse a certain amount of time to plow each row of a field. If we hitched up two horses to the plow, we might be able to plow the field in half the time. That's because with two horses we have twice as much power being applied to the plow.

POWERFLOW

As we describe the operation of components of the driveline we will be concerned with the flow of power. The flow of power, or powerflow, is the path the power takes from the engine to the wheels that drive the vehicle.

Understanding the powerflow through a powertrain component is basic to understanding how the component works. The technician must understand how a component works in order to properly diagnose and repair a driveline concern.

MANUAL TRANSMISSION SYSTEMS

There are many different types and variations of manual transmission systems. However, most of these systems have the same basic components. The following are basic descriptions of the systems that will be covered in this course.

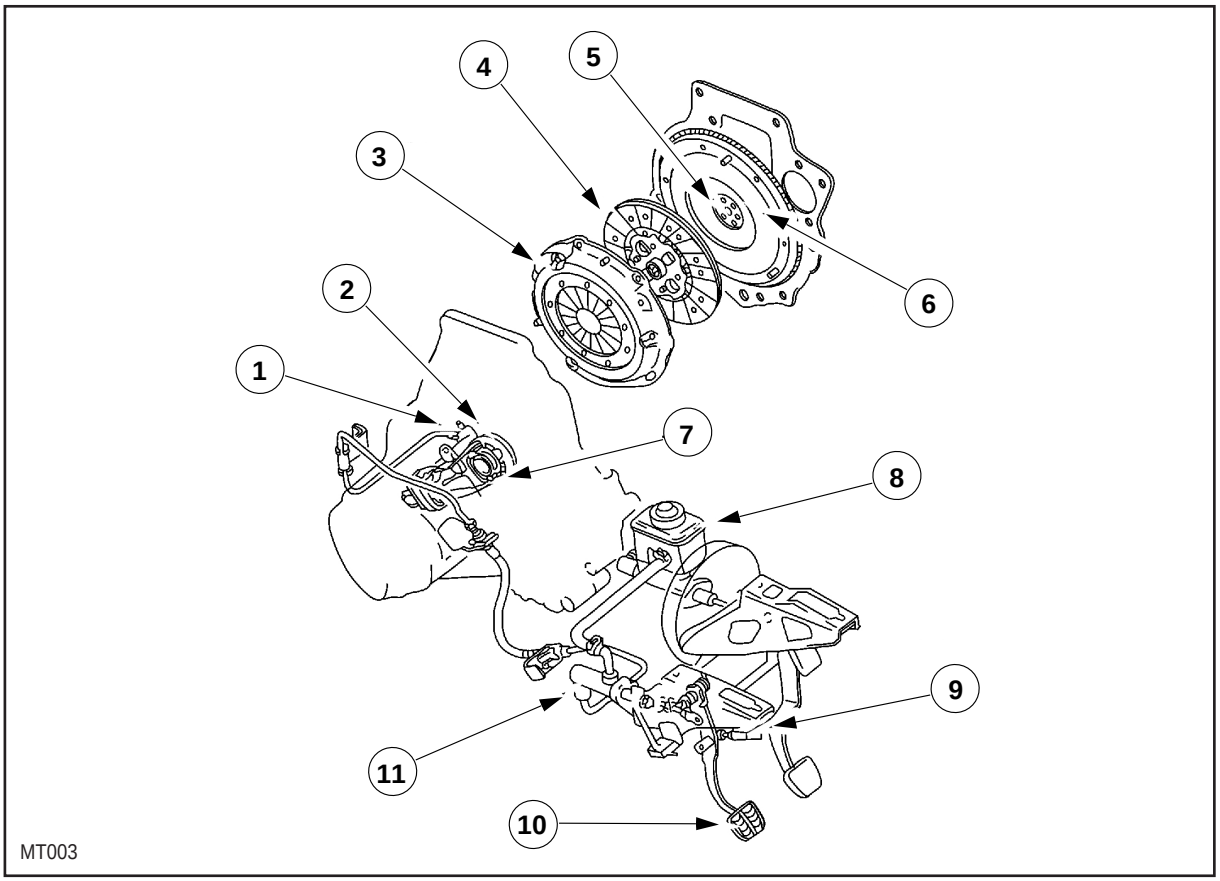
CLUTCH

The purpose of the manually operated clutch is to couple and uncouple the engine from the transmission.

When you crank the engine for starting, it must be disconnected from the transmission.

If a transmission was engaged to a running engine with the vehicle stopped, the engine would likely stall and could cause transmission damage. A clutch allows the running engine and transmission to be disconnected, and allows them to be engaged smoothly at take off.

When driving, uncoupling the engine from the transmission also makes shifting easier.



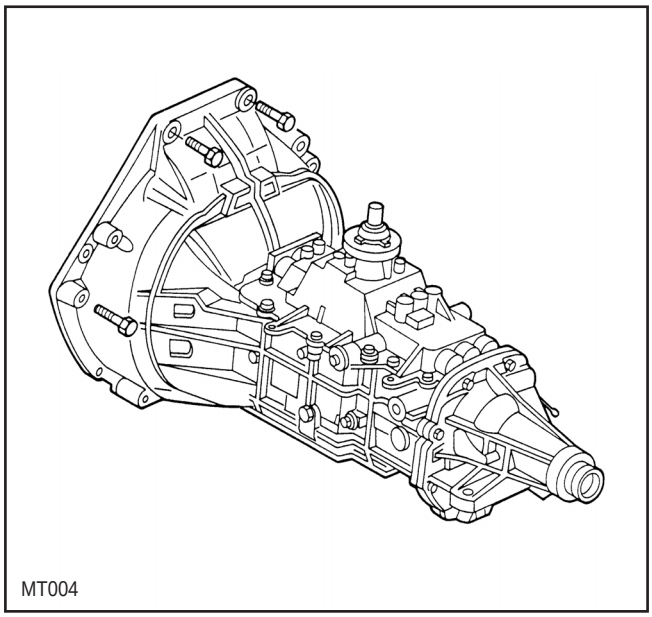
Clutch Assembly

Item	Description
1	Clutch Slave Cylinder
2	Clutch Release Hub and Bearing
3	Clutch Pressure Plate
4	Clutch Disc
5	Pilot Bearing
6	Flywheel
7	Clutch Release Fork
8	Clutch/Brake Master Cylinder Reservoir
9	Clutch Pedal Position (CPP) Switch
10	Clutch Pedal
11	Clutch Master Cylinder

MANUAL TRANSMISSION

A manual transmission is a housing containing a number of gears. It is usually bolted to the rear of the engine. The torque from the engine goes through the clutch and into the transmission. The gears in the transmission multiply the engine's torque to get the vehicle moving. Another important job of the transmission is to provide a reverse gear for the vehicle.

Manual transmissions are used on rear wheel drive and 4-wheel drive vehicles.

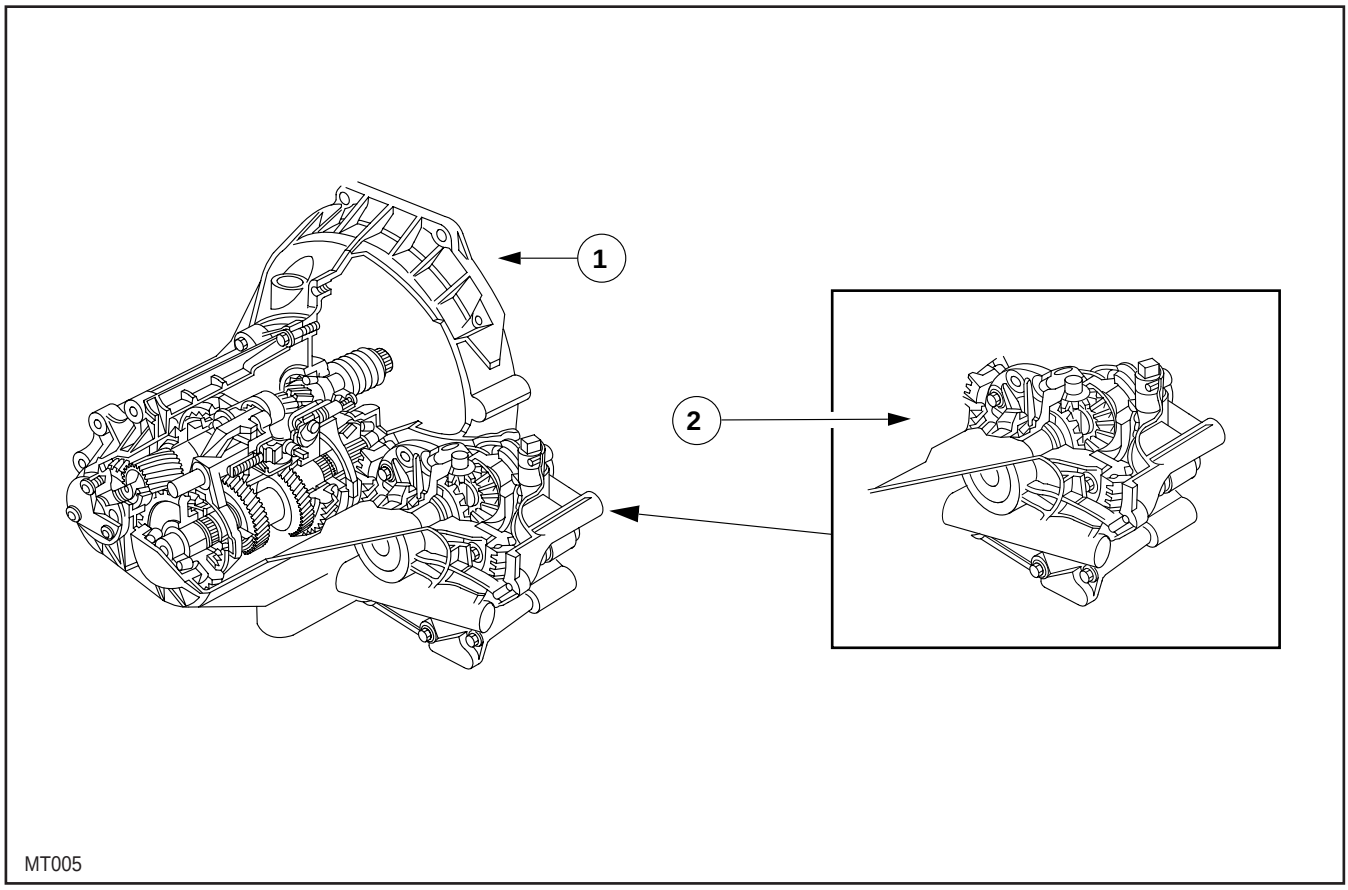


Manual Transmission

MANUAL TRANSAXLE

The manual transaxle is very similar to the manual transmission. It contains gears to multiply engine torque received through the clutch. However, it has one major difference. It also provides the differential action required by powered wheels that are rotating at different speeds. So basically it serves the same function as both the transmission and differential.

Ford uses transaxles on front-wheel drive vehicles.

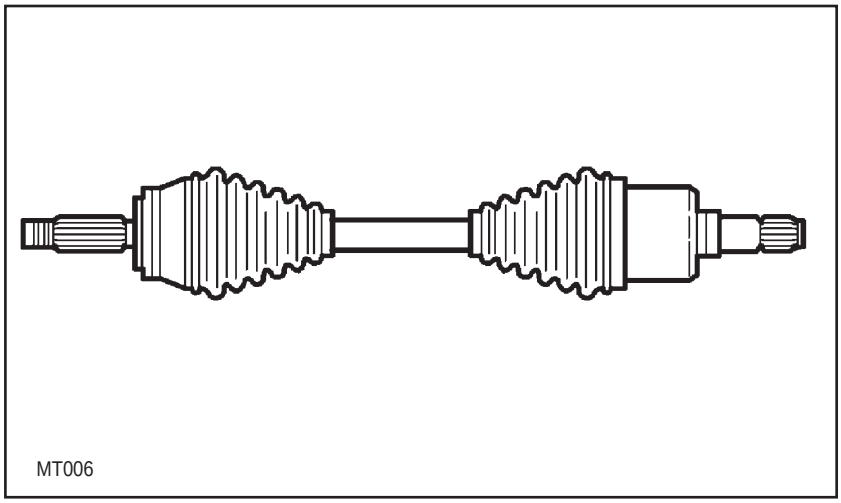


Manual Transaxle

Item	Description
1	Manual Transaxle
2	Differential

HALFSHAFTS

Transferring power from a transaxle to the front wheels of a vehicle requires a unique type of drive shaft. This is because not only do the wheels drive the vehicle, but they also steer and must be able to react to the action of the suspension system. These front wheel driveshafts are known as halfshafts.



Halfshaft Assembly

REVIEW QUESTIONS

Directions: Use the information you have learned to answer the following questions.

1. The rotating force created by an engine is called:

   A. Differential action
   B. Gear Ratios
   C. Torque
   D. Rolling resistance

2. Which of the following let transmissions multiply engine torque?

   A. Differential action
   B. Gear Ratios
   C. Torque
   D. Rolling resistance

3. The rate of speed that work is done is called:

   A. Powerflow
   B. Torque
   C. Differential action
   D. Power

4. The path power takes from the engine to the wheels is:

   A. Powerflow
   B. Torque
   C. Differential action
   D. Power

5. Match the component on the left with its correct function on the right by. Write the letter corresponding to the correct function in the space between the component and function descriptions.

Component	Function
A. Manual Transmission	Couples and uncouples the engine from the transmission.
B. Clutch	Multiplies torque on rear wheel drive vehicles.
C. Halfshaft	Provides differential action on front wheel drive vehicles.
D. Manual Transaxle	Transfers power to the front wheels on front wheel drive vehicles.

NOTES

LESSON 2: CLUTCHES

LESSON OBJECTIVES

OBJECTIVES

- Explain the purpose of the clutch.
- Identify clutch operation.
- Describe clutch components.
- Identify common clutch diagnostic proce dures.
- Explain common clutch service procedures.

CONTENTS

LESSON 2: CLUTCHES

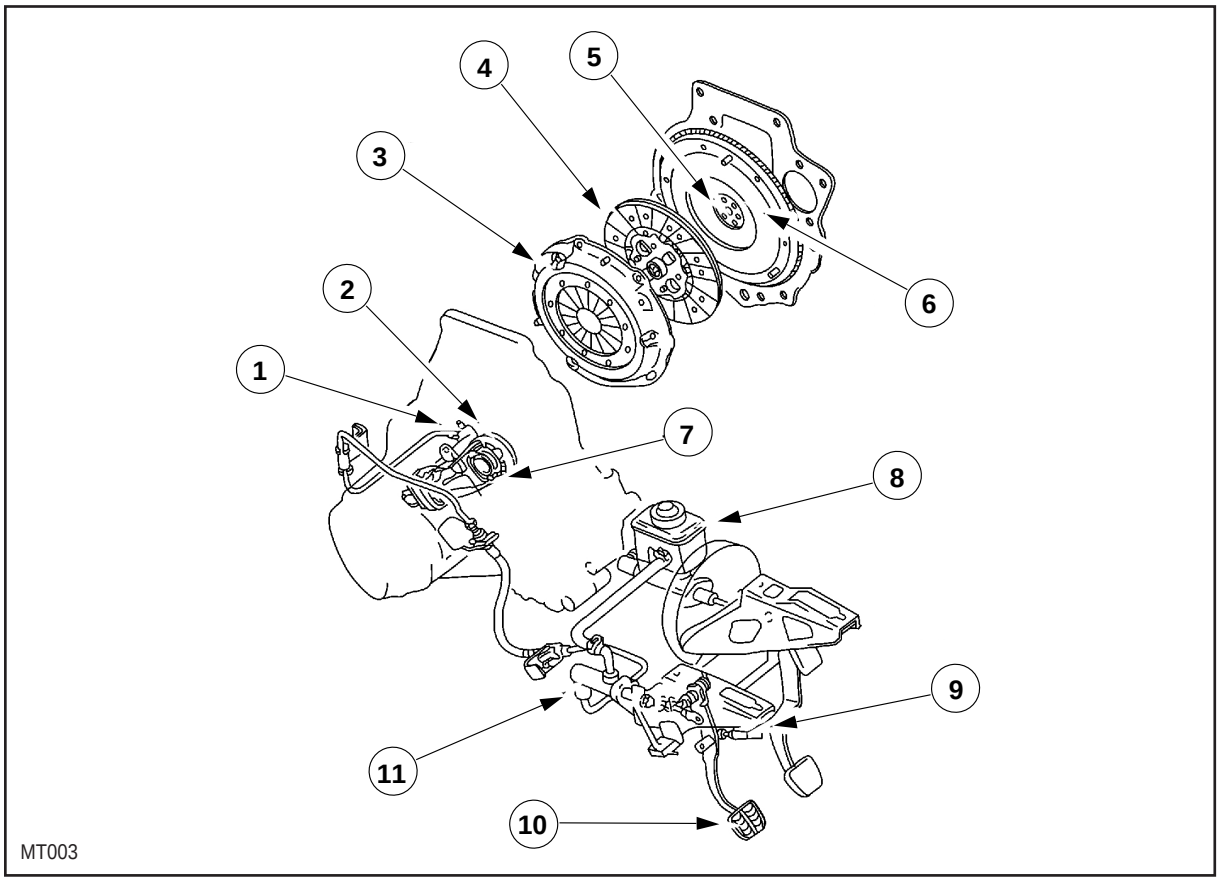
PURPOSE OF THE CLUTCH

The clutch disconnects the engine from the transmission or transaxle when the driver pushes down the clutch pedal. As the driver allows the pedal to come up, the engine connects to the transmission/transaxle, and the vehicle moves.

The clutch must be designed so that this connecting(engaging) and disconnecting (disengaging) is smooth and can occur gradually. It must not jump abruptly from no connection at all to a direct, solid connection. To move a vehicle the engine must speed up to get enough power. It cannot in one moment bring the speed of the wheels up to the speed of the engine.

Shifting gears in a moving car creates a similar situation. The driving wheels are not turning at the same speed as the engine. To make smooth shifts between gears the clutch will slip a little, take hold gently at first, and gradually grab harder and harder. Thus the driving wheels can start to move slowly and gradually pick up speed, until finally everything is turning at the same speed and the clutch is solidly engaged.

PURPOSE OF THE CLUTCH (Continued)

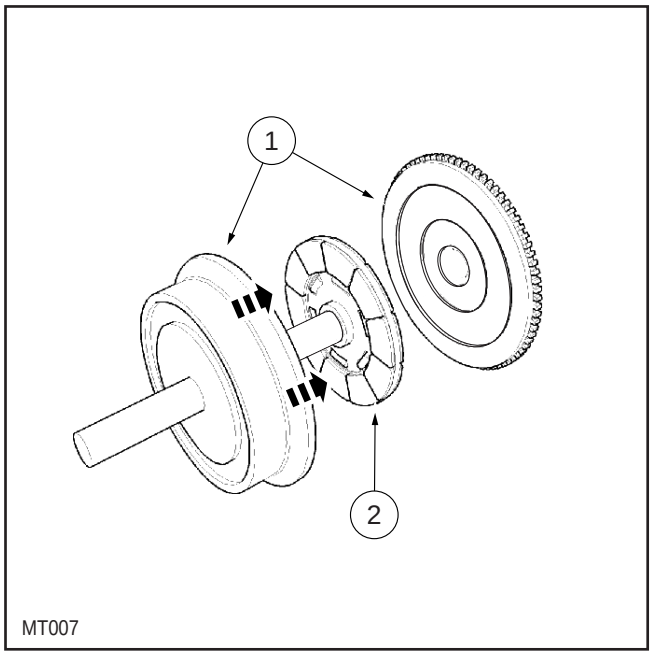


Clutch Assembly

Item	Description
1	Clutch Slave Cylinder
2	Clutch Release Hub and Bearing
3	Clutch Pressure Plate
4	Clutch Disc
5	Pilot Bearing
6	Flywheel
7	Clutch Release Fork
8	Clutch/Brake Master Cylinder Reservoir
9	Clutch Pedal Position (CPP) Switch
10	Clutch Pedal
11	Clutch Master Cylinder

CLUTCH OPERATION

Ford cars and light trucks use a single dry-disc clutch. Basically, this system has one plate squeezed tightly between two other plates, as shown in the figure below.

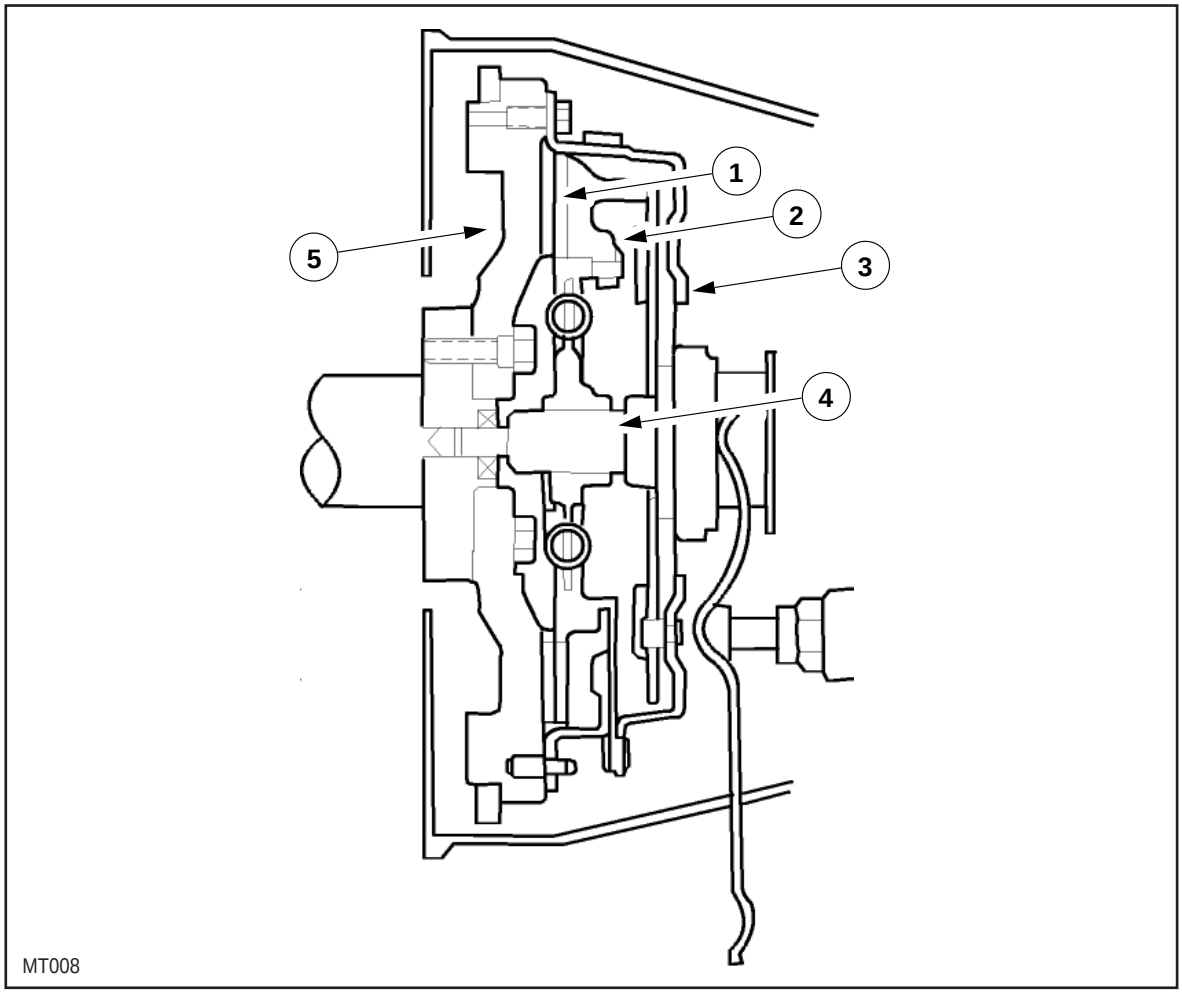


Single Dry-Disc Clutch Operation

Item	Description
1	Driving Members
2	Driven Member

The middle plate is driven. A strong spring or set of springs forces the two driving members together. This tightens their grip on the middle plate until all are turning together as one unit.

CLUTCH OPERATION (Continued)



Cutaway View of Clutch Assembly

Item	Description
1	Clutch Disc
2	Clutch Pressure Plate
3	Clutch Cover
4	Transmission Input Shaft
5	Flywheel

CLUTCH OPERATION (continued)

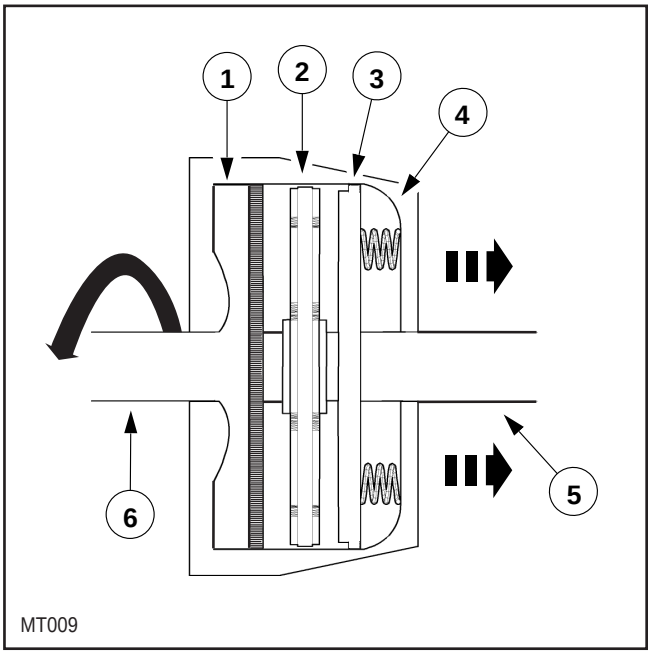
- The engine flywheel is used for one of the driving members. Its surface is machined very smooth where the friction plate pushes up against it.

- The other driving member is called the pressure plate. It is a heavy ring of cast iron that is smooth on one side. The pressure plate is fastened to the clutch cover, which is bolted to the flywheel, so they all turn together.

The driven plate is a flat disc of steel with friction material facing on each side. The disc is fastened by splines to the input shaft of the transmission.

- Since the clutch disc has internal splines, it fits on the transmission input shaft and must rotate when the input shaft rotates.

- The clutch disc is free to move back and forth on the input shaft due to its straight splines.



Clutch Disengaged

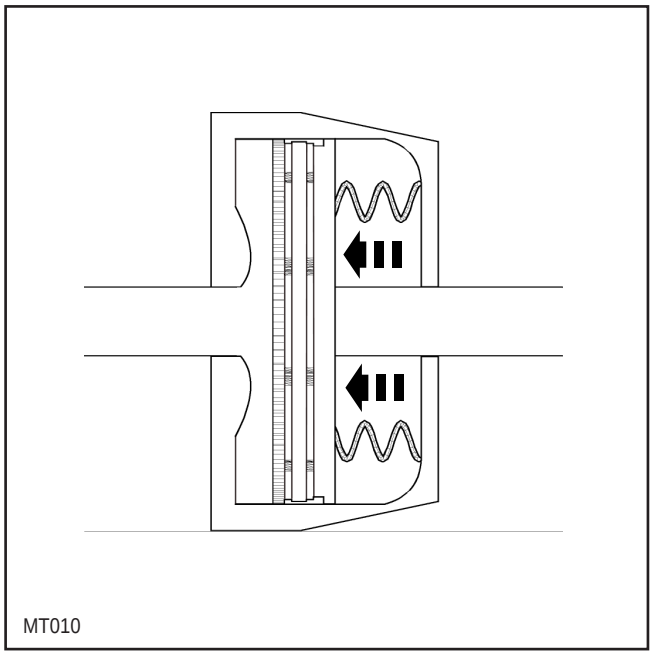
Item	Description
1	Flywheel
2	Clutch Disc
3	Clutch Pressure Plate
4	Clutch Cover
5	Transmission Input Shaft
6	Engine Crankshaft

When the driver pushes down the clutch pedal (clutch disengaged), the pressure plate is forced away from the flywheel. Since the clutch disc is no longer held against the flywheel, the engine no longer drives the clutch disc and transmission input shaft.

CLUTCH OPERATION (continued)

- Clutch disengagement allows the transmission input shaft to stop rotating, so the vehicle can be stopped without stalling the engine.

- If the vehicle is moving, releasing the torque on the input shaft allows smooth shifts because the transmission/transaxle gears are not under a load.



Clutch Engaged

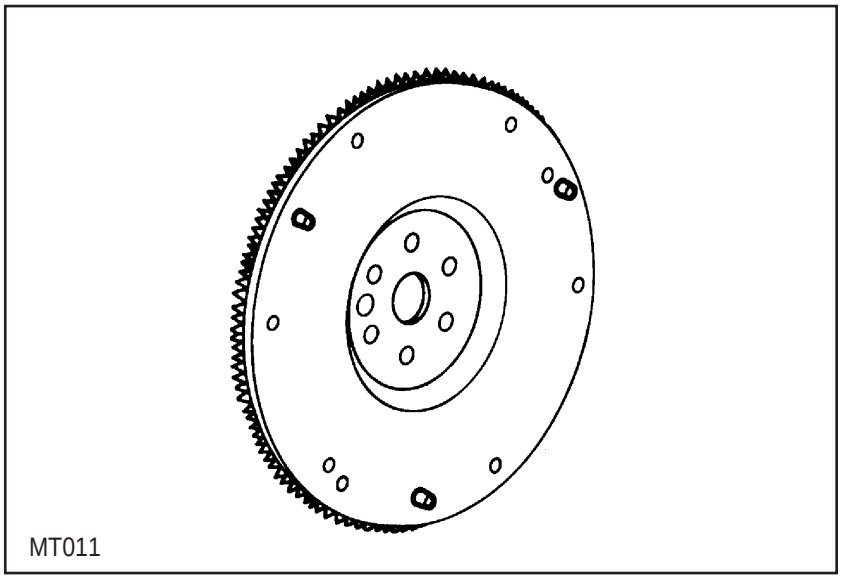
When the clutch pedal is up (clutch engaged), the pressure plate assembly squeezes the clutch disc against the flywheel. This action forces the clutch disc to turn with the flywheel and drive the transmission input shaft.

CLUTCH COMPONENTS

Clutch component size will vary based upon the type of vehicle in which they are used. Larger heavy duty vehicles will use heavy duty components so the clutch can handle the load of the vehicle. However, each type of clutch uses six major clutch components. These are the:

- Flywheel.
- Clutch disc assembly.
- Pressure plate assembly (cover, plate, internal springs and levers).
- Release bearing.
- Pilot bearing.
- Hydraulic or mechanical linkage.

FLYWHEEL

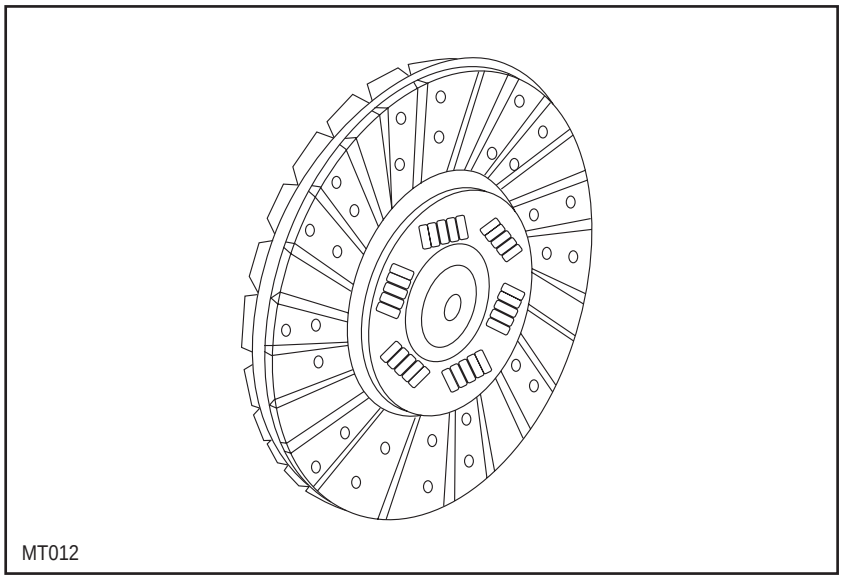


Typical Flywheel

The flywheel is the foundation on which the entire clutch is attached. It is bolted to the engine crankshaft and rotates with it. The flywheel is machined smooth to provide a uniform friction surface. Because the flywheel is very heavy its rotation helps dampen the firing pulses of the engine.

Some diesel engine equipped vehicles use a special flywheel, called the dual-mass flywheel. This type of flywheel has built in dampening springs that further reduce the firing pulses and vibration that passes from the engine to the transmission input shaft.

CLUTCH DISC



Typical Clutch Disc

The clutch disc receives the torque of the engine and transfers it through a splined hub to the transmission input shaft.

The disc has grooved friction material on both sides where it contacts the flywheel and the pressure plate. These grooves allow cleaner disengagement action and enhance air flow over the disc for cooling.

Dampening springs in the hub are used to absorb engine pulses.

NOTE: Most Ford Motor Company vehicles use a single-disc clutch system. Some heavy trucks, however, use a multiple-disc clutch system for adequate torque transfer.

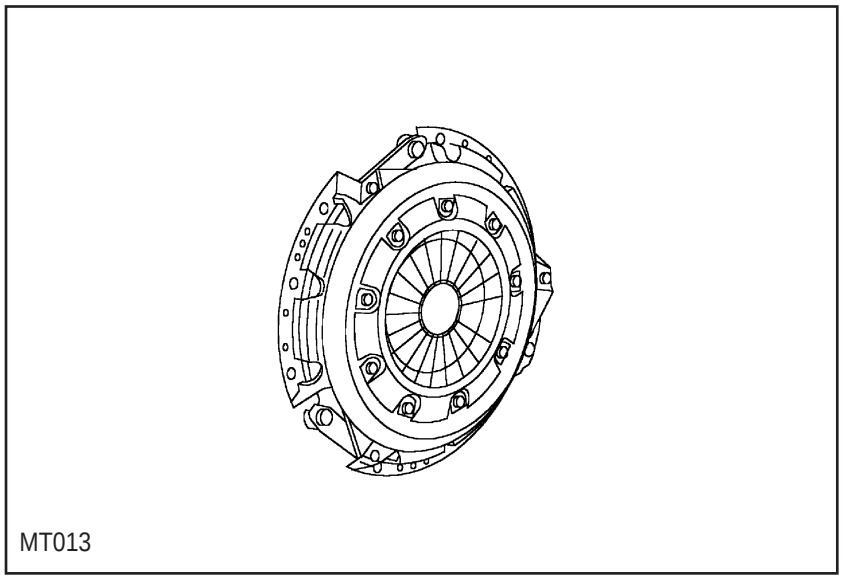
PRESSURE PLATE ASSEMBLY

The pressure plate assembly is bolted to the engine flywheel. When engaged, it applies pressure against the clutch disc, holding it tightly against the surface of the flywheel. One side of the pressure plate is machined smooth. This side presses the clutch disc against the flywheel.

On the other side of the pressure plate is the clutch cover. This cover bolts to the flywheel and provides the solid base for the pressure plate apply spring(s) to use to force the pressure plate against the clutch disc and flywheel.

Although all pressure plates perform the same function, the types of pressure plates vary.

Diaphragm Spring Pressure Plate Assembly



Typical Diaphragm Spring-Type Pressure Plate

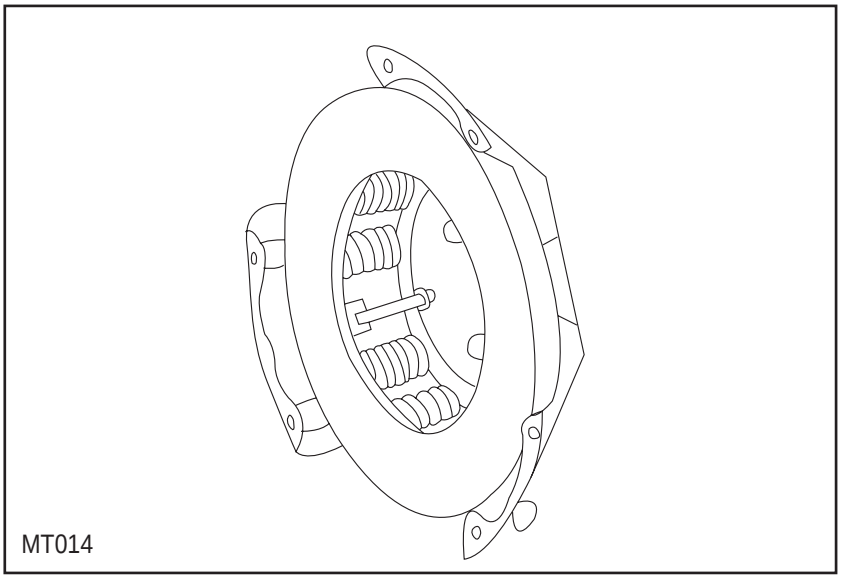
The diaphragm spring pressure plate assembly uses a conical piece of spring steel to press the pressure plate against the friction disc and flywheel. The center portion of the spring is slit into numerous fingers that act as release levers.

When the clutch is disengaged the release bearing is forced against the fingers of the diaphragm spring which causes the outer rim of the spring to move away from the flywheel. When this occurs, the force on the pressure plate is released which releases the friction disc from the flywheel.

Many Ford vehicles with diaphragm-type pressure plates are self-adjusting. During clutch replacement, the self-adjuster must be set before the pressure plate is installed on the vehicle.

