CHAPTER 8

TRANSAXLE/ TRANSMISSION SERVICE

OBJECTIVES

After studying Chapter 8, the reader should be able to:

1. Perform the maintenance operations needed to keep a transaxle or transmission operating properly.
2. Diagnose the cause of common transaxle/transmission problems.
3. Recommend the proper transaxle/transmission repair method.
4. Remove and replace a transaxle or transmission.
5. Overhaul a transaxle or transmission.
6. Inspect used transaxle/transmission components to determine their condition and usability.
7. Complete the ASE tasks for transmission and transaxle diagnosis and repair.

KEY TERMS

Brinelling (p. 209)
Burr (p. 204)
Chip (p. 204)
Contamination (p. 209)
Crack (p. 204)
Differential clearance (p. 220)
Dynamic shift test (p. 183)
Electric arcing (p. 209)
End play (p. 227)
Engine support (p. 186)
Excessive wear (p. 204)
Fretting (p. 209)
Galling (p. 204)
Gear clash (p. 181)
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Jumps out of gear (p. 179)
Leak (p. 178)
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Nick (p. 204)
Noisy transmission (p. 181)
Peeling (p. 209)
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Step wear (p. 204)
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INTRODUCTION

Transaxle/transmission service includes preventive maintenance, problem diagnosis, and transaxle/transmission repair and overhaul. On most transmissions, the extension housing bushing and seal, backup light switch, and speedometer gear can be serviced with the transmission still in the vehicle. On some transmissions, the side cover with the shift mechanism can also be removed for service and inspection of the gears.

In-vehicle service for most transaxles includes replacement of the output shaft seals, the backup light switch, and the speedometer gear. The left-side bearings and portions of the gear set can be removed, checked, and replaced with some transaxles.

These service operations vary depending on vehicle manufacturer and the transmission model. Service information should be consulted to determine what operations are required and how they should be performed.

TRANSAXLE/TRANSMISSION IN-VEHICLE SERVICE

In-vehicle service, also called on-vehicle service, in most cases is a normal maintenance operation. It includes a periodic check of the lubricant level, linkage adjustment, mount replacement, and visual inspection for leaks and other abnormal conditions. Other repair operations are done on an as-needed basis. When a problem such as hard shifting occurs, the shift linkage is also checked and readjusted, if necessary. If possible, service and repair operations are done with the transaxle/transmission in the vehicle. Transmission removal and replacement (R&R) takes about 2 1/2 hours; transaxle removal and replacement may take up to 4 1/2 hours. This varies greatly depending on the vehicle and the experience of the technician, but in any case, transmission/transaxle removal and replacement is time consuming.

Lubricant Check

Often, the **lubricant check** is a neglected operation in our modern, fast-paced world. It is recommended to check the lubricant level at each engine oil change and is normally performed together with the other routine fluid checks. With the correct fluid level, most transaxle/transmissions can operate for the life of the vehicle, but the gears and bearings can cook in a few minutes if operated while low on lubricant. A transmission usually requires that the vehicle be raised to gain access to the filler/level plug. While checking fluid level, you should also note the condition of the fluid.

TECH TIP

Manual transmission fluids should remain in like new color and smell. Dirty fluid should be changed. Fluid with silver or gold metallic flakes indicates severe wear inside the transaxle/transmission.

To check the fluid level in a transmission/transaxle:

1. Park the vehicle on a level surface. Raise and securely support a transmission-equipped vehicle on a hoist or jack stands.

   CAUTION: When working under a vehicle that is raised, make sure that it is supported securely in the proper manner.

2. If equipped with a dipstick, remove the dipstick, wipe it clean, reinsert it making sure it goes completely into the opening, remove it again, and read both sides (Figure 8-1).

   NOTE: If there is a difference in the readings, believe the lower one. The fluid level should be between the "full" and "low" marks.

   If equipped with a level plug, remove the plug, being prepared for a fluid spill due to a possible high fluid level. The fluid level should be even with the bottom of the opening (Figure 8-2a).

TECH TIP

If you cannot see any fluid, carefully insert a finger straight into the opening, and then bend it downward to serve as a level indicator (Figure 8-2b). Remove your finger, and check the fluid level on it.

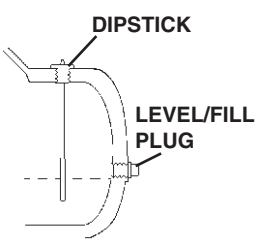


FIGURE 8-1 Some transaxles and transmissions use a dipstick to check the oil level.

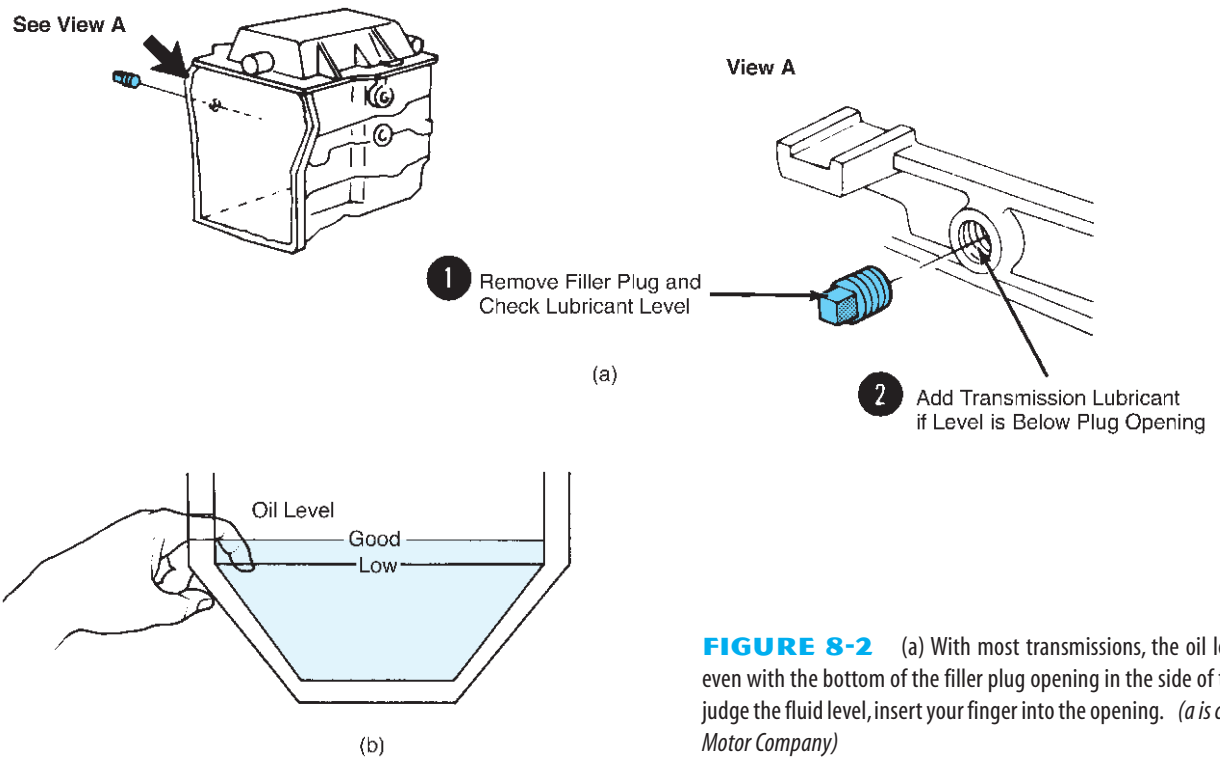


FIGURE 8-2 (a) With most transmissions, the oil level should be even with the bottom of the filler plug opening in the side of the case. (b) To judge the fluid level, insert your finger into the opening. *(a is courtesy of Ford Motor Company)*

3. If the fluid level is low, add the proper fluid to bring it to the correct level. Also, check for leaks or the reason for the low fluid level. If the level is high, drain out the excess fluid.

Lubricant Change. Some manufacturers recommend changing the lubricant after the first 5,000 miles (8,000 km) and then every 30,000 miles (48,000 km) after that. This removes any metal contaminants that can increase wear and helps ensure good lubrication. Draining the lubricant when it is hot, after driving the vehicle, helps the fluid drain faster.

REAL WORLD FIX

A 1996 Acura Integra (140,000 mil) came in with a hard shifting complaint. A road test confirmed that you have to lightly force the shift into every gear. There is no grinding that would indicate faulty clutch operation. The fluid level is good, and it seems to be 5W/30.

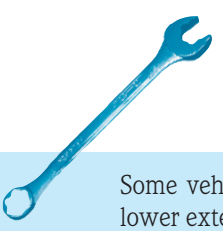
The technician drained, flushed, and filled the transaxle with Honda MTF, and this fixed the hard shift problem.

TECH TIP

Gear oil breaks down at temperatures over 275°F (528°C). It should be changed immediately if subjected to these temperatures.

To change transaxle/transmission fluid, you should:

1. If possible, drive the vehicle to bring the lubricant up to operating temperature.
2. Raise and securely support the vehicle on a hoist or jack stands.
3. Locate the drain plug at the bottom of the transaxle/transmission, place a drain pan under it, and remove the drain plug.



TECH TIP

Some vehicles do not have a drain plug. The lower extension housing bolts are often drilled through to the inside of the case so these bolts can be removed to drain the case.

4. Allow the lubricant to drain out completely before replacing the plug.

NOTE: It is recommended to wrap Teflon tape around the threads of drain plugs using tapered pipe threads to prevent leaks.

5. Inspect the old lubricants for any contamination, and dispose of it in the proper manner.
6. Check the vehicle's owner's manual or shop information system to determine the correct lubricant type and refill quantity.
7. Refill the transaxle/transmission to the correct level.

