Figure 125-1 The differential assembly changes the direction of engine torque and increases the torque to the drive wheels.

Figure 125-2 The difference between the travel distance of the drive wheels is controlled by the differential.
Figure 125-3 When the vehicle turns a corner, the inner wheel slows and the outer wheel increases in speed to compensate. The difference in rotational speed causes the pinion gears to "walk" around the slower side gear.

Figure 125-4 A hypoid gear set uses a drive pinion that meshes with the ring gear below the center line of the ring gear.

Figure 125-5 The differential case provides the support for the ring gear, side bearings, and side gears.
Figure 125-6 The relationship among the ring gear and drive pinion as well as the side and spider gears.

Figure 125-7 The drive side is the convex side of the ring gear except for some front axle used in four-wheel vehicles, and they often use the concave side on the drive side.

Figure 125-8 A close-up view of the side gears and spider (pinion) gear. Note the ridges on the gear teeth. These ridges are manufactured into the gear teeth to help retain lubricant so that no metal-to-metal contact occurs.
Figure 125-9  (a) A two-wheel-drive vehicle equipped with an open differential. (b) A two-wheel-drive vehicle equipped with a limited-slip differential.

Figure 125-10  Trac-loc limited-slip differential. This type of limited-slip differential uses the frictional force between a pair of clutch packs and the torque generated in the ring gear by the two side gears at different rates to apply the clutches and limit the amount of difference in the speed of two axles.

Figure 125-11  An Eaton locker differential.
REAL WORLD FIX: I Used to Have a Limited-Slip Differential

An owner of a Chevrolet S-10 pickup truck equipped with a 5.0L and five-speed manual transmission complained that he used to be able to spin both rear tires on dry pavement, but lately only one rear tire. The service technician assigned to the repair order was very familiar with what might have occurred. Many General Motors pickup trucks are equipped with an Eaton locking differential that uses a torque-limiting disc. The teeth of this disc are designed to shear to prevent the possibility of breaking an axle. ■ SEE FIGURE 125–12.

The service procedure to correct the customer's concern is to replace the left-hand clutch plates. Usually, the shearing of the torque-limiting teeth is associated with a loud bang in the rear axle. The differential will continue to function normally as a standard (open) differential.

Figure 125–12  The Eaton design differential uses a torque-limiting disc to prevent the possibility of breaking an axle in the event of a high-torque demand. When the disc tangs shear, the differential will continue to function but as an open rather than as a limited-slip differential.

Figure 125–13  A Torsen differential. This type of differential provides torque to both drive wheels even if one tire is on ice. The complex system of gears allows this smooth transfer of torque without the use of clutches.
Figure 125-14  This pinion flange is equipped with a damper weight to help dampen driveline vibrations.

Figure 125-15  A collapsible spacer-type drive pinion shaft.

Figure 125-16  Side bearings are press fit on the differential case.
Some side bearings use threaded adjusters to adjust preload.

The axle shaft itself is the inner race if a straight roller bearing is used.

The straight roller bearings are lubricated by the rear axle fluid, and a leak at the rear axle seal can cause this fluid to get onto brake components.
Figure 125-19  The pinion gear thrust washers can be destroyed by spinning one wheel for an extended period of time.

**TECH TIP: Don’t Spin Those Wheels!**

While driving on ice or snow-covered roads, it is common to see drivers moving slowly up a hill by simply spinning one drive wheel. However, when one wheel is spinning and the other wheel is stationary (or close to stationary), the pinion gears are spinning twice as fast as the drive wheel. This spinning of the drive wheel has been known to completely wear down the pinion gear thrust washers in less than one minute!  *See Figure 125–19*. The same wear can occur if different-size tires are used on the same drive axle. Therefore, to prevent expensive repairs, avoid unnecessary tire spinning and check that both tires on the same axle are the same size, brand name, and condition.

Figure 125-20  This differential has obviously been leaking. If the differential lubricant is low, wear may have occurred that would require further inspection.
Backlash is determined by mounting a dial indicator to the differential housing and placing its button against a tooth of the ring gear. Moving the ring gear back and forth will indicate backlash on the dial indicator.

Backlash is the clearance between the drive pinion and the ring gear teeth.

Ring gear runout should be less than 0.002 inch (0.05 mm) as measured by a dial indicator.
TECH TIP: A Quick-and-Easy Backlash Test

Excessive clearance (lash) between the drive pinion and the ring gear can cause driveline clash noise during a gear selector change. To check if the cause is due to the differential, simply hoist the vehicle and, while one wheel and the driveshaft are being held stationary, use your hand to move the opposite wheel. The maximum amount the tire should move is 1 inch (2.5 cm) measured at the tread of the tire. If backlash is greater than this, then further inspection of the differential assembly is required. Besides excessive clearance between the drive pinion and the ring gear, the wear may also be between the pinion and the side gears.

Figure 125-23  Force has to be applied to the ring gear to achieve a proper contact pattern.