PRESSURE PLATE ASSEMBLY (continued)

Coil-Spring Pressure Plate Assembly



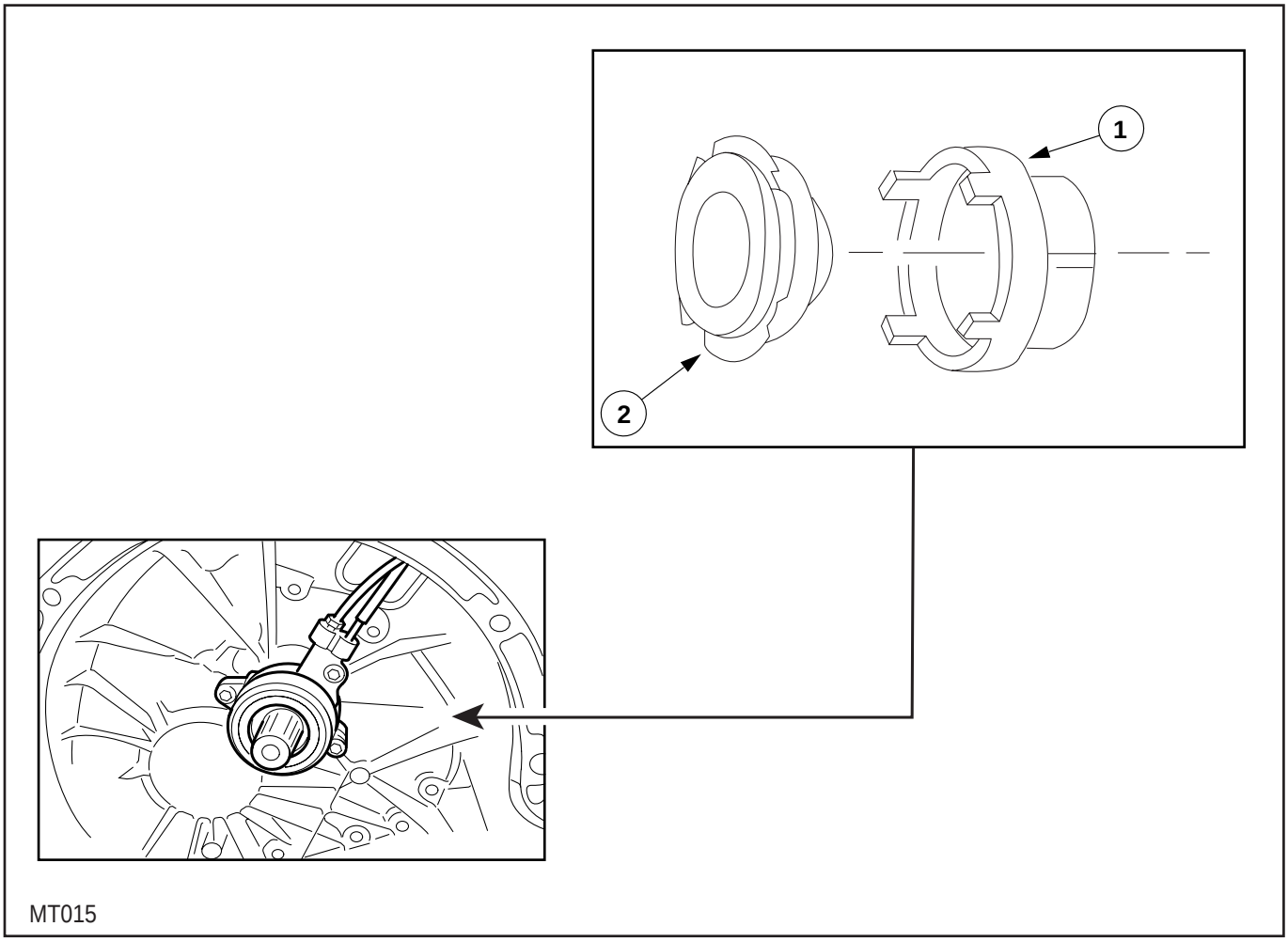
Typical Coil Spring-Type Pressure Plate

Heavy-duty vehicles require that more force be applied to the clutch disc. These vehicles often use a coil-spring type pressure plate. On this type of pressure plate several coil springs are placed between the clutch cover and the pressure plate.

When a coil spring clutch is disengaged, the release bearing is forced against equally spaced release levers that are attached to the pressure plate. As these levers pivot they force the pressure plate against the coil springs, causing them to compress. This releases the pressure place force against the clutch disc and flywheel allowing the clutch to disengage.

Some coil-spring pressure plates have weighed release levers that allow the centrifugal force of the rotating clutch to increase the force that the pressure plate applies to the clutch disc.

RELEASE BEARING



Typical Release Bearing

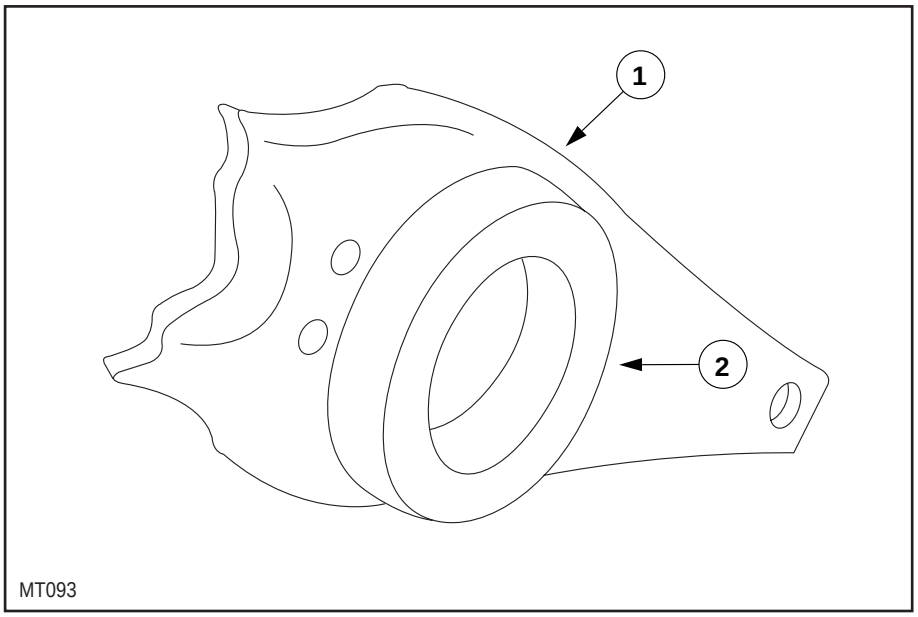
Item	Description
1	Bearing Carrier
2	Release Bearing

The release bearing is a sealed ball bearing that acts upon the diaphragm fingers or release levers of the pressure plate to disengage the clutch.

The release bearing is mounted to either a release lever or hydraulic cylinder. When the driver presses the clutch pedal down, the release bearing is forced into the pressure plate release fingers or levers, forcing them inward. This causes the pressure plate force to be released and disengages the clutch. Often the release bearing is mounted in a carrier as shown in the above art.

Many release bearings are designed to be in contact with the pressure plate fingers even when the clutch pedal is fully released.

CLUTCH FORK



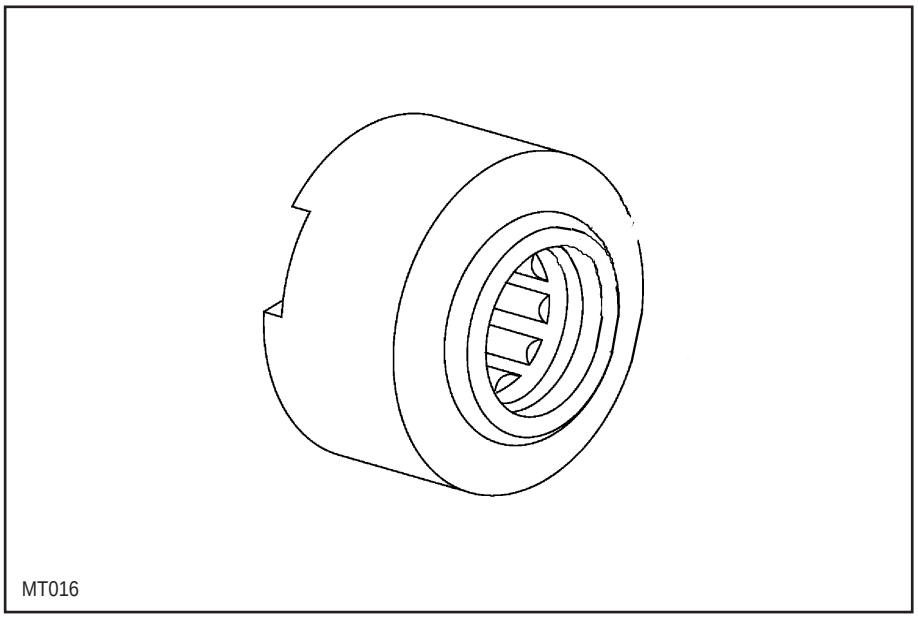
Typical Clutch Fork

Item	Description
1	Clutch Fork
2	Release Bearing

A clutch fork is used on some clutch assemblies to move the release bearing into and out of the fingers or levers of the pressure plate. It mounts to a pivot ball on the transmission and uses mechanical leverage for application and release of the pressure plate.

Clutch forks are commonly used on transmissions with mechanical-type linkages, however, they are also used in combination with some hydraulic clutch systems.

PILOT BEARING



Typical Pilot Bearing

The pilot bearing is used on many Ford clutches. It mounts either in the center of the flywheel or in the rear of crankshaft. Its purpose is to support the input shaft of the transmission while allowing the shaft to rotate independently of the crankshaft.

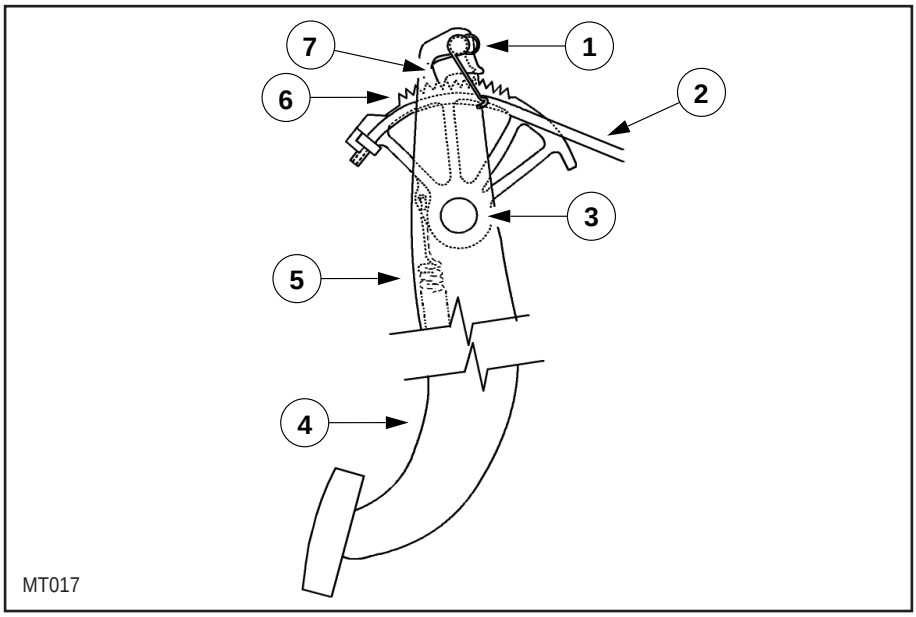
Some front wheel drive vehicles do not use a pilot bearing in their clutch systems.

CLUTCH LINKAGE

The connection between the clutch pedal and the release bearing is the clutch linkage. Ford uses two types of clutch linkage.

- Cable Linkage with Self-Adjuster
- Hydraulic Linkage

Cable Linkage with Self-Adjuster



Cable Linkage and Self-Adjuster at Clutch Pedal

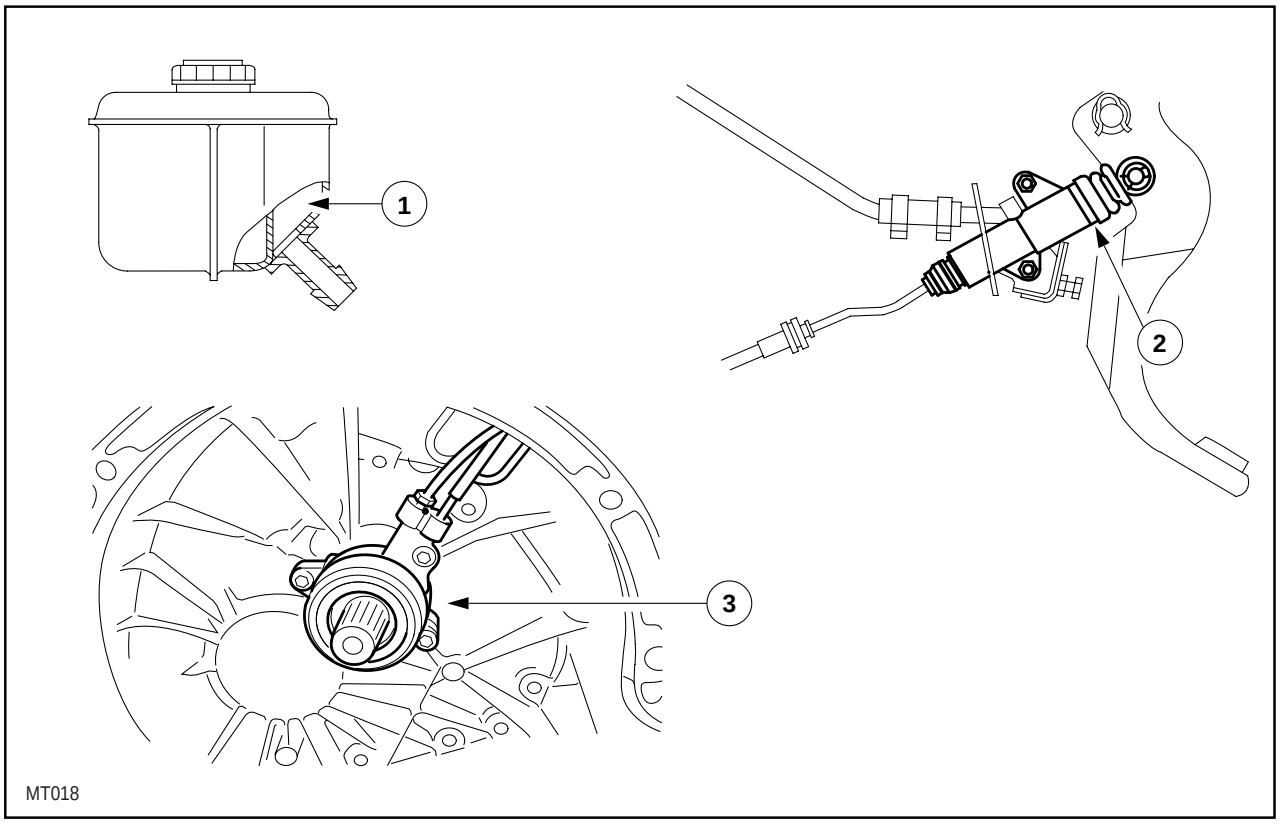
Item	Description
1	Pawl Tension Spring
2	Clutch Cable
3	Pivot
4	Clutch Pedal
5	Tension Spring
6	Quadrant
7	Pawl

A cable linkage with self-adjuster is used on some Ford compact vehicles. This type of linkage connects the clutch pedal to the release fork. At the top of the clutch pedal where the cable attaches is a self-adjuster.

During operation there is a slight preload applied to the release bearing by a spring-loaded ratcheting pawl. This pawl engages into a toothed wheel (quadrant) that is mounted at the clutch pedal pivot point. When the clutch is disengaged the pawl engages a tooth on the quadrant. As the clutch wears, the slack in the cable allows the pawl to move to the next tooth of the quadrant, automatically taking the slack out of the cable and maintaining the correct adjustment on the clutch.

CLUTCH LINKAGE (continued)

Hydraulic Clutch Controls



Hydraulic Clutch Controls

Item	Description
1	Clutch/Brake Master Cylinder Reservoir
2	Clutch Master Cylinder
3	Clutch Slave Cylinder with Integrated Release Bearing

Hydraulic clutch controls use hydraulic pressure to move the release bearing against the release fingers or levers of the pressure plate. Similar to a brake system, it has a master cylinder, hydraulic tubing, and a slave cylinder.

When the driver depresses the clutch pedal a linkage arm connected to the master cylinder forces the master cylinder piston down its bore.

- This applies pressure to the brake fluid contained in the master cylinder, which sends this pressure to the slave cylinder.
- The piston in the slave cylinder changes this pressure into mechanical force by moving outward.
- This mechanical action forces the release bearing into the pressure plate release fingers or levers, disengaging the clutch.

CLUTCH DIAGNOSIS

Clutch diagnosis requires a complete knowledge of clutch operation. As with all diagnosis, a technician must use symptoms and clues to determine the cause of a vehicle concern.

To aid the technician when diagnosing vehicles, Ford Motor Company has taken the strategies of many successful technicians and incorporated them into a diagnostic strategy and our service publications.

SYMPTOM-TO-SYSTEM-TO-COMPONENT-TO CAUSE DIAGNOSTIC METHOD

Using the "Symptom-to-System-to-Component-to Cause" diagnostic routine provides you with a logical method for correcting customer concerns:

- First determine what the "Symptom" of the customer concern is.
- Next, you will want to determine which "System" on the vehicle could be causing the symptom.
- Once you identify the particular system, you then want to determine which "Component(s)" within that system could be the cause for the customer concern.
- After determining the faulty component(s) you should always try to identify the cause of the failure. In some cases parts just wear out. However, in other instances something other than the failed component is responsible for the problem.

For example, if a clutch is chattering because it is oil soaked, replacing the clutch assembly will correct the chattering problem. However, if the oil leak that caused the clutch failure is not corrected at the same time the clutch will certainly fail again.

WORKSHOP MANUAL

The vehicle Workshop Manual contains information for the following clutch diagnostic steps and checks:

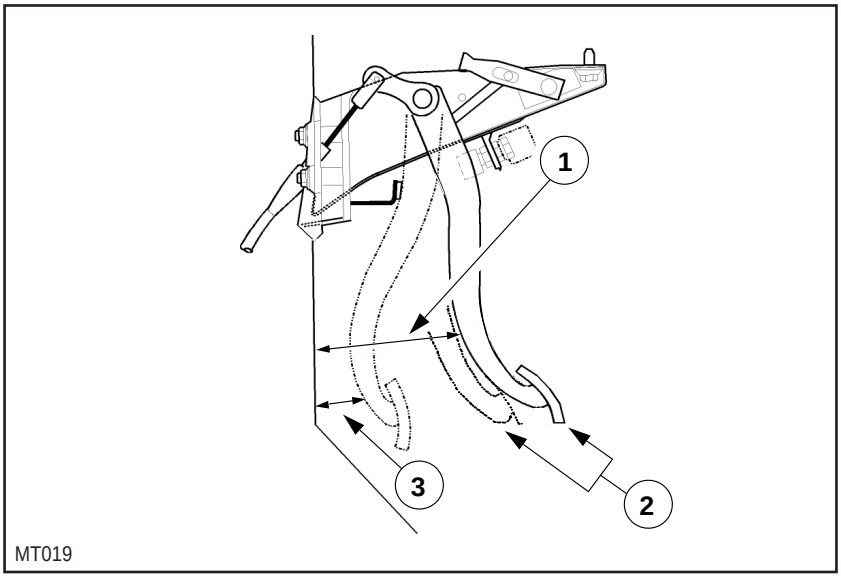
- Preliminary Checks
- Verification of customer concern/special driving conditions
- Road Test
- Diagnostic Pinpoint Tests

ROAD TESTING

When road testing a vehicle attempt to match the driving conditions under which the customer concern occurs (cold, hot, hills, vehicle loaded/unloaded etc.). Move the shifter through all positions during vehicle operation. Make sure you understand the customer concern before performing any service.

Clutch Pedal Free Play and Free Travel

Clutch pedal free play and clutch pedal free travel are very important clearances to check during the road test. These clearances indicate whether the clutch is disengaging and engaging completely.



Clutch Pedal Free Travel and Free Play

Item	Description
1	Total Pedal Movement Area
2	Free Play
3	Free Travel

ROAD TESTING (continued)

Clutch Pedal Free Play – When the clutch pedal is depressed there is a small amount (0.04 to 0.12 inch) of clutch pedal movement that will occur before the clutch begins to disengage. This free play indicates that the clutch is fully engaged when the pedal is released.

If there is not enough free play it indicates that the clutch is not being fully engaged. This may be caused by linkage problems or a friction disc that is excessively worn. Often this will be accompanied by clutch slippage.

Clutch Pedal Free Travel – When the clutch is pedal is released there is a certain amount (about 1 inch) of clutch pedal movement that will occur before the clutch begins to engage. This free travel from the floor indicates that the clutch is completely disengaged when the clutch pedal is depressed.

If there is not enough free travel it indicates that the clutch is not being fully disengaged. This may be caused by linkage problems or a pressure plate that is damaged. Often this will be accompanied by clutch dragging and/or harsh shifting.

COMMON CLUTCH SYMPTOMS AND CAUSES

Symptoms of a clutch problem can vary widely. The following are some common clutch symptoms, how to test for them, and possible causes.

Slippage — Clutch slippage is a condition in which the engine overspeeds without creating any increase in the torque to the driving wheels. A common test for determining if a clutch is slipping is the stall test.

When performing a stall test:

1. Block the wheels and apply the parking brake.

2. Place the transmission in fourth gear.

3. Increase the engine speed to 2000 rpm and slowly release the clutch pedal slowly.
   - If the engine stalls within 5 seconds the clutch is not slipping.
   - If the engine does not stall, the clutch is slipping.

Common causes for clutch slippage include:

- Clutch disc friction surfaces worn, damaged, oil soaked, or glazed (hardened).

- Pressure plate diaphragm or coil springs damaged.

- Clutch pedal or cable sticking or damaged.

- Hydraulic release system leaking or damaged.

COMMON CLUTCH SYMPTOMS AND CAUSES (continued)

Chatter or Shudder — A shaking or shuddering vibration that occurs when the clutch releases is known as chatter or shudder.

Common causes for these concerns are:

- Damaged motor or transmission mounts.
- Oil on clutch disc.
- Glazed (hardened) clutch disc.
- Excessive pressure plate or flywheel runout.
- Damaged pressure plate diaphragm or coil springs.

Clutch Drag — The symptom of this condition is usually a grinding or clashing of the transmission gears during shifting, or hard shifting. What is occurring is that the clutch is failing to completely release, which allows the transmission input shaft to turn when the clutch is disengaged. This usually results in grinding in all gears, but the grinding may be more noticeable when the vehicle is put in first or reverse.

Common causes for this concern include:

- Hydraulic release system leaking or damaged.
- Cable release system damaged.
- Damaged clutch disc.
- Clutch disc splines rusted or worn.
- Excessive runout on clutch disc, pressure plate or flywheel.
- Damaged pilot bearing.

Clutch Noises — Clutch noises include a wide variety of sounds. Clutch noises can be rattles or bearing noises. They can change pitch based on whether the clutch pedal is in or out. The following are some common examples of noises and how to determine which component is causing them.

COMMON CLUTCH SYMPTOMS AND CAUSES (continued)

Clutch Vibrations — Vibrations that are related to the clutch are usually most noticeable during clutch engagement or disengagement. They are usually high frequency vibrations whose intensity increase and decrease with engine rpm.

Causes of clutch vibration include:

- Motor or transmission mounts loose or damaged.
- Engine component grounding against frame.
- Excessive flywheel runout.
- Out of balance pressure plate.
- Loose flywheel bolts.

Bearing Noise – **Only occurs with clutch pedal depressed** – This noise can be the result of a damaged pilot bearing.

- If it is a damaged pilot bearing there is also likely to be gear grinding when the transmission is engaged in gear. This may occur because the damaged pilot bearing may keep the input shaft rotating even with the clutch disengaged.
- A pilot bearing noise will disappear when the clutch is engaged and the vehicle is moving because the transmission input shaft and flywheel are locked together and there is no pilot bearing rotation.
- Pilot bearing noise will be more audible when the clutch pedal is depressed (vehicle not moving) and the transmission is in gear. This is because the weight of the engaged gears and shaft gives the input shaft more resistance to rotation

Bearing Noise – **Occurs with clutch pedal released**– This is likely to be a release bearing.

- Because the release bearing is loaded when the clutch is disengaged it is most likely to be noisy with the pedal depressed.
- However, because many release bearings are constantly rotating with the pressure plate they may make a noise when the clutch is released or engaged depending on the severity of the damage. If this is the case, the bearing noise will likely change pitch as the clutch pedal is released and applied.
- A transmission input bearing or countershaft bearings may also make noise when the clutch is engaged, even with the vehicle in neutral.

COMMON CLUTCH SYMPTOMS AND CAUSES (continued)

Rattling – Clutch pedal depressed – Possible damaged dampening springs. This noise may sometimes be heard with the pedal depressed (clutch disengaged) but will be louder with the pedal released (clutch engaged.)

Clicking Or Squeaking Noises – If these noises are heard consistently when the clutch pedal is being depressed or released they may be the result of a damaged self-adjuster on a cable release, damaged clutch release fork, or a clutch pedal pivot arm in need of lubrication.

Clutch Pedal Pulsation – This can be caused by excessive runout in the flywheel or damage to the clutch disc.

CLUTCH SERVICE PROCEDURES

Clutch service procedures will vary based on the year and model of the vehicle you are working on. However, some procedures are common to all clutches. The following are some examples of common clutch service procedures.

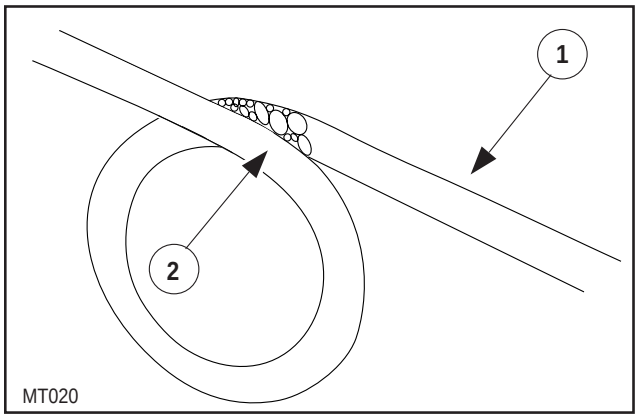
HYDRAULIC SYSTEM SERVICE PROCEDURES

The hydraulic release system uses brake fluid and like a brake system must be bled to make sure that no air is in the system.

When inspecting the hydraulic systems look for:

- Fluid Level – If the level is low, check the system for leaks.
- Leaks at the master cylinder – If the master cylinder is leaking it is often at the clutch pedal rod seal. This can be seen by looking for leaks where the clutch pedal rod enters the master cylinder at the bulkhead.
- Leaks at the slave cylinder – Look for leaks at the slave cylinder seals.
- Distorted or damaged hydraulic lines or hoses.

Bleeding



Air Trapped in Hydraulic hose

Item	Description
1	Hydraulic Clutch Line
2	Trapped Air

HYDRAULIC SYSTEM SERVICE PROCEDURES (continued)

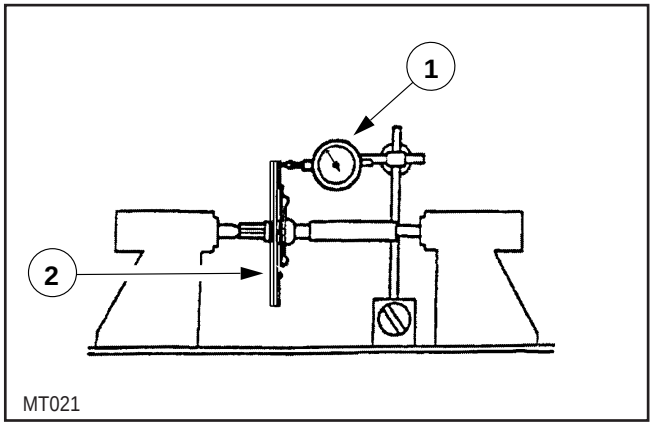
Air trapped in the hydraulic lines can cause the clutch not to completely disengage. The most effective method for bleeding clutch hydraulic systems is to use a Vacuum Bleeding System. To vacuum bleed the system:

- Fill the master cylinder.
- Connect the vacuum hose of the bleeder to the bleeder fitting at the slave cylinder.
- Bleed the fluid from the system until no air bubbles appear in the fluid.
- Use only High Performance DOT3 Motor Vehicle Brake Fluid C6AZ-19542-AB meeting Ford specification ESA-M6C25-A.

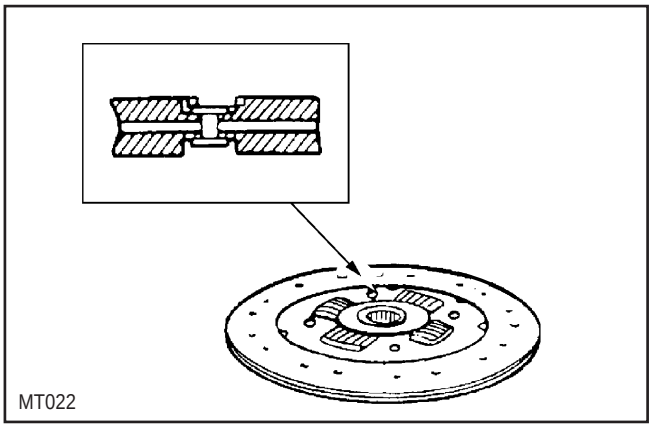
Some vehicles have no bleeder screw at the slave cylinder. The hydraulic systems of these vehicles require a special bleeding procedure. Refer to the vehicle workshop manual for specific directions for bleeding these systems.

CLUTCH INSPECTION PROCEDURES

When inspecting clutch assemblies look for the following:



Clutch Disc Runout Check



Measuring Friction Material Depth

Item	Description
1	Dial Indicator
2	Clutch Disc

Clutch Disc

- disc runout
- depth of the friction material from the rivets
- oil or grease saturation
- worn or loose friction material
- warpage (runout)
- broken dampening springs
- worn or rusted clutch hub splines

Release Bearing

- smooth rotation of the bearing
- damage to the clutch fork retaining grooves
- grooves on the clutch sleeve of the transmission

CLUTCH INSPECTION PROCEDURES (continued)

Clutch Fork

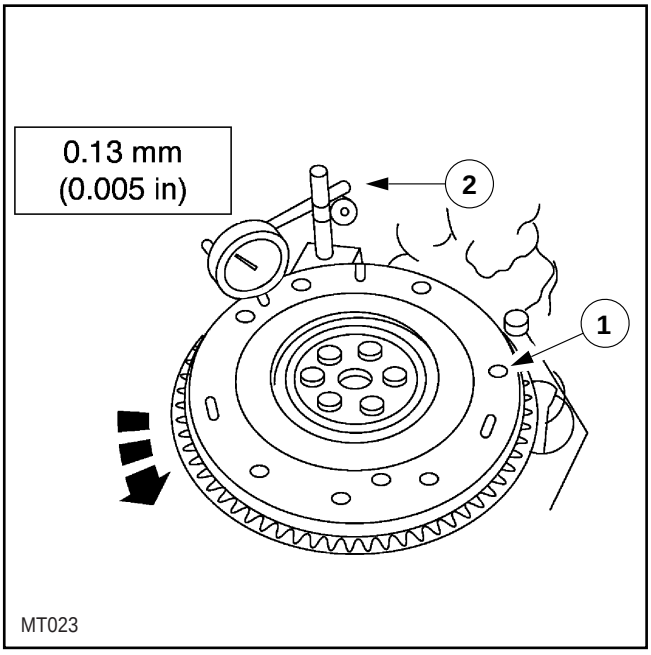
- grooves on fingers that contact release bearing
- bent release bearing fingers
- damaged pivot ball retaining spring

Pilot Bearing

- smooth rotation of the bearing
- rust
- damage to the tip of the transmission input shaft from bearing seizure

Pressure Plate Assembly

- warpage (runout)
- hot spots or heat cracks
- damaged diaphragm or coil springs
- damaged pivot arms where they contact release bearing
- damaged diaphragm spring fingers where they contact the release bearing



Flywheel Runout Check

Item	Description
1	Flywheel
2	Dial Indicator

CLUTCH INSPECTION PROCEDURES (continued)

Flywheel

- excessive runout
- hot spots or heat cracks
- grooves
- flywheel ring gear damage

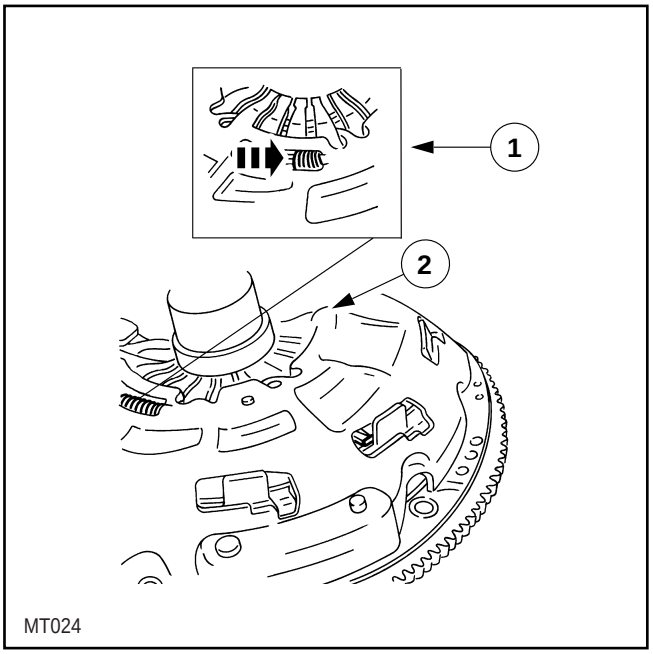
Cable with Self-adjuster Linkage

- damaged quadrant teeth
- damage to the pawl
- frayed or damaged cable

CLUTCH REPLACEMENT PROCEDURES

When replacing a clutch there are some common procedures that should be followed.

- Always replace a clutch disc and pressure plate as a set.
- Never get oil or grease on clutch disc friction linings.
- Machine the surface of a flywheel when excessive wear or damage is apparent on the flywheel surface.
- After machining the flywheel, always check its specifications as described in the work shop manual.

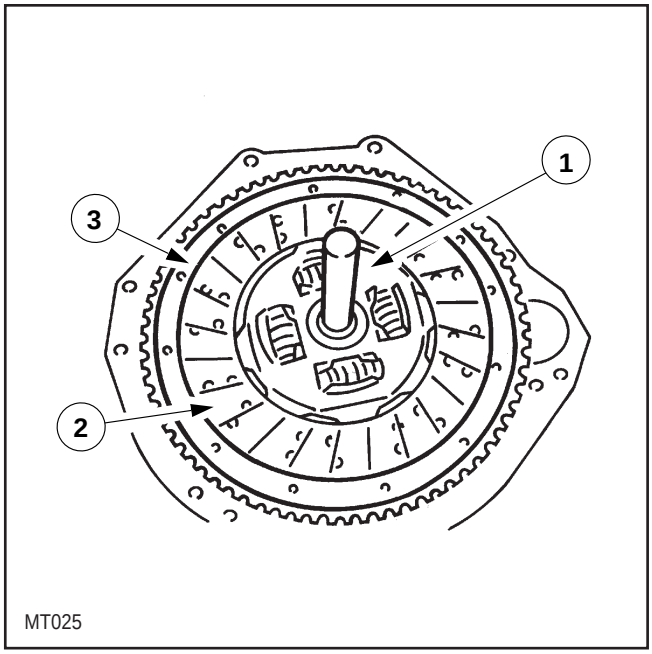


Adjusting Pressure Plate

Item	Description
1	Direction of Adjustment
2	Adjuster

- On adjustable pressure plates, always set the pressure plate adjustment as described in the workshop manual before installing it on the vehicle.

CLUTCH REPLACEMENT PROCEDURES (continued)



Clutch Alignment Procedure

Item	Description
1	Clutch Alignment Tool
2	Clutch Disc
3	Flywheel

- Always use the correct clutch alignment tool when installing the clutch and pressure plate on the flywheel.

- On hydraulic clutches, check the fluid level and refer to the workshop manual for bleed ing the system after installing a new clutch assembly.

REVIEW QUESTIONS

Directions: Use the information you have learned to answer the following questions.

1. When the clutch is engaged all of the following is true EXCEPT the:
   A. clutch pedal is up.
   B. pilot bearing is allowing the crankshaft to spin without turning the input shaft.
   C. pressure plate locks the friction disc to the flywheel.
   D. dampening springs of the clutch are dampening out engine pulsation.

2. Which of the following components attaches to the splines of the transmission input shaft?
   A. The release bearing
   B. The pressure plate
   C. The pilot bearing
   D. The clutch disc

3. What should always be done after installing a new clutch assembly on a vehicle equipped with a hydraulic clutch?
   A. Reset the self-adjuster.
   B. Adjust the self-adjusters on the pressure plate.
   C. Bleed the hydraulic system.
   D. Install a new thrust bushing on the clutch pedal.

4. When performing a stall test you should perform all of the following EXCEPT:
   A. place the transmission in 1st gear.
   B. increase engine speed to 2000 rpm.
   C. release the clutch pedal slowly.
   D. block the wheels and apply the parking brake.