TECH TIP

Many transmissions do not use the 90-weight gear oil of the past. If the wrong lubricant is put into a transmission, it can soak into the nonmetallic blocker ring lining that is commonly used today. Even if drained immediately and refilled with the correct fluid, noise or erratic shifts can occur.

TECH TIP

Many shops have found that the wrong fluid can produce problems. In 90% of the cases, OEM fluids make the transmission operate as it was designed.

TECH TIP

It is normally recommended to use the manufacturer's recommendation for the fluid type and amount. If a unit is noisy or experiences hard shifting, a fluid replacement might cure the problem. A lubrication guide showing the recommendation of a leading rebuilder of manual transmissions and transfer cases is given in Appendix B.

REAL WORLD FIX

A 1984 Porsche Carrera (68,000 mil) had a slight grind when shifting up or down into second gear. The transmission was overhauled using new shift sleeves, synchronizers, 1–2 and 3–4 forks and brake bands, and a few bearings as needed.This did not cure the problem. The transmission was disassembled again, and the second gear set was replaced. The rest of the transmission appeared good, but the second gear-shift grind was still there.

The 80–90, GL-5 gear oil was replaced with synthetic gear oil, and the shift coupler, that appeared good, was replaced. This fixed this shift problem.

Transaxle Linkage Adjustment

The exact method of adjusting transaxle shift linkage varies among manufacturers. Some provide no adjustment; others provide adjustments with gauging methods to ensure accuracy. The description provided here is a composite of the procedure for two different domestic cars.

To adjust the shift linkage for a transaxle:

1. Shift the transaxle into neutral, and position the shift lever in the 1–2 neutral position.
2. Remove the lock pin or adjustment hole plug from the selector shaft housing.
3. Depending on the vehicle, reverse the pin and replace it with the long end inward (Figure 8-3) or install a gauge pin of the correct size into the opening. This should lock the transaxle selector shaft in the 1–2 neutral position.
4. If the shift lever is not in the 1–2 neutral position, loosen the shift linkage clamp bolt, move the shift lever to the 1–2 neutral position, and retighten the clamp bolt to the correct torque (Figure 8-4).
5. Remove the gauge pin, reinstall the adjustment hole plug (or reverse the pin), and tighten it to the correct torque.
6. Move the gear selector to each gear position, checking for smooth operation and complete engagement. It might be necessary to start the engine and slip the clutch to align the gears to allow shifting.

Transmission Linkage Adjustment

Transmissions that use internal linkage usually do not have a linkage adjustment. Most transmissions with external shift

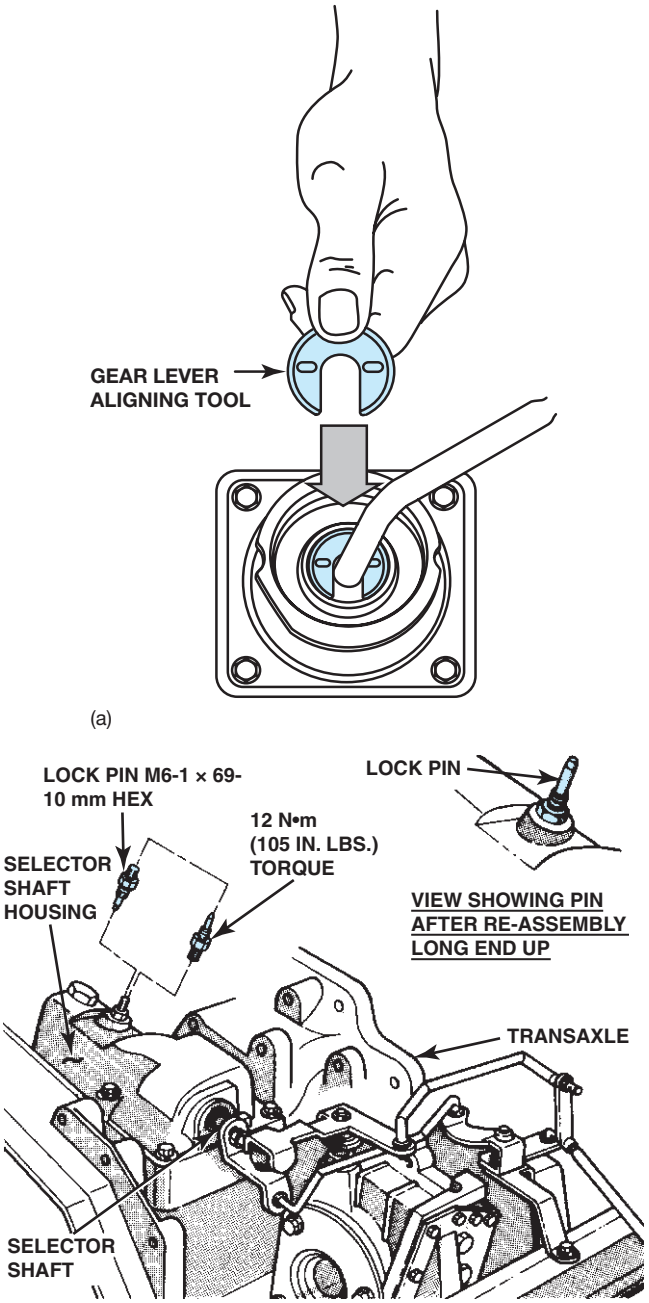


FIGURE 8-3 (a) An opening for an alignment tool to aid in the shift linkage adjustment is provided in some transaxles. (b) With some, the plug for the opening can be turned around and used for the gauge pin. *(b is courtesy of DaimlerChrysler Corporation)*

mechanisms provide a gauge pin hole to lock the shift assembly levers in neutral.

To adjust the shift linkage on a transmission:

1. Raise and support the vehicle securely on a hoist or jack stands.

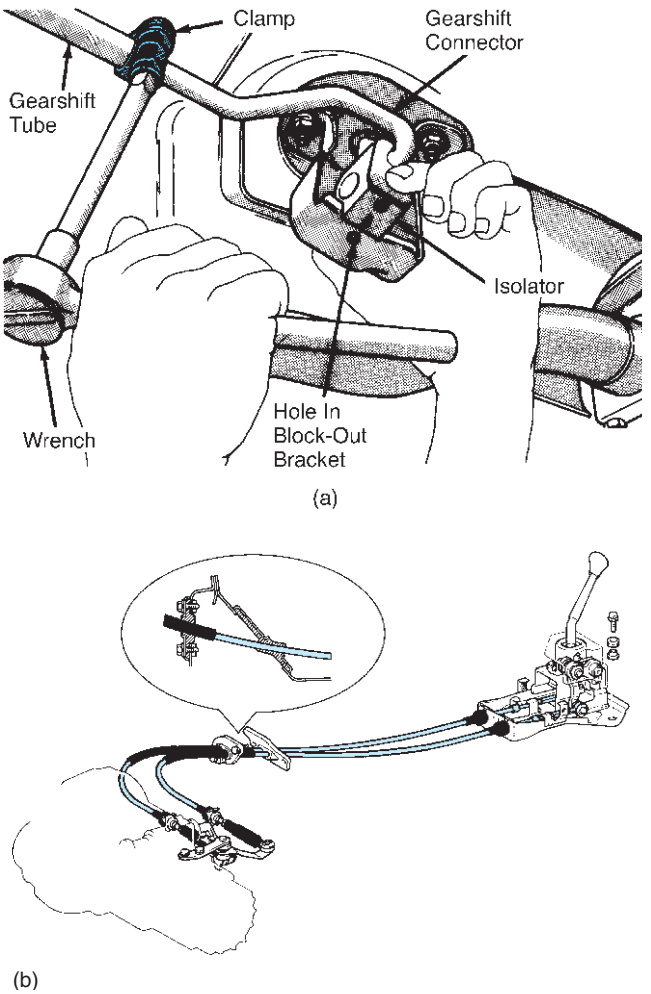


FIGURE 8-4 Loosening the clamp on the gearshift tube allows adjustment of the tube length and positioning of the shift lever (a). On vehicles using cable linkage, an adjustment is provided at the cable ends (arrows) (b). *(a is courtesy of DaimlerChrysler Corporation; b is courtesy of Toyota Motor Sales USA, Inc.)*

TECH TIP

Many technicians use the smooth end of the largest drill bit that will pass through the hole for a gauge pin.

2. Place the linkage in neutral. Locate the gauge pin hole, and install a pin of the correct size into the hole (Figure 8-5). This should lock all of the shift levers into neutral.
3. Disconnect one end of a shift rod, move the shift rod or shift lever to locate the neutral detent in the transmission, and check to see if the rod is the exact length to reconnect. If the rod is the wrong length, adjust it as

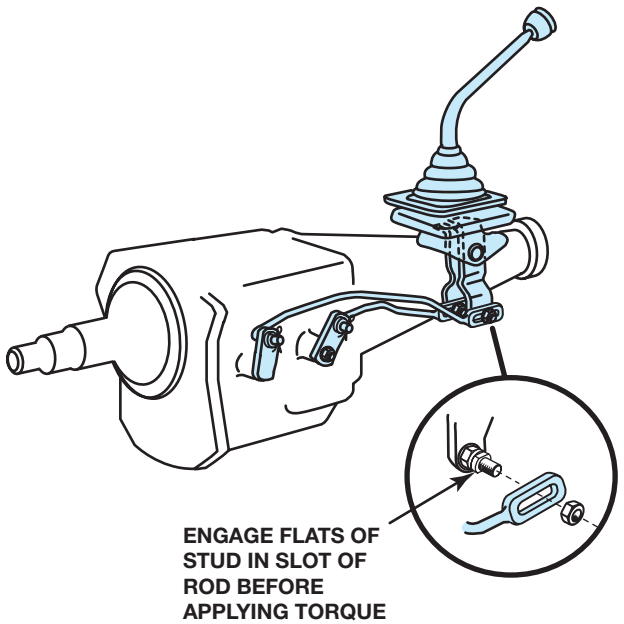


FIGURE 8-5 This transmission-mounted shifter has a hole so an alignment pin can be inserted to hold the shift levers in neutral. The shift rods are adjusted at the shifter end.

necessary. Reconnect the first rod, and repeat this operation on the remaining shift rods.