Figure 125-24  Tooth contact pattern.
Figure 125-25  Mark the differential bearing caps before removing them to make sure that they are replaced in the same location.

Figure 125-26  Pinion gear and associated parts. The pinion end yoke is also called the pinion flange.

Figure 125-27  The pinion on the left uses a collapsible spacer, and the pinion on the right uses shims to provide the necessary preload to the pinion shaft bearings.
Figure 125-28  The ring and pinion gears are a matched set and are marked for correct pinion depth variance.

Figure 125-29  Special tool kit used for determining the correct pinion shaft shim thickness.

Figure 125-30  Using an inch-pound torque wrench to check the rotating torque of the drive pinion. This procedure is very important if the axle uses a collapsible spacer. The drive pinion nut should be gradually tightened and the rotating torque checked to prevent overtightening the nut. If the rotating torque is higher than specifications, the collapsible spacer will require replacement and the installation procedure must be repeated.
Figure 125-31 If the ring gear has been removed from the differential case or if a new ring gear is being installed, always replace the ring gear bolts.

Figure 125-32 Backlash should be between 0.005 and 0.008 inch on most differentials. If the backlash is too great, add shim thickness to the ring gear side and subtract shim thickness from the opposite side.

Figure 125-33(a) Some vehicle manufacturers recommend using a housing spreader tool that fits into the machined openings on both sides.
Figure 125-33 (b) The spreader tool being installed. The housing is spread a specified amount and the differential is then installed into the housing.

**TECH TIP:**

*Click-Click* Is Okay — *Clunk-Clunk* Is Not

An experienced service technician was observed checking the backlash on a differential. The test involved turning the drive pinion by grasping the pinion flange and using wrist action to quickly rotate it first in one direction and then the other. The technician explained that if it made a *click-click* sound, the backlash was usually between 0.005 and 0.008 inch, which is usually within specifications for most differentials. However, if the sound made was more like a *clunk-clunk*, then the backlash was greater than 0.010 inch and had to be corrected. To summarize what the sounds mean when the drive pinion is moved back and forth:

- **No sound when turned back and forth** — too little or no backlash; backlash must be adjusted.
- **A *click-click* sound** — backlash is usually within specifications; double-check with a dial indicator and compare against specifications for the axle being serviced.
- **A *clunk-clunk* sound** — usually too much backlash; correction is required to restore proper backlash.

Figure 125-34 (a) Note the hex shape of the threaded adjuster used to adjust side bearing preload and ring gear backlash on a Dodge Dakota truck.
Figure 125-34 (b) A long handled adjuster tool is needed to turn the side bearing adjuster on this truck.

Figure 125-35 On many axles, it is necessary to use a special tool to install steel spacers (shims) to achieve the specified backlash and side bearing preload.

Figure 125-36 A spool used in a rear end for drag racing only.
Figure 125-37 Install the axle shaft, being careful to not damage the seal.

FREQUENTLY ASKED QUESTION
What Is a Spool Rear End?
A spool is a solid piece of metal that takes the place of the side gears and pinion gears in a differential assembly (See Figure 125–36). A spool used in drag racing is not suitable for street driving because the spool does not allow for any differences in the speeds of the drive wheel during cornering. Obviously, drag vehicles do not turn corners while racing and the spool rear end is one of the reasons they bounce when turning around at the end of the strip to return to the pits.

FREQUENTLY ASKED QUESTION
What Do I Do About Drive Pinion Bearing Preload When I Replace Just the Pinion Seal?
To replace a pinion seal, the drive pinion nut and pinion flange must be removed.

CAUTION: Do not use an air impact wrench on the drive pinion nut. The pinion bearings can be damaged by the impact of the wrench.

Before the nut is removed, make a mark on the pinion nut and on the axle housing. After the new pinion seal is installed, tighten the pinion nut to the same position it was in before disassembly. This extra rotation makes sure that the collapsible space (crush sleeve) is still able to maintain the proper preload on the pinion bearing. Another method is to measure the rotating torque of the drive pinion using an inch-pound beam-type torque wrench after removing both rear wheels and brake drums. After installing the replacement pinion shaft seal, tighten the drive pinion nut until the rotating torque is 3 to 5 in-lb more than the reading obtained before the pinion nut was removed.
Figure 125-38 A container of GL-5 SAE 80W-90 gear lubricant.

Figure 125-39 The beginning automotive student did not realize that the axle housing cover could fit the wrong way. The only problem was that the ring gear scraped against the cover.

REAL WORLD FIX
I Didn't Know It Would Fit the Wrong Way!
An automotive student changed the differential lubricant by removing the housing cover. The cover was reinstalled and then filled with the correct lubricant. However, when the student drove the vehicle it made a grinding sound that was not there before the differential service. When the cover was removed, it was discovered that the cover had been installed with the raised area on the right side of the housing instead of on the left side and the ring gear had rubbed a groove in the cover, as shown in Figure 125–39. Installing the cover correctly stopped the grinding sound.