5. If you have a damaged pilot bearing, which of the following would MOST LIKELY be the symptom that would occur?
   A. Squeaking noise when the clutch is engaged or released.
   B. A bearing noise that occurs only when the clutch pedal is depressed with the transmission in gear.
   C. A bearing noise that occurs when the clutch pedal is depressed or released.
   D. A rattling noise that occurs only when the clutch pedal is released.

6. Adjustable pressure plates must be:
   A. machined before they are installed.
   B. adjusted after they are installed.
   C. adjusted using the cable linkage system.
   D. adjusted before they are installed.

LESSON 3: GEARS

LESSON OBJECTIVES

OBJECTIVES

- Explain the purpose of gears in a manual transmission and transaxle.
- Describe the rotation of gear in a transmis sion.
- Identify the design of the gears used in a manual transmission and transaxle.
- Explain gear ratios in a manual transmission and transaxle.
- Determine a gear ratio and how it affects torque.

CONTENTS

LESSON 3: GEARS

PURPOSE OF GEARS

The purpose of the gears inside a transmission or transaxle is to transmit rotating motion. Gears are normally mounted on a shaft and they transmit rotating motion from one shaft to another.

Gears and shafts act upon each other in one of three ways:

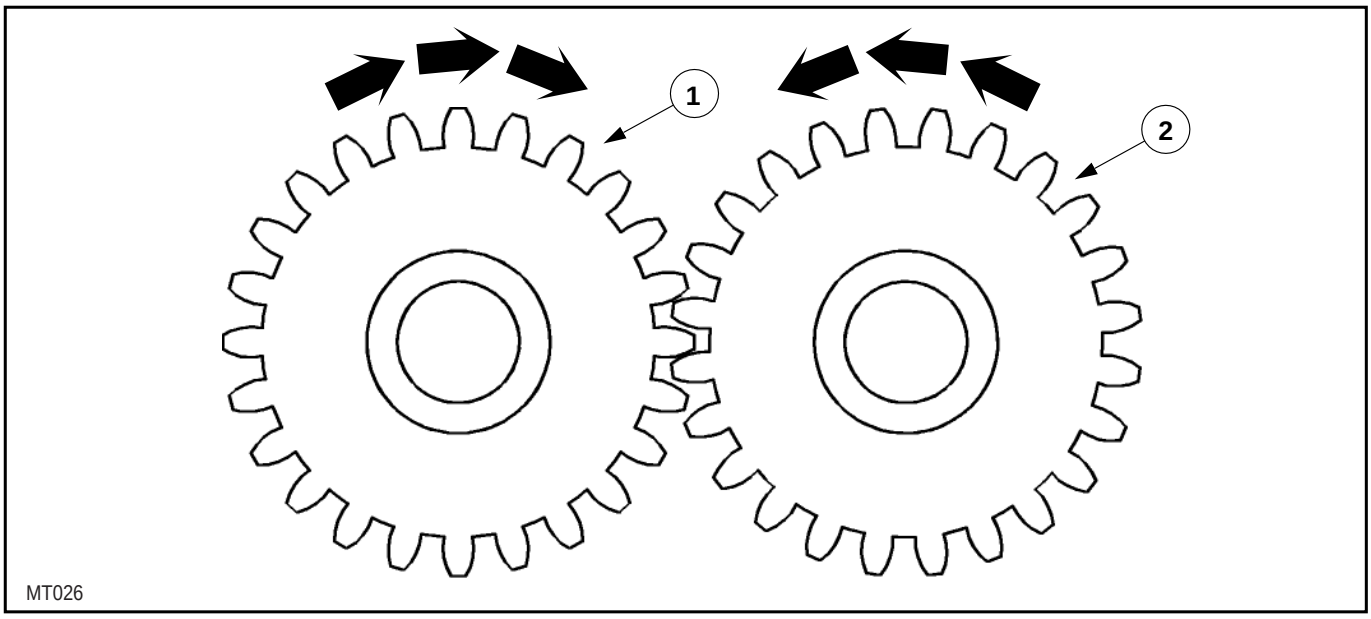
- The shaft can drive the gear
- The gear can drive the shaft
- The gear can be free to turn on the shaft

Sets of gears can be used to multiply torque and decrease speed, increase speed and decrease torque, transfer torque and leave the speed the same, or change the direction of torque.

GEAR ROTATION

Gear rotation inside a manual transmission or transaxle must be understood when performing diagnosis and service.

A basic gear rule that applies to gears is two external gears in mesh rotate in opposite directions.



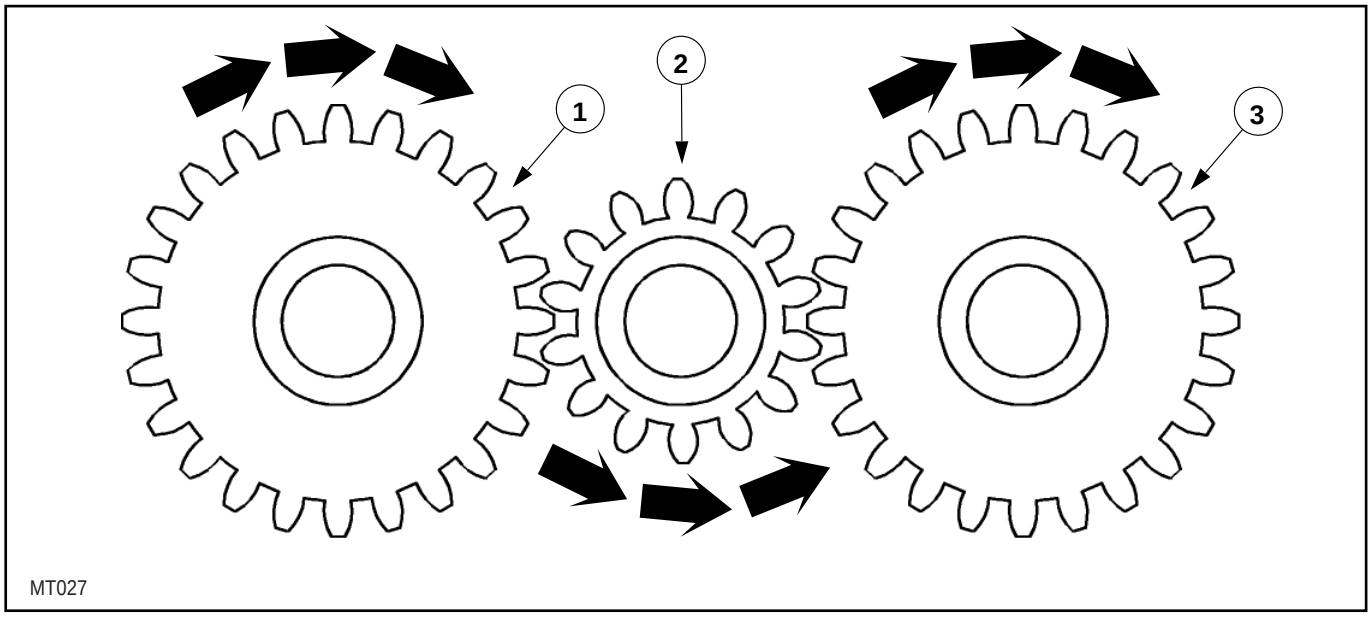
Gears in Mesh Rotate in Opposite Directions

Item	Description
1	Clockwise Rotating Gear
2	Counterclockwise Rotating Gear

This means that an engine that is driving a gear clockwise will cause any gear in mesh with this gear to rotate counterclockwise. To get that driven gear to turn the wheels in a clockwise direction, a third gear must be added.

GEAR ROTATION (continued)

Another basic gear rule is that when the third gear is added, the output from the gearset is in the same direction as the input.



Input and Output Rotation in Same Direction

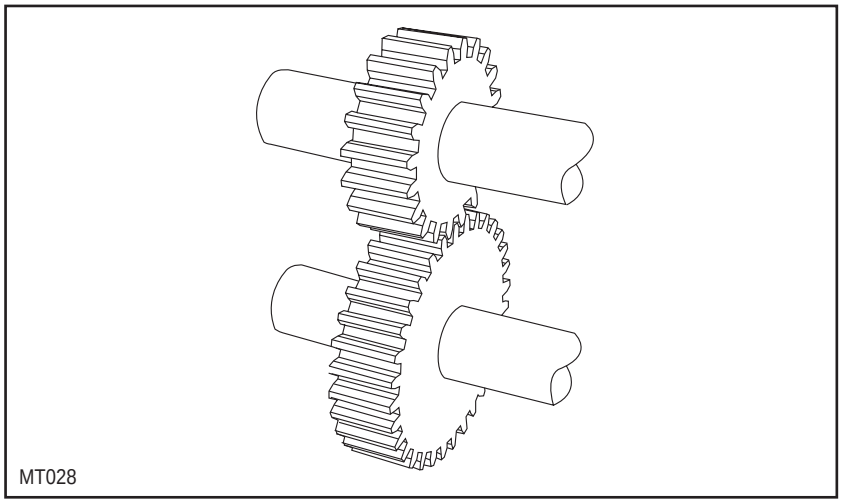
Item	Description
1	Input Gear Rotating Clockwise
2	Idler Gear Rotating Counterclockwise
3	Output Gear Rotating Clockwise

GEAR DESIGN

There are many types of gears, and each has its own operating characteristics. Common gears that are found in manual transmissions and transaxles include:

- Spur gears
- Helical gears
- Spur bevel gears

SPUR GEARS



Spur Gears

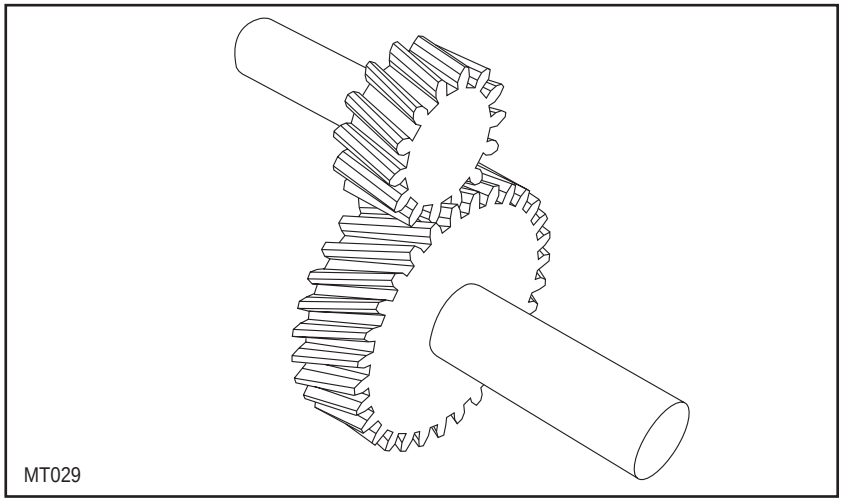
The spur gear is the simplest gear design used in manual transmission/transaxles.

- Its main advantage is that its teeth are cut straight so it can slide in and out of contact with other gears.

- Its main disadvantage is that it is noisy during operation. Spur gears whine at high speed.

- If a spur gear is found in a manual transmission/transaxle it is usually only used for reverse gear.

HELICAL GEARS



Helical Gears

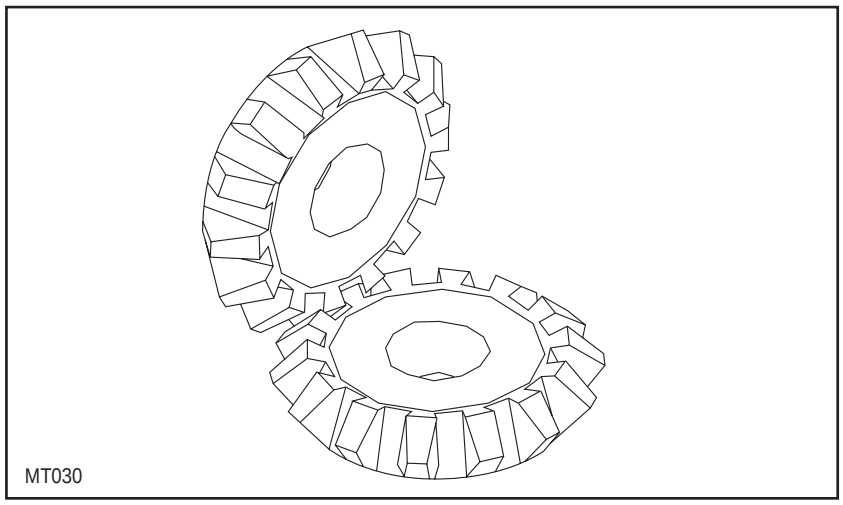
Helical gears are the most common types of gears used in manual transmission and transaxles. These gears are cut at an angle to the gear's axis of rotation. This allows two or more teeth to be in full contact at all times during operation.

- The main advantage of helical gears is that they operate much more quietly and are much stronger than spur gears.

- The main disadvantage of helical gears is that cannot be slid into and out of contact with their adjoining gears. They must maintain contact at all times. Helical gears are somtimes referred to as constant mesh gears.

- Helical gears are used for all forward speed gears, and in some cases for reverse as well.

SPUR BEVEL GEARS



Spur Bevel Gears

Spur bevel gears allow gears that rotate on an axis that is 90 degrees offset from the gear in which it contacts.

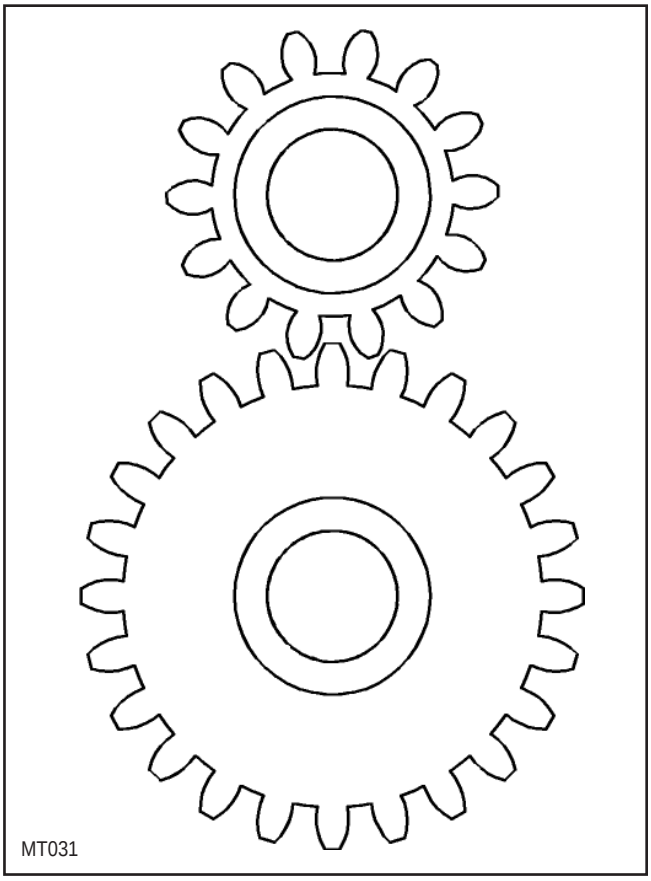
- Spur bevel gears are only used as pinion gears and side gears in the differential assembly of a manual transaxle.

GEAR RATIOS

The ancient Greek engineer Archimedes once said, “Give me a lever long enough, and a place to put it and I can lift the world.”

This statement refers to the ability of a lever to multiply force. Transmission gears are basically a set of levers arranged in a circle. They multiply force by the differences in size and number of teeth in the gear.

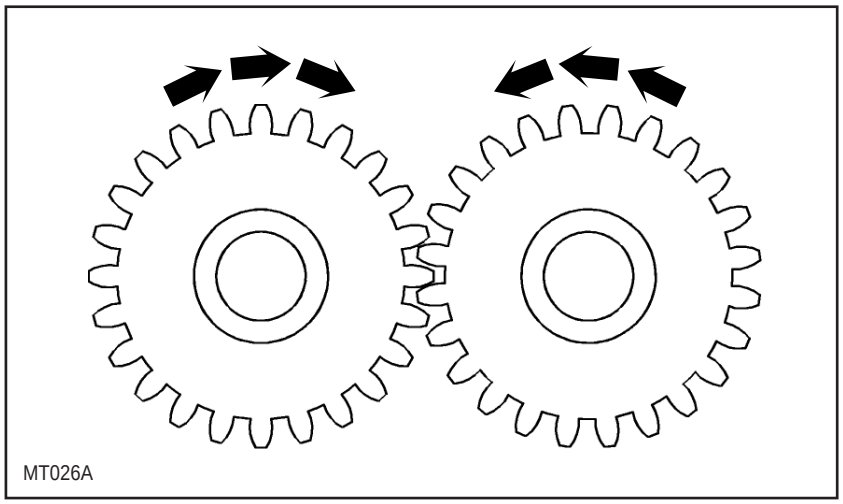
GEAR RATIOS (continued)



Transmission Gears are Circular Levers

This is how an engine that produces 300 foot pounds of torque can move and drive a 3000-pound vehicle? This ability is the result of transmission gear ratios. A gear ratio is a term that describes the differences in the number of teeth on gears in mesh.

GEAR RATIOS (continued)



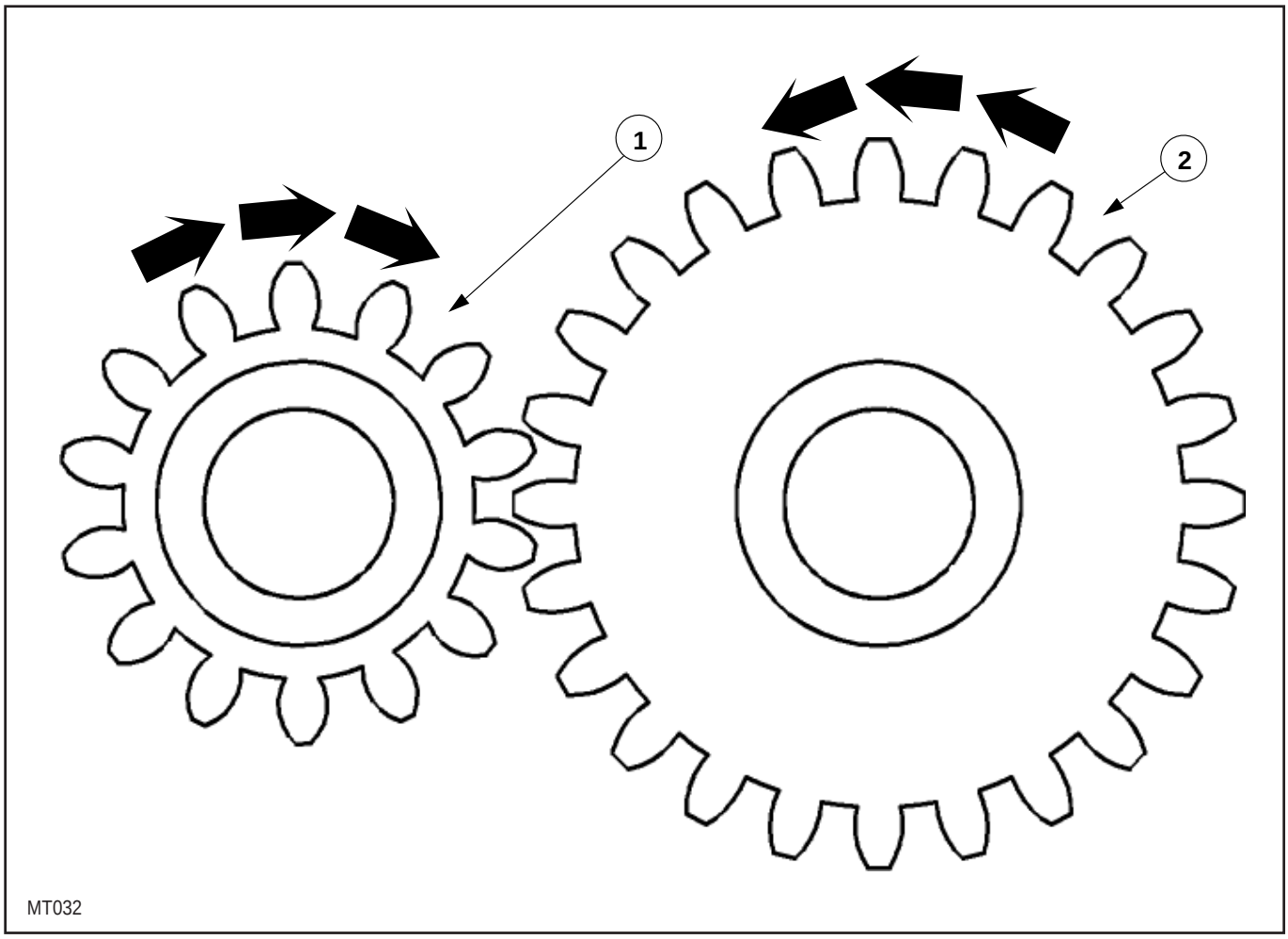
Gears of the Same Size in Mesh = 1:1 Gear Ratio

For example:

- The two gears in the art above are both the same size and have the same number of teeth.
- Each time the driving gear on the left makes a complete rotation so does the driven gear on the right.
- They are turning at the same speed, and because they are the same size and have the same number of teeth, they are turning with the same amount of torque.
- The only difference between them is that they are rotating in opposite directions.
- This is considered a 1 to 1 gear ratio because the driving gear is rotating 1 time for each rotation of the driven gear.
- Gear ratios are usually written with a colon between them so 1 to 1 would be written 1:1.

GEAR RATIOS (continued)

Now look at the two gears below.



Reduction Gear Ratio

Item	Description
1	Input Gear with 12 Teeth
2	Output Gear with 24 Teeth

- The smaller gear on the left has 12 teeth.
- It is driving the larger gear on the right that has 24 teeth.
- The 12 tooth driving gear is turning with 10 pounds of torque. But it rotates twice for every rotation of the 24 tooth driven gear.
- This causes the driven gear to have twice as much torque in every rotation. The driven gear now turns with 20 pounds of torque.
- This is a reduction gear ratio of 2:1.

GEAR RATIOS (continued)

This is the same principle that allows the engine that produces 300 pounds of torque to move a 3000-pound vehicle. If this engine is connected to a drive train that has a 10:1 gear ratio, the result is that 3000 pounds of torque is applied at the wheels, which is the amount of power needed to move the 3000 pound vehicle.

However, there is a draw back to reduction gear ratios. The driving gear must turn many more times than the driven gear. So an engine that is operating at 6000 rpm will only turn a drive train with a 10:1 gear ratio at 600 rpm.

But once a vehicle begins moving it does not require as much power to maintain its speed as it did to get it to move in the first place. Because of this gear ratios can be changed to allow increased rotation speed. This is why manual transmissions have several gears.

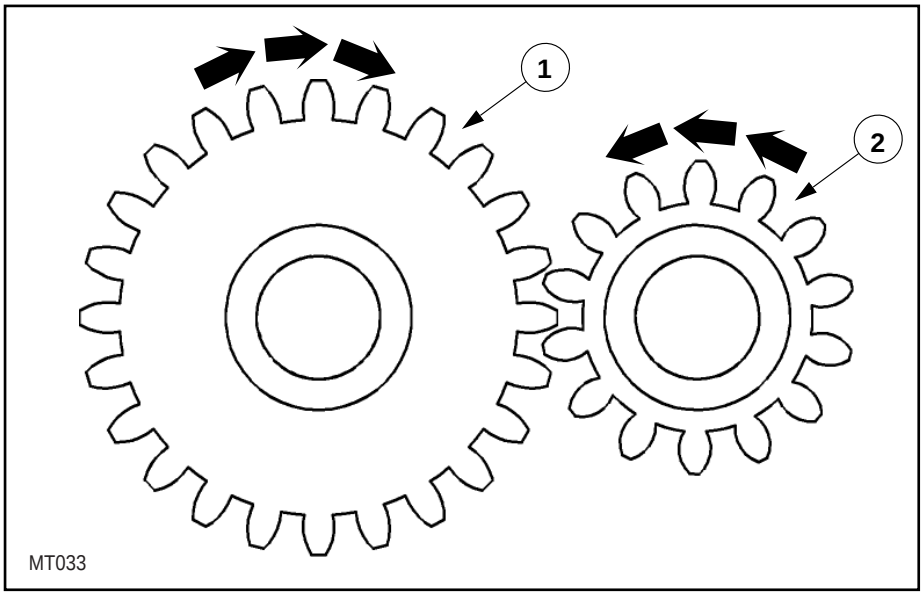
An example of the gear ratios in a manual transmission would be:

- Reverse = 3.40:1
- 1st gear = 3.97:1
- 2nd gear = 2.34:1
- 3rd gear = 1.46:1
- 4th gear = 1:1
- 5th gear = .79:1

As you can see, Reverse and 1st through 3rd gears are reduction gears.
4th gear is 1:1 meaning that the driving and driven gears have the same number of teeth and are rotating at the same speed, this is called direct drive.

GEAR RATIOS (continued)

However, if you look at 5th gear you will notice that the ratio is .79:1. This means that the driving gear is actually rotating less than one rotation for each rotation of the driven gear.



Overdrive Gear Ratio

Item	Description
1	Input Gear with 24 Teeth
2	Output Gear with 12 Teeth

Any time the driving gear is rotating slower than the driven gear it's called an **overdrive** gear ratio.

Overdrive ratios allow the drive train to actually turn faster than the engine because at high speed very little torque is needed to keep the vehicle moving. Since overdrive ratios allow the engine to operate at lower rpm they provide better fuel economy.

To determine the total gear ratio of the entire driveline all that has to be done is to multiply the ratio of the specific gear by the ratio of the differential. For example, assume you have a differential with a 3.78:1 ratio. To determine that actual gear ratio that is being used in any specific gear just multiply that gear ratio by 3.78.

For example, if 1st gear has a 3.97:1 ratio, multiply it by the differential ratio of 3.78:1 and you find that the total gear reduction from the engine to the wheels is 15.01:1. So the torque of the engine is being multiplied 15.01 times by the driveline.

REVIEW QUESTIONS

Directions: Use the information you have learned to answer the following questions.

1. Transmission gears sets can do all of the following EXCEPT:
   A. multiply torque and decrease speed.
   B. increase speed and increase torque .
   C. transfer torque and leave the speed the same.
   D. change the direction of torque.

2. What must be done in order to get the output gear to rotate in the same direction as the input gear?
   A. A third gear must be added.
   B. Spur gears must be used.
   C. Two additional gears must be added.
   D. Helical gears must be used.

3. Which of the following is a disadvantage of helical gears?
   A. They are noisy.
   B. They have only one tooth in contact with each other at a time.
   C. They cannot slide into and out of contact with each other.
   D. They cannot be used for Reverse gears.

4. Which of the following types of gear is used for side gears in a manual transaxle?
   A. Spur gear
   B. Helical gear
   C. Hypoid gear
   D. Spur bevel gear

5. A driving gear has 20 teeth and is turning with 20 lbs./ft. of torque. The gear it is driving has 100 teeth. How much torque is the driven gear producing?
   A. 40 lb-ft
   B. 80 lb-ft
   C. 100 lb-ft.
   D. 400 lb-ft

6. What type of gear is represented by a gear ratio of .69:1?
   A. Gear Reduction
   B. Direct drive
   C. Overdrive
   D. Reverse

LESSON 4: MANUAL TRANSMISSIONS

LESSON OBJECTIVES

OBJECTIVES

- Describe the purpose of the manual transmision.
- Explain the operation of a manual transmis sion.
- Identify the parts of a manual transmission.
- Describe the powerflow of a manual transmision.
- Explain manual transmission diagnostic procedures.
- Identify common manual transmission service procedures.

CONTENTS

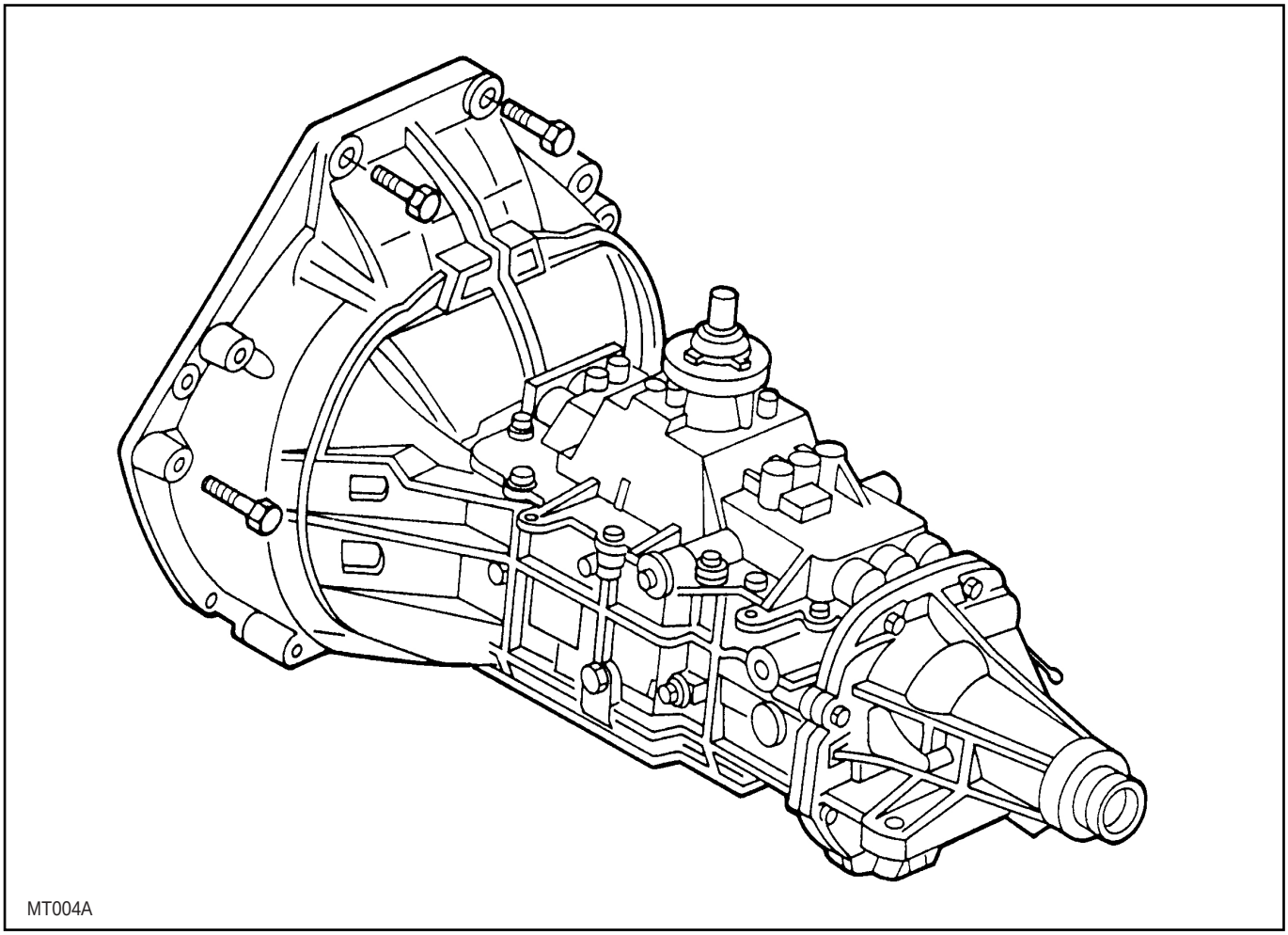
LESSON 4: MANUAL TRANSMISSIONS

PURPOSE OF THE MANUAL TRANSMISSION

The manual transmission is a vital link in the driveline of many modern vehicles. The manual transmission uses different size gears to give the engine a mechanical advantage over the driving wheels. Without this mechanical advantage, an engine can generate only limited torque at low speeds. Without enough torque, moving a vehicle from a standing start would be impossible.

During normal operating conditions power from the engine is transferred through the engaged clutch to the transmission input shaft. The input shaft transfers this power to gears in the transmission, which alter its torque and speed and then send it to the rest of the power train.

Ford uses manual transmissions on rear wheel and four wheel drive vehicles. On front wheel drive vehicles manual transaxles are used. While manual transmissions and transaxles are similar, they are also very different. Manual transaxles will be covered later in this book.



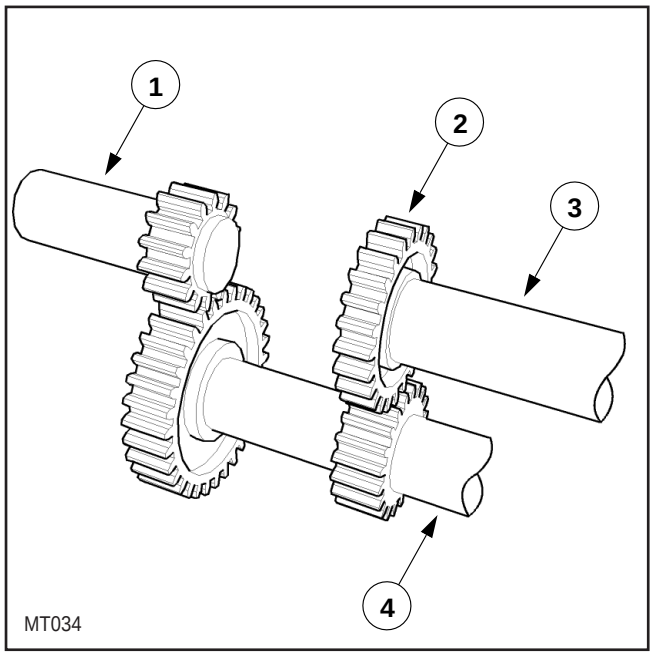
MT004A

M5OD Manual Transmission

BASIC 3-SPEED MANUAL TRANSMISSION OPERATION

To understand how modern transmissions work we should first look at the operation of a basic 3-speed transmission. In this section we will build up a simple set of gears to see how a basic 3-speed transmission works.

1st GEAR



Basic Transmission in 1st Gear

Item	Description
1	Input Shaft
2	1st Speed Gear
3	Output Shaft
4	Countershaft

To get a manual transmission into 1st gear takes the use of four gears and three shafts as shown in the above art.

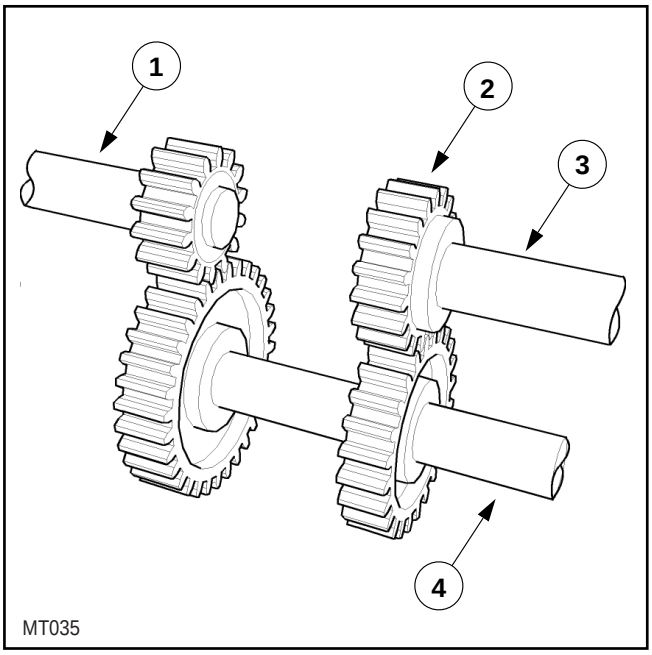
- A small gear on the input shaft from the engine drives a larger gear fastened to the transmission countershaft.

- Another smaller gear fastened on the countershaft drives a large gear on the third shaft, which is the output shaft.

Looking at the size of the gears you can see that there is gear reduction between the input shaft gear and the countershaft input gear. Additionally, there is more gear reduction between the countershaft 1st gear and the output shaft 1st speed gear.

Note that the input shaft and the output shaft are turning in the same direction because the countershaft acts as an idler gear between them.

2nd GEAR



Basic Transmission in 2nd Gear

Item	Description
1	Input Shaft
2	2nd Speed Gear
3	Output Shaft
4	Countershaft

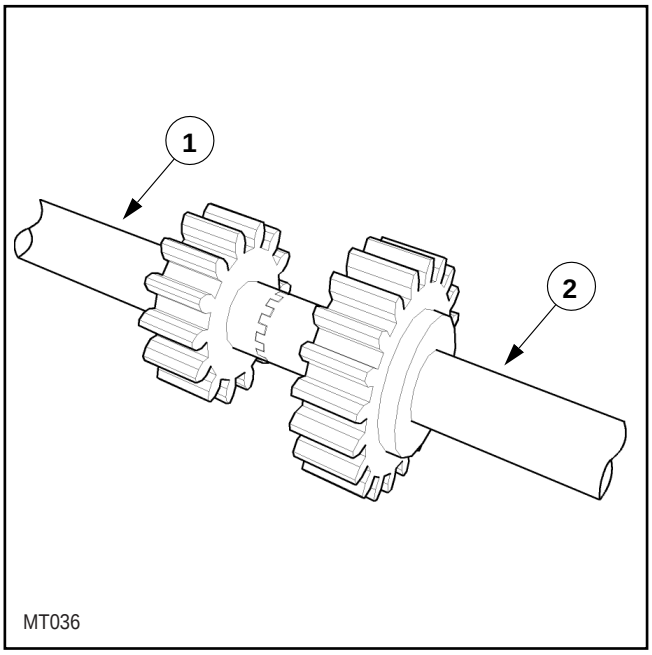
2nd gear works in about the same way as 1st.