4. Remove the gauge pin, and move the shift lever to each gear position, checking for smooth operation and complete engagement.

Align Transaxle Mounts

The mount for a RWD transmission is aligned by the mounting bolts, so there are few problems with the mount or its replacement. A FWD transaxle must be aligned to the two front driveshafts. The alignment check is accomplished by completely compressing both inboard CV joints and measuring the distance between the joint and the transaxle (Figure 8-6). The position of the transaxle is then adjusted so that both distances are equal. Adjustment is accomplished by loosening the mounts and sliding the engine and transaxle sideways.

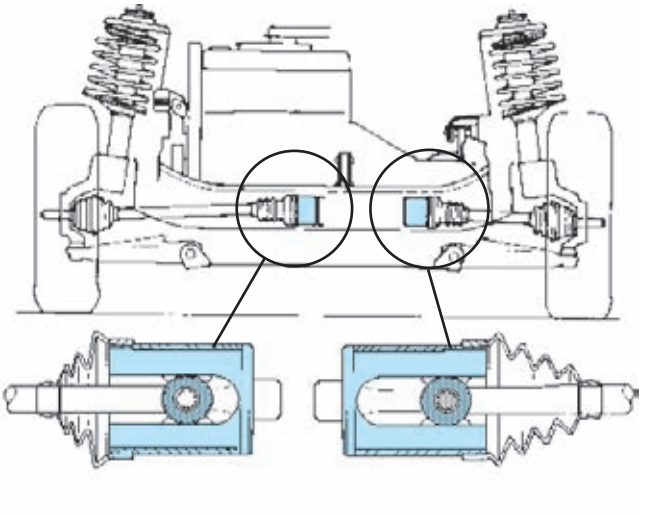


FIGURE 8-6 The enlarged views of the inner CV joints show that the engine and transaxle are misaligned; they should be moved toward the right.

REAL WORLD FIX

A 1996 Pontiac Grand Am (103,000 mil) will not shift into reverse, second, or fourth gears; all of these gears require a rearward movement of the shift lever. The transaxle can be shifted into these gears when the shift cables are disconnected and the levers moved manually. Both shift cables move normally and appear good.

Closer inspection of the selector cable, under the rubber sheath, showed a separation of the cable housing. Replacement of the selector cable fixed this problem.

REAL WORLD FIX

A 2001 Mazda Tribute ES (20,000 mil) had a vibration problem. It occurred while driving uphill just before the 4–3 downshift, and it lasted for a few seconds. The vibration seemed to be coming from the left front. A visual inspection of the transmission and driveshaft showed nothing wrong.

Replacement of the transmission mounts cured this problem.

PROBLEM DIAGNOSIS

Most transaxle/transmission problems fall into one of these categories:

- **Leak:** fluid escapes from the transaxle/transmission
- **Hard shift:** requires an abnormally high amount of force to shift into gear
- **Shift blockout:** will not shift into one or more gears
- **Locked into gear:** will not shift out of a gear

- **Jumps out of gear:** will shift into neutral on its own
- **Clash/grinding during shift:** gear clash/grinding noise and vibration occur as shift is made
- **Noisy in neutral:** a grinding, growling noise while in neutral
- **Noisy in one gear:** a grinding, growling bearing noise or rough growling, buzzing gear noise in only one gear
- **Noisy in all gears:** same as above but in all gears
- **Noisy in all reduction gear ranges:** same as above, but quiet in the 1:1 gear range.

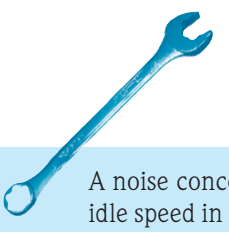
TECH TIP

An experienced technician completely diagnoses transmission concerns before removing the transmission. Once the transmission is out of the vehicle, it is too late to run further tests, so guessing begins as to what caused the problem.

REAL WORLD FIX

The clutch was replaced in a 1990 Honda Civic (150,000 mil). The customer came back with a complaint of noise, so the release bearing was replaced, but the noise was still there.

Further tests showed the noise to be the input shaft bearings. Replacement of these bearings cured this noise complaint. A more thorough diagnosis before replacing the clutch would have caught these other two problems and would have saved pulling the transaxle three times.



TECH TIP

A noise concern that occurs with the vehicle at idle speed in neutral can be caused by harmonic vibrations. Slowly increase engine speed to about 2500 rpm; if the noise goes away, it is engine harmonics. The problem is not in the transmission; it could be caused by a faulty clutch disc damper, bad dual-mass flywheel, or out-of-tune engine.

REAL WORLD FIX

A 1994 Ford Ranger pickup (148,000 mil) has a definite fluid leak, but they cannot find the source. The technician has asked if it would be a good idea to put a sealer on each of the transmission bolts.

Following advice, the technician checked the rubber plugs for the three shift rails, and they were leaking. Removing the transmission support allowed lowering the transmission for access. Replacement of the rubber plugs with iron plugs fixed this problem.

REAL WORLD FIX

A 1997 Mitsubishi Mirage (53,000 mil) would always grind on the 1–2 shift when it was cold. There was also difficulty shifting into first. Inspection of the internal parts showed no abnormal wear or abuse. The transmission had been rebuilt three times by the dealer and had updated synchronizers installed.

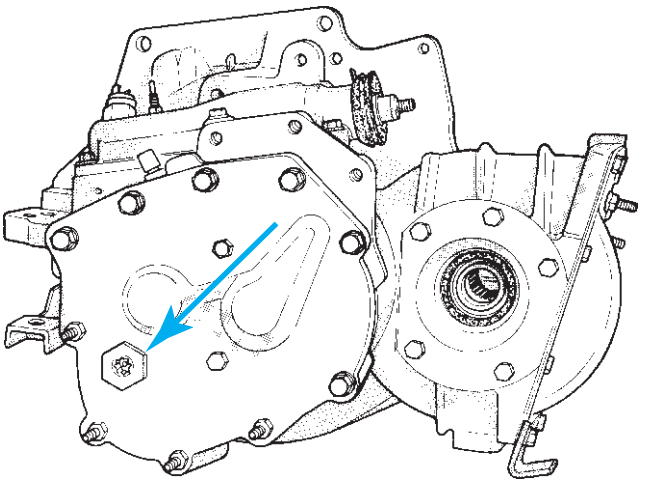
Replacement of the gear oil with 30-weight nondetergent engine oil cured this shift problem.

NOTE: This repair is not recommended by most vehicle manufacturers. A better choice would have been to use a synthetic gear oil.

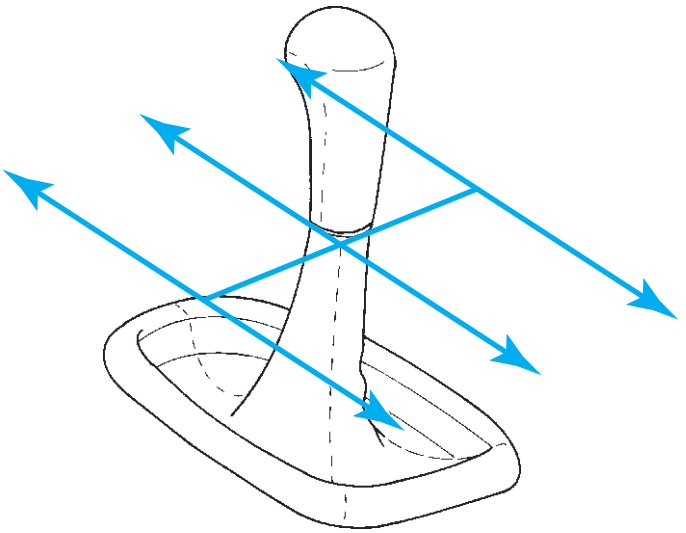
REAL WORLD FIX

A 2000 Volkswagen Jetta (67,000 mil) makes a loud bang type of noise as the clutch is let out. At times, the noise also occurs during a gear or throttle change. A visual inspection shows that there is a lot of backlash inside the transaxle. There are metal flakes in the oil drained from the transaxle.

Transaxle disassembly revealed that the rivets holding the final drive ring gear to the differential case were loose, and the holes in the gear and case were wallowed out. Replacement of the differential and ring gear with a used assembly fixed this problem.



(a)



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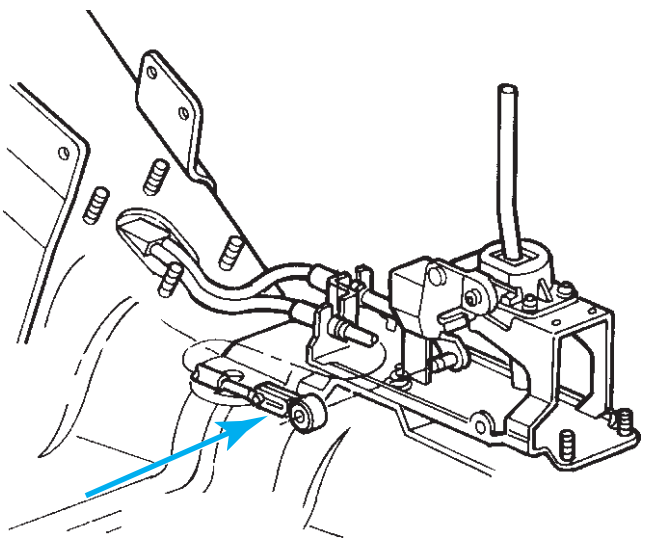

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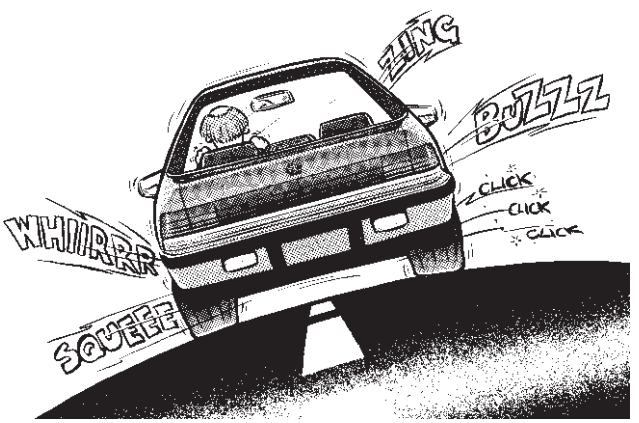


(d)

FIGURE 8-7 When diagnosing transmission problems, begin by making sure that the lubricant is at the proper level (a); next, operate the shift levers through all of the gears with the engine off and again with it running (b). If necessary, adjust the shift linkage (c). When making a road test, listen for unusual noises and check for proper operation (d).