- The input shaft gear and the countershaft input shaft gears are the same ones that were used in 1st gear.

- However, the countershaft 2nd gear and the output shaft 2nd speed gear are almost the same size.

Because the vehicle is already moving not as much torque is required to keep it moving. But for vehicle speed to increase the gear ratio must be lower than in 1st gear. For this reason the countershaft 2nd gear and output shaft 2nd speed gear are almost the same size.

3rd GEAR (DIRECT DRIVE)



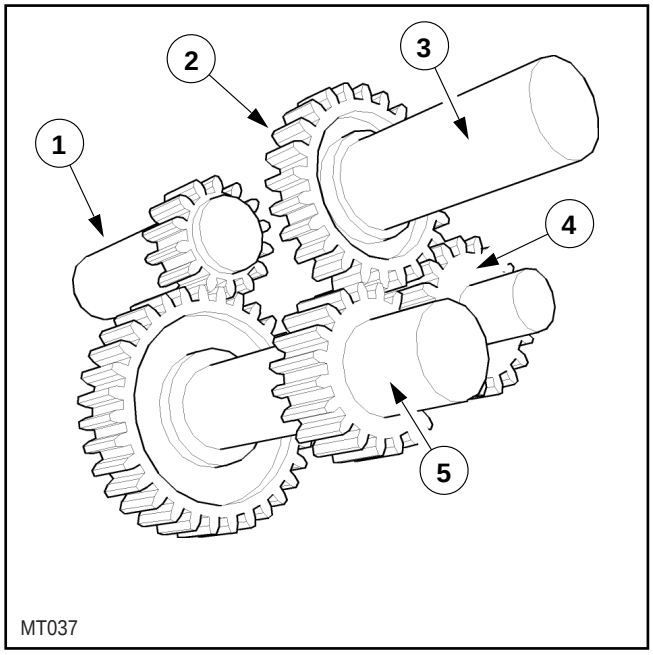
Basic Transmission in 3rd Gear (Direct Drive)

Item	Description
1	Input Shaft
2	Output Shaft

3rd gear in our basic transmission is direct drive. In direct drive no gear reduction takes place.

- The input shaft is mechanically connected directly to the output shaft.
- Each rotation of input shaft results in a rotation of the output shaft giving it a 1:1 ratio.

REVERSE



Basic Transmission in Reverse

Item	Description
1	Input Shaft
2	Reverse Speed Gear
3	Output Shaft
4	Reverse Idler Gear
5	Countershaft

To achieve reverse in a manual transmission requires the use of an additional gear and shaft. This gear is commonly known as the reverse idler gear. In some transmissions the reverse idler gear actually slides in and out of contact with its adjoining gears. On others it is a helical gear that is constantly in mesh.

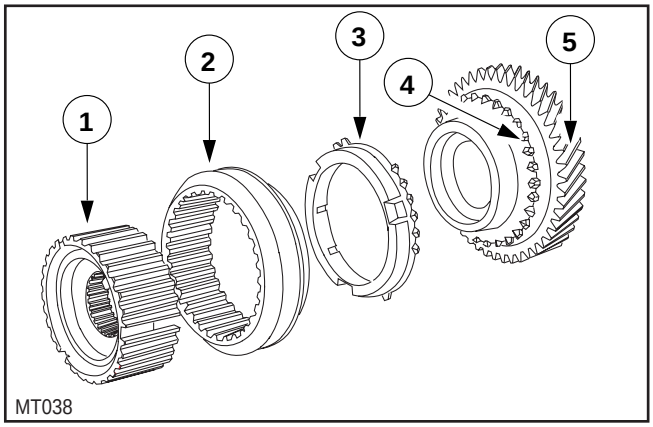
- In reverse, power still enters the transmission through the input shaft and is transferred to the countershaft input gear.
- However, the countershaft reverse gear and the output shaft reverse gear are not in direct contact.
- In order for the countershaft reverse gear to transmit rotation to the output shaft reverse gear, the reverse idler gear meshes between with the teeth on both gears.
- This reverses the normal rotation of the output shaft, allowing it to rotate in reverse.

Note that the countershaft reverse gear is smaller than the reverse speed gear on the output shaft. This provides a reduction gear ratio to multiply power in reverse. This is needed since reverse can only be engaged from a standing stop.

MANUAL TRANSMISSION COMPONENTS

Although the operation of a manual transmission is very straight forward many different components are needed to make its operation practical. The following is a description of these components and how they work.

SYNCHRONIZERS AND SPEED GEARS



Basic Synchronizer and Speed Gear

Item	Description
1	Synchronizer Hub
2	Synchronizer Sleeve
3	Blocking Ring
4	Clutching Teeth
5	Speed Gear

As explained in the previous lesson all forward gears in modern transmissions are helical gears. This makes them quiet and gives them additional strength. However, because the teeth of helical gears are angled they cannot be slid into and out of engagement with each other.

For this reason the speed gears are not directly splined to the shaft upon which they ride. Their inner diameter is smooth allowing them to rotate freely on the shaft.

When the gear needs to be connected to the shaft, the synchronizer sleeve moves over and engages the clutching teeth on the side of the gear.

- This locks the synchronizer sleeve to the speed gear.
- The synchronizer sleeve inner diameter has internal teeth that slide along the external teeth of the synchronizer hub outer diameter.
- The synchronizer hub is splined to the shaft's inner diameter.

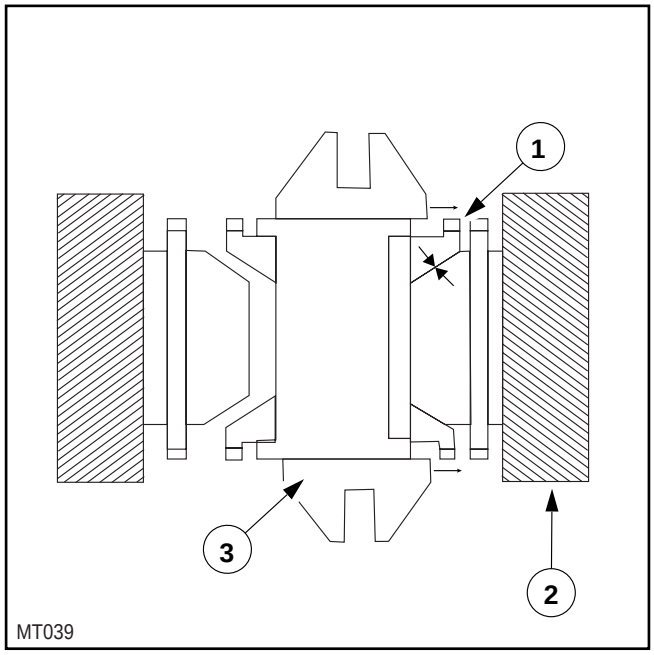
SYNCHRONIZERS AND SPEED GEARS (continued)

This connects the speed gear to the output shaft through the synchronizer allowing the torque of the gear to be transmitted.

In most instances each synchronizer works with two speed gears because its sleeve can slide both forward and rearward. For this reason, synchronizers will be named for the gears they control. For example, the 1-2 synchronizer works on both 1st and 2nd speed gears.

Synchronizing Gear and Shaft Speed

Another function of the synchronizer is to make the speed of the speed gears match that of their shaft, before the gear is locked to the shaft. This must be done since the rotating speed of the gear is different than the speed of the shaft. If the speed of the gear and shaft wasn't the same before the synchronizer sleeve engaged the gear's clutching teeth, both the sleeve and the clutching teeth could be damaged.



Synchronizer Operation – Blocking Ring and Gear Shoulder Come Into Contact

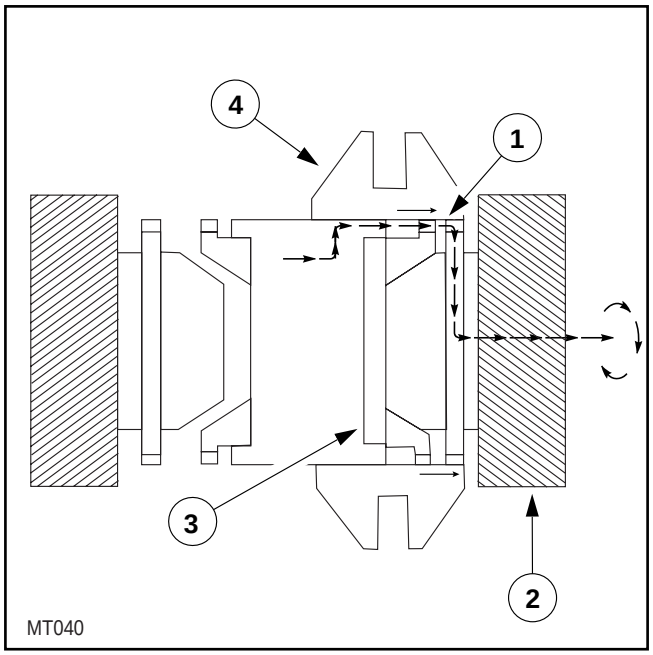
Item	Description
1	Blocking Ring
2	Driven Gear
3	Synchronizer Sleeve

SYNCHRONIZERS AND SPEED GEARS (Continued)

Synchronizing Gear and Shaft Speed (continued)

When a gear is selected the shift fork forces the synchronizer sleeve toward the speed gear.

- A blocking ring, which has a cone-shaped inner surface, is pushed into contact with the cone-shaped shoulder of the speed gear.
- As the synchronizer sleeve continues to move it compresses the inserts against the retaining springs.
- As it moves further, the sleeve splines mate with teeth on the blocking ring.
- Friction between the blocking ring and gear shoulder causes the gear, which is rotating freely on the shaft, to speed up or slow down to the same speed of the synchronizer.
- The blocking ring prevents the sleeve's splines from engaging the gear's clutching teeth until they are all rotating at the same speed.



Synchronizer Operation – Synchronizer Sleeve in Full Engagement with Speed Gear

Item	Description
1	Point where sleeve and gear mesh
2	Driven Gear
3	Blocking Ring
4	Synchronizer Sleeve

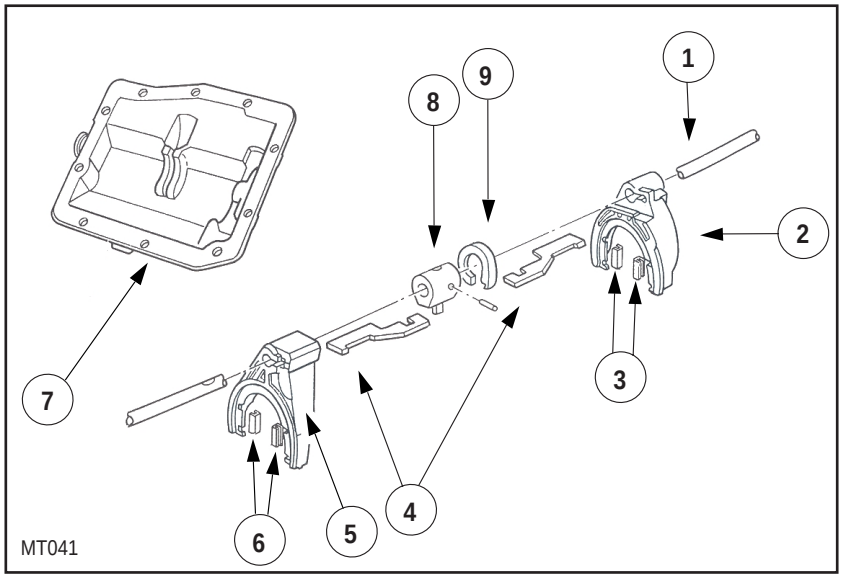
SYNCHRONIZERS AND SPEED GEARS (Continued)

Synchronizing Gear and Shaft Speed (continued)

- When the blocking ring (which is connected to the synchronizer) and the speed gear teeth are lined up, the synchronizer sleeve can slide over the gear's clutching teeth locking the gear to the shaft.

- As this happens the compressed inserts move into a notch on the inner diameter of the sleeve. This helps hold the sleeve in place.

SHIFT MECHANISMS



Typical Shift Mechanism – Exploded View

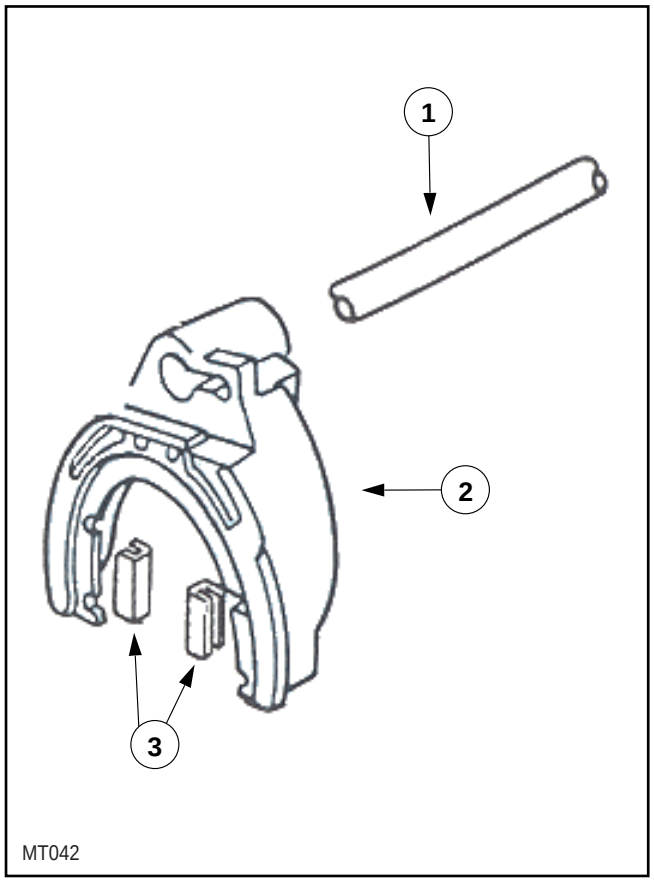
Item	Description
1	Shift Rail
2	1-2 Shift Fork
3	Inserts
4	Selector Arm Plates
5	3-4 Shift Fork
6	Inserts
7	Shift Cover
8	Selector Arm
9	Interlock Plate

SHIFT MECHANISMS (continued)

The transmission is shifted by means of shift mechanisms. Common components of the shift mechanisms include:

- Shift Forks
- Shift Rails
- Interlock Plates
- Detents

Shift Forks and Shift Rails



Shift Fork and Shift Rail

Item	Description
1	Shift Rail
2	Shift Fork
3	Shift Fork Inserts

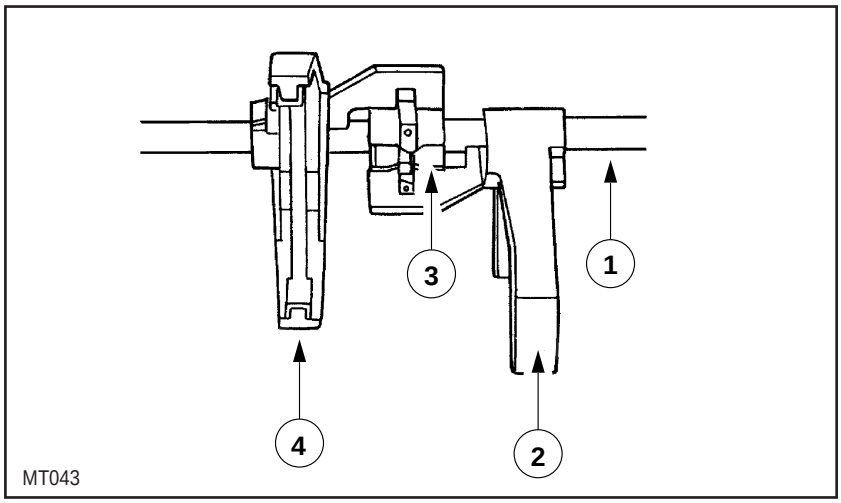
SHIFT MECHANISMS (continued)

The transmission is shifted by means of shift forks that fit into a groove cut into the center of the synchronizer sleeve. The forks ride on shift rails that are moved by the driver using the gearshift.

When the driver moves the gearshift the selector shaft will move. This causes the shift fork to move the synchronizer sleeve and engage the speed gear.

The shift forks usually have plastic inserts on their tips to that fit snugly into the synchronizer sleeve and prevent shift fork wear.

Interlocks and Detents

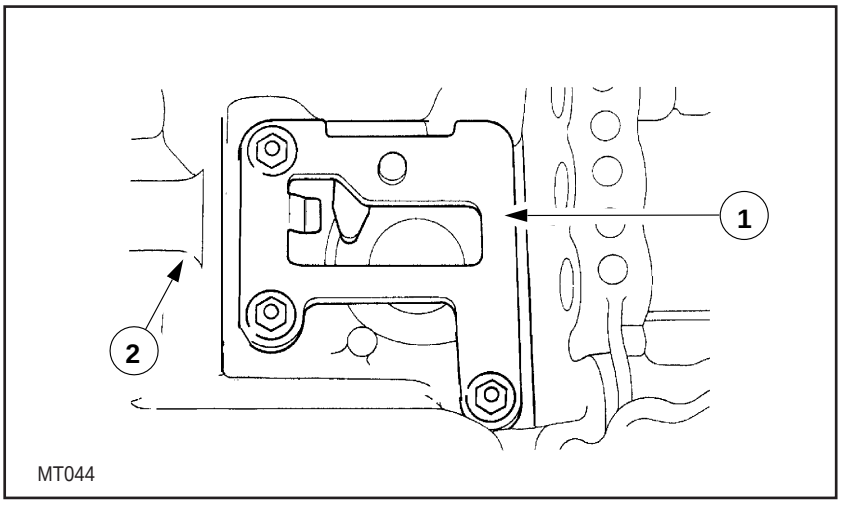


Interlock Sleeve

Item	Description
1	Shift Rail
2	Shift Fork
3	Interlock Sleeve
4	Shift Fork

SHIFT MECHANISMS

Interlocks and Detents (continued)



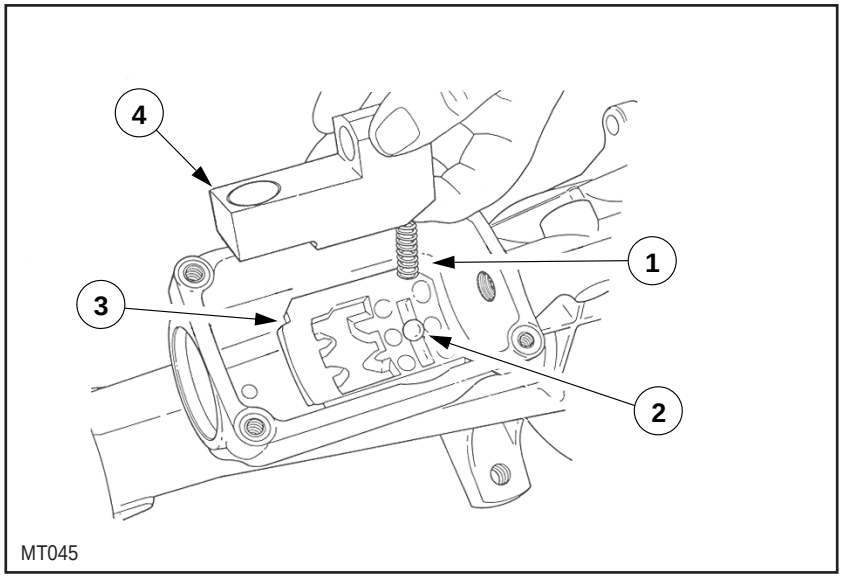
Interlock Plate

Item	Description
1	Interlock Plate
2	Shift Cover

To prevent transmission damage, the shift mechanism uses interlocks. These devices can be connected to the selector shafts or the shift cover. They are designed to prevent the transmission from being shifted into more than one gear at a time.

SHIFT MECHANISMS

Interlocks and Detents (continued)

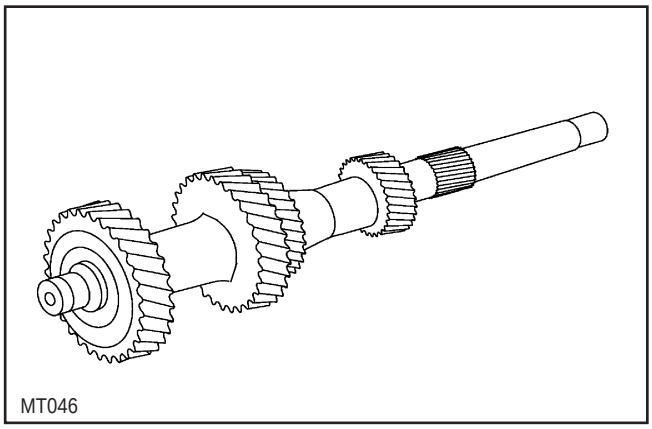


Detents

Item	Description
1	Detent Spring
2	Detent Ball
3	Detent Plate
4	Offset Lever

Detents are used to hold the shift forks in position once a gear has been selected. They are usually a ball and spring design and can either fit into notches on the selector shafts or in a lever called the offset lever. Once the shift fork is moved, the spring of the detent forces the ball into a notch on the selector lever or shift rail. This locks the shift fork in position.

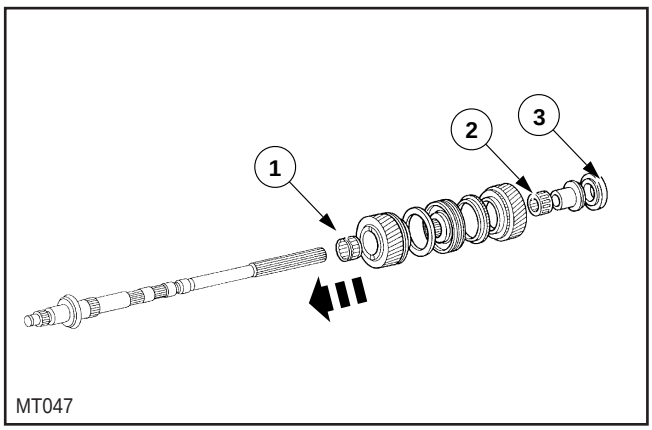
COUNTERSHAFT



Typical Countershaft

The countershaft is made up of a series of gears that can be machined from one piece of hardened steel or may have a series of individual gears that are splined to single shaft. Some countershafts do have synchronizers and smooth inner diameter gears as well as splined gears.

BEARINGS



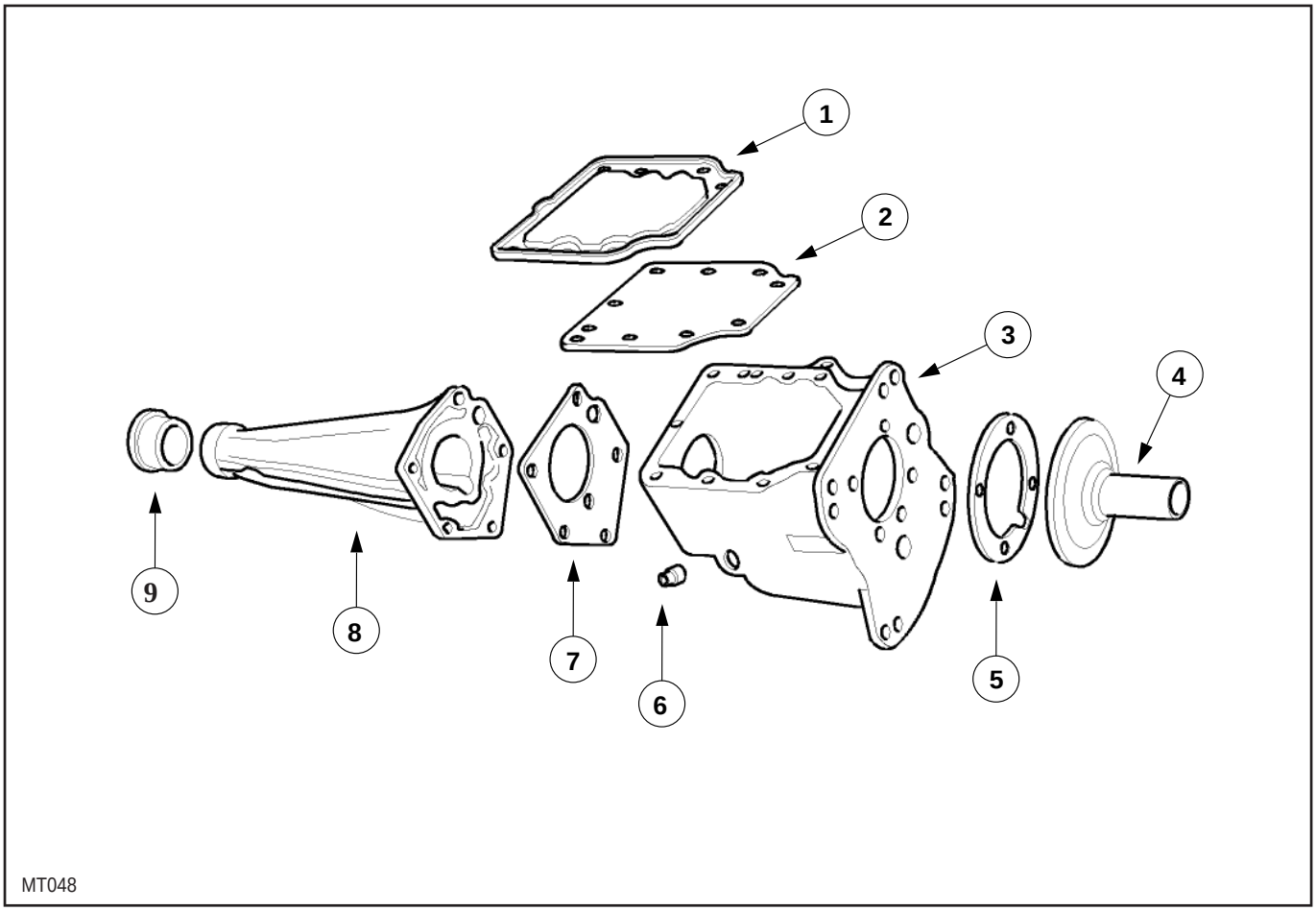
Typical Transmission Bearings

Item	Description
1	Gear Bearing
2	Gear Bearing
3	Output Shaft Support Bearing

All transmission shafts and many of the gears ride on bearings. These can be caged needle bearings, ball bearings, or tapered roller bearings. These bearing are designed to allow free rotation while providing the support necessary for the component.

Many of the bearings inside a transmission require special service tools for removal and installation.

HOUSING

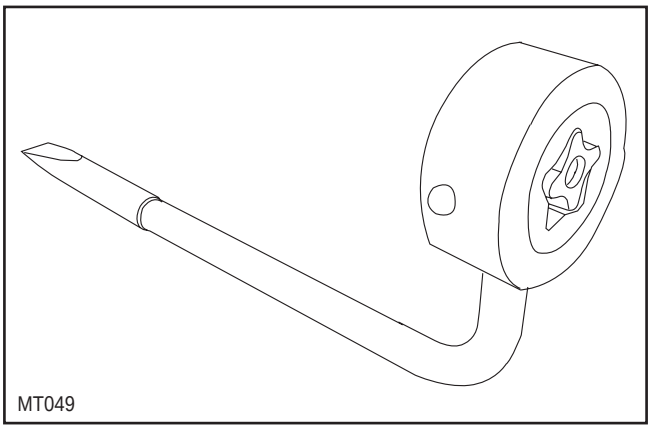


Typical Transmission Housing Assembly

Item	Description
1	Cover Plate
2	Cover Gasket
3	Transmission Case
4	Front Bearing Retainer
5	Gasket
6	Fill Plug
7	Gasket
8	Extension Housing
9	Extension Housing Seal

The shafts and gears of the transmission are contained in a housing. The parts of the housing include the transmission case, the extension housing, and the top cover. The parts are bolted together with gaskets and seals providing a leak-proof seal at all joints. The housing is filled with transmission fluid to provide constant lubrication and cooling for the spinning gears and shafts.

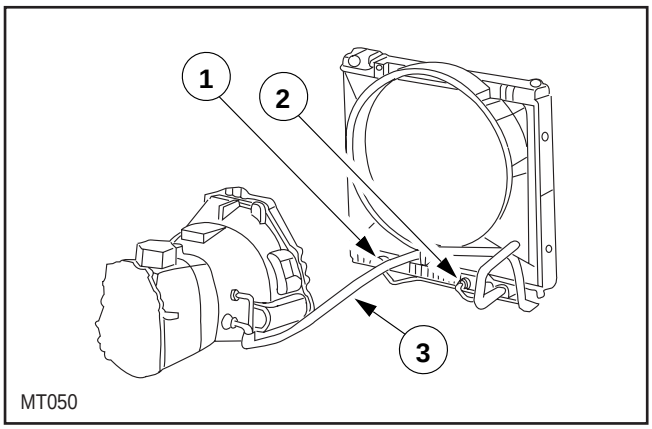
PUMP



Some new manual transmissions use a pump to improve cooling and lubrication of the internal components. An example of a manual transmission that uses a pump is the new ZF6 transmission used on the F Series trucks.

The pump in the ZF6 is a geroter type pump and is driven by the countershaft.

OIL COOLER



ZF6 Oil Cooler

Item	Description
1	Oil Cooler Inlet
2	Oil Cooler Outlet
3	Oil Tubes

Another new system found on F Series trucks using the ZF6 transmission is the oil cooler. This oil cooler is part of the radiator and uses the engine coolant to also cool the transmission oil.

The transmission pump sends the hot oil to the cooler through oil tubes. In the radiator it is cooled using the engine coolant. The oil then returns to the transmission.

LUBRICANT

Many Ford manual transmissions use MERCON® Multi-Purpose Automatic Transmission Fluid XT-2-QDX or DDX or equivalent meeting Ford MERCON® specifications.

When filling the transmission fill the transmission to the bottom of the fill hole and install the case plug. Torque to specifications. Always refer to the workshop manual or owner's manual to determine the type of fluid used in the transmission upon which you are working.

POWERFLOW

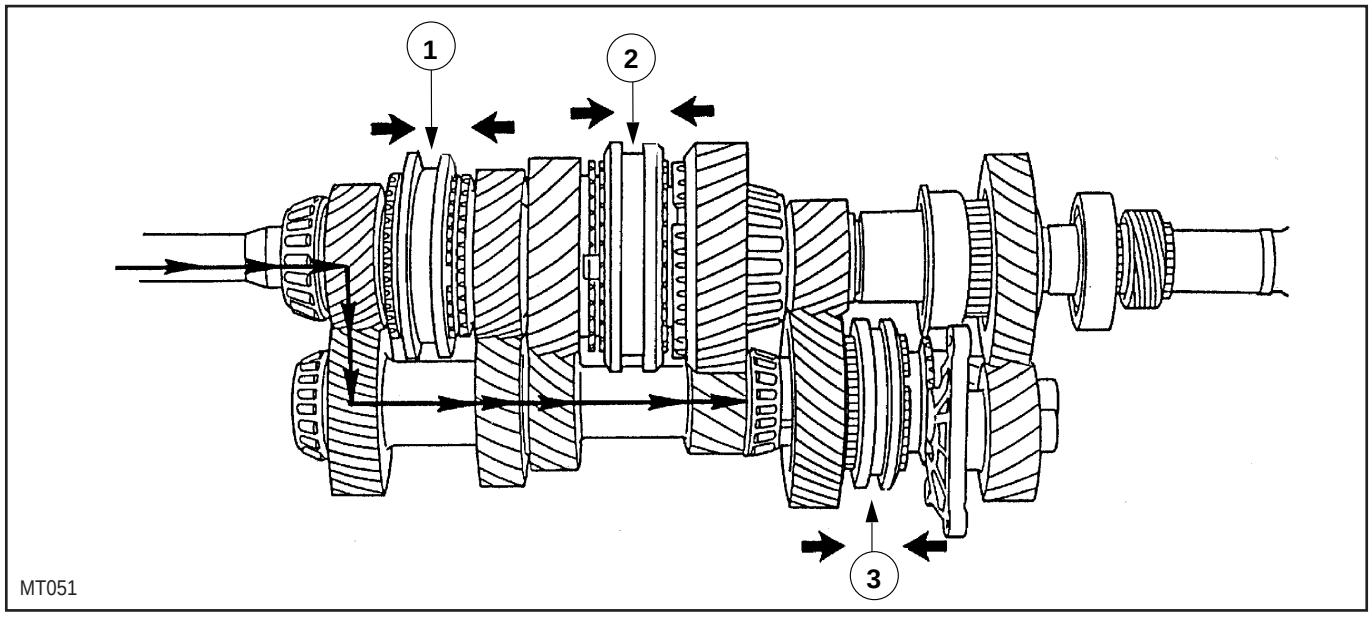
The path that power follows from the input shaft to the output shaft in a manual transmission is called powerflow. Understanding this powerflow is essential for the diagnosis of manual transmission concerns.

Although the powerflow through some transmissions may be slightly different because of differences in parts, all manual transmission powerflow is very similar. As an example of powerflow, the M5OD manual transmission powerflow will be shown on the following pages.

M50D MANUAL TRANSMISSION OPERATION AND POWERFLOW

On the M5OD, the input shaft is powered through the clutch and drives the countershaft. The countershaft then transfers the power to the gear engaged to the output shaft by the synchronizer.

M50D Powerflow in Neutral



Powerflow in Neutral

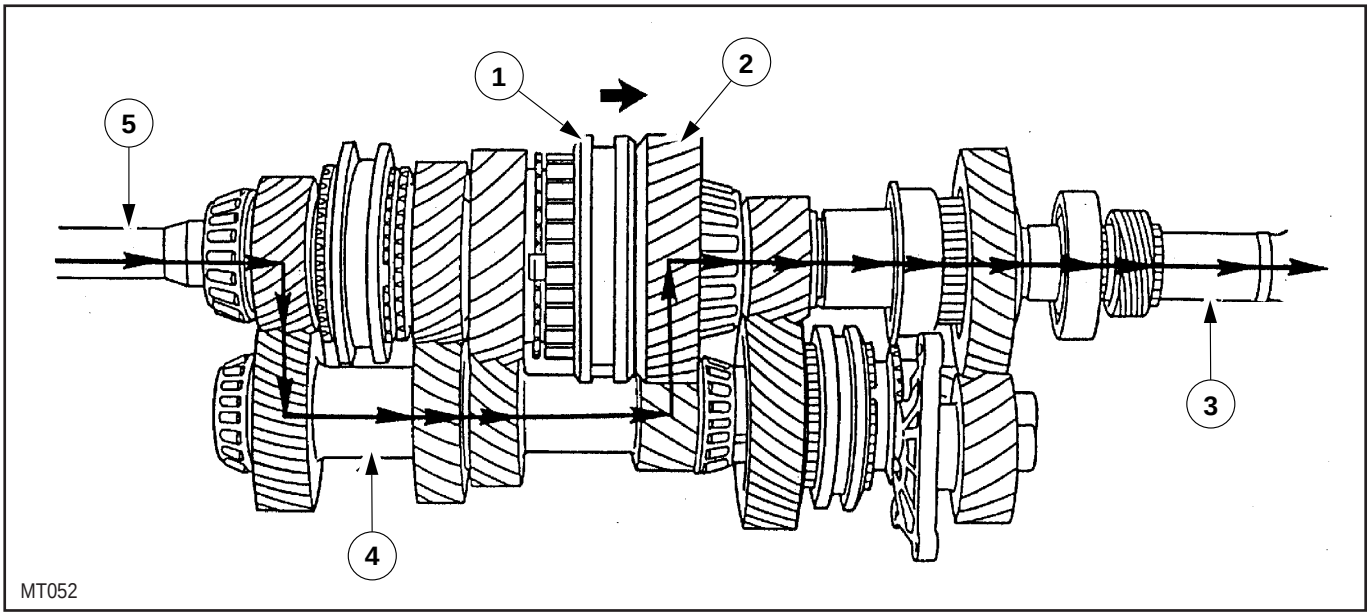
Item	Description
1	3-4 Synchronizer
2	1-2 Synchronizer
3	Fifth/Reverse Synchronizer

- The input gear drives the countershaft
- The countershaft gears drive the first, second and third gears on the output shaft.
- All synchronizers are centered (disengaged).
- No gears are driving the output shaft.
- Since the output shaft is not engaged to the input shaft, no power is transferred

M50D MANUAL TRANSMISSION OPERATION AND POWERFLOW

(continued)

M50D Powerflow in First Gear



Powerflow in 1st

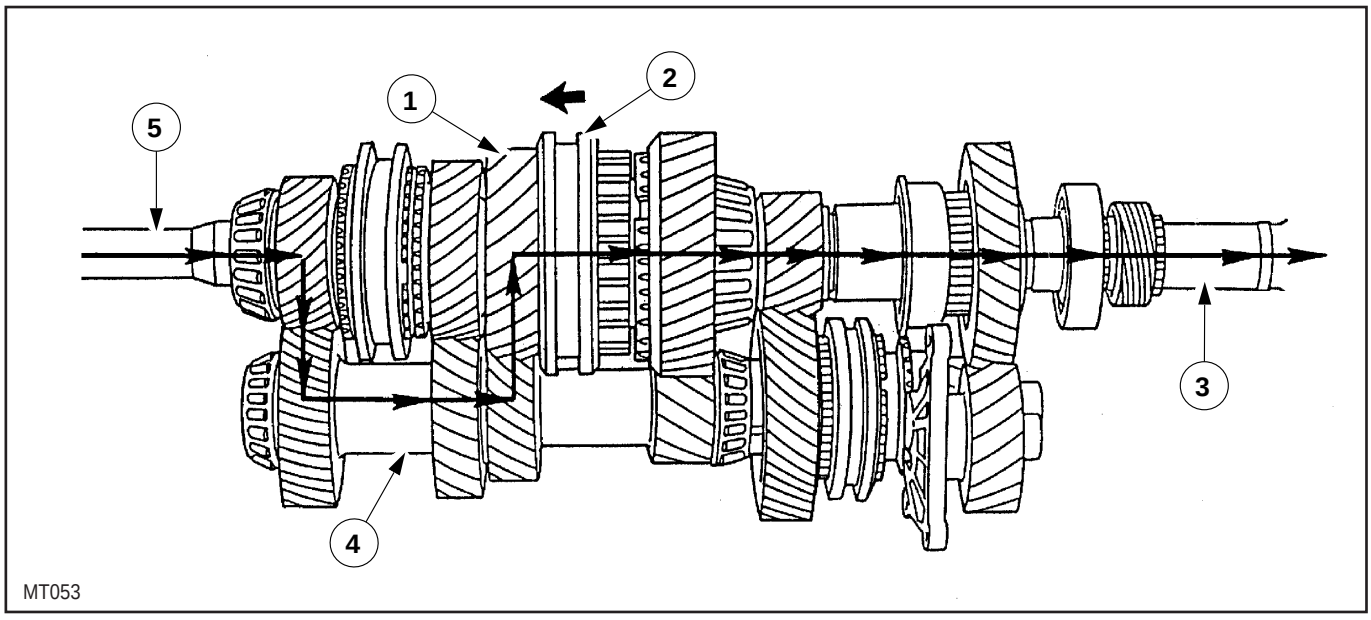
Item	Description
1	1-2 Synchronizer
2	1st Speed Gear
3	Output Shaft
4	Countershaft
5	Input Shaft

- The input gear drives the countershaft.
- The first/second synchronizer sleeve moves rearward and locks the first speed gear to the output shaft.
- First gear on the countershaft turns first speed gear on the output shaft in reduction at a 3.90:1 ratio.