Many of these conditions result from internal problems and will require transaxle/transmission removal for repair, rebuilding, or replacement. A few problems can be cured while the unit is in the vehicle (Figure 8-7).

An experienced technician will usually follow a test procedure that varies depending on the nature of the customer's concern and the technician's experience with the particular transaxle/transmission. Visual inspection for leaks or exterior damage, clutch pedal free play, engine-off shift tests, engine-running shift tests, and a road test are checks that can be made during problem diagnosis.

Transmission Noises

Noise problems fall into the noise, vibration, and harshness (NVH) category. Manual transmission noises will vary greatly between different makes and models. Some older transmission models were very noisy, especially in reverse or first gear; most modern units operate quietly. These variations are due to build/manufacturing variations, transmission type (heavy duty trucks are usually noisier), clutch disc damper, flywheel type, and amount of vehicle noise insulation. Some transmission noises are caused by the uneven power flow pulses from

TECH TIP

A **noisy transmission** usually has gear or bearing damage and probably needs repair. One rebuilder recommends draining the fluid from a noisy transmission, inspecting the drained fluid for metal particles, and if there is any doubt of its condition, refilling it with ATF and repeating the road test. If the unit is still noisy, it has internal damage. If the unit is filled with 90-weight gear oil, the heavy oil could cushion the worn parts and muffle the noise. This gives the impression that the problem is fixed, but it really only puts it off for a while. After the test drive, refill the transmission with the lubricant recommended by the manufacturer or in Appendix B.

TECH TIP

Don't forget that a bearing noise problem while in neutral with the clutch disengaged is related to clutch bearing noises. See Chapter 5.

TECH TIP

Don't forget that noises travel. For example, the drive shaft can transmit rear drive axle noises so they seem to be coming from the transmission. An NVH diagnostic tool, Chassis Ear, consists of a head set and six sensors that can be attached to various locations under the vehicle (see Figure 10-4). The vehicle is then driven on a road test while the technician listens to each of the six different locations. This should help locate the exact source of the noise.

REAL WORLD FIX

A 1991 Mustang (125,000 mil) five-speed transmission developed a whining noise in first, second, and third gears after a fluid change. Dexron II ATF, the recommended fluid, was used, but it was noticeably different from the fluid drained out. The transmission shifts smoothly through all gears.

Following advice, the technician removed and disassembled the transmission. The input/main drive gear teeth were found to be worn to a knife edge. Replacing this gear along with the cluster gear fixed this noise problem. A rebuild/small parts kit was installed at the same time.

Apparently, the gear wear was caused by a low fluid level and thicker gear oil was used to cover up the noise. This can create a future problem because the thick fluid cannot lubricate needle bearings properly.

the engine. Poor dampening of these pulses produce noise as the gears speed up and slow down; the gears will slap each other and make metallic rapping noise.

Some of the more common noise problems are called:

- **Gear rattle:** normally occurs as the vehicle is driven and is usually most noticeable while accelerating at low rpm and lugging the engine.
- **Neutral rattle/rollover:** occurs with the engine running in neutral with the clutch engaged.
- **Backlash**: occurs when the driveline load or direction is changed like when the throttle is changed abruptly or when the vehicle is brought to a stop and shifted into reverse.
- **Gear clash:** the grinding that occurs if the clutch is released too quickly while making a shift or a shift is made too quickly with nonsynchronized gears. Clash can be the result of improper shifts (rushed too quickly), wrong gear oil, or worn synchronizers.

TECH TIP

Noisy operation along with fourth-gear jump-out can be caused by a misaligned clutch housing. If transmission disassembly reveals no internal problem, check clutch housing alignment as described in Chapter 5.

REAL WORLD FIX

A 1996 GMC Sonoma pickup (37,000 mil) had a noisy transmission. The noise stopped as the clutch pedal was depressed. The gear oil was drained and inspected; there were no signs of metal. It was refilled using the correct GM fluid, and the noise was still there. The transmission was disassembled, and new bearings and seals were installed. This did not help.

The addition of an aftermarket, high-viscosity gearbox additive quieted this unit somewhat.

TECH TIP

If a leak is noted and you are trying to locate its source, remember that a fluid normally runs downward and that the wind under the vehicle will move the fluid to the rear, so the point of leakage is normally above and forward of the fluid drips.

Visual Check

Visual checks are made both under the hood and under the vehicle. **The under-the-hood checks are for:**

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

The under-the-vehicle checks are for:

- Damage to the transaxle/transmission case, mounts, and support
- Worn, bent, or sloppy shift linkage
- Loose or missing transaxle/transmission or clutch housing mounting bolts
- Fluid leaks from the transaxle/transmission or clutch area

Engine-Off Shift Test

The engine-off shift test, also called a **static shift test** or a **shift effort test**, measures the amount of effort it takes to move the synchronizer sleeve or gear, fork, and shift rail past the neutral detent and into mesh with the other detent engaged.

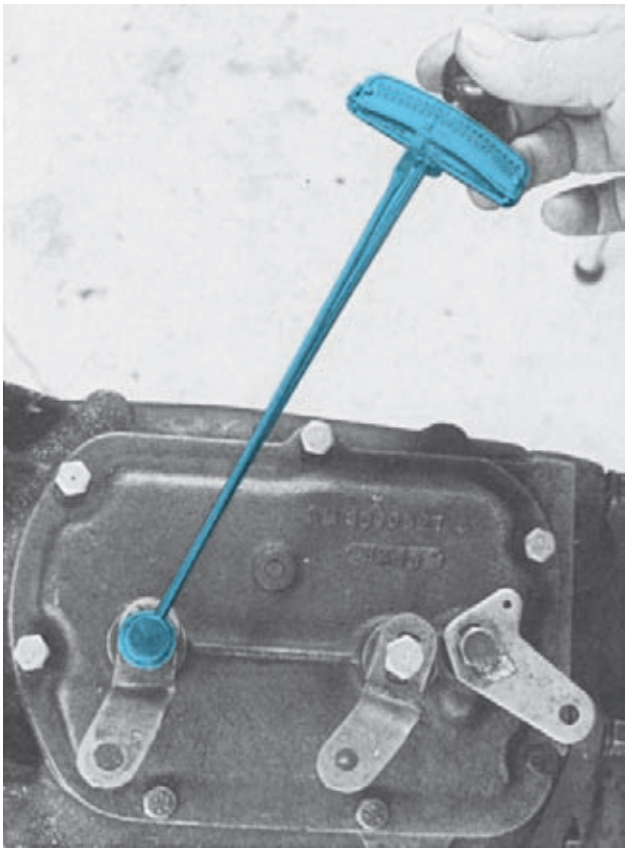


FIGURE 8-8 An inch-pound torque wrench is being used to measure the torque required to shift this transmission.

On transmissions with exterior linkage, you can disconnect the shift rod and make the shift using a torque wrench and a socket on the shift lever bolt. This enables you to measure the actual amount of torque required to make a shift (Figure 8-8). Some manufacturers publish the torque for a normal shift.

The amount of shift effort will vary with transmission and synchronizer design; heavy-duty transmissions usually require greater shift effort. Shift effort also varies with temperature and is usually higher at cold temperature because the transmission fluid is thicker. It is also greater if the shifts are rushed; slower shift speeds usually require less effort.

TECH TIP

If no specifications are available, shifting a synchronizer sleeve should take about 40 to 60 in.-lb (4 1/2 to 7 N-m) of torque. Over 72 in.-lb (8 N-m) of torque indicates a hard shift and internal problems.

On vehicles with internal linkage, the amount of effort is subjective and is checked by the amount of force needed to move the shift lever. You can compare the effort to shift into one gear with the effort for shifts into the gears on a similar transaxle/transmission. As the test is made, listen for any unusual noises that might occur in the transaxle/transmission or linkage.

To make an engine-off shift test:

1. Depress the clutch pedal to release the clutch.
2. Shift the transaxle/transmission into a gear to align the parts and then shift back to neutral.
3. Shift back into the same gear, carefully noting the amount of effort required.
4. Repeat this check on the remaining gears, noting any shift that requires a greater effort.

Engine-Running Shift Test

The engine-running shift test, also called a **dynamic shift test**, is almost a repeat of the engine-off check except that it checks for clutch drag as well as transaxle/transmission problems. Remember that a dragging clutch will cause the gears to rotate, and the synchronizer action will block shifts until equal speeds occur.

To make an engine-running shift test:

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

NOTE: A problem of "hard shifting when cold" can often be cured by draining out the old lubricant and replacing it with synthetic gear oil.

Road Test

If the customer's problem has not been located by the previous checks, the vehicle should be driven. At this time, the technician checks the quality of the upshifts and downshifts, listens for any unusual noises, and feels for any unusual movements or vibrations as he or she accelerates or decelerates in each gear. In cases where there is doubt about proper operation, the operation can be compared with that of a similar vehicle.