M50D MANUAL TRANSMISSION OPERATION AND POWERFLOW

(continued)

M50D Powerflow in Second Gear



Powerflow in 2nd

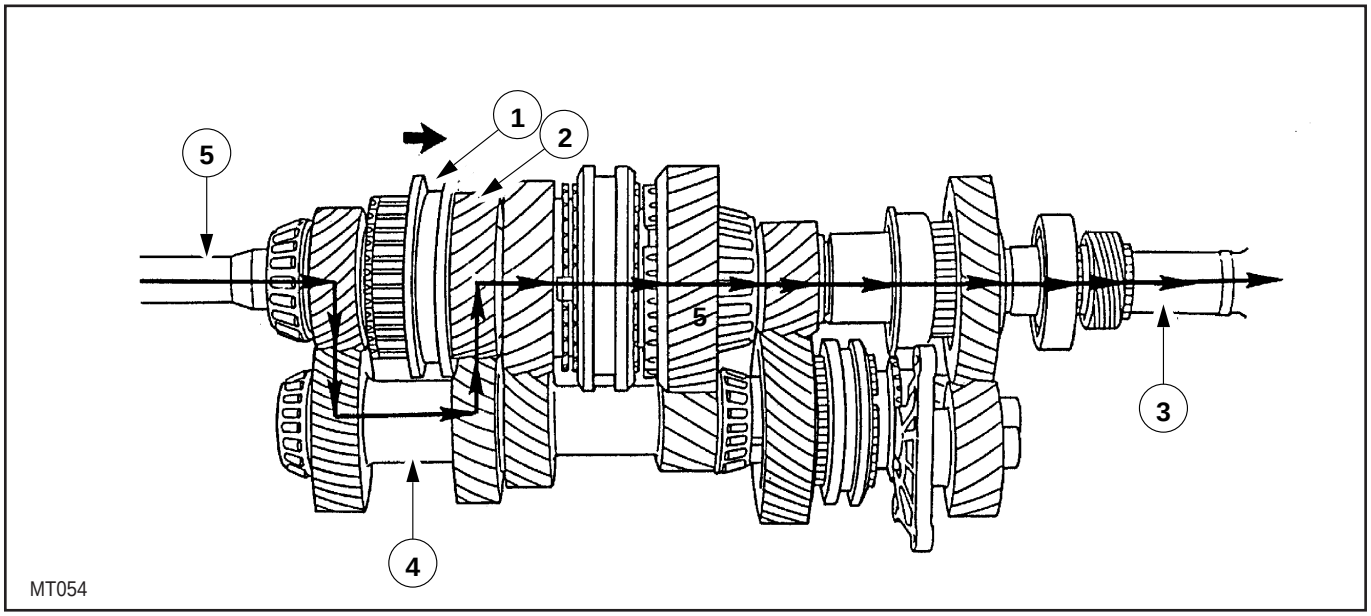
Item	Description
1	2nd Speed Gear
2	1-2 Synchronizer
3	Output Shaft
4	Countershaft
5	Input Shaft

- The input gear drives the countershaft.
- The first/second synchronizer sleeve moves forward and locks the second speed gear to the output shaft.
- Second gear on the countershaft turns the second speed gear on the output shaft in reduction at a 2.25:1 ratio.

M50D MANUAL TRANSMISSION OPERATION AND POWERFLOW

(continued)

M50D Powerflow in Third Gear



Powerflow in 3rd

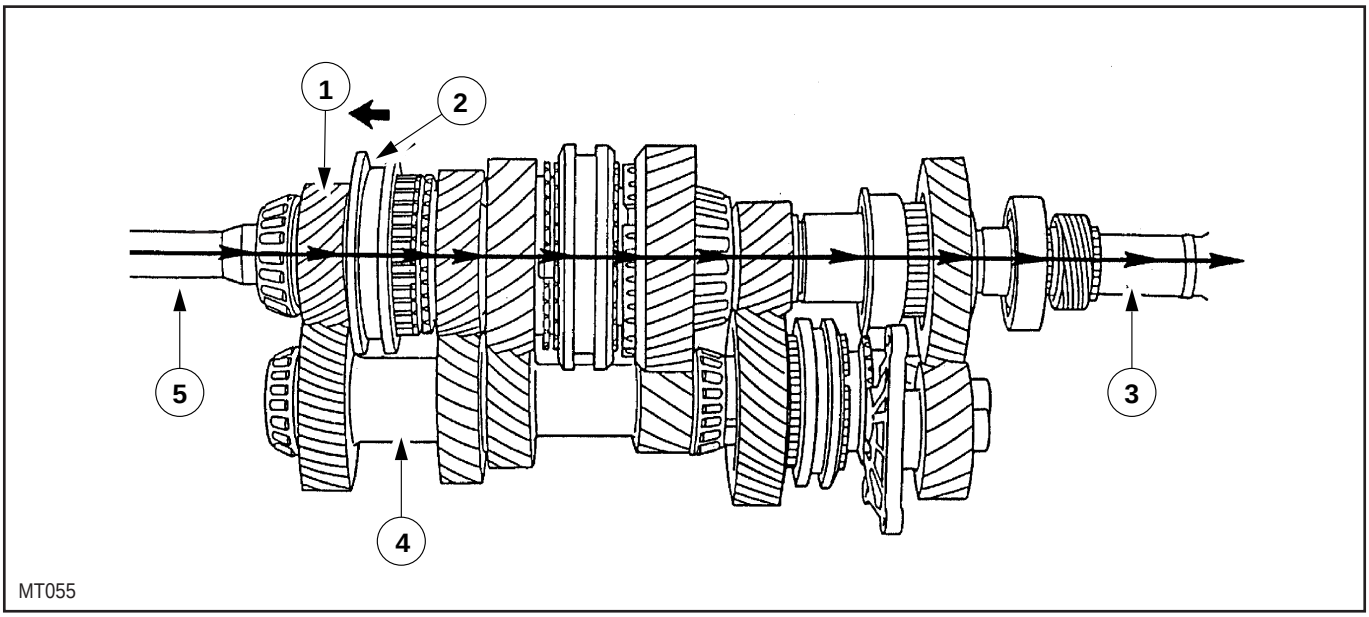
Item	Description
1	3-4 Synchronizer
2	3rd Speed Gear
3	Output Shaft
4	Countershaft
5	Input Shaft

- The input gear drives the countershaft.
- The third/fourth synchronizer sleeve moves rearward and locks the third speed gear to the output shaft.
- Third gear on the countershaft turns the third speed gear on the output shaft in reduction at a 1.49:1 ratio.

M50D MANUAL TRANSMISSION OPERATION AND POWERFLOW

(continued)

M50D Powerflow in Fourth Gear



Powerflow in 4th

Item	Description
1	4th Speed Gear
2	3-4 Synchronizer
3	Output Shaft
4	Countershaft
5	Input Shaft

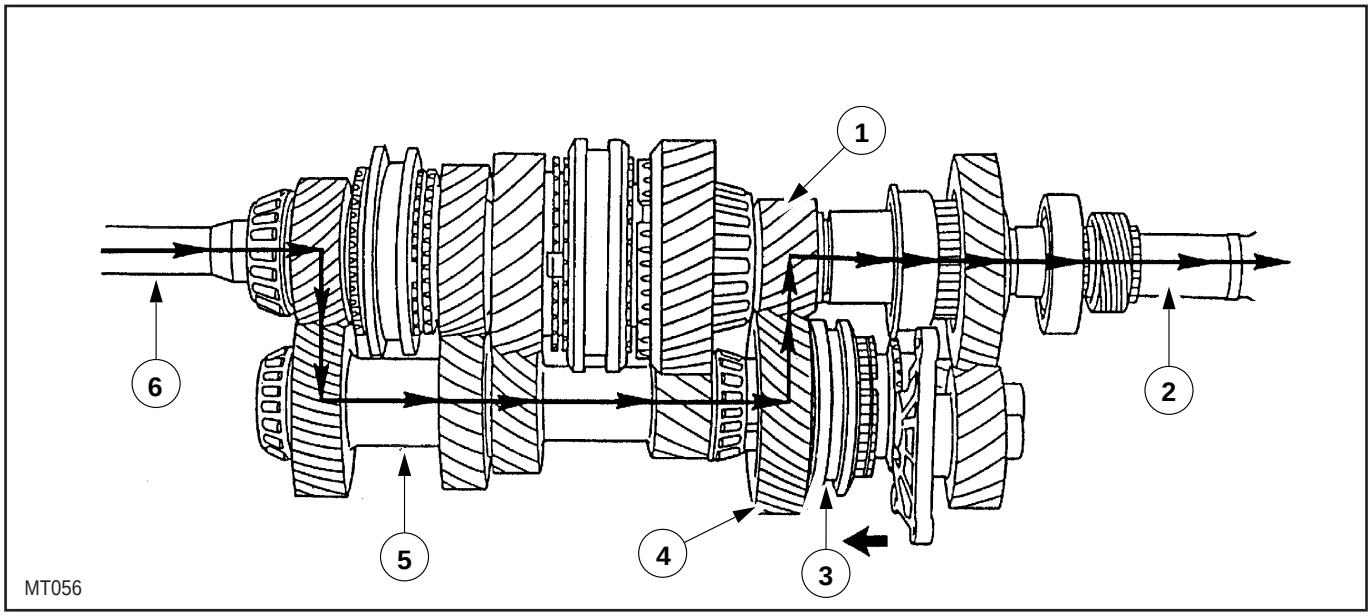
- The input shaft is driven by the engine through the clutch.
- The third/fourth synchronizer sleeve moves forward and locks the input shaft to the output shaft.
- The input shaft and output shaft rotate at the same speed at a 1:1 ratio.

Note: Although the countershaft is rotating, it does not transfer its rotation to the output shaft.

M50D MANUAL TRANSMISSION OPERATION AND POWERFLOW

(continued)

M50D Powerflow in Fifth Gear



Powerflow in 5th

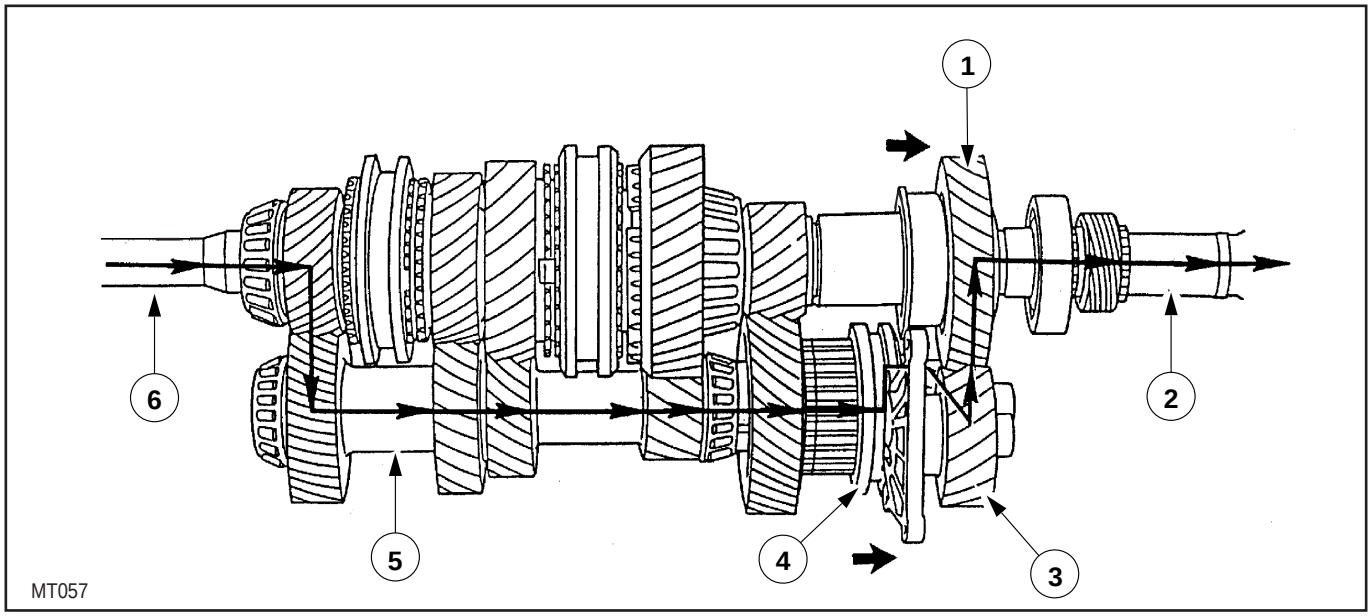
Item	Description
1	5th Speed Gear
2	Output Shaft
3	Fifth/Reverse Synchronizer
4	Countershaft 5th Gear
5	Countershaft
6	Input Shaft

- The input gear drives the countershaft.
- The fifth/reverse synchronizer sleeve moves forward and locks the countershaft 5th gear to the countershaft.
- Countershaft 5th gear drives the 5th speed gear that is splined to the output shaft.
- Fifth gear on the countershaft turns the fifth speed gear on the output shaft in overdrive at a 0.80:1 ratio.

M50D MANUAL TRANSMISSION OPERATION AND POWERFLOW

(continued)

M50D Powerflow in Reverse



Powerflow in Reverse

Item	Description
1	Reverse Speed Gear
2	Output Shaft
3	Reverse Idler Gear
4	Fifth/Reverse Synchronizer
5	Countershaft
6	Input Shaft

- The input gear drives the countershaft.
- The fifth/reverse synchronizer sleeve moves rearward and locks the reverse gear to the countershaft.
- The reverse gear synchronizer sleeve on the output shaft slides rearward and locks the reverse speed gear to the output shaft.
- The countershaft reverse gear drives the reverse idler gear.
- The reverse idler gear drives the reverse speed gear on the output shaft.
- The output shaft is driven in the opposite direction of the input shaft at a ratio of 3.91:1.

DIAGNOSTIC PROCEDURES

The ability to diagnose manual transmissions is a key skill. As with all other automotive systems the workshop manual is an essential tool during diagnosis. A logical diagnostic strategy is another important ingredient when diagnosing manual transmissions. Use of the Symptom-to-System-to Component-to-Cause strategy as described in the Lesson 2 of this book will be a great help in manual transmission diagnosis.

Each manual transmission used in Ford vehicles will have some unique diagnostic procedures. For this reason the workshop manual pinpoint tests should always be followed. However, many diagnostic procedures are common to all manual transmissions. The following are some of these.

WORKSHOP MANUAL

The vehicle Workshop Manual contains information for the following manual transmission diagnostic steps and checks:

- Preliminary Checks
- Verification of customer concern/special driving conditions
- Road Test
- Diagnostic Pinpoint Tests

ROAD TESTING

When road testing a vehicle attempt to match the driving conditions under which the customer concern occurs (cold, hot, hills, vehicle loaded/unloaded etc.). Move the shifter through all positions during vehicle operation. Make sure you understand the customer concern before performing any service.

The road test is a very key part of manual transmission diagnosis. Many transmission concerns can be caused by other vehicle systems. For example, a damaged clutch can cause a transmission to be hard to shift, and broken motor mounts can cause a transmission to jump out of gear under acceleration.

Always listen closely when diagnosing transmission concerns. Noises and vibrations are a common complaint, but they can be coming from another system. Sometimes a noise or vibration that seems transmission related because it only occurs in 1st or 2nd gears can be coming from another system. The only reason they are noticeable because in those gears the engine is operating at high rpm under a load.

Note: Since the manual transmission is controlled by the driver, the transmission can be damaged by improper driver operation and abuse. Always try and determine if this may be the cause of the transmission damage.

COMMON MANUAL TRANSMISSION SYMPTOMS AND CAUSES

There are many different symptoms of manual transmission problems. The following are some of the more common symptoms you may experience, how to test for them and what the possible causes of the symptom may be.

NOTE: Before diagnosing any transmission concern make sure that the transmission fluid level is correct and that the correct type of oil is in the transmission.

Gear Clash During Shifting – This symptom can occur in only a specific gear or in all gears. If the problem occurs in all gears the cause is likely the clutch system. Refer to Lesson 2 for possible causes. However, if the clash occurs only in one or two gears than the transmission is probably at fault.

Causes for gear clash include:

- worn or damaged blocking rings
- worn or damaged synchronizer teeth
- damaged clutching teeth on the speed gear
- damaged shift fork

Clicking or Knocking Noise– If clicking or knocking noises can be heard from the transmission you must determine if the noise occurs only in one specific gear, or if it occurs in all gears.

If the noise occurs in only one specific gear the cause may be:

- damaged teeth on the countershaft gear for that specific gear
- damaged teeth on the speed gear

If the noise occurs in all gears, including neutral (with clutch engaged) the cause may be:

- damaged teeth on the input gear
- damaged teeth on the countershaft input gear

NOTE: Noise may not be as noticeable on the hoist when running the vehicle because the weight of the vehicle is not loading the gears.

COMMON TRANSMISSION SYMPTOMS AND CAUSES (continued)

Does Not Shift Into Any One Gear – This symptom can occur on any gear. However, even though this is the customer concern always check all other gears for correct operation. This may give you a clue to its cause. For example, if it does not go into first gear, and second gear is also hard to get the damage is likely something common to both of those gears (shift fork, synchronizer, linkage etc.). However, if only one gear is having a problem the cause will be more specific to that gear (damaged clutching teeth, synchronizer sleeve etc.)

Causes for this concern include:

- damaged linkage or selector shaft
- selector shaft detents damaged
- shift lever worn or damaged
- damaged shift fork
- synchronizer sleeve worn or damaged
- speed gear clutching teeth worn or damaged

Bearing Noise – Bearing noise can be very challenging to diagnose. Your knowledge of powerflow will be of great help for these concerns. As you probably know, bearing noise increases when the bearing is loaded. For this reason you may have a noise that only occurs in specific gears because that is when the bearings are under the most stress.

A transmission bearing noise that occurs in neutral with the clutch engaged that disappears when the clutch is disengaged may be caused by:

- input shaft bearing
- countershaft bearings

A bearing noise that occurs only when the vehicle is moving and only in a specific gear may be caused by the speed gear bearing.

A bearing noise that occurs when the vehicle is moving in all gears may be caused by the:

- output shaft rear bearing
- extension housing support bushing

COMMON TRANSMISSION SYMPTOMS AND CAUSES (continued)

A bearing noise that occurs when the vehicle is moving in all gears, but is much quieter or disappears when the vehicle is placed in direct drive:

- Countershaft bearings
- Output shaft pilot bearing

Jumps Out of Gear – Diagnosing this concern also requires a complete check of all the gears. This may give you a clue to its cause. For example, if it jumps out of both 1st and 2nd the damage is likely something common to both of those gears (synchronizer inserts, shift fork, linkage etc.). However, if only one gear is having a problem the cause will be more specific to that gear (detents, damaged clutching teeth, synchronizer sleeve etc.).

If the problem only occurs when the vehicle is in 1st gear or reverse, examine the motor and transmission mounts. Because the drive train is most heavily loaded in 1st and reverse when starting from a stop, if the mounts are excessively worn or damaged the drive train may be moving causing the transmission to jump out of gear.

Causes for this concern include:

- Worn or damaged motor and/or transmission mounts
- Shift lever damaged
- Damaged detents
- Synchronizer inserts worn or damaged
- Shift fork damaged
- Damaged input shaft bearing
- Damaged synchronizer sleeve
- Damaged clutching teeth

COMMON TRANSMISSION SYMPTOMS AND CAUSES (continued)

Locked in One Gear – This concern is very easy to verify (obviously).

The causes of this type of concern include:

- worn or damaged shift lever.
- damaged linkage or selector shaft.
- damaged selector shaft detents.
- damaged shift fork.
- damaged synchronizer.
- broken gear teeth.

Transmission Locked Up – This symptom can occur when the transmission has two gears engaged at the same time or if there is severe internal transmission damage. When this occurs the engine will start and run normally but when the clutch is engaged the engine will stall. This problem can be mistaken for rear brakes that are locked or a damaged differential. However, when the driveshaft is removed the vehicle will roll freely.

This symptom can be caused by:

- damaged or incorrectly installed interlocks.
- seized/Damaged bearings.
- damaged countershaft gear .

COMMON MANUAL TRANSMISSION SERVICE PROCEDURES

The service procedures for manual transmissions are unique to the specific type of transmission that you are working on. Most internal manual transmission repairs require many special service tools. When working with a manual transmission you must pay close attention to detail. Any overlooked damage or incorrectly installed part can result in more serious (and expensive) damage.

There are some service procedures that are common to most type of manual transmissions. This section will focus on descriptions of some of these procedures.

TRANSMISSION REMOVAL AND INSTALLATION

The removal and installation process for manual transmissions is usually pretty straight forward. Although there are some unique procedures for each specific vehicle, there are also procedures that are common to all manual transmissions.

Removal

1. Always disconnect the battery ground cable.

2. Inspect all parts being removed for damage. For example, if a transmission mount is worn and damaged it should be found during the removal process. Customers get annoyed when they are called back after getting a price and told “Oh by the way, while we were installing the transmission we found that you need a transmission mount.” They should get that information when the rest of the job is priced.

3. After raising the vehicle on the hoist drain the transmission if it is going to be disassembled. If the transmission is being removed for clutch service, once the drive shaft is removed insert the extension housing seal replacer into the extension housing seal to prevent fluid from leaking.

4. Always mark the drive shaft position at the differential and on the shaft. Incorrect drive shaft positioning during installation will result in a vibration concern.

5. When the driveshaft is removed, tape the U-joint cups to prevent them from falling off the joint and spilling their bearings.

6. Do not let hydraulic slave cylinders hang by their hoses. After removal always support them with mechanics wire.

7. During removal, always connect the transmission to the jack with a safety chain.

8. After the bell housing bolts are removed and you are removing the transmission from the engine, pull the transmission straight back. Pulling down on the transmission can damage the pilot bearing and/or the clutch assembly.

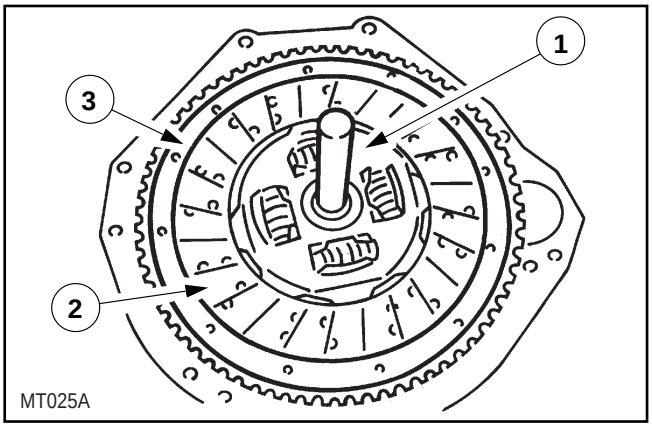
These are just some common procedures for transmission removal. Always follow the procedures as described in the vehicle workshop manual.

TRANSMISSION REMOVAL AND INSTALLATION (continued)

Installation

When installing the transmission there are some common procedures that apply to most vehicles. These include:

1. When installing the transmission to the engine always use a clutch alignment tool to make sure the clutch assembly is correctly aligned.



Clutch Alignment Procedure

Item	Description
1	Clutch Alignment Tool
2	Clutch Disc
3	Flywheel

2. During installation always secure the transmission to the jack with a safety chain.

3. Connect the transmission to the engine with a straight motion.

4. NEVER pull the transmission bell housing into contact with the engine using the bell housing bolts. This will damage the clutch and transmission.

5. Always make sure that the drive shaft is in the same position it was originally by lining up the marks you made during removal.

6. Always check and fill the transmission with the correct lubricant after installation (this can be missed when performing clutch service).

7. Always bleed hydraulic clutch systems and make sure they are full of fluid.

8. Make sure you follow the correct procedure when connecting the cable on a cable-type system. Incorrectly connecting the cable can result in damage to the self-adjuster.

Use the workshop manual directions for transmission and clutch installation for the vehicle you are working on.

TRANSMISSION DISASSEMBLY, INSPECTION AND ASSEMBLY

Disassembly procedures for specific types of transmissions vary widely. However, some procedures and inspection points are common to most of them. It is critical that you use the correct special service tools and follow workshop manual procedures.

Disassembly and Assembly

After removing the transmission clean any excess dirt and mud from the case. Use a clean bench for disassembly and keep your parts in a logical order.

- Make sure you note the position and direction of any gears that are removed from the shafts.
- Keep the blocking rings and inserts with the synchronizers that they were on. They must be installed at the same location during assembly.
- Bearing removal and installation often requires the use of force. Always use the correct puller for removal. During bearing installation always use a press. Never beat a bearing on with a hammer.
- Snap rings should be inspected and if damaged they should be replaced.
- All gaskets and seals must be replaced with new ones during assembly.
- During assembly of the transmission, never attempt to force parts into place. If tapping is required to position a part use only a soft faced hammer or brass drift.
- Never attempt to force parts into place by tightening the front bearing retainer or extension housing bolts. All parts must be fully in place before tightening any bolts.
- Always check for free rotation and shifting of the transmission after assembly.
- Always check end-play and preloads.

Inspection

Inspection of transmission parts requires close attention to detail. A small part that is overlooked can end up being a big problem later.

Each type of transmission has it’s own unique inspections and checks. These are described in the vehicle workshop manual. However, as with the other procedures that have been described, there are some common inspections and checks that can be made to most manual transmissions.

TRANSMISSION DISASSEMBLY, INSPECTION AND ASSEMBLY

Inspection (continued)

1. During disassembly clean all parts thoroughly.

2. Inspect the front of the transmission case for nicks or flywheel housing. Remove all nicks and burrs.

3. If there is a vent in the case, make certain it is open.

4. Inspect ball bearings by holding the outer race stationary and rotating the inner race several times. Inspect the raceway of the inner race from both sides for pits and spalling. Light particle indentation is acceptable wear, but all other types of wear merit replacement of the bearing assembly. Next, hold the inner race stationary and rotate the outer race. Examine the outer race for wear and replace as needed.

5. Examine the surfaces of all bearings. Replace the bearings if there are cracks on the front and rear faces of the outer or inner races, cracks on the outside diameter or outer race, or deformation or cracks in the ball cage.

6. Lubricate the cleaned bearing raceways with a light coat of oil. Hold the bearing by the inner race in a vertical position. Spin the outer race several times by hand. If roughness or vibration is felt, or the outer ring stops abruptly, replace the bearing. NEVER spin a bearing with compressed air.

7. Replace any roller bearings that are broken, worn, or rough. Inspect their respective races. Bearings and races must be replaced together.

8. Replace the countershaft (cluster) gear if its gear teeth are chipped, broken, or excessively worn. Replace the countershaft if the shaft is bent, scored, or worn.

9. Replace the reverse idler gear or sliding gear if its teeth are chipped, worn, or broken. Replace the idler gear shaft if it is bent, worn, or scored.

10. Replace the input shaft and gear if its splines are damaged or if the teeth are chipped, worn, or damaged. If the roller bearing surface in the bore of the gear is worn or rough, or if the cone surface is damaged, replace the gear and the gear rollers.

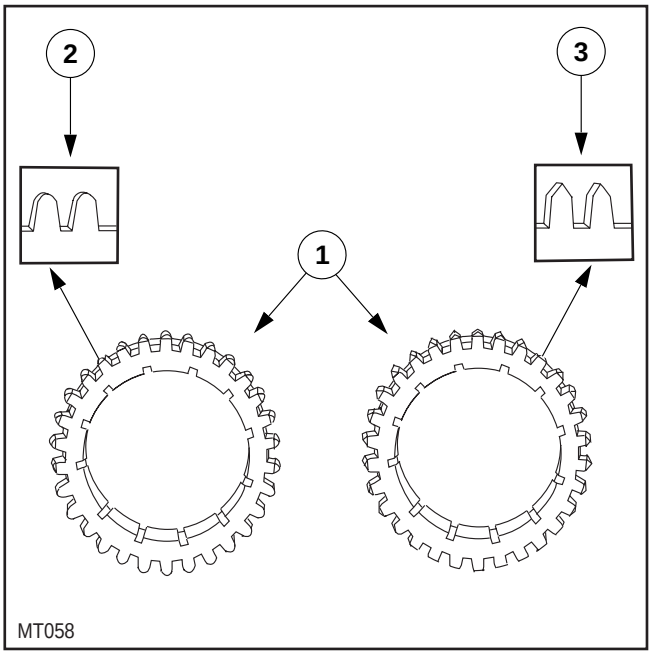
11. Replace all main or speed gears that are chipped, broken, or worn.

12. Check the synchronizer sleeves for free movement on their hubs.

Note: Whenever damage is found to a component, check for damage to other components that it is in contact with.

TRANSMISSION DISASSEMBLY, INSPECTION AND ASSEMBLY

Inspection (continued)



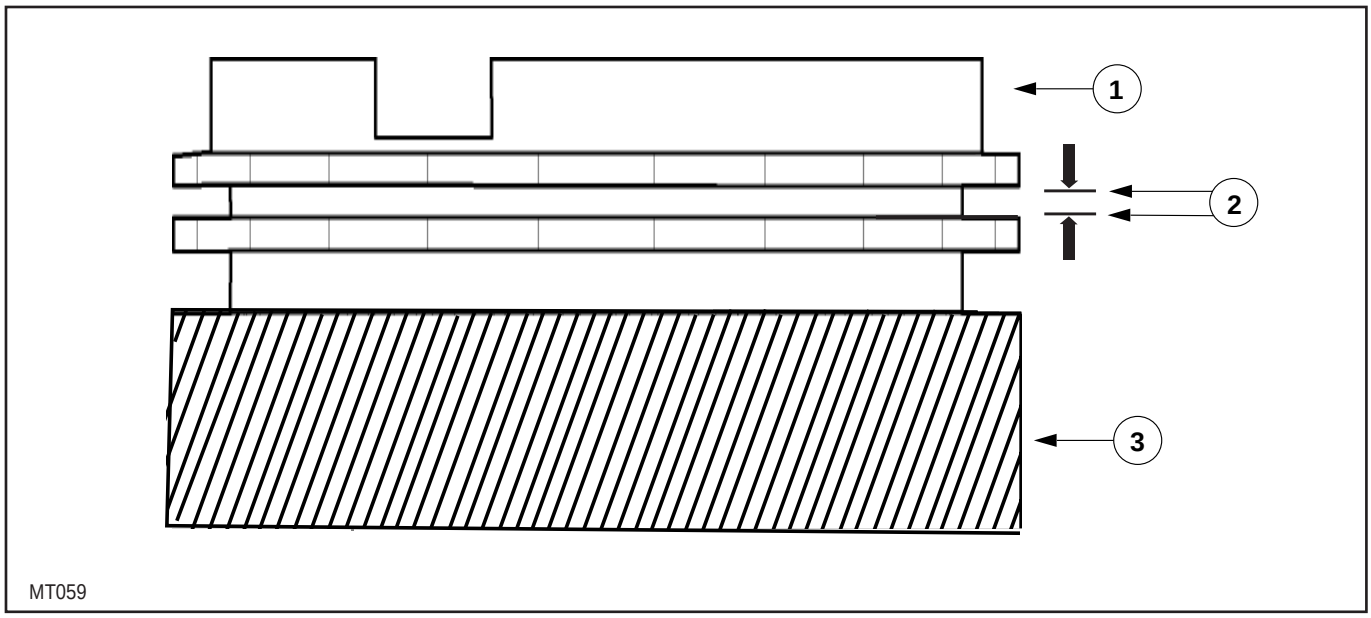
Blocking Ring Groove Checks

Item	Description
1	Blocking Rings
2	Dull Grooves (Bad)
3	Sharp Grooves (Good)

13. Inspect the synchronizer blocking rings for widened index slots, rounded clutching teeth, and smooth internal surfaces. Remember that the blocking rings have machined grooves on their internal surfaces to cut through lubricant. Units with worn, flat grooves must be replaced.

TRANSMISSION DISASSEMBLY, INSPECTION AND ASSEMBLY

Inspection (continued)



Blocking Ring Clearance Check

Item	Description
1	Blocking Ring
2	Clearance
3	Gear

14. Also, check the clearance between the blocking ring and gear clutching teeth. Too little clearance means that the blocking rings are worn or distorted. Make sure the clearance is within workshop manual specifications.

15. Replace the output shaft if there is any sign of wear or if any of the splines are damaged.

16. Inspect the bushings in the extension housing, and replace if worn or damaged.

REVIEW QUESTIONS

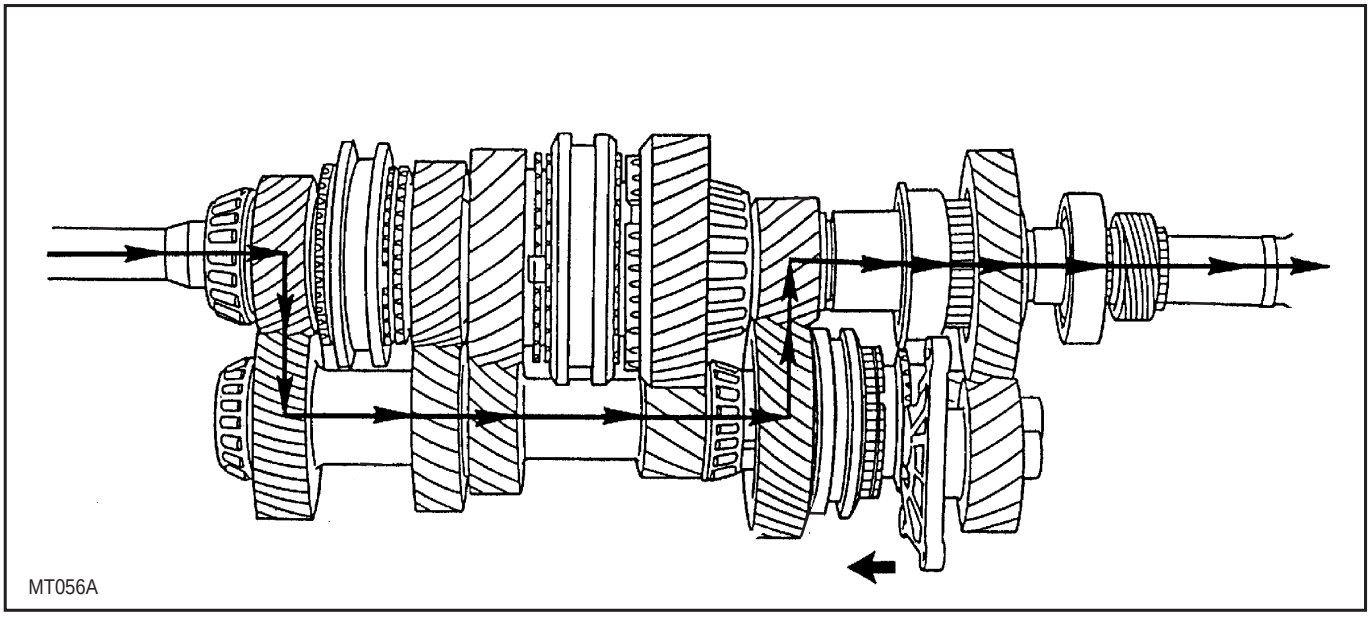
Directions: Use the information you have learned in this lesson to answer the following questions.

1. All of the following are true about manual transmissions EXCEPT:
   A. Uses different size gears to provide mechanical advantage over the driving wheels.
   B. Torque is sent from the engine to the transmission through an input shaft.
   C. Manual transmissions are used on rear wheel and four-wheel drive vehicles.
   D. Manual transmissions use the clutch to multiply the engine's torque.