REAL WORLD FIX

A 1992 Honda Civic (65,000 mil) gearshift lever locked up and the transaxle wouldn't shift. The problem was very intermittent, occurring only once in a while. Fluid level was correct, and shift lever and bushings appeared good.

Disassembly revealed badly worn synchronizer assemblies. The customer did not want to spend the money needed to rebuild the transaxle, so a used one was installed. This fixed the problem.

REAL WORLD FIX

The five-speed transmission in a 1989 Mustang (255,000 km) blocked 4–3 and 5–3 downshifts. There was no gear clash, and all upshifts were normal.

On inspection, a faulty third-gear blocker ring was found; replacement of this blocker ring fixed this shift problem.

REAL WORLD FIX

A 1996 Ranger 4×4 (60,000 mil) was difficult to shift into first gear at a stop unless the shifter was first moved in the direction of second gear. All of the other shifts and the rest of the transmission operation were normal. The fluid was clean.

The transmission was disassembled, and the blocker rings and shift forks that had wear grooves 1/8" deep were replaced. The worn clutch was also replaced while the transmission was out, but the transmission repairs probably were what fixed this problem.

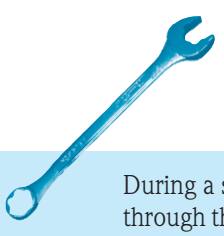
TECH TIP

While on a road test it is possible to isolate a mainshaft bearing noise from the other noises by depressing the clutch and shifting to neutral and coasting. At this time, the mainshaft will be the only thing turning in a transmission; in a transaxle, the differential, final drive gear, and output shaft will be turning.

One vehicle manufacturer recommends a test-drive procedure similar to the following:

To test drive a vehicle:

1. Check clutch pedal free play.
2. Check transmission oil level.
3. Warm up transmission before testing (drive aluminum case units for about 20 minutes).
4. With vehicle stationary, engine idling, clutch depressed, and in neutral:
   a. Release clutch and listen for noise, depress pedal; repeat 10 times, noting any noises.
   b. Release clutch, depress pedal, wait 3 seconds, and shift into reverse, then first, and then back to reverse. Repeat, but wait 20 seconds. Note any differences in noise or shifting ability.
   c. Note pedal movement, position point at which clutch engages, and any noises.
   d. Shift into reverse, release pedal, and while carefully backing, increase engine speed to 2500 rpm, and note any noises.
5. Drive vehicle on road with little traffic:
   a. Start in first, accelerate, and upshift at 4000 rpm (1–2, 2–3, and 3–4). Upshift 3–4 and 4–5 as possible depending on speed limits and driving conditions. Note shift quality and any noises.



TECH TIP

During a shift, the synchronizer ring must cut through the lubricant to contact the speed gear cone. Hard shifts can result from a lubricant that is too thick or from worn synchronizer rings (the threadlike grooves are no longer sharp).

TECH TIP

Downshifts are normally harder to execute than upshifts. During an upshift, the synchronizer must slow down the gear being shifted into, which the gear is doing naturally as soon as the clutch is depressed. During a downshift, the synchronizer must speed up those gears, and this normally requires a little more time and effort.

   b. Decelerate using engine braking, downshifting in each gear at about 3000 rpm. Note shift quality and any noises.
   c. Drive in fourth gear at speed limit or 60 mph, accelerate (if speed limit allows), and shift to fifth gear.
   d. Drive in fifth gear for a moment, and downshift to fourth gear. Repeat six times and note any problems.

Transaxle/Transmission Diagnosis Charts

A technician may consult a chart like the one in Figure 8-9 to help locate the possible cause of a transaxle/transmission concern. It should be noted that some of the problems can be the cause of a faulty clutch. Others can be corrected by adjusting the shift linkage or tightening mounting bolts. Some problems can be corrected with the transaxle/transmission in the vehicle. Internal transaxle/transmission problems, however, usually require removal.

TRANSAXLE/TRANSMISSION REMOVAL

Removal and replacement of a transaxle/transmission is required to repair internal transaxle/transmission problems or gain access to the clutch assembly. The exact operation varies somewhat between vehicle models, so it is highly recommended that a service manual covering the particular vehicle model be used when you remove and replace a transaxle/transmission. It should be noted that the transaxle/transmission in some vehicles can only be removed along with the engine. With most 4WDs, the transfer case is removed prior to or along with the transmission.

Removal and replacement of the driveshaft(s) are described in Chapter 10. Some transaxles/transmissions are quite heavy and awkward to handle, so it is recommended that a transmission jack be used to support and move the unit in and out of the vehicle.

Problem	*Possible Cause*
Leak	• Excessive lubricant • Wrong lubricant • Slight mist from trans. vent • Faulty seal • Faulty gasket
Hard shift	• Dragging clutch • Binding shift linkage • Faulty synchronizer assembly • Damaged shift rail, detent, or interlock • Improper lubricant
Shift blockout	• Damaged shift linkage • Interference with shift linkage or lever • Damaged synchronizer • Restricted travel of shift fork
Locked into gear	• Damaged shift linkage • Damaged synchronizer • Worn or damaged internal shift linkage
Jumps out of gear	• Improper linkage adjustment • Worn or damaged shift linkage • Interference with shift linkage movement • Broken or loose engine/trans. mounts • Worn pilot or main drive gear bearing • Worn shift fork • Worn synchronizer
Clash during shift	• Clutch drag • Worn or damaged shift fork • Worn synchronizer parts
Noisy in neutral	• Low lubricant level • Worn or damaged input shaft bearings • Worn countershaft bearings
Noisy in one gear	• Damaged teeth on that particular gear set
Noisy in all gears	• Low lubricant level • Contact between trans. and vehicle body or exhaust • Loose mounting bolts • Worn or damaged gear teeth

FIGURE 8-9 Nine most common transaxle/transmission problems and their possible causes.

Transaxle Removal and Replacement

To remove a transaxle:

1. Disconnect the negative (−) battery cable.
2. Disconnect the following accessible parts: shift cables or rods, clutch linkage, backup light switch or wires, speedometer cable or speed sensor connections, and any hose or cable brackets with connections to the body or engine.

REAL WORLD PROBLEM

Imagine that you are working in a general automotive repair shop and these problems are brought to you.

Case 1

The customer's complaint is a gear clash as she shifts into first or reverse. During your road test, you confirm the problem and find the rest of the transmission's operation to be normal. What do you need to do to fix this problem?

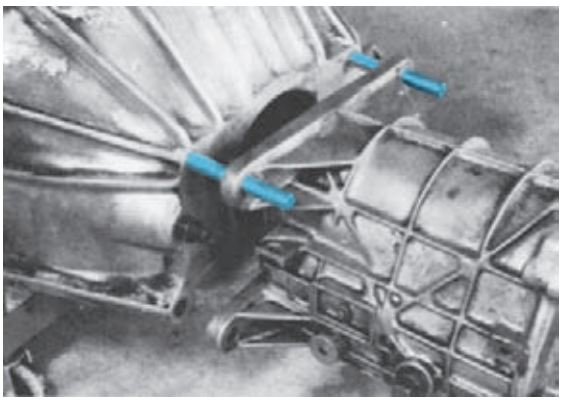
Case 2

The transaxle is very noisy; running in neutral makes a definite worn-bearing noise. When you check the fluid level, you can't find any fluid on the dipstick. What is probably wrong in this unit?

TECH TIP

Another simple aid that helps greatly during removal and installation is the use of guide pins (Figure 8-10). These are common grade-2 bolts with the heads cut off. The bolts must be the same size and thread as the transaxle/transmission mounting bolts, about 2 to 4 in. (50 to 100 mm) long. When they replace one or two of the mounting bolts, they support the transaxle/transmission so it can be slid straight out or into place with the clutch and bell housing or engine block. In most cases, the transaxle/transmission must be slid straight away from the engine 1 or 2 in. (25 to 50 mm) as the clutch shaft leaves or enters the clutch disc. In very tight installations, 1 to 2 in. is the maximum length that the guide pins can be.

CAUTION: With the linkage disconnected, the clutch pedal can lower quite violently. Some manufacturers recommend placing a block of wood under the clutch pedal as a safety measure.



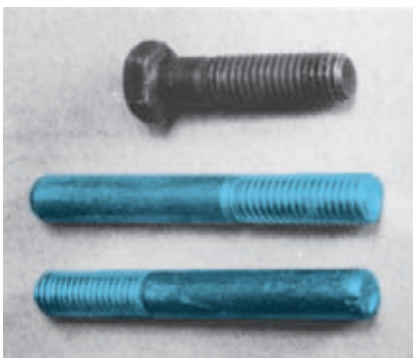


FIGURE 8-10 A pair of guide pins has been installed in place of two mounting bolts to support the transmission as it is slid out of or into the clutch and bell housing. The pins, about 3 in. long, were made by cutting the heads off of grade 2 bolts of the same size as the transmission mounting bolts.

TECH TIP

Some switches are operated through a pin on a steel ball. After the removal of a switch, it is a good practice to probe into the hole using a small magnet to ensure that no small parts have been overlooked.

TECH TIP

In vehicles with the starter mounted to the clutch housing, it is necessary to disconnect and remove the starter.

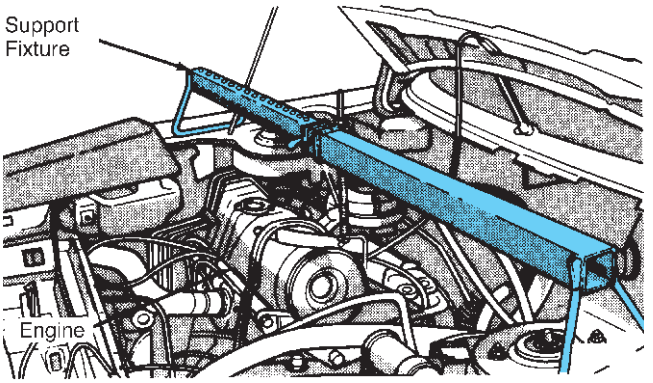


FIGURE 8-11 With most FWD vehicles, it is usually necessary to a fixture to support the engine before removing the transaxle. *(Courtesy of DaimlerChrysler Corporation)*

3. Many vehicles require the installation of an **engine support** to keep the engine in the proper location as the transaxle and its mounts are removed (Figure 8-11).
4. Remove the upper clutch housing bolts and install a guide pin into one or two of the bolt holes.
5. Raise and securely support the vehicle on a hoist or on jack stands.
6. If a drain opening is provided, drain the transaxle oil, noting the condition and the amount that comes out.
7. Remove the left driveshaft as described in Section Chapter 10 on page 273. Some vehicles require removal of the right driveshaft as well.
8. If necessary, remove parts of the body, suspension system, subframe, splash shield, and so on, or parts of the transaxle itself. Remove any items listed in step 2 that connect the transaxle to the body or engine.
9. Position a transmission jack to support the transaxle, remove any transaxle mounts or supports, remove the remaining clutch housing bolts, and install the second guide pin (if not already installed). Slide the transaxle away from the engine to clear the clutch, and lower it out of the vehicle (Figure 8-12).

WARNING: Do not depress the clutch pedal while the transaxle is removed.

Replacement of the transaxle usually follows the procedure just described, only in reverse. The following points should be observed during transaxle installation:

To replace a transaxle:

- Use guide pins and/or a transmission jack to support the unit to eliminate the possibility of hanging the transaxle on the clutch shaft.

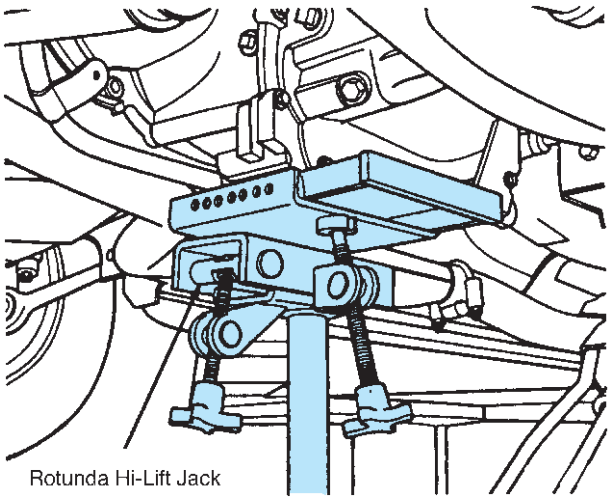


FIGURE 8-12 A transmission jack has been positioned to support this transaxle before removing the mounts and supports. *(Courtesy of Ford Motor Company)*

- Be sure that wires, cables, and hoses are positioned correctly as the transaxle is slid into place.
- Install the mounts, mounting bolts, and supports before removing the transmission jack.
- Tighten all nuts and bolts to the correct torque.
- If the front suspension mounting points were disturbed, perform a wheel alignment to ensure proper vehicle operation.
- Fill the transaxle to the correct level with the correct lubricant before starting the engine.
- If necessary, check and adjust clutch pedal free travel and the shift linkage.

Transmission Removal and Replacement

To remove a transmission:

1. Disconnect the negative (−) battery cable.
2. Raise and securely support the vehicle.
3. If a drain plug is provided, drain the fluid, noting the amount and condition of liquid that comes out. Remove the driveshaft as described in Chapter 10 on page 277. If the fluid is not drained, install a stop-off tool into the rear seal. This can be a commercial tool, an old driveshaft slip yoke, or a plastic bag secured by a rubber band (Figure 8-13).
4. Remove the backup light wires, speedometer cable or speed sensor connections, any hose or cable brackets attached to the vehicle, and the shift linkage. Check under any switches for removable operating pins or balls. On

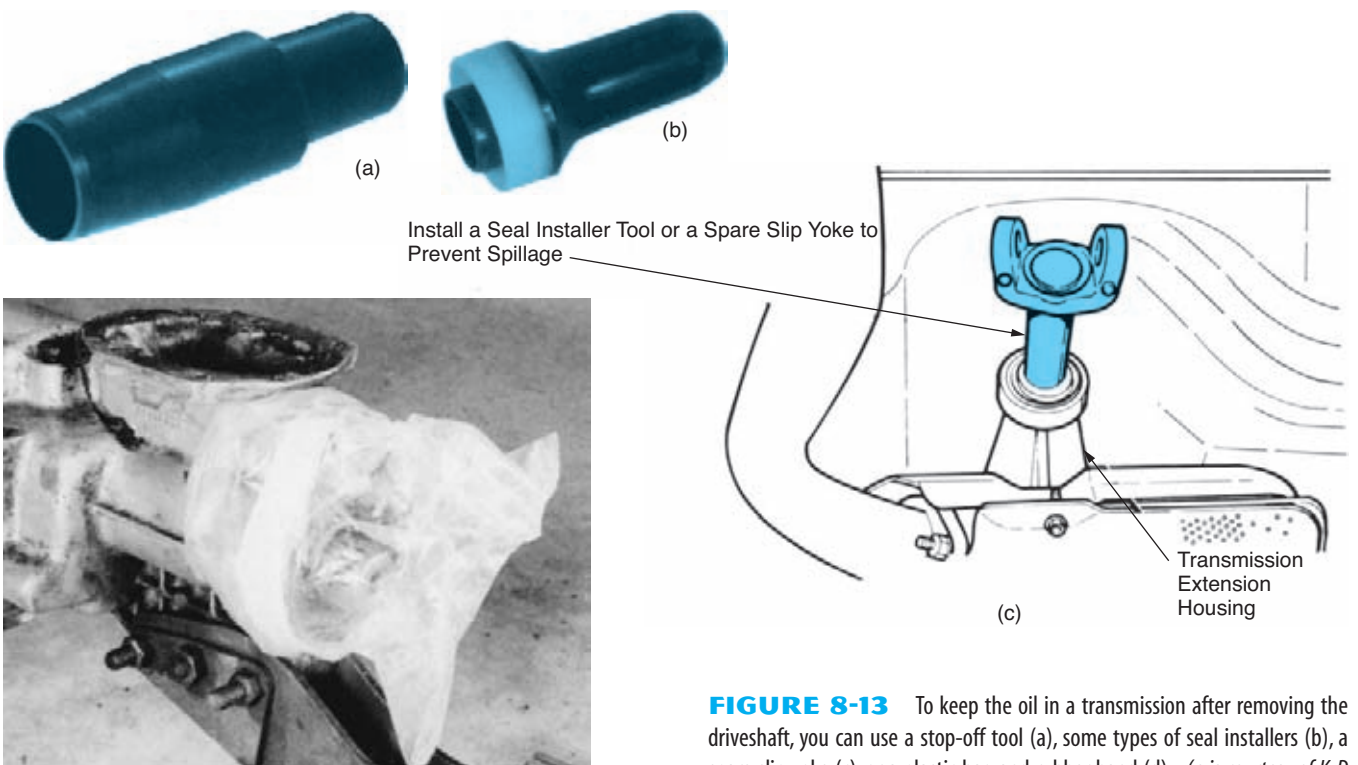


FIGURE 8-13 To keep the oil in a transmission after removing the driveshaft, you can use a stop-off tool (a), some types of seal installers (b), a spare slip yoke (c), or a plastic bag and rubber band (d). *(a is courtesy of K-D Tools; b is courtesy of Kent-Moore; c is courtesy of Ford Motor Company)*

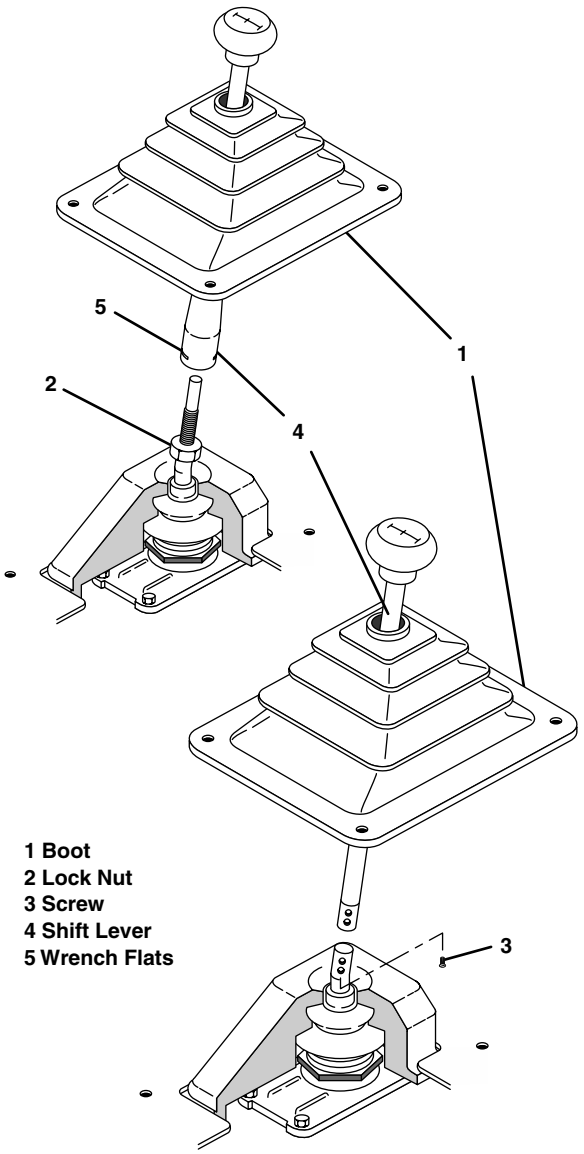


FIGURE 8-14 It is usually necessary to remove the shift lever (floor mounted) before removing the transmission. *(Courtesy of Transmission Technologies Corporation, TTC)*

transmissions with internal linkage, it is usually necessary to remove the boot and shift lever from inside the vehicle before it is lifted (Figure 8-14). On some vehicles it is necessary to remove part of the exhaust system.