2. On a 3-speed transmission, torque from the input shaft goes through the countershaft and to the output shaft in all the gears EXCEPT:
   A. 1st
   B. 2nd
   C. 3rd
   D. Reverse

3. The purpose of shift fork is to move the:
   A. selector shaft.
   B. synchronizer sleeve.
   C. countershaft into mesh.
   D. input shaft into mesh.

4. In the art below, what gear is engaged?



   A. 2nd
   B. 4th
   C. 5th
   D. Reverse

REVIEW QUESTIONS (continued)

5. A vehicle is brought to you with a manual transmission that has a knocking noise in all gears. Which of the following would MOST LIKELY cause this?
   A. Damaged teeth on the input gear.
   B. Damaged plastic pads on the shift fork.
   C. Damaged clutching teeth on the countershaft.
   D. Damaged 4th gear blocking ring.

6. Which of the following blocking rings are out of specifications on a transmission that has a blocking ring clearance of 0.030?
   A. 0.035
   B. 0.025
   C. 0.032
   D. 0.040

LESSON 5: MANUAL TRANSAXLES

LESSON OBJECTIVES

OBJECTIVES

- Describe the purpose of the manual transaxle.
- Explain the operation of a manual transaxle.
- Identify the parts of a manual transaxle.
- Describe the powerflow of a manual transaxle.
- Explain manual transaxle diagnostic procedures.
- Identify unique manual transaxle service procedures.

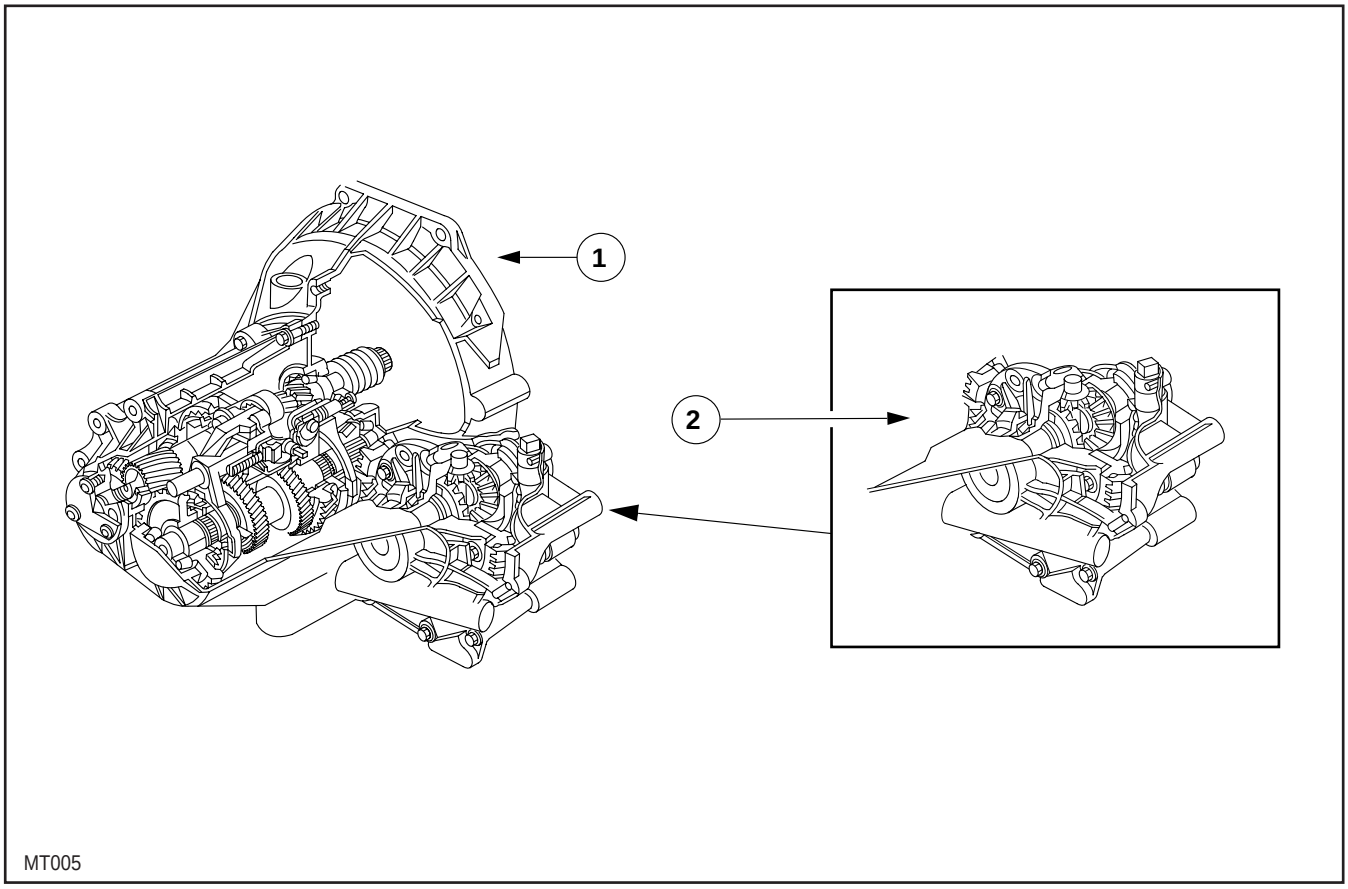
CONTENTS

LESSON 5: MANUAL TRANSAXLES

PURPOSE OF THE MANUAL TRANSAXLE

Manual transaxles basically perform the same function as manual transmissions. They use different size gears to give the engine a mechanical advantage over the driving wheels. This allows the engine to drive the vehicle at different speeds while operating within its power band.

However, transaxles also have one additional function, they contain the differential which provides final gear reduction and differential action for the wheels. This is done through a differential unit that is mounted inside the transaxle housing. This differential receives torque directly from the output gear of the transmission components inside the transaxle. It then uses a gear ratio to multiply this torque and transmits it to the wheels via halfshafts (halfshafts will be explained in Lesson 6 of this book.)

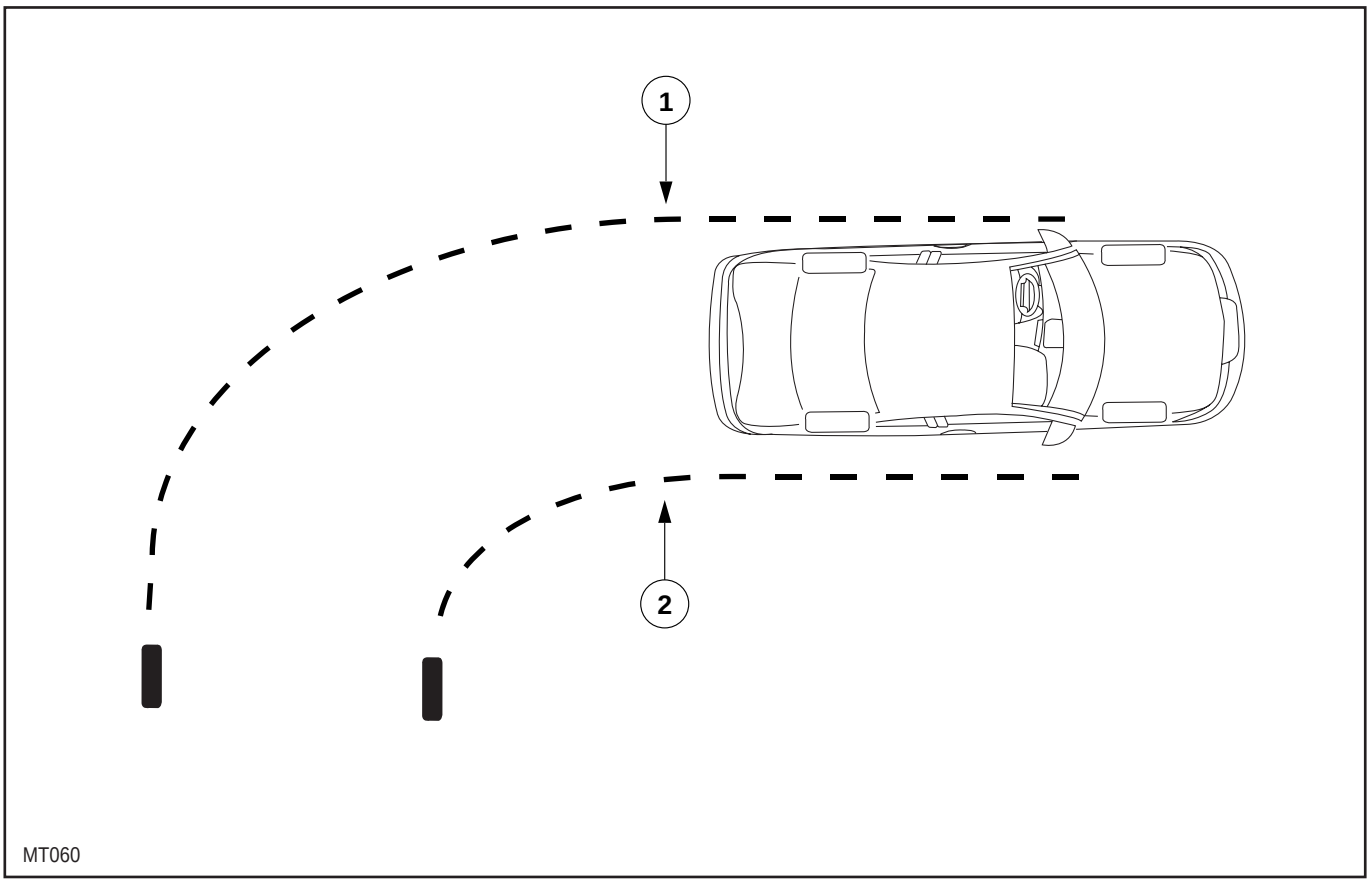


Cutaway View of Manual Transaxle

Item	Description
1	Transaxle
2	Differential

PURPOSE OF THE DIFFERENTIAL

When a vehicle turns a corner the outside wheel must travel farther and faster than the inside wheel. For this reason there must be a mechanism that will allow differences in wheel rotation speed, while still transferring power. This is the purpose of the differential.



Requirements of Wheels During Turns

Item	Description
1	Track of Outer Wheel = 60 feet
2	Track of Inner Wheel = 40 feet

The differential also splits torque between the drive axles (halfshafts). Each drive wheel receives an equal amount of torque. The torque delivered to each wheel is no greater than the torque required by the wheel with the least amount of traction. If one wheel begins to slip, it requires much less torque to turn it. Less torque is then delivered to the wheel that is not slipping. In such a situation, unless the differential is a limited-slip design the vehicle loses traction. This is why when a vehicle has one wheel spinning in the snow and the other wheel is on dry pavement the vehicle will still not move.

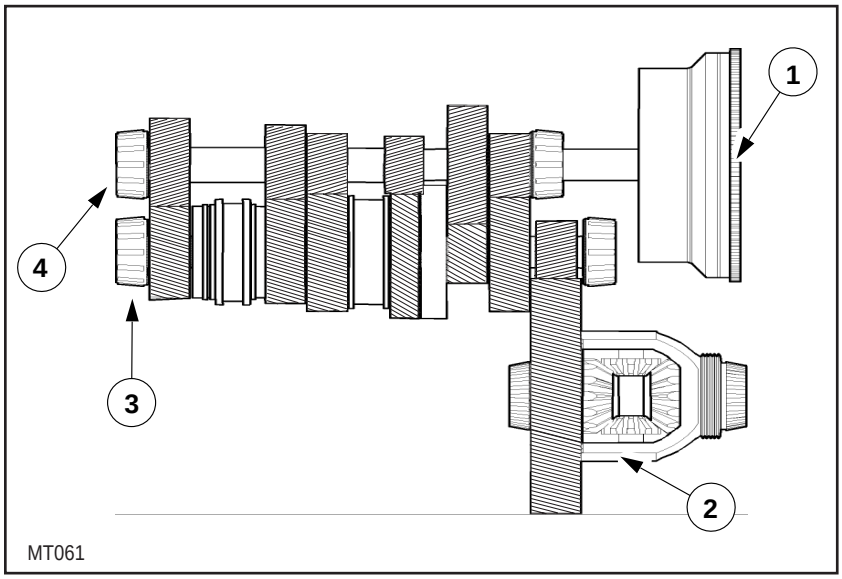
Differentials also have a drive gear that is smaller than the driven gear. This provides an additional gear ratio for torque multiplication. The larger the difference in the number of teeth between the drive and driven gear, the better the acceleration and pulling power of the vehicle. However, this will also reduce vehicle fuel economy.

MANUAL TRANSAXLE OPERATION

The manual transaxle can basically be divided into two sections, the transmission section and the differential section.

The transmission section uses the same types of components as a manual transmission. Shift forks, synchronizers, and gears are basically the same design. But there is one major difference between a manual transaxle and a manual transmission; there is no countershaft.

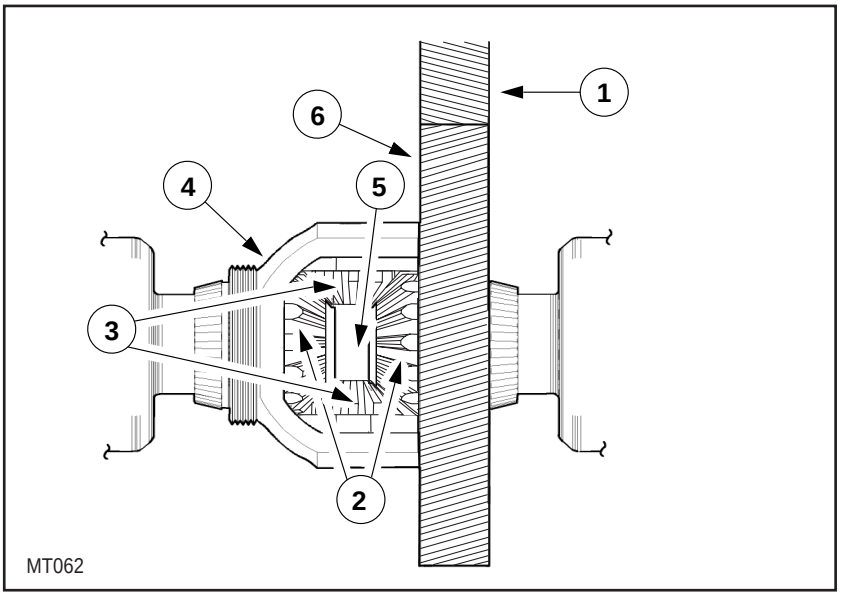
The countershaft is not needed because rotation from the input shaft and the main shaft (sometimes called the output shaft) is transferred to the differential, which then sends the torque to the wheels in the same direction-of-rotation as the input shaft (except when the vehicle is in reverse.)



Manual Transaxle Basic Powerflow

Item	Description
1	Clutch Assembly
2	Differential Assembly
3	Output Shaft
4	Input Shaft

DIFFERENTIAL OPERATION



Basic Differential Components

Item	Description	Item	Description
1	Output Pinion	4	Carrier
2	Side Gears	5	Pinion Shaft
3	Pinion Gears	6	Ring Gear

The differential of the transaxle transfers power to the wheels, provides a final gear ratio, and enables the wheels to rotate at different speeds during turns.

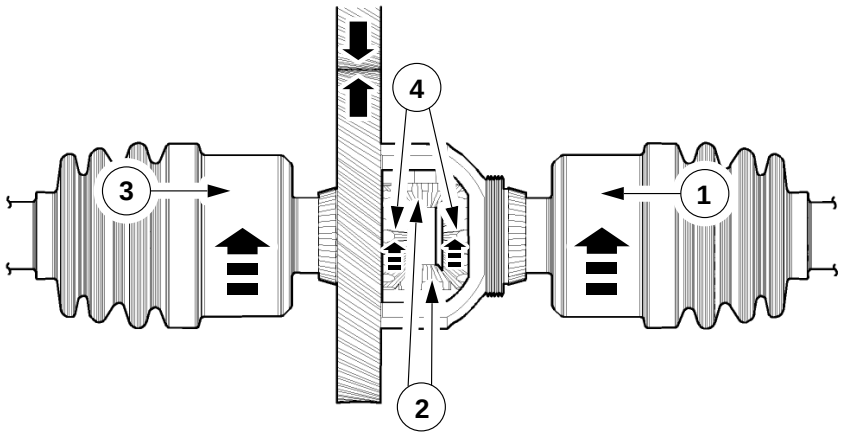
This is done using four small gears mounted inside a carrier, which in turn is driven by the output shaft output gear through a ring gear.

- Inside the carrier are two side gears. These gears are splined to the halfshafts.
- Between the side gears, and providing connections between them are two pinion gears, which ride on a shaft that is supported by the carrier.
- The side gears are only connected to the carrier through the pinion gears. Therefore it is the pinion gears that actually drive them.

Let’s look at an example of how these parts work together to provide differential action.

DIFFERENTIAL OPERATION (continued)

Differential Action When Driving Straight Ahead



MT063

Differential Operation When Driving Straight Ahead

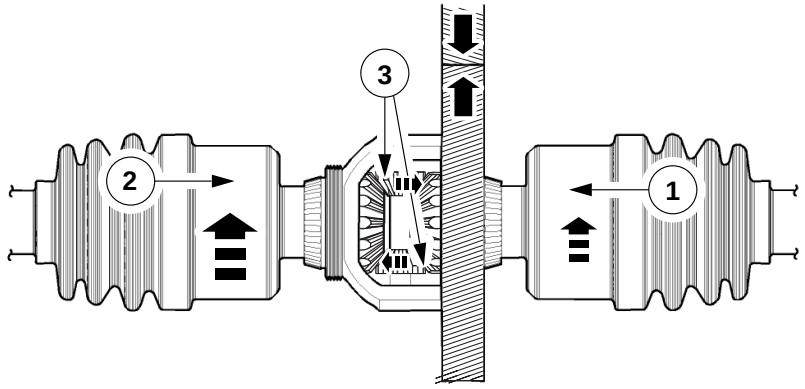
Item	Description
1	Right Axle Rotating at 100 rpm
2	Pinion Gears Not Rotating
3	Left Axle Rotating at 100 rpm
4	Left and Right Side Gears Rotating at 100 rpm

During straight ahead driving:

- Power is sent from the output shaft output gear to the ring gear.
- The ring gear is bolted to the carrier.
- As the carrier rotates, it transfers power to the pinion gears.
- Since both wheels have the same amount of traction and are rotating at the same speed, the pinion gears send equal power to each of the side gears.
- This results in no rotation of the pinion gears.
- The carrier, pinion gears, and side gears all rotate as a single unit.

DIFFERENTIAL OPERATION (continued)

Differential Action During Turns



MT064

Differential Operation During Turn

Item	Description
1	Right Axle Rotating at 80 rpm
2	Left Axle Rotating at 120 rpm
3	Pinion gears rotating to allow for rpm difference between the wheels

Now lets look at the action of the differential during a turn. In this example we will look at operation in a right-hand turn.

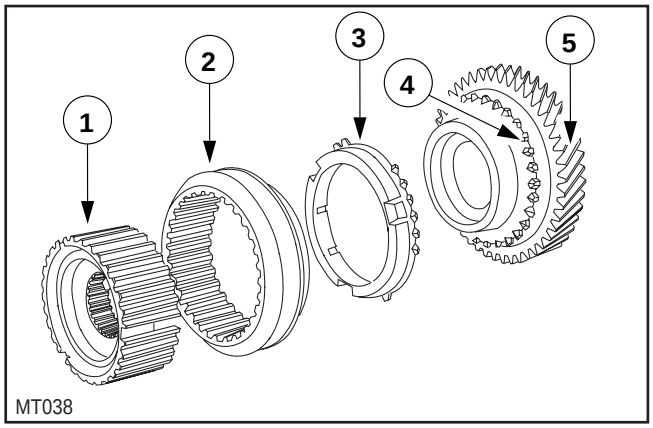
- When the vehicle is turned the left-side wheel must rotate faster that the right-side wheel.
- This is possible because the pinions, which are meshed with the side gears, are free to rotate on the pinion shaft.
- The increased speed of the left-side wheel causes the side gear to rotate faster that the differential carrier, which causes the pinions to “walk around” the left side gear.
- As the pinions turn to allow the left-side gear increase speed, the opposite action occurs at the right-side gear. It is slowed down an amount that is inversely proportional to the increase in the left-side gear rotation speed.

During diagnosis it is important to remember that the pinions and side gears only rotate independently of the carrier during turns.

MANUAL TRANSAXLE COMPONENTS

Although many of the components inside a transaxle are very similar to those of a manual transmission, there are some that are unique. The following are descriptions of the transaxle components.

SYNCHRONIZERS AND SPEED GEARS



Basic Synchronizer and Speed Gear

Item	Description
1	Synchronizer Hub
2	Synchronizer Sleeve
3	Blocking Ring
4	Clutching Teeth
5	Speed Gear

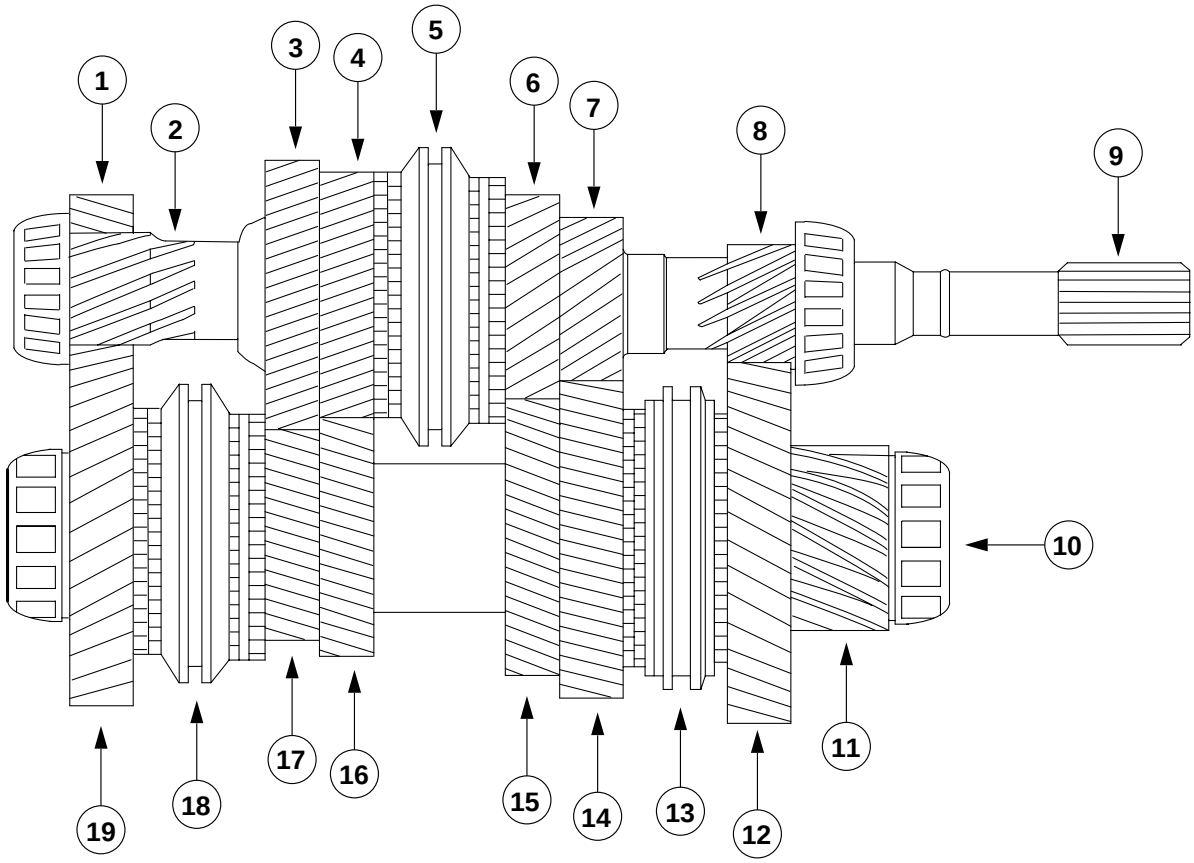
The synchronizers in the manual transaxle perform the same function and operate the same way as synchronizers in manual transmissions.

When the gear needs to be connected to the shaft, the synchronizer sleeve moves over and engages the clutching teeth on the side of the gear.

- This locks the synchronizer sleeve to the gear.
- The synchronizer sleeve inner diameter has internal teeth that slide along the external teeth of the synchronizer hub outer diameter.
- The synchronizer hub is splined to the shaft upon which it rides.

This connects the gear to the shaft through the synchronizer allowing its torque to be transmitted through the shaft.

INPUT AND OUTPUT SHAFT ASSEMBLIES



MTX-75 Input and Output Shaft

Item	Description	Item	Description	Item	Description
1	Reverse gear idler (partially obscured)	7	Second gear	13	1/2 synchronizer
2	Reverse gear	8	First gear	14	Second speed gear
3	Fifth gear	9	Input shaft	15	Third gear
4	Fourth speed gear	10	Output shaft	16	Fourth gear
5	3/4 synchronizer	11	Output pinion gear	17	Gear wheel (fifth gear)
6	Third speed gear	12	First speed gear	18	Fifth/reverse gear synchronizer
				19	Reverse speed gear

INPUT AND OUTPUT SHAFT ASSEMBLIES (continued)

Input Shaft

The input shaft of transaxles transfers crankshaft rotation to the output shaft assembly. Along its length are the drive gears for all the different gear ratios. Some of these gears are cut directly from the shaft while those gears whose synchronizers are on the input shaft are separate. This type rides on the input shaft the same way the speed gears of a manual transmission ride on the output shaft.

An example of this arrangement can be seen on the MTX-75 input shaft shown above. 1st, 2nd and reverse gears are cut into the shaft itself. 3rd and 4th gears ride on the shaft and, during operation must be locked to it through a synchronizer. 5th gear is a separate gear, but it is splined directly to the shaft.

Output Shaft

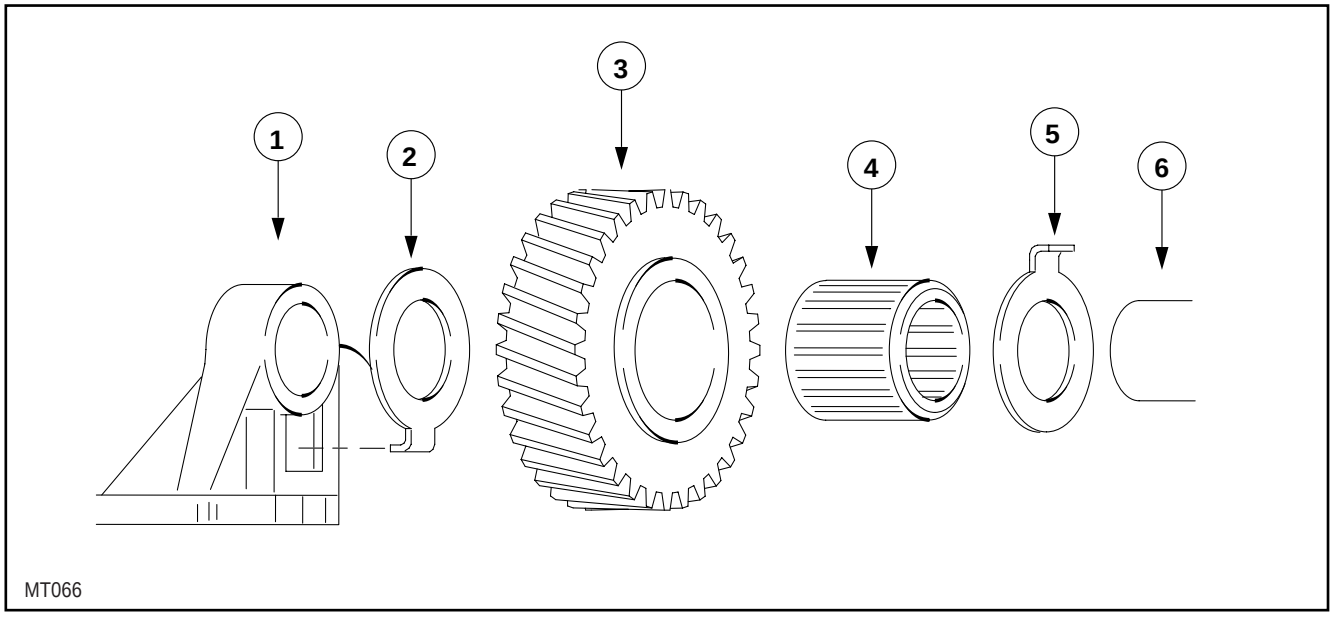
The output shaft of the transaxle transfers power to the differential at the selected gear ratio. On the MTX-75 Output shaft shown above the 1st, 2nd, 5th and reverse driven gears ride on the shaft and are engaged through the first/second or fifth/reverse synchronizer respectively.

3rd and 4th driven gears are cut into the output shaft. Additionally, the differential output gear is a separate gear but it is splined directly to the shaft.

REVERSE IDLER GEAR

Ford uses two types of reverse idler gears in their transaxles. One is basically the same as those in manual transmissions, while the other is a sliding type that is engaged by a shift fork.

MTX-75 Reverse Idler



MTX-75 Reverse Idler

Item	Description	Item	Description
1	Reverse gear idler shaft mount	4	Needle roller bearing
2	Thrust washer	5	Thrust washer
3	Reverse idler gear	6	Reverse idler shaft

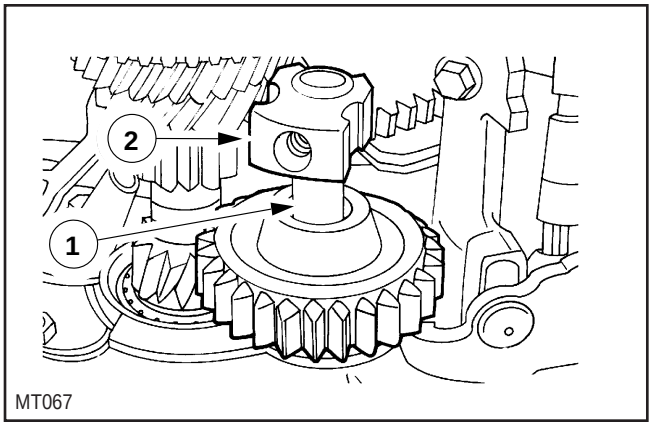
The MTX-75 Transaxle has a synchronized, constant mesh, helical-type reverse idler gear.

- It is in constant mesh with the both the reverse driving gear on the input shaft and the driven gear on the output shaft.

- Reverse is engaged when the fifth/reverse synchronizer engages the reverse driven gear with the output shaft.

REVERSE IDLER GEAR (continued)

G15M-R Reverse Idler



G15M-R Reverse Idler

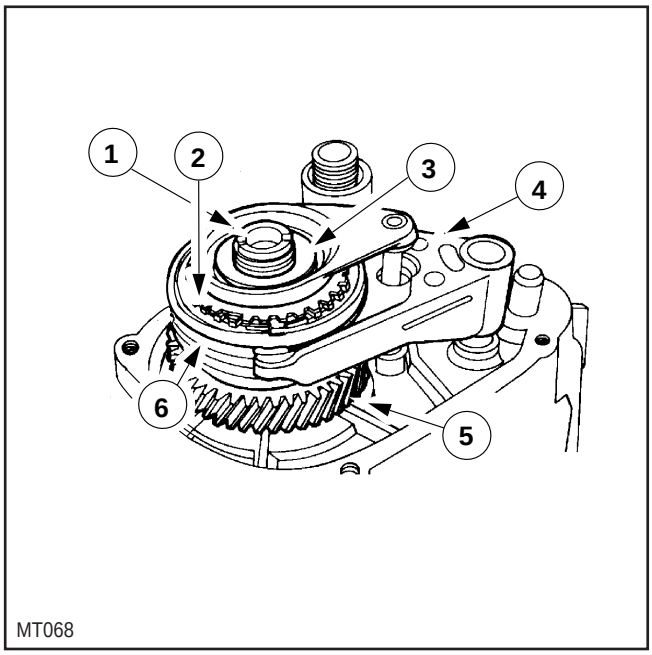
Item	Description
1	Reverse idler gear
2	Reverse idler gear shaft

The G15M-R Transaxle has a spur-cut reverse idler gear that is moved by a shift fork along its own shaft.

- When engaged it meshes between the spur cut reverse drive gear on the input shaft and the spur cut reverse driven gear on the outside diameter of the first/second synchronizer sleeve.

- This action reverses rotation of the output shaft and differential and drives the vehicle in reverse.

REVERSE IDLER GEAR (continued)



G15M-R Reverse Synchronizer

Item	Description	Item	Description
1	Input shaft	4	Gear Shifter Fork, Fifth/Reverse
2	Reverse Blocking Ring	5	Fifth Speed Cluster Gear
3	Reverse Blocking Ring Retainer	6	Fifth/Reverse Synchronizer

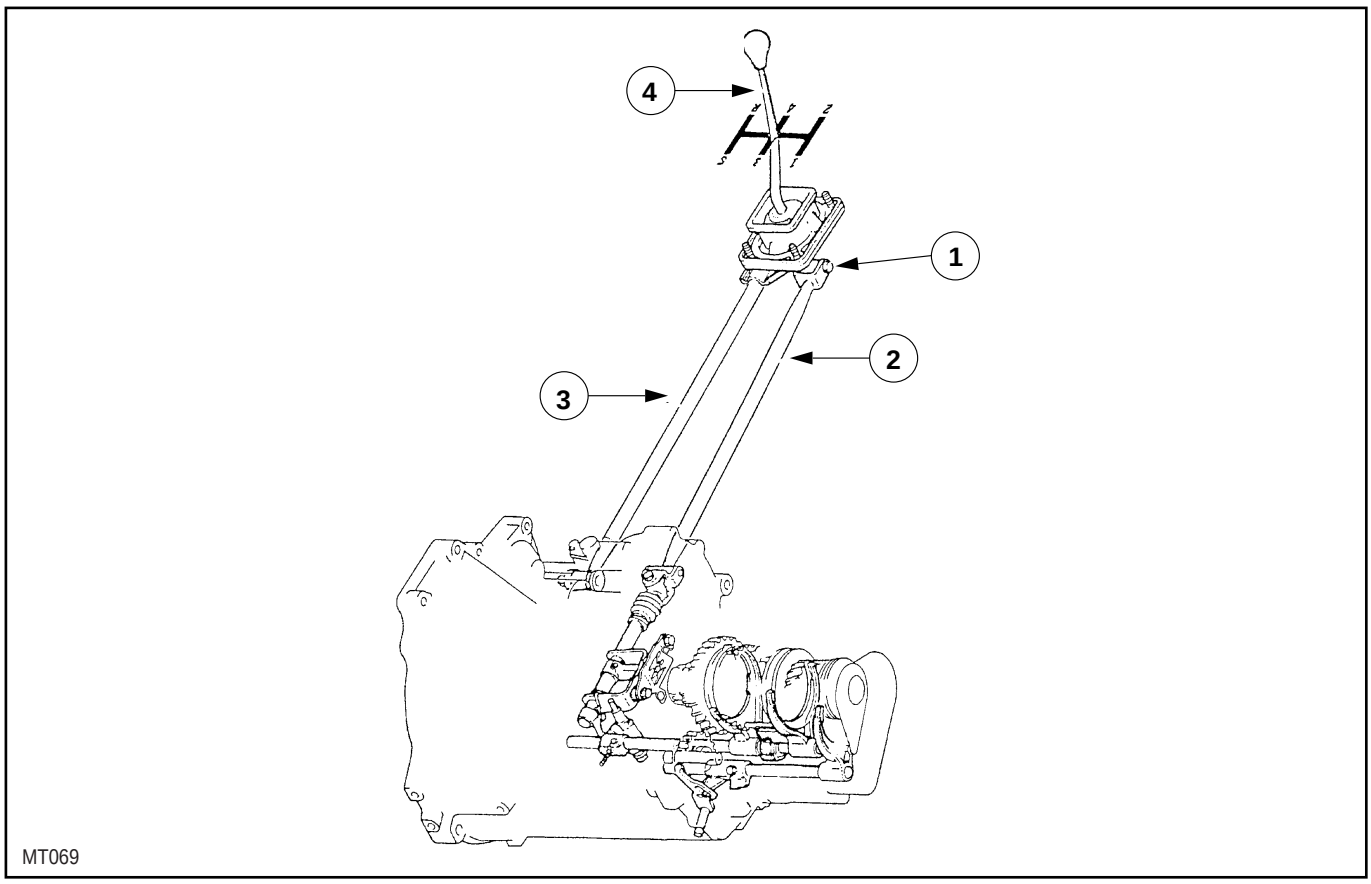
Reverse engagement is synchronized by the fifth/reverse synchronizer.

- When reverse is selected by the driver, the fifth gear synchronizer hub is pressed against the reverse blocking ring, which is pressed against the reverse blocking ring retainer.
- This retainer is connected to the input shaft.
- As the blocking ring cone surface engages the cone surface of the retainer, it stops rotation of the input shaft and allows the smooth meshing of the reverse idler and the reverse speed gear.

SHIFT LINKAGES

Because of the location of the transaxle, shift linkage must be used between the transaxle and the shift lever inside the vehicle. Ford uses two types of linkages.

Rod and Clevis Linkage



Rod and Clevis Linkage

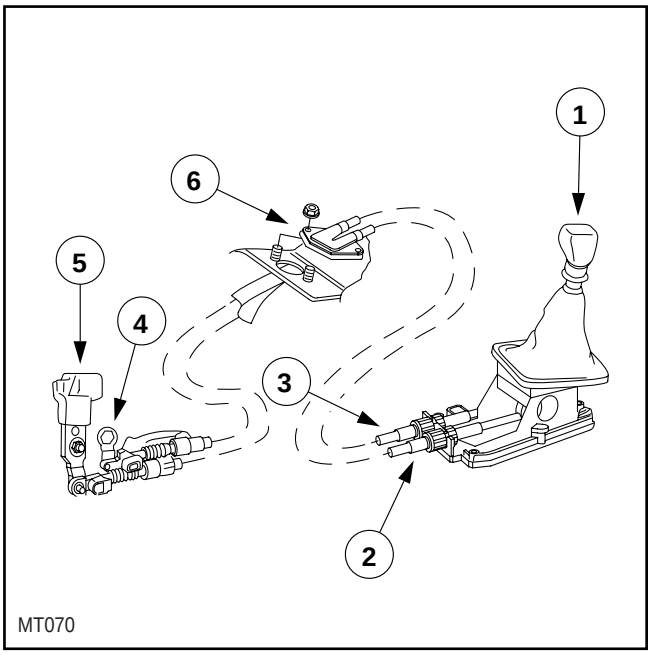
Item	Description
1	Rod Support Bushing
2	Gearshift Rod and Clevis
3	Stabilizer Bar
4	Shifter

Rod and Clevis Linkage uses a rod that connects to the shift rails inside the transaxle. This rod and clevis allows movement of the shift rails, which in turn moves the shift forks inside the transaxle.

This type of linkage also uses a stabilizer bar between the gearshift assembly and transaxle. The rod connects to the shift lever through support bushings.

SHIFT LINKAGES (continued)

Cable Linkage



Cables and Shifter

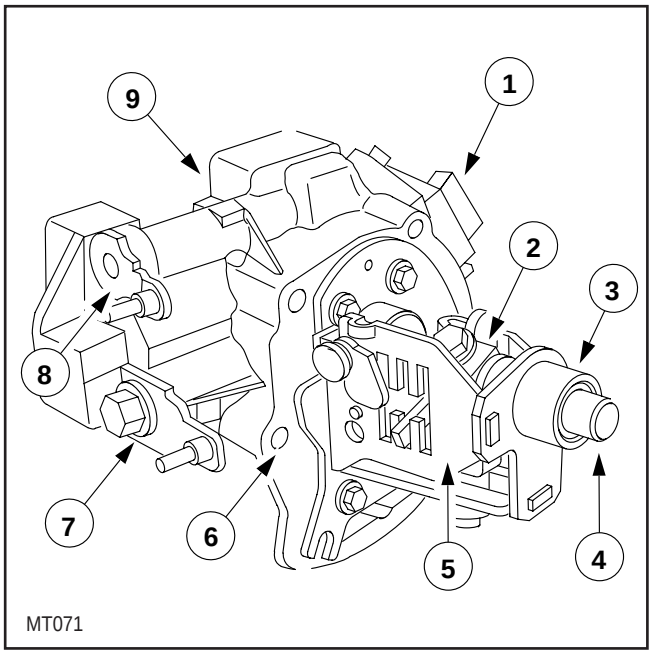
Item	Description	Item	Description
1	Gearshift lever	4	Gear selector lever on the transaxle
2	Shift cable	5	Gearshift lever on the transaxle
3	Selector cable	6	Cable guide

The Ford MTX-75 transaxle is equipped with a cable gearshift linkage. The cables are color-coded. The shift cable is white and the selector cable is black. They are adjustable using a special tool. Because they are jointly connected to the floor assembly, the selector and shift cables may only be replaced as a pair.

The cables on this type of linkage are connected to a selector mechanism on the transaxle. These cables work in combination with each other to allow the driver to select gears.

SHIFT LINKAGES (continued)

Cable Linkage Selector Mechanism

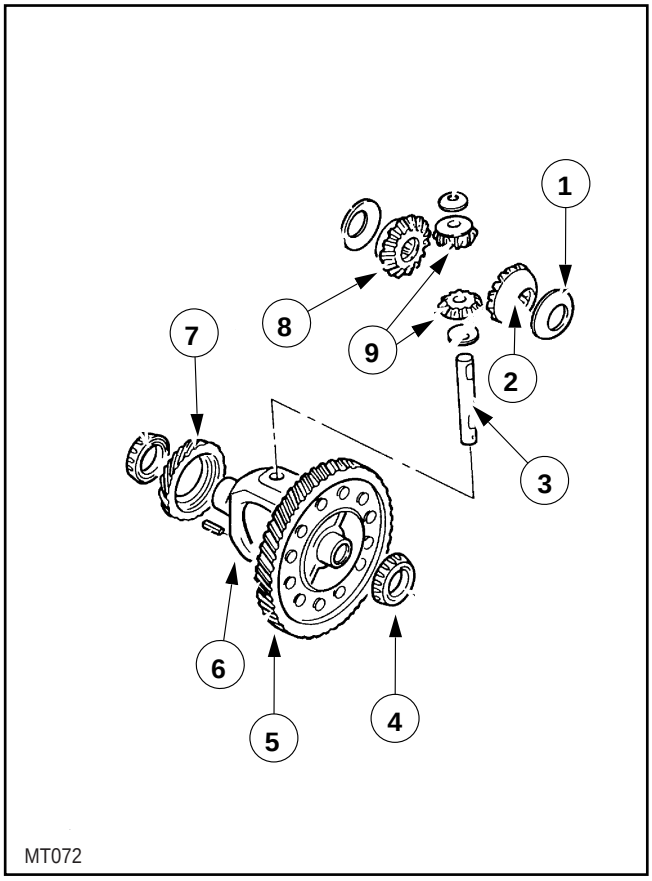


Selector Mechanism

Item	Description	Item	Description
1	Reversing lamp switch	5	Selector gate
2	Selector finger	6	Selector mechanism housing
3	Selector finger bracket	7	Selector lever
4	Selector shaft	8	Gearshift lever
		9	Selector mechanism cover

Cable linkage systems require the use of a selector mechanism. The selector and shift cables connect to this mechanism and movements of the mechanism's selector levers determine the transaxle gear.

DIFFERENTIAL COMPONENTS



Differential Components

Item	Description	Item	Description
1	Differential Side Gear Thrust Washer	6	Differential Carrier
2	Differential Side Gear	7	Speedometer Drive Gear
3	Differential Pinion Shaft	8	Differential Side Gear
4	Differential Bearing (Ring Gear End)	9	Pinion Gears
5	Differential Ring Gear		

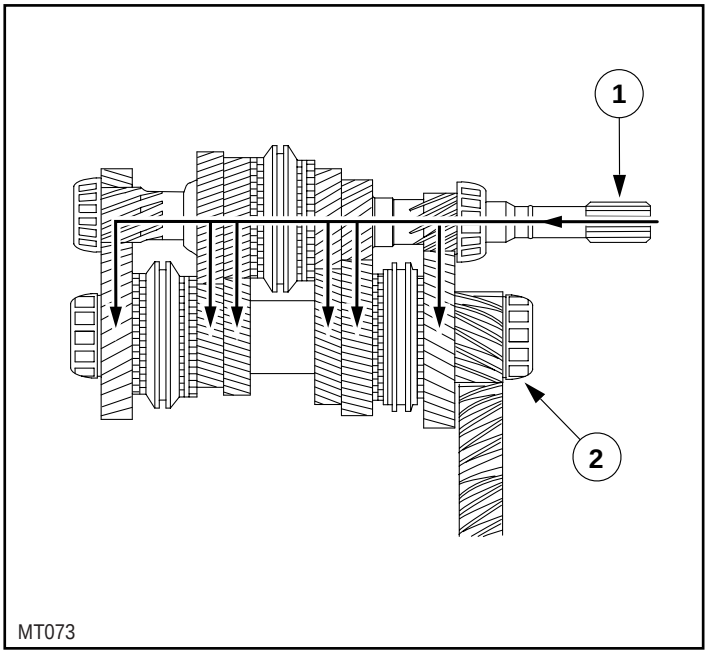
The components that make up the differential include the ring gear, which transfers power from the output shaft to the carrier. The carrier, which contains the pinion gears that ride on the pinion shaft. The carrier also contains the side gears, which are in mesh with the pinion gears and connect to the halfshafts.

The differential is supported by tapered roller bearings that fit into races in the transaxle housing. The differential also contains thrust washers, which are located beneath the pinion and side gears.

POWERFLOW

Understanding powerflow is essential for the diagnosis of manual transaxle concerns. Although the powerflow through some transaxles may be slightly different because of differences in parts, all manual transaxle powerflow is very similar. As an example of powerflow, the MTX-75 manual transaxle powerflow will be shown on the following pages.

MTX-75 Powerflow in Neutral



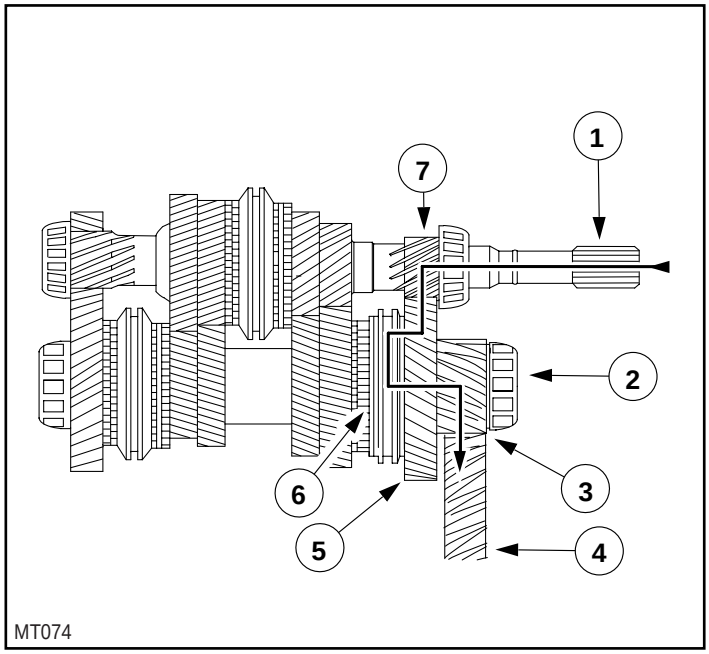
Powerflow in Neutral

Item	Description
1	Input Shaft
2	Output Shaft

- Engine power drives the input shaft.
- All the synchronizer sleeves on both the input and output shafts are centered.
- Gears in mesh on the input shaft and output shaft are not engaged to their shaft by the synchronizers so they turn freely.
- The output shaft is stationary, and there is no powerflow to the differential.

POWERFLOW (continued)

MTX-75 Powerflow in First Gear



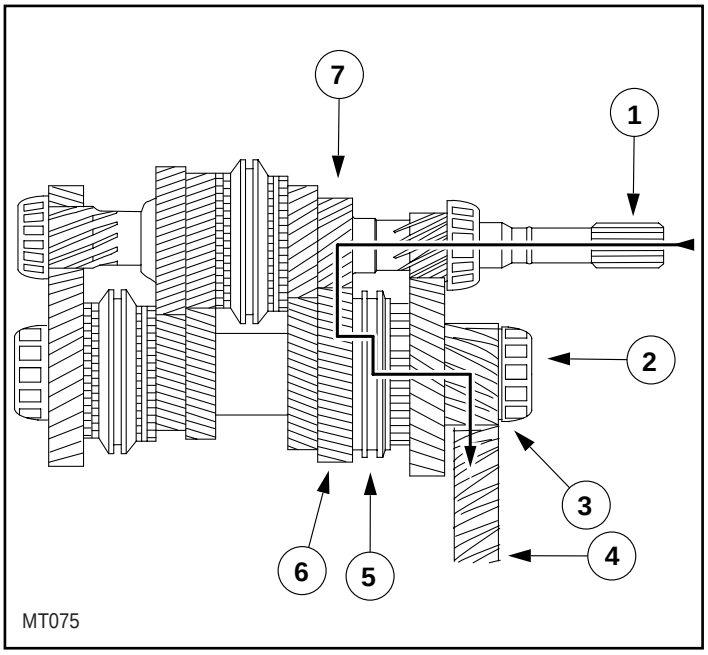
Powerflow in 1st Gear

Item	Description	Item	Description
1	Input shaft	5	First Speed Gear
2	Output Shaft	6	1-2 Synchronizer
3	Output Pinion	7	First Drive Gear
4	Differential Ring Gear		

- Engine power drives the input shaft.
- The 1-2 synchronizer on the output shaft moves forward to engage the first speed gear.
- The synchronizer hub is engaged to the output shaft.
- The first drive gear on the input shaft drives the first speed gear on the output shaft.
- The output shaft drives the differential ring gear.
- Power flows through the differential to the halfshafts.

POWERFLOW (continued)

MTX-75 Powerflow in Second Gear



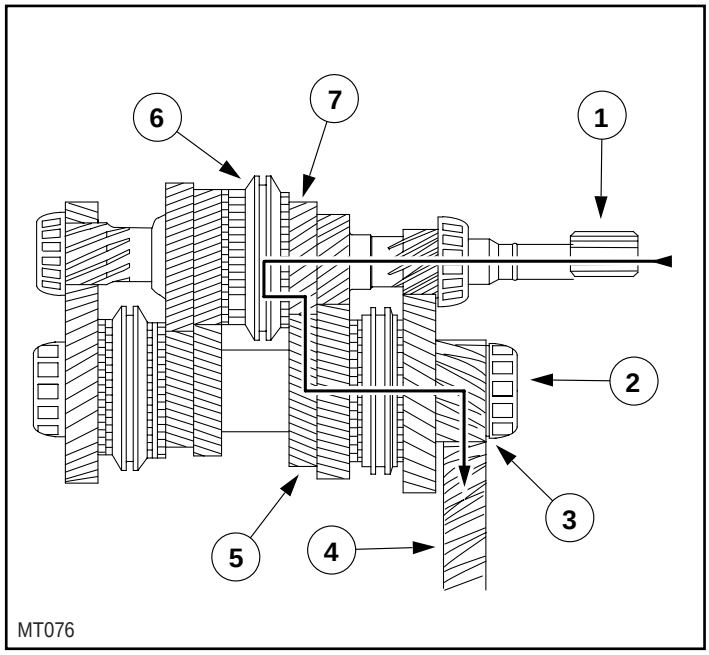
Powerflow in 2nd Gear

Item	Description	Item	Description
1	Input shaft	5	1-2 Synchronizer
2	Output Shaft	6	Second Speed Gear
3	Output Pinion	7	Second Drive Gear
4	Differential Ring Gear		

- Engine power drives the input shaft.
- The 1-2 synchronizer on the output shaft moves rearward to engage the second speed gear.
- The synchronizer hub is engaged to the output shaft.
- The second drive gear on the input shaft drives the second speed gear on the output shaft in gear reduction.
- The output shaft drives the differential ring gear.
- Power flows through the differential to the halfshafts.

POWERFLOW (continued)

MTX-75 Powerflow in Third Gear



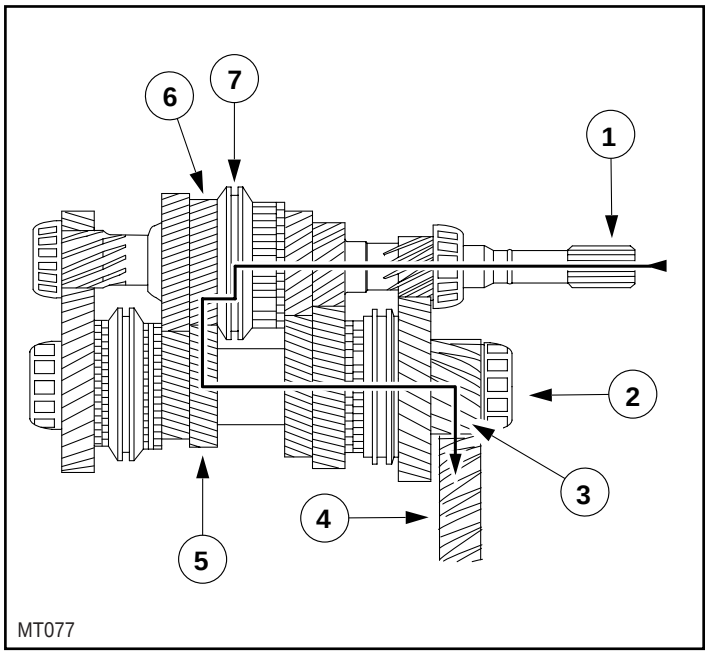
Powerflow in 3rd Gear

Item	Description	Item	Description
1	Input shaft	5	Third Driven Gear
2	Output Shaft	6	3-4 Synchronizer
3	Output Pinion	7	Third Speed Gear
4	Differential Ring Gear		

- Engine power drives the input shaft.
- The 3-4 synchronizer sleeve on the input shaft moves forward to engage the third speed gear.
- The synchronizer hub is engaged to the input shaft.
- The third speed gear on the input shaft drives the third driven gear on the output shaft in gear reduction.
- The output shaft drives the differential ring gear.
- Power flows through the differential to the halfshafts.

POWERFLOW (continued)

MTX-75 Powerflow in Fourth Gear



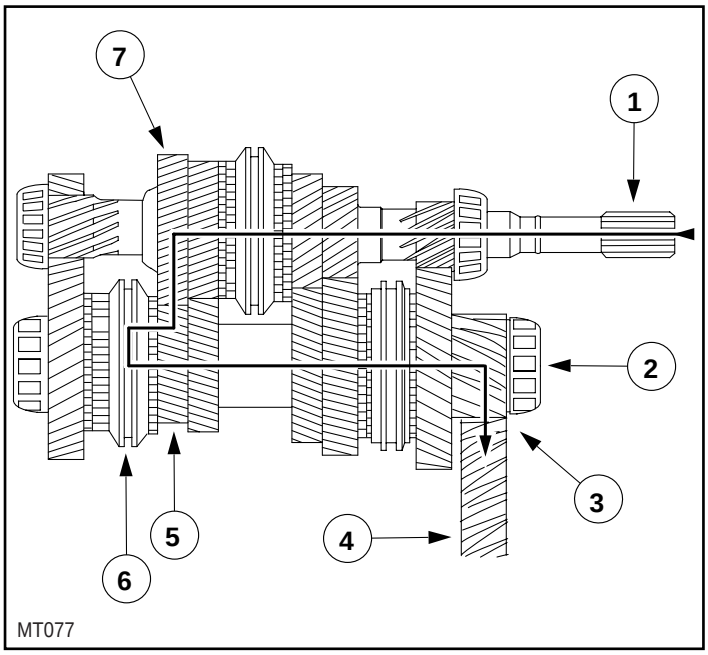
Powerflow in 4th Gear

Item	Description	Item	Description
1	Input shaft	5	Fourth Driven Gear
2	Output Shaft	6	Fourth Speed Gear
3	Output Pinion	7	3-4 Synchronizer
4	Differential Ring Gear		

- Engine power drives the input shaft.
- The 3-4 synchronizer sleeve on the input shaft moves rearward to engage the fourth speed gear.
- The synchronizer hub is engaged to the input shaft.
- The fourth speed gear on the input shaft drives the fourth driven gear on the output shaft at a 1:1 ratio.
- The output shaft drives the differential ring gear.
- Power flows through the differential to the halfshafts.

POWERFLOW (continued)

MTX-75 Powerflow in Fifth Gear



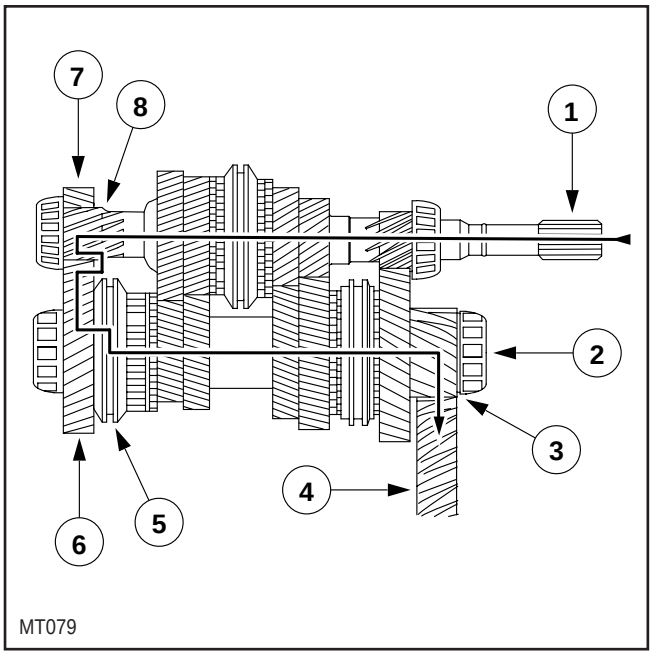
Powerflow in 5th Gear

Item	Description	Item	Description
1	Input shaft	5	Fifth Speed Gear
2	Output Shaft	6	Fifth/Reverse Synchronizer
3	Output Pinion	7	Fifth Drive Gear
4	Differential Ring Gear		

- Engine power drives the input shaft.
- The fifth/reverse synchronizer on the output shaft moves forward to engage the fifth speed gear.
- The synchronizer hub is engaged to the output shaft.
- The fifth drive gear on the input shaft drives the fifth speed gear on the output shaft at an overdrive ratio.
- The output shaft drives the differential ring gear.
- Power flows through the differential to the halfshafts.

POWERFLOW (continued)

MTX-75 Powerflow in Reverse



Powerflow in Reverse

Item	Description	Item	Description
1	Input shaft	5	Fifth/Reverse Synchronizer
2	Output Shaft	6	Reverse Speed Gear
3	Output Pinion	7	Reverse Idler Gear
4	Differential Ring Gear	8	Reverse Drive Gear

- Engine power drives the input shaft.
- The fifth/reverse synchronizer on the output shaft moves rearward to engage the reverse speed gear.
- The synchronizer hub is engaged to the output shaft.
- The reverse drive gear on the input shaft drives the reverse idler gear.
- The reverse idler gear drives the reverse speed gear on the output shaft in gear reduction.
- The output shaft drives the differential ring gear in reverse.
- Power flows through the differential to the halfshafts.

DIAGNOSTIC PROCEDURES

Manual transaxle diagnostic procedures are very similar to those outlined in the manual transmission lesson of this reference book. Manual transaxle bearings, blocking rings, shift forks etc. will cause the same types of concerns as those in a manual transmission. For this reason a description of the diagnostic procedures those types of concerns will not be repeated in this lesson.

However, due to addition of the differential in a transaxle there are some unique concerns that will only occur in a transaxle. The following descriptions will focus on these types of concerns.

UNIQUE MANUAL TRANSAXLE SYMPTOMS AND CAUSES

Unique manual transmission symptoms occur in the differential system. The following are some of these symptoms, how to test for them and what the possible causes may be.

NOTE: Before diagnosing any transaxle concern make sure that the transmission fluid level is correct and that the correct type of oil is in the transaxle.

NOTE: When diagnosing clutch or transaxle bearing concerns be aware that some transaxles do not have pilot bearings as part of their clutch system.

Does Not Shift Correctly – In addition to those causes spelled out in the transmission section, manual transaxles may not shift correctly because of the external linkages. Both cable type and rod and clevis type linkages may be damaged or out of adjustment. This can result in shift concerns including:

- hard shifting in all gears.
- hard shifting in specific gears.
- unable to shift into any gear.
- jumps out of gear(s).
- locked in gear.

Any time a vehicle with a manual transaxle is brought in for any of these concerns the external linkage should be checked for:

- correct adjustment.
- worn or damaged bushings.
- worn or damaged cables.
- worn or damage cable shift mechanism.

UNIQUE MANUAL TRANSAXLE SYMPTOMS AND CAUSES (continued)

Differential Carrier Bearing Noise – Carrier bearing noise will occur anytime that the wheels are turning. This noise will be present in all gears but will get louder as vehicle speed increases.

When diagnosing this type of bearing concern special attention should be paid to the location of the source of the noise. In some cases a noisy front wheel bearing can be mistaken for differential bearing noise. During diagnosis, always check the location of the noise using a Chassis Ear® while driving on the road.

Differential Gear Noise – Noise from the differential gears may vary depending on which gears are damaged.

Output and Ring Gear Damage – If the output and/or ring gear teeth are damaged you will generally get a clicking or knocking noise when the vehicle is moving. This noise will usually be loudest under heavy load but will likely be present at all vehicle speeds.

This type of damage will never cause a clicking or knocking noise when the vehicle is stopped or in neutral. If clicking or knocking can be heard coming from the transaxle with the vehicle stopped in neutral with the clutch pedal out, the source is likely the gears on the input or output shaft.

Side Gears and Pinion Gear Damage – Since these gears do not rotate when the vehicle is going straight ahead, damage to these gears will result in noise when the vehicle is turning corners. The noise will occur weather the vehicle is turning right or left and will be more noticeable during slow sharp turns.

If a vehicle is operated for a period of time with different size tires damage to the side and pinion gears will result. This causes the gears to rotate all the time since the tires will rotate at different speeds. If the vehicle has two different size tires on the drive wheels the side and pinion gears will make noise when going straight ahead.

MANUAL TRANSAXLE SERVICE PROCEDURES

When working with manual transaxles there are some unique service procedures that should be followed.

- During transaxle removal and installation there are also some unique external linkage inspection and adjustment procedures.
- During transaxle assembly, if certain parts are replaced there are unique procedures for setting clearances and preloads on the differential assembly.
- During transaxle installation correct subframe alignment is critical.
- Always check transaxle and motor mount condition, security, and alignment.

These procedures are described in detail in the vehicle Workshop Manual.

Otherwise, the procedures for removing, inspecting, servicing, and installing manual transaxles are generally the same as those for manual transmissions. Refer to Lesson 4 for additional details.

REVIEW QUESTIONS

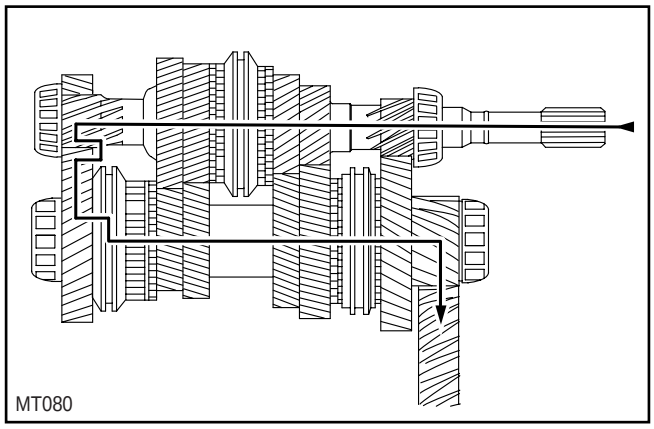
Directions: Use the information you have learned in this lesson to answer the following questions.

1. A manual transaxle has all of the following components EXCEPT:
   A. synchronizers
   B. input shaft
   C. countershaft
   D. shift linkage

2. What is the purpose of the differential?
   A. To allow for differences in wheel rotation speed during turns.
   B. To allow for differences between the input shaft and output shaft.
   C. To allow for differences between the shift lever position and the shift forks.
   D. To allow for differences in rotating speed between the engine and the input shaft.

3. When driving straight ahead the pinion gears are:
   A. rotating at the speed of the halfshafts.
   B. not rotating.
   C. synchronized to maintain correct speed.
   D. not meshed.

4. What gear is the transaxle in the art below engaged in?



   A. 1st
   B. 3rd
   C. 5th
   D. Reverse

REVIEW QUESTIONS (continued)

5. Which of the following is MOST LIKELY to cause a hard shifting concern on a manual transaxle?
   A. Damaged differential side gears.
   B. Worn input shaft bearing.
   C. Damaged cluster bearing.
   D. Damaged rod and clevis bushing.

6. When will damaged differential side gears make noise?
   A. When driving straight ahead.
   B. During turns.
   C. In neutral with the clutch pedal out.
   D. Whenever the engine is running.

NOTES

LESSON 6: HALFSHAFTS

LESSON OBJECTIVES

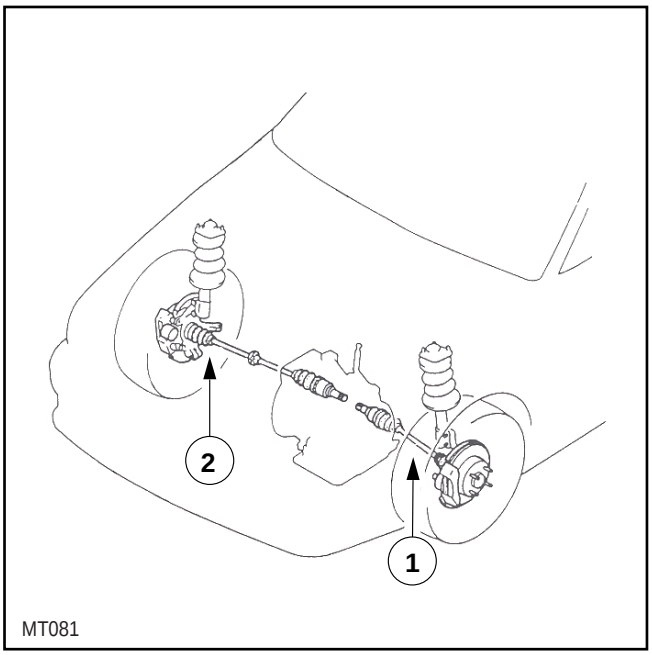
OBJECTIVES

- Describe the purpose of the halfshaft.
- Explain the operation of a halfshaft.
- Identify the parts of a halfshaft.
- Describe halfshaft diagnostic procedures.
- Identify halfshaft service procedures.

CONTENTS

LESSON 6: HALFSHAFTS

PURPOSE OF THE HALFSHAFT

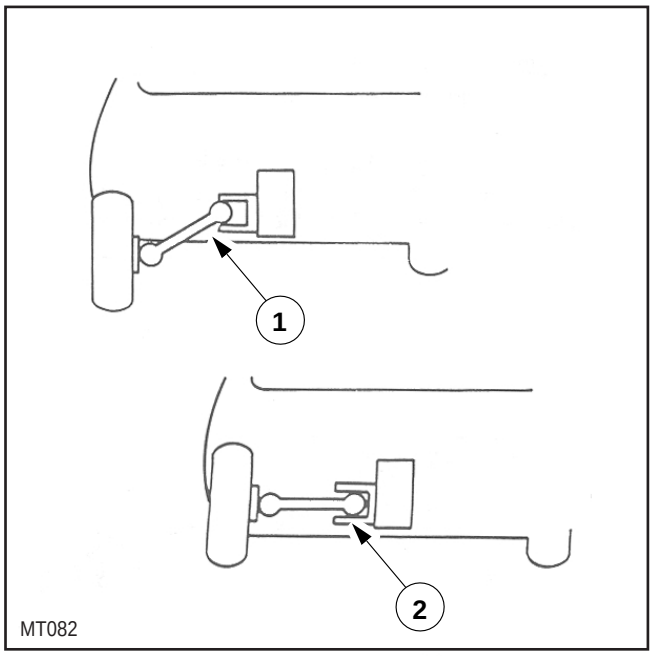


Typical Halfshaft Assembly on Front Wheel Drive Vehicle

Item	Description
1	Left Halfshaft Assembly
2	Right Halfshaft Assembly

Front wheel drive vehicles require unique drive axles called halfshafts. The halfshafts transfer power from the differential in the transaxle to the wheels. Halfshafts are connected between the side gears of the differential and the wheel hub. They must be able to smoothly transmit torque during turns and also change length as the vehicle travels over bumps, or as vehicle load changes.

HALFSHAFT OPERATION



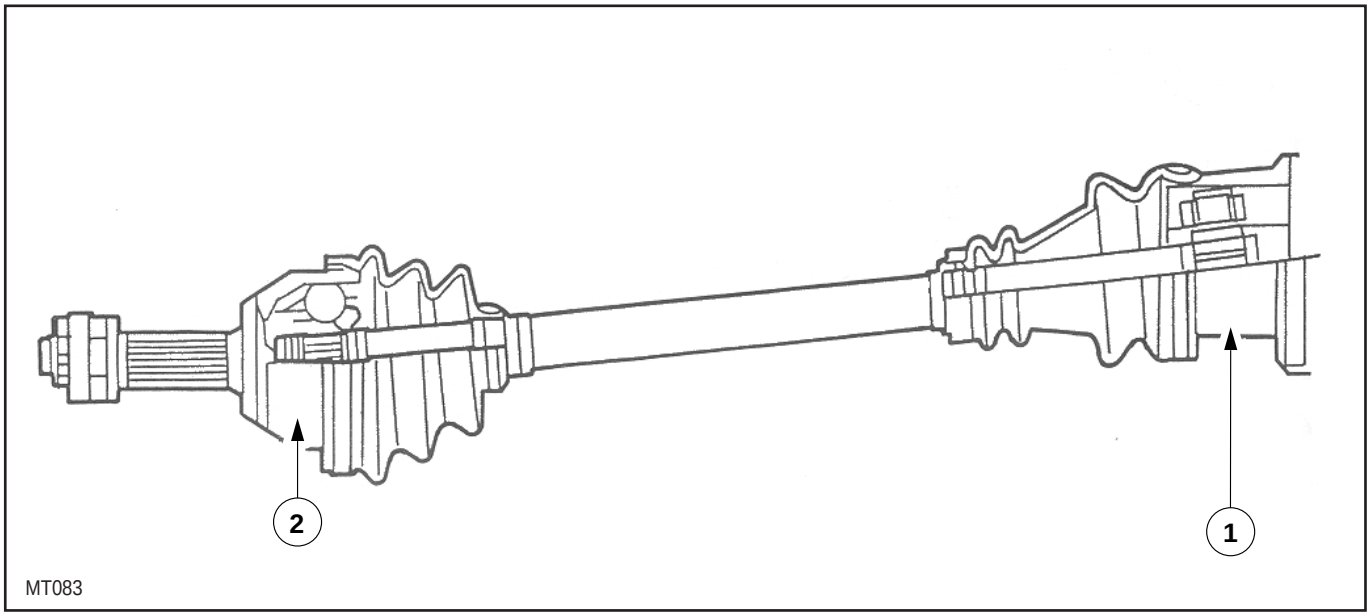
Varying Halfshaft Length

Item	Description
1	Halfshaft Extended
2	Halfshaft Compressed

The halfshaft provides this smooth transfer of power because of the constant velocity (CV) joints located at each end of the shaft. CV joints are designed to allow a smooth transfer of torque while allowing for steering and front suspension movement. As the suspension moves, the CV joints allow the halfshafts to change length and operate smoothly through varying angles.

The outer CV joints allow the steering system to turn the wheels, as well as allow for the up and down movement of the suspension. The inner CV joint allows for halfshaft length change (plunge) due to suspension movement.

HALFSHAFT OPERATION (continued)

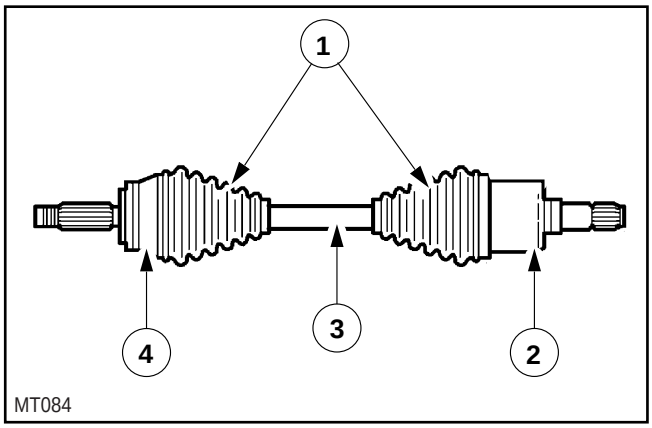


Typical Halfshaft Assembly on Front Wheel Drive Vehicle

Item	Description
1	Inner CV Joint can change length also called “Plunge”
2	Outer CV Joint is fixed

During vehicle operation the outer CV joint pivots allowing the shaft to change angles quickly and smoothly. This allows power to be transferred even when the vehicle is being turned sharply. At the same time the inner joint also allows pivoting, but it also can change length. This is done because the components of the inner joint ride in a sleeve and can move in and out along its length as needed when the suspension is reacting to the contours of the road. This ability is called “plunge”.