5. Position a transmission jack to support the transmission. Remove the transmission support bolts, raise the transmission slightly, and remove the transmission support. In some cases, it may also be necessary to remove the crossmember (Figure 8-15).
6. Remove the transmission-to-clutch housing or transmission-to-engine bolts, and install a pair of guide pins. On many vehicles you can lower the transmission enough to gain access to the upper mounting bolts.

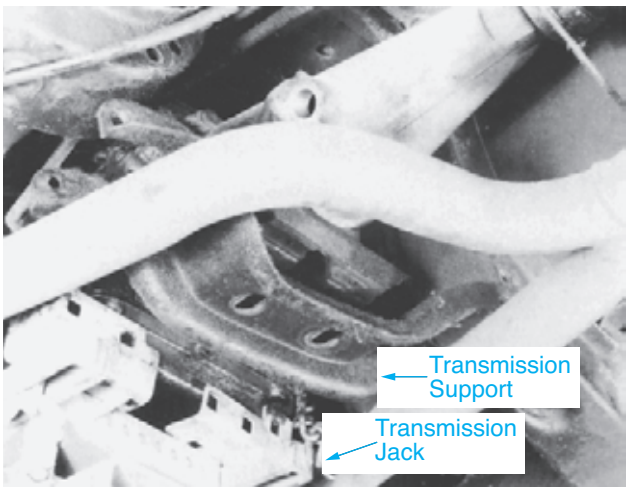


FIGURE 8-15 A transmission jack has been positioned under this transmission before removing the mount/insulator and transmission support.

7. Move the transmission and jack to the rear to clear the clutch shaft, and lower the unit out of the vehicle.

To replace a transmission:

Transmission replacement usually follows the procedure just described, only in reverse. In addition, the installation points on page 186–187 should be observed.

TECH TIP

A film of high-temperature grease should be applied to the transmission output shaft splines before installing the driveshaft.

TECH TIP

The rear seal of some transmissions includes a dust boot that covers the driveshaft end and seal lip. Improper driveshaft installation can roll the seal lip inward and cause a future leak. When installing the driveshaft on these units, be sure to lubricate the driveshaft yoke and rotate the driveshaft as it slides under the seal lip.

TRANSAXLE/TRANSMISSION OVERHAUL

The overhaul operations for most transaxles/transmissions are very similar. These include disassembly of the unit, gear inspection, bearing inspection, reconditioning of the subassemblies, and checking gear end float and adjusting bearing clearances as the unit is reassembled. The exact procedure for doing each of these will vary depending on the make and model. It is highly recommended that the service manual procedure be followed along with the clearances and torque specifications.

At one time, manual transmissions were rebuilt in the general automotive repair shop. The evolution of the transmission into a more complex unit and the development of the transaxle with its rather exacting repair procedures, along with the increasing amount of special tooling for both, has resulted in the emergence of shops that specialize in manual transaxle/transmission repair.

NOTE: The overhaul begins with the draining and inspection of the oil. Little or no oil, or oil that is burned or contaminated with metal particles, usually indicates an expensive rebuild.

As the transaxle/transmission is disassembled, the experienced technician will look for the possible causes of the problem. For example, if a transaxle/transmission jumps out of fifth gear, the technician would check for a worn internal shift linkage, fork, or synchronizer sleeve; burred fifth-gear clutching teeth; or excessive fifth-gear end float. Experienced technicians diagnose the problem and know its probable cause before the transmission is removed from the vehicle. The following are normally checked during disassembly:

- The internal shift linkages for rough operation and wear
- Clearance between all shift forks and sleeves
- All shafts for excessive end play and rough operation
- All floating gears for excess end float or rough rotation
- All blocker rings for free motion and excessive or insufficient clearance
- All gears for chipped or broken teeth

It is advisable to know what is required to remove a part before trying to remove it, and this is found in service information. A press and special puller may be required. Many bearings, synchronizer assemblies, and some countershafts will slide out of and into the proper location using only light pressure. For example, when a shift rail will not slide out of the case, it is usually held by a detent or interlock. Shafts, gears, shift rails, and most other parts must never be struck with a steel hammer. If struck with a steel hammer, a shaft will mushroom and a bearing or gear could chip. If it is necessary to hit these parts, you should use a "soft" hammer (plastic, brass, or lead) or a soft punch made from either brass or aluminum.

Worn parts are normally replaced with new ones, and the source for most new power train parts is the vehicle dealership. There are also several aftermarket gear companies that specialize in replacement parts. When purchasing parts, sometimes upgraded parts, stronger than the original, are available to solve problems with particular units.

TECH TIP

An experienced technician realizes that when he or she rebuilds a transaxle/transmission, the average motorist will judge the repair by how the unit shifts and whether there are leaks or noise present. If the transaxle/transmission operates quietly and smoothly, without oil leaks and noise, it will be considered a good-quality rebuild. If not, there will probably be a comeback for the job to be done over at the technician's and shop's expense. It is a wise practice to note any noise or shifting problems during the diagnosis stages and make sure that these are cured in the rebuild.

Transaxle Disassembly

The procedure described in this text is very general and intended to provide you with an idea of what service operations are involved and how to perform them. Refer to a service manual for the exact procedure (Figure 8-16).

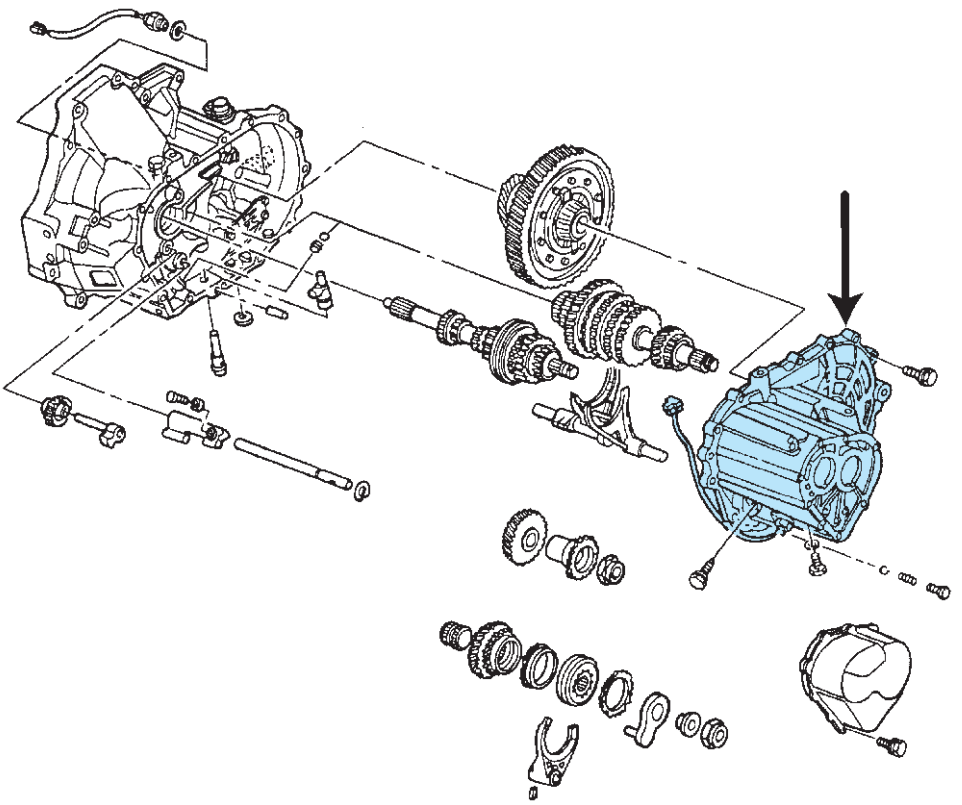
To disassemble a transaxle:

1. Clean all of the oil, dirt, and grease from the outside of the transaxle.

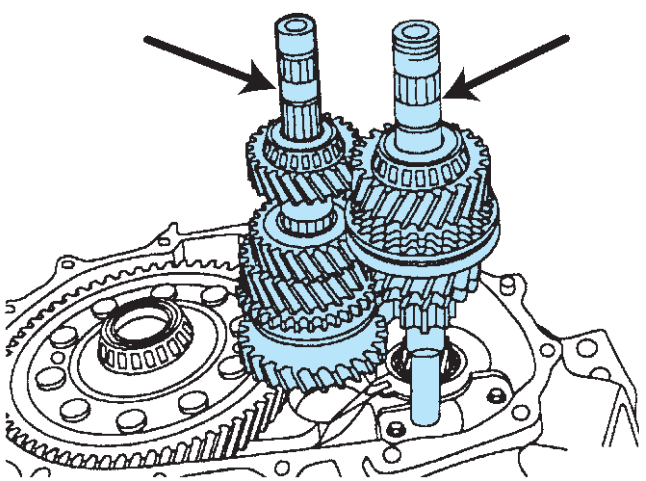
TECH TIP

An experienced technician realizes that he or she is the final quality control check for all parts, new or used, and checks each new and used part thoroughly during and after assembly for proper operation.