HALFSHAFT COMPONENTS



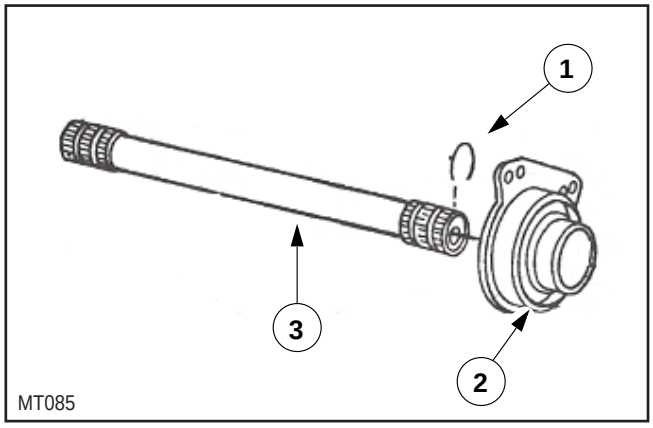
Typical Halfshaft Assembly on Front Wheel Drive Vehicle

Item	Description
1	CV Joint Boots
2	Inner CV Joint
3	Shaft
4	Outer CV Joint

HALFSHAFT COMPONENTS (continued)

Common components found on all halfshafts include:

- CV joint boots
- Inner CV joint
- Shaft
- Outer CV joint

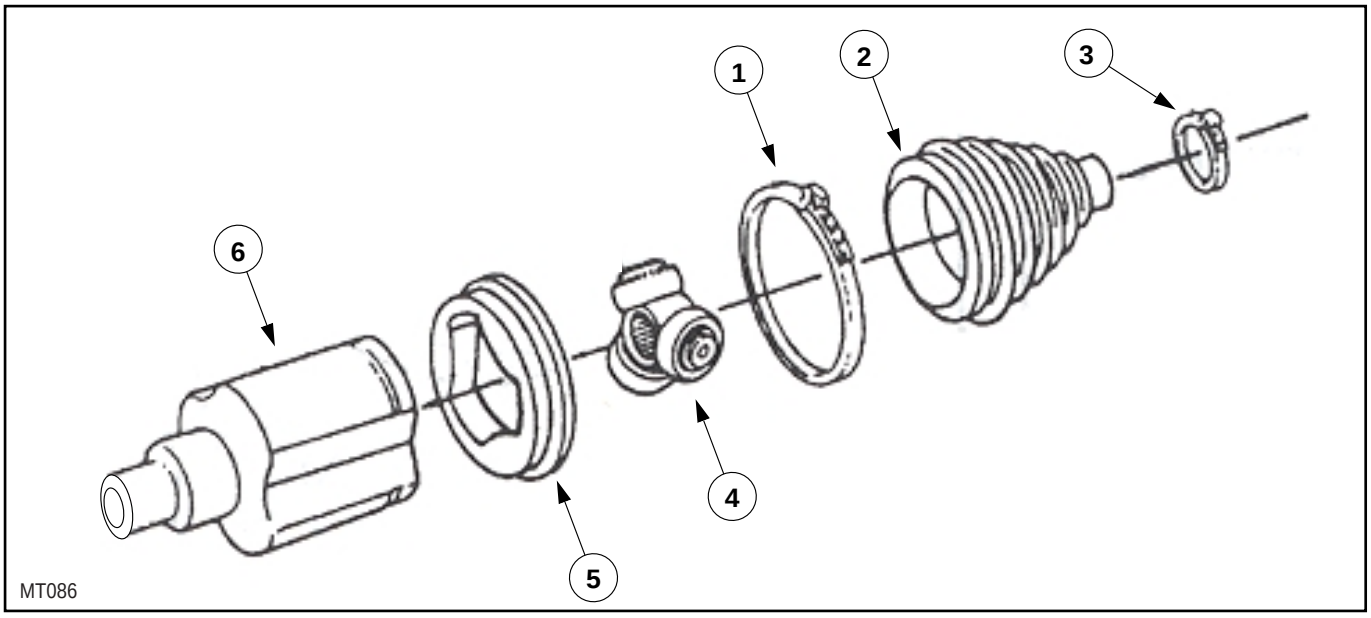


Intermediate Shaft

Item	Description
1	Circlip
2	Hanger Bearing
3	Intermediate Shaft

INNER CV JOINT

The inner CV joint is splined to the side gear of the differential. To prevent the inner CV from easily pulling out of the side gear it is held in place using a spring steel circlip. There are two common types of inner CV joints used on Ford vehicles.



Inner Tripod Joint

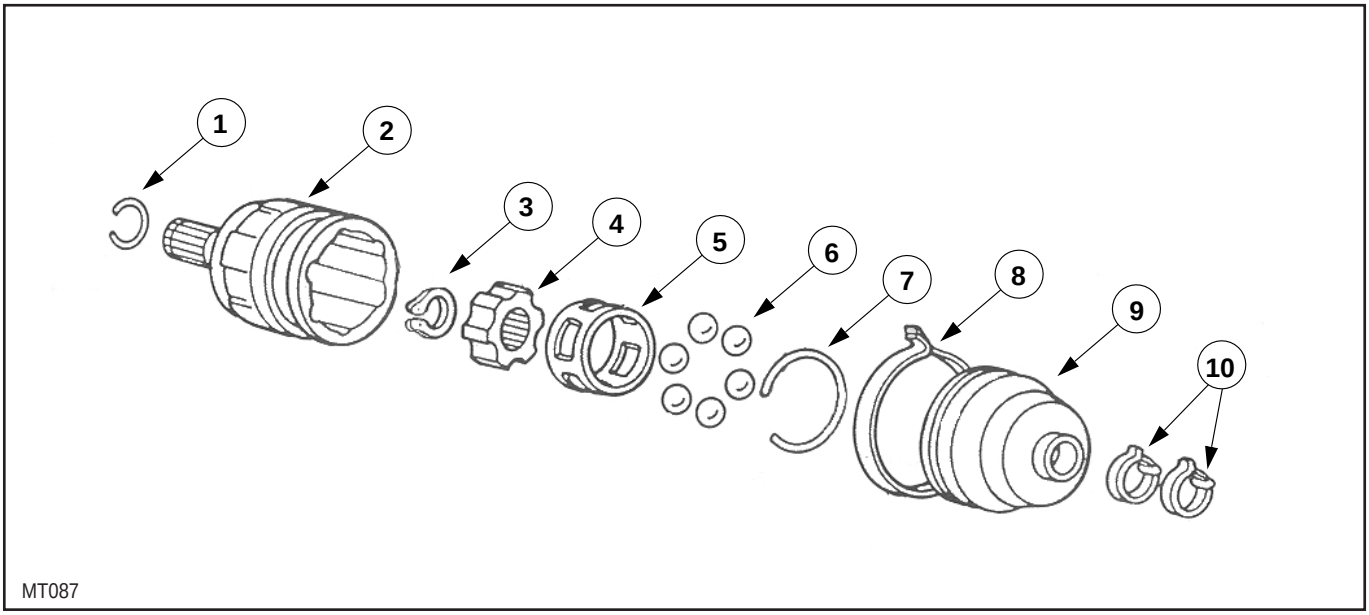
Item	Description	Item	Description
1	Boot Clamp	4	Tripod Joint
2	CV Boot	5	Inner Sleeve Insert
3	Boot Clamp	6	Inner Sleeve (Tulip)

The tripod type joint shown above has three trunnions fitted with special rollers that ride on needle bearings.

- Tripod joints ride inside the sleeved race of the joint housing (sometimes called the tulip because of its appearance).
- Since the rollers are not fixed to the joint housing they are free to move back and forth inside the joint housing.
- This allows for angulation of the shaft as well as letting it change length for suspension action.

INNER CV JOINT (continued)

However, to transfer power over greater distances and eliminate torque steer (which is a pulling at the steering wheel during acceleration) some halfshafts have an additional component called the intermediate shaft.



Plunging Ball Joint

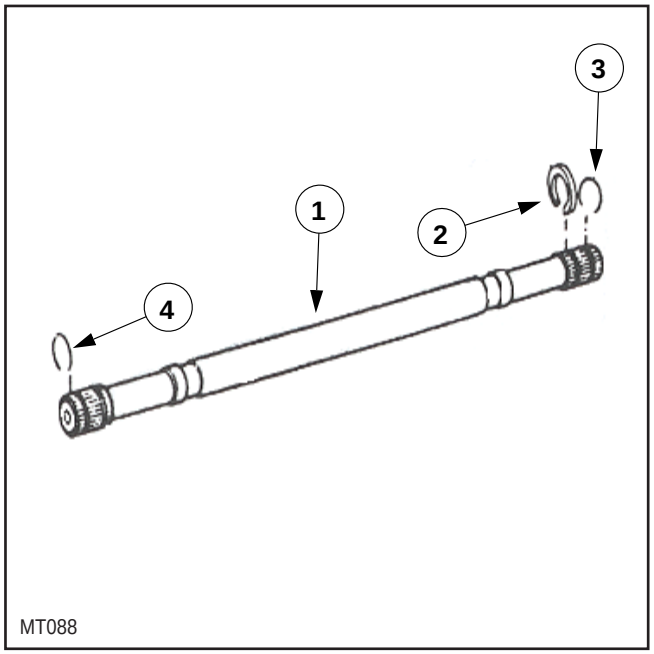
Item	Description	Item	Description
5	Bearing Cage	10	Boot Clamps
6	Ball Bearings	4	Inner Race
7	Bearing Retainer	3	Snap Ring
8	Boot Clamp	2	Housing/Outer Race
9	CV Boot	1	Circlip

The plunging ball type inner CV joint uses an outer race that has straight grooves machined into it.

- The inner race is connected to the shaft and large caged ball bearings ride between the inner and outer races.

- As the shaft changes length the inner race and caged ball bearings are free to move in and out along the grooves of the outer race thus letting the shaft angulate and change length.

SHAFT



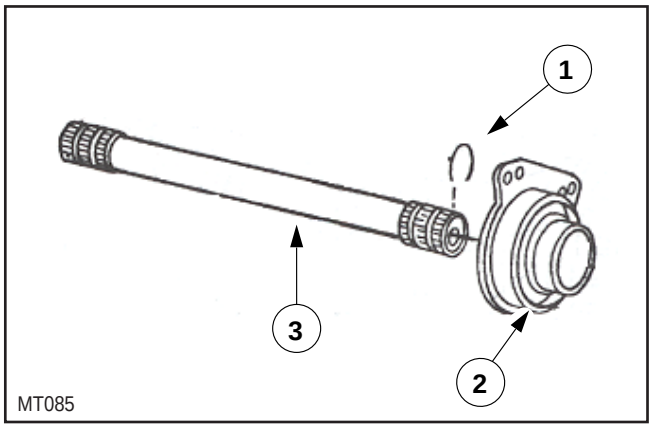
Shaft

Item	Description	Item	Description
1	Shaft	3	Circlip
2	Snap Ring	4	Circlip

The shaft of the halfshaft assembly is splined at both ends to allow the CV joints to be fitted to it.

- Since the shaft rotates at only about 1/3 the speed of a rear wheel drive driveshaft, it does not need to be balanced.
- Some shafts used rubber dynamic dampeners to help eliminate small vibrations that may be generated during vehicle operation.
- Shorter shafts may be made of solid steel, while longer shafts are made of hollow tubing.
- The splines of the shaft have grooves cut into them to allow snap rings and/or circlips to be installed to retain the CV joints.

INTERMEDIATE SHAFT



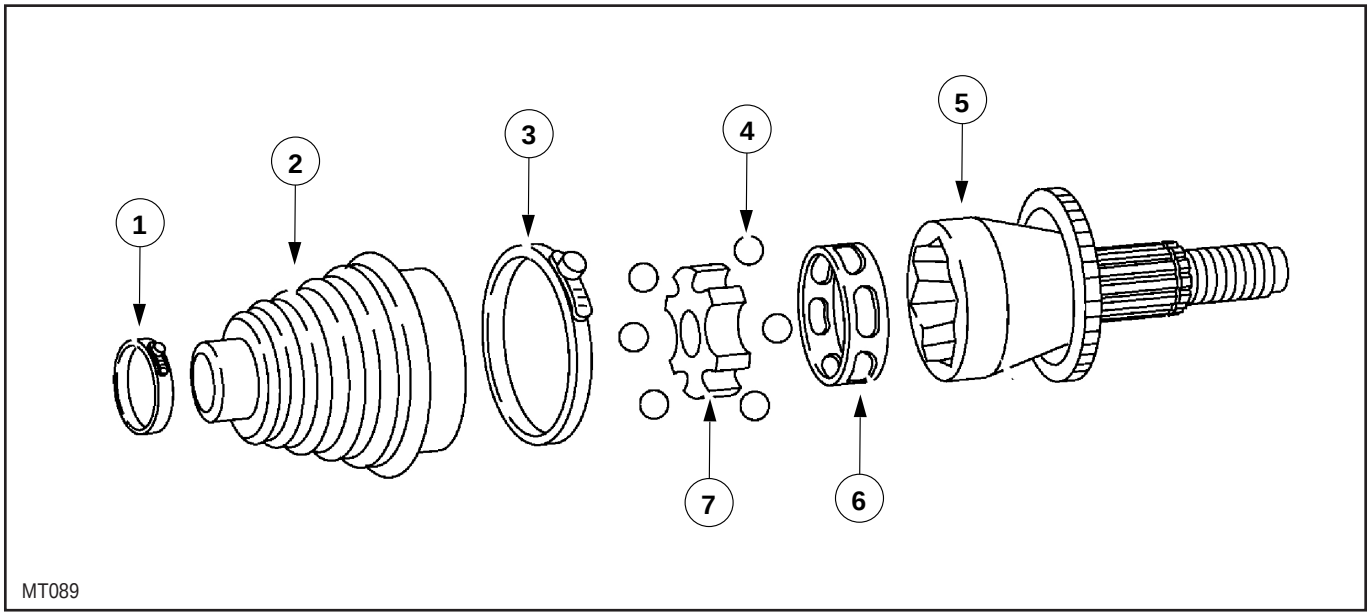
Intermediate Shaft Assembly

Item	Description
1	Circlip
2	Hanger Bearing
3	Intermediate Shaft

Vehicles with larger engines may require the use of an intermediate shaft. This is a shaft that connects from the transaxle to the halfshaft assembly and is supported by a hanger bearing that is bolted to the vehicle frame.

The intermediate shaft is needed on some vehicles because the farther from the center of the vehicle that the halfshafts are connected to the transaxle, the more torque steer is felt at the steering wheel. Torque steer is where the steering wheel pulls during acceleration. It can be very pronounced on vehicles with large engines whose transaxles are not located at the vehicle centerline.

OUTER CV JOINT



Outer CV Joint

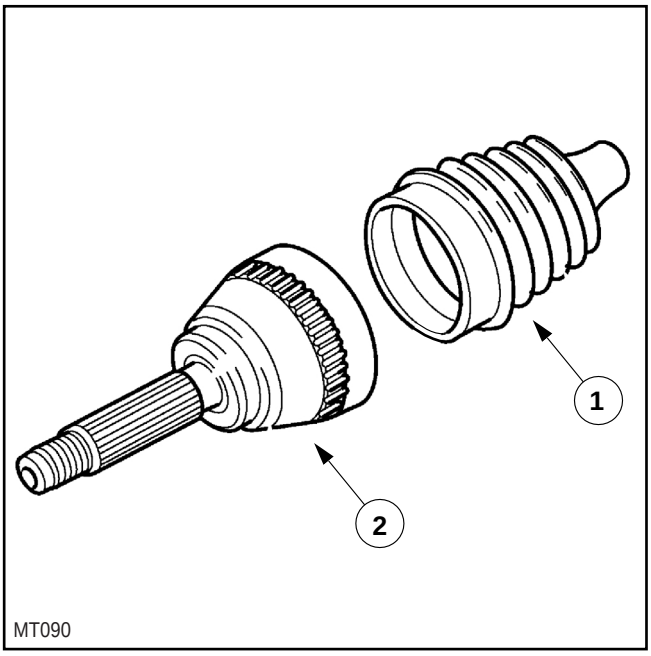
Item	Description	Item	Description
1	Boot Clamp	5	Outer Housing
2	CV Boot	6	Bearing Cage
3	Boot Clamp	7	Inner Race
4	Ball Bearings		

The outer CV joints used by Ford are Rzeppa-type joints (named for their inventor). These are fixed ball joints that consist of an inner ball race, a set of large ball bearings that are caged into position. These ball bearings move inside of races machined into the outer housing. When the wheels are turned for vehicle steering, the ball bearings allow the inner race, which is splined to the shaft, and the outer race, which is splined to the wheel, to operate at angles to each other.

The outer race of the CV joint is splined to the wheel hub using an interference fit. This interference fit eliminates backlash between the wheel hub and the halfshaft. However, because of the extremely tight fit of interference fit splines, a special service tool must be used when removing the CV joint from the wheel hub.

Vehicles with anti-lock brake systems (ABS) will have the wheel speed sensor ring of the ABS system around the outside of the outer CV joint housing.

CV JOINT BOOTS



CV Joint and Boot

Item	Description
1	CV Joint Boot
2	CV Joint

Both inner and outer CV joints have rubber or plastic boots that cover the opening of the joint where it connects to the shaft. These boots are held in place by special clamps.

- The boots are designed to keep contamination out of the CV joint, and to keep the special grease used to lubricate the joints from escaping.
- As long as the boots are intact the joint requires no periodic maintenance or lubrication.
- Any tear in the boot, or damage to the boot clamp that allows contamination into the joint requires either boot or joint replacement, depending on vehicle model.

HALFSHAFT DIAGNOSIS

Halfshaft concerns usually appear as noise or vibration. For this reason whenever a halfshaft concern occurs make sure that the tire and wheel balance is checked before performing any halfshaft service.

Halfshaft diagnosis symptom charts are contained in the workshop manual. These charts use the Symptom-to-System-to-Component-to-Cause Diagnostic Strategy as outlined in Lesson 2 of this book. Always refer to the symptom charts when you suspect a concern is being caused by the halfshaft.

COMMON HALFSHAFT SYMPTOMS AND CAUSES

There are several concerns that can be caused by halfshafts. Usually these concerns are caused by contamination of the CV joints because of damage to their boots. When you suspect that a CV joint is the cause of a vehicle concern always perform a thorough visual inspection looking for boot damage or escaping grease at the CV joint.

Clicking, Popping, or Grinding During Turns and/or Acceleration – This is a common symptom of a damaged outer CV joint. The noise will occur during sharp turns at low speed, and may also occur under acceleration. This concern is almost always caused by CV joint contamination as a result of damaged boots. Joints that are clicking or popping must be replaced.

Grease Leaking from a Damaged or Unsecured Boot – If a CV joint is leaking grease because of a torn boot or because a boot clamp has failed, the boot or clamp can usually be replaced. Refer to the service section of this lesson for more details.

Shudder or Vibration During Acceleration – This type of concern is often caused by high CV joint operating angles. Check the vehicle ride height and spring rate to ensure that the suspension is operating within specifications.

If the halfshaft has an intermediate shaft, a worn or damaged hanger bearing may also be the cause this type of concern.

A damaged CV joint may also be the source of the problem, but CV joint damage is usually caused by a contamination as a result of a torn CV joint boot, which can be seen with a visual inspection.

Noise or Vibration with Extreme Suspension Movement – This can be caused by a worn or damaged inner CV joint.

COMMON HALFSHAFT SYMPTOMS AND CAUSES (continued)

Vibration at Speeds Over 35 mph – This concern is usually a result of a wheel or tire that is out of balance. However, it can be caused by an outer CV joint that is incorrectly seated into the wheel hub. It may also be caused by an excessively worn inner CV joint. If the halfshaft has an intermediate shaft, a worn or damaged hanger bearing may also be at fault.

Identifying the exact source of this type of vibration may be difficult in some cases. Use of the Electronic Vibration Analyzer will often make this diagnosis much easier.

Vehicle Will Not Move - If a halfshaft or CV joint breaks, or comes out of the differential side gear, the vehicle will not move due to the action of the differential.

If the inner CV joint is broken or pulled out of the differential always look for the cause. It could be a result of a misaligned transaxle, damaged motor mounts, suspension problems or some other component that would allow the transaxle or wheel to shift from their correct operating position.

HALFSHAFT SERVICE PROCEDURES

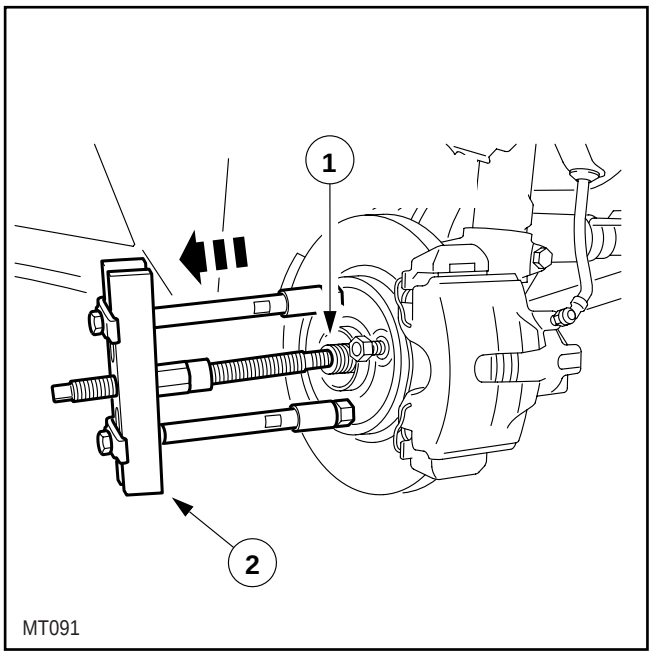
The service procedures for halfshafts will be different depending on whether you are working on an inner or outer CV joint. On some inner CV joints the joints themselves are not serviceable. If more than a boot replacement is needed, the entire shaft must be replaced.

Service procedures will also vary based on the type of CV joint is being serviced. When servicing vehicle halfshafts, always refer to the vehicle workshop manual for specific procedures.

REMOVAL PROCEDURES

Although each vehicle has special halfshaft removal procedures, some common steps should be observed with all vehicles. The following are some of these common procedures.

CAUTION: To avoid damage joints and boots, do not bend the inner halfshaft joint by more than 18 degrees, the outer one by not more than 45 degrees. Do not allow the halfshaft to hang from either CV joint.



Removing Halfshaft from Wheel Bearing Hub

Item	Description
1	CV Joint Stub Shaft
2	Front Hub Remover/Installer

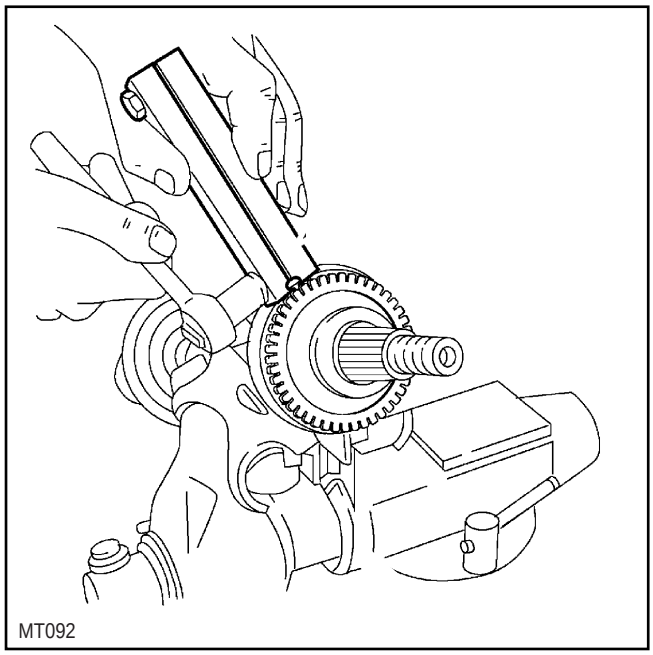
- The wheel hub and outer CV joint stub shaft are interference fit. During removal of the outer CV joint always use the appropriate puller to force the stub shaft of the joint out of the wheel hub.

CAUTION: Use of air tools during disassembly or assembly will cause hub bearing or CV joint damage.

DISASSEMBLY/ASSEMBLY AND INSPECTION PROCEDURES

The following are some common procedures to follow when disassembling/assembling and inspecting the halfshafts.

- During disassembly, after the CV boot is removed rub a small amount of the CV joint grease between your fingers. If any grit is felt it indicates the grease is contaminated and the joint must be disassembled, cleaned and repacked with new grease.
- A CV joint that has been run dry cannot be serviced. It must be replaced.
- During assembly always install new circlips or snap rings.
- When removing an inner tripod joint from the outer race, tape the rollers in place to make sure they don't fall off.



CV Boot Clamp Installation

- Only special CV joint boot clamps can be used on CV joints. Never use hose clamps or any other type of clamp to hold boots in place. Clamps can only be tightened using the correct special service tool.
- During CV joint service use only Ford High Temp Constant Velocity Joint Grease E43Z-19590-A or equivalent meeting Ford specification ESP-M1C207-A.

INSTALLATION PROCEDURES

The following are some common installation procedures.

- During installation of the halfshaft the following new parts must be installed :
  - front axle wheel hub retainer nut.
  - front suspension lower arm-to-ball joint nut.
  - circlip.
- During installation, make sure that the circlips of the inner CV joint have seated into the side gears of the transaxle after the joint is installed. This can be done by firmly pulling on the joint to make sure it has seated and that the circlips have expanded to lock it in place.
- Use of the special service tool during installation of the outer CV joint is critical. The interference fit splines of the CV joint must be fully seated into the wheel hub before installing the wheel hub retainer nut. NEVER draw the CV joint into the hub by tighten ing the nut.

REVIEW QUESTIONS

Directions: Use the information you have learned in this lesson to answer the following questions.

1. The halfshaft does all of the following EXCEPT:
   A. transfer power between the transaxle and wheel hubs.
   B. change length to allow for suspension travel.
   C. allow smooth power transfer during turns.
   D. allow smooth shifting between forward and reverse.

2. Which of the following components help eliminate torque steer?
   A. The inner CV joint
   B. The intermediate shaft
   C. The outer CV joint
   D. The halfshaft retaining clips

3. What is the purpose of the interference fit splines of the outer CV joint?
   A. To eliminate backlash between the wheel hub and halfshaft.
   B. To reduce the amount of lateral runout of the halfshaft.
   C. To allow the CV joint to pivot during turns.
   D. To eliminate the backlash between the tripod joint and the wheel hubs.

4. A popping sound during a sharp turn at low speeds is a common symptom of a damaged:
   A. inner CV joint .
   B. intermediate shaft.
   C. outer CV joint.
   D. loose dynamic dampener.

5. All of the following must be replaced with new parts during the installation of a halfshaft EXCEPT:
   A. front axle wheel hub retaining nut.
   B. front suspension control arm bushing.
   C. circlip.
   D. front suspension lower arm-to-ball joint nut.

REVIEW QUESTION ANSWERS APPENDIX

LESSON 1 REVIEW QUESTION ANSWERS

Directions: Use the information you have learned to answer the following questions.

1. The rotating force created by an engine is called:
   A. Differential action
   B. Gear Ratios
   C. Torque
   D. Rolling resistance

2. Which of the following let transmissions multiply engine torque?
   A. Differential action
   B. Gear Ratios
   C. Torque
   D. Rolling resistance

3. The rate of speed that work is done is called:
   A. Powerflow
   B. Torque
   C. Differential action
   D. Power

4. The path power takes from the engine to the wheels is:
   A. Powerflow
   B. Torque
   C. Differential action
   D. Power

5. Match the component on the left with its correct function on the right by. Write the letter corresponding to the correct function in the space between the component and function descriptions.

Component		**Function**
A. Manual Transmission	**B**	Couples and uncouples the engine from the transmission.
B. Clutch	**A**	Multiplies torque on rear wheel drive vehicles.
C. Halfshaft	**D**	Provides differential action on front wheel drive vehicles.
D. Manual Transaxle	**C**	Transfers power to the front wheels on front wheel drive vehicles.

REVIEW QUESTION ANSWERS APPENDIX

LESSON 2 REVIEW QUESTION ANSWERS

Directions: Use the information you have learned to answer the following questions.

1. When the clutch is engaged all of the following is true EXCEPT the:
   A. clutch pedal is up.
   B. pilot bearing is allowing the crankshaft to spin without turning the input shaft.
   C. pressure plate locks the friction disc to the flywheel.
   D. dampening springs of the clutch are dampening out engine pulsation.

2. Which of the following components attaches to the splines of the transmission input shaft?
   A. The release bearing
   B. The pressure plate
   C. The pilot bearing
   D. The clutch disc

3. What should always be done after installing a new clutch assembly on a vehicle equipped with a hydraulic clutch?
   A. Reset the self-adjuster.
   B. Adjust the self-adjusters on the pressure plate.
   C. Bleed the hydraulic system.
   D. Install a new thrust bushing on the clutch pedal.

4. When performing a stall test you should do all of the following EXCEPT:
   A. place the transmission in 1st gear.
   B. increase engine speed to 2000 rpm.
   C. release the clutch pedal slowly.
   D. block the wheels and apply the parking brake.

5. If you have a damaged pilot bearing, which of the following would MOST LIKELY be the symptom that would occur?
   A. Squeaking noise when the clutch is engaged or released.
   B. A bearing noise that occurs only when the clutch pedal is depressed with transmission in gear.
   C. A bearing noise that occurs when the clutch pedal is depressed or released.
   D. A rattling noise that occurs only when the clutch pedal is released.

6. Adjustable pressure plates must be:
   A. Machined before they are installed.
   B. Adjusted after they are installed.
   C. Adjusted using the cable linkage system.
   D. Adjusted before they are installed.

REVIEW QUESTION ANSWERS APPENDIX

LESSON 3 REVIEW QUESTION ANSWERS

Directions: Use the information you have learned to answer the following questions.

1. Transmission gears sets can do all of the following EXCEPT:
   A. multiply torque and decrease speed.
   B. increase speed and increase torque.
   C. transfer torque and leave the speed the same.
   D. change the direction of torque.

2. What must be done in order to get the output gear to rotate in the same direction as the input gear?
   A. A third gear must be added.
   B. Spur gears must be used.
   C. Two additional gears must be added.
   D. Helical gears must be used.

3. Which of the following is a disadvantage of helical gears?
   A. They are noisy.
   B. They have only one tooth in contact with each other at a time.
   C. They cannot slide into and out of contact with each other.
   D. They cannot be used for Reverse gears.

4. Which of the following types of gear is used for side gears in a manual transaxle?
   A. Spur gear
   B. Helical gear
   C. Hypoid gear
   D. Spur bevel gear

5. A driving gear has 20 teeth and is turning with 20 ft-lbs of torque. The gear it is driving has 100 teeth. How much torque is the driven gear producing?
   A. 40 ft-lbs
   B. 80 ft-lbs
   C. 100 ft-lbs
   D. 400 ft-lbs

6. What type of gear is represented by a gear ratio of .69:1?
   A. Gear Reduction
   B. Direct drive
   C. Overdrive
   D. Reverse

REVIEW QUESTION ANSWERS APPENDIX

LESSON 4 REVIEW QUESTION ANSWERS

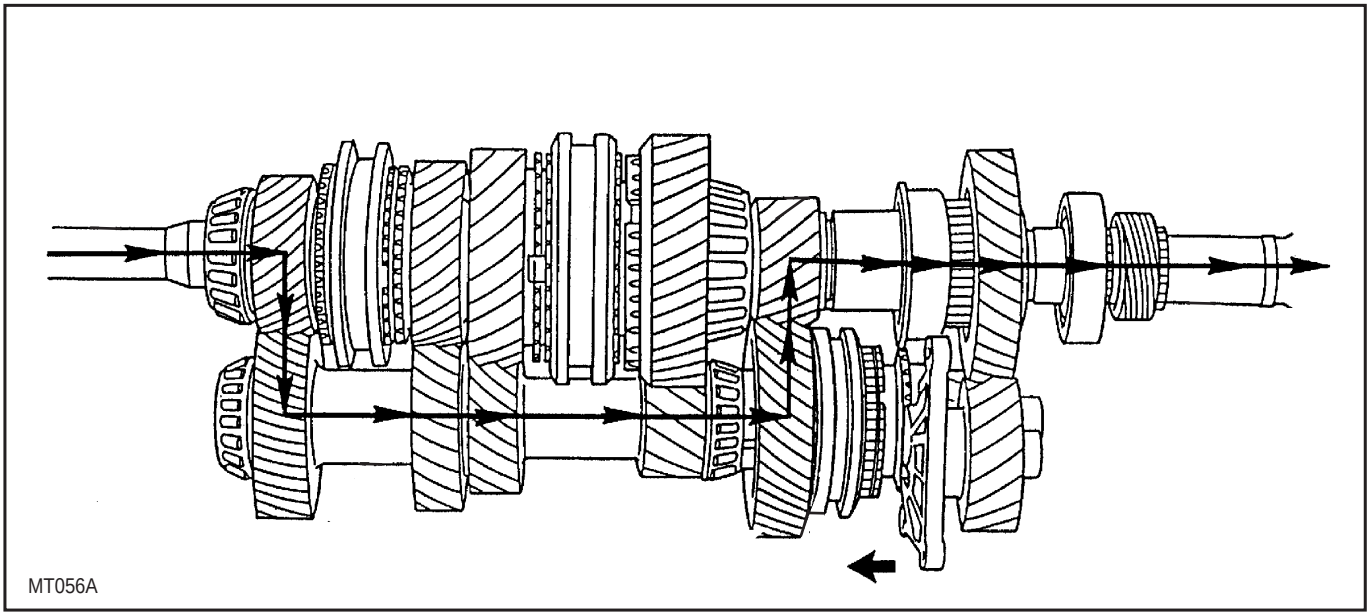
Directions: Use the information you have learned in this lesson to answer the following questions.

1. All of the following are true about manual transmissions EXCEPT:
   A. Uses different size gears to provide mechanical advantage over the driving wheels.
   B. Torque is sent from the engine to the transmission through an input shaft.
   C. Manual transmissions are used on rear wheel and four-wheel drive vehicles.
   D. Manual transmissions use the clutch to multiply the engine's torque.

2. On a 3-speed transmission, torque from the input shaft goes through the countershaft and to the output shaft in all the gears EXCEPT:
   A. 1st
   B. 2nd
   C. 3rd
   D. Reverse

3. The purpose of shift fork is to move the:
   A. selector shaft.
   B. synchronizer sleeve.
   C. countershaft into mesh.
   D. input shaft into mesh.

4. In the art below, what gear is engaged?



   A. 2nd
   B. 4th
   C. 5th
   D. Reverse

LESSON 4 REVIEW QUESTION ANSWERS (continued)

5. A vehicle is brought to you with a manual transmission that has a knocking noise in all gears. Which of the following would MOST LIKELY cause this?
   A. Damaged teeth on the input gear.
   B. Damaged plastic pads on the shift fork.
   C. Damaged clutching teeth on the countershaft.
   D. Damaged 4th gear blocking ring.

6. Which of the following blocking rings are out of specifications on a transmission that has a blocking ring clearance of 0.030?
   A. 0.035
   B. 0.025
   C. 0.032
   D. 0.040

REVIEW QUESTION ANSWERS APPENDIX

LESSON 5 REVIEW QUESTION ANSWERS

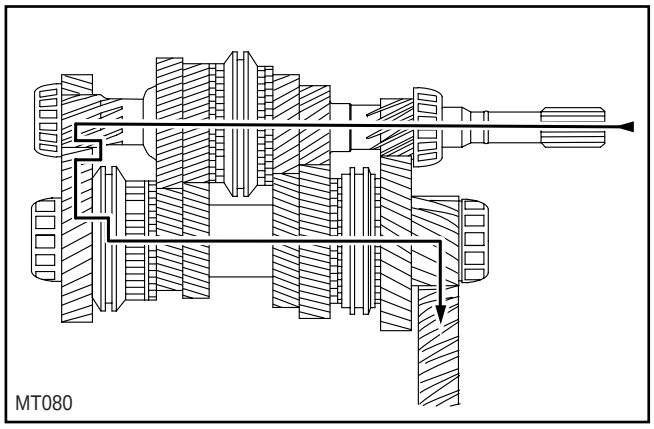
Directions: Use the information you have learned in this lesson to answer the following questions.

1. A manual transaxle has all of the following components EXCEPT:
   A. synchronizers
   B. input shaft
   C. countershaft
   D. shift linkage

2. What is the purpose of the differential?
   A. To allow for differences in wheel rotation speed during turns.
   B. To allow for differences between the input shaft and output shaft.
   C. To allow for differences between the shift lever position and the shift forks.
   D. To allow for differences in rotating speed between the engine and the input shaft.

3. When driving straight ahead the pinion gears are:
   A. rotating at the speed of the halfshafts.
   B. not rotating.
   C. synchronized to maintain correct speed.
   D. not meshed.

4. What gear is the transaxle in the art below engaged in?



   A. 1st
   B. 3rd
   C. 5th
   D. Reverse

LESSON 5 REVIEW QUESTION ANSWERS (continued)

5. Which of the following is MOST LIKELY to cause a hard shifting concern on a manual transaxle?
   A. Damaged differential side gears.
   B. Worn input shaft bearing.
   C. Damaged cluster bearing.
   D. Damaged rod and clevis bushing.

6. When will damaged differential side gears make noise?
   A. When driving straight ahead.
   B. During turns.
   C. In neutral with the clutch pedal out.
   D. Whenever the engine is running.

REVIEW QUESTION ANSWERS APPENDIX

LESSON 6 REVIEW QUESTION ANSWERS

Directions: Use the information you have learned in this lesson to answer the following questions.

1. The halfshaft does all of the following EXCEPT:
   A. transfer power between the transaxle and wheel hubs.
   B. change length to allow for suspension travel.
   C. allow smooth power transfer during turns.
   D. allow smooth shifting between forward and reverse.

2. Which of the following components help eliminate torque steer?
   A. The inner CV joint
   B. The intermediate shaft
   C. The outer CV joint
   D. The halfshaft retaining clips

3. What is the purpose of the interference fit splines of the outer CV joint?
   A. To eliminate backlash between the wheel hub and halfshaft.
   B. To reduce the amount of lateral runout of the halfshaft.
   C. To allow the CV joint to pivot during turns.
   D. To eliminate the backlash between the tripod joint and the wheel hubs.

4. A popping sound during a sharp turn at low speeds is a common symptom of a damaged:
   A. inner CV joint.
   B. intermediate shaft.
   C. outer CV joint.
   D. loose dynamic dampener.

5. All of the following must be replaced with new parts during the installation of a halfshaft EXCEPT:
   A. front axle wheel hub retaining nut.
   B. front suspension control arm bushing.
   C. circlip.
   D. front suspension lower arm-to-ball joint nut.