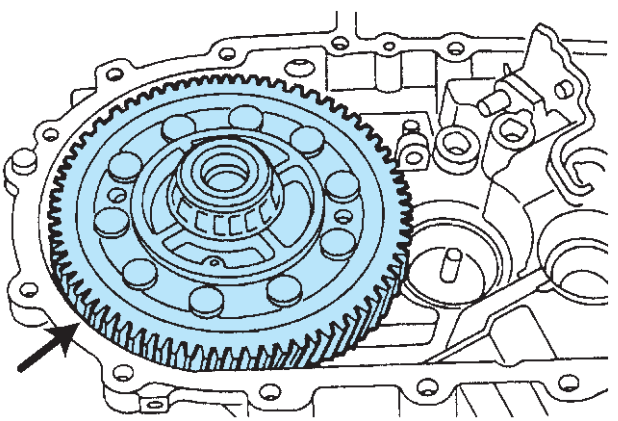
2. Remove the drain plug, and check the quantity and condition of the fluid. Also, remove the fill plug to ensure that it is not seized or has damaged threads.
3. On some transaxles, begin by removing the differential bearing retainer, extension housing, and differential (Figure 8-17). Disassembly of another transaxle may begin with the removal of the leftside case cover, fifth-gear synchronizer assembly, and the fifth countergear (Figure 8-18). Disassembly of a third transaxle may begin with the removal of the backup light switch, reverse idler



(a) Remove Case Cover

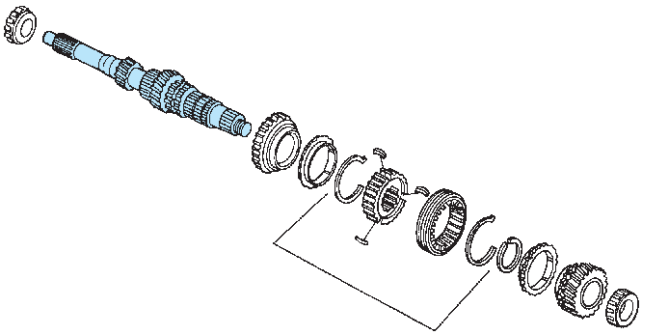


(b) Remove Input and Output Shaft Assemblies

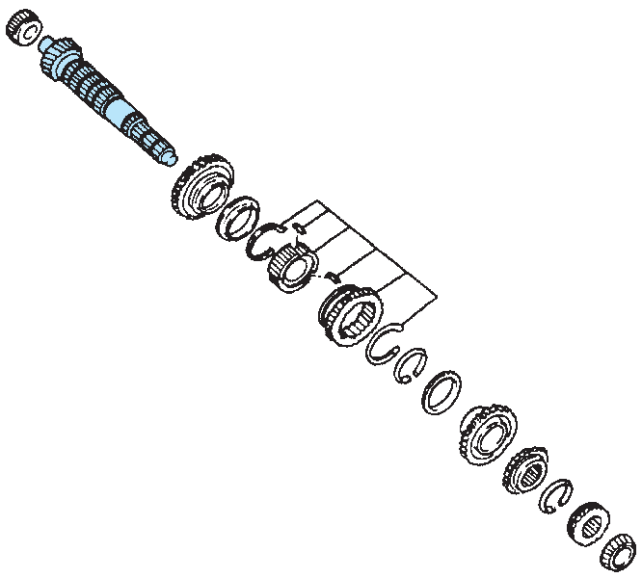


(c) Remove Differential Assembly

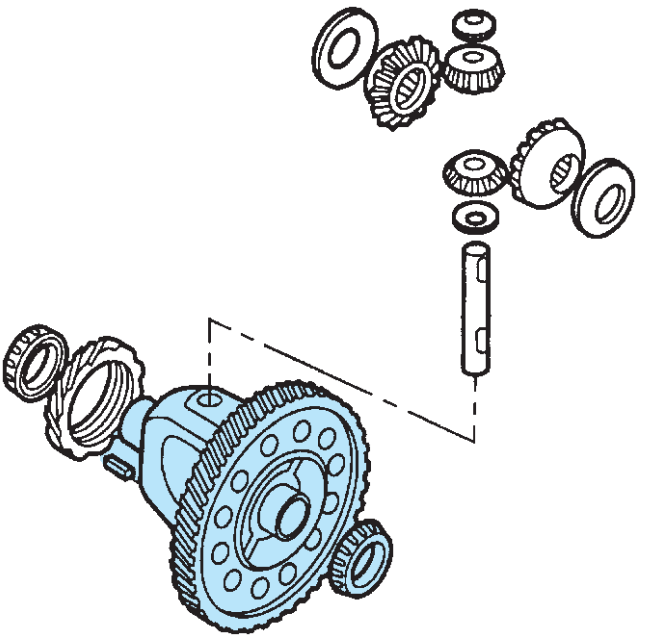
FIGURE 8-16 The procedure to disassemble most transaxles is to remove the case cover (a), remove the transmission shafts (b), remove the differential assembly (c), and then disassemble the input (d) and output (e) shafts and differential (f).



(d) Disassemble Input Shaft



(e) Disassemble Main Shaft



(f) Disassemble Differential

FIGURE 8-16 *(Continued)*

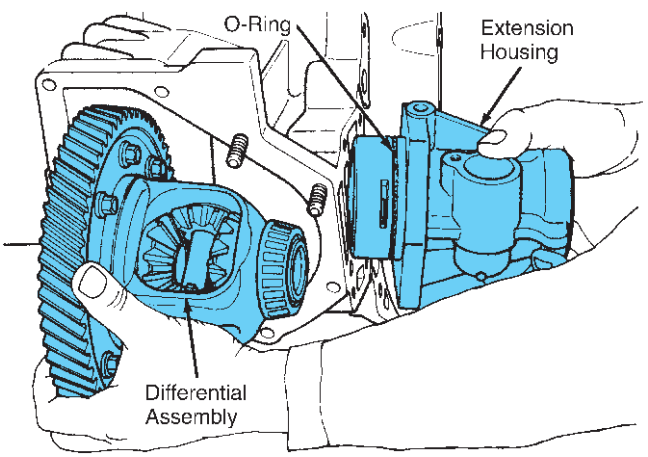


FIGURE 8-17 Disassembly of this Chrysler transaxle begins with the removal of the differential cover, extension housing, and differential assembly. *(Courtesy of DaimlerChrysler Corporation)*

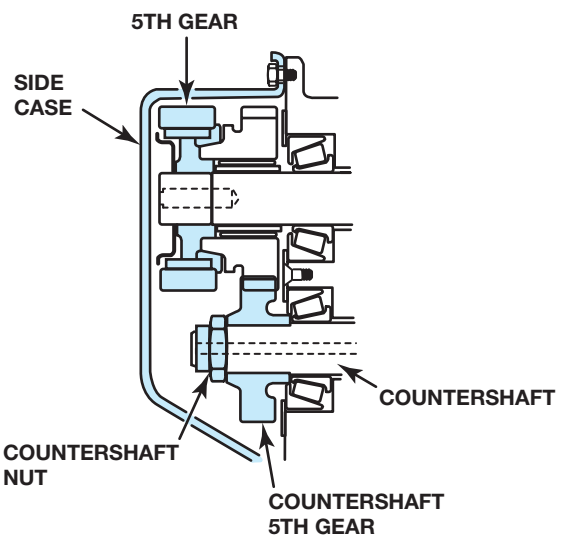
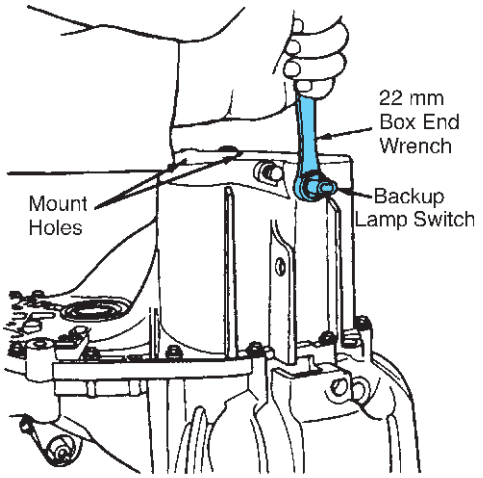
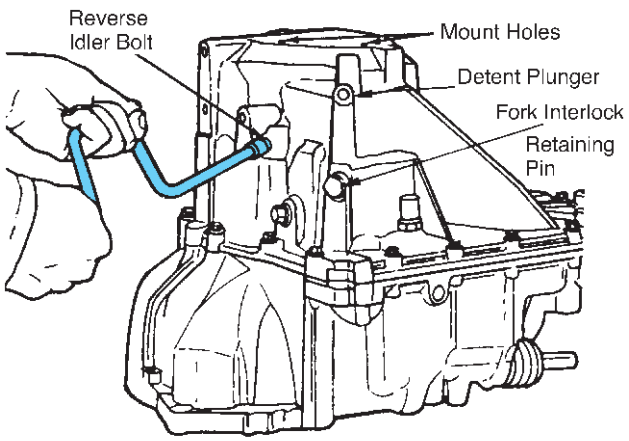


FIGURE 8-18 Disassembly of this transaxle begins with the removal of the side case, fifth-gear synchronizer assembly, and the countershaft fifth gear.



(a)



(b)

FIGURE 8-19 Disassembly of this Ford transaxle begins with the removal of the backup lamp switch (a), reverse idler bolt, detent plunger, fork interlock retainer pin, and filler plug (b). *(Courtesy of Ford Motor Company)*

shaft retaining bolt, detent plunger retaining screw, interlock sleeve retaining pin, and fill plug (Figure 8-19). During this step, you should remove all of the exterior parts that block or hinder removal of the case.

4. Remove the case-to-clutch housing or end-cover-to-case attachment bolts. As these bolts are removed, note their length so that they can be replaced in the proper location. It will usually be necessary to tap the case with a plastic hammer or pry upward using a small pry bar to break the seal between the two parts (Figure 8-20). If you use a prying tool, try not to scratch the sealing surfaces.
5. After removing the cover, remove the shift mechanism, the reverse idler gear, and its shaft, if necessary (Figure 8-21).
6. Remove the input and mainshaft assemblies together, holding them so that the gears stay in mesh until the shafts leave their bearings (Figure 8-22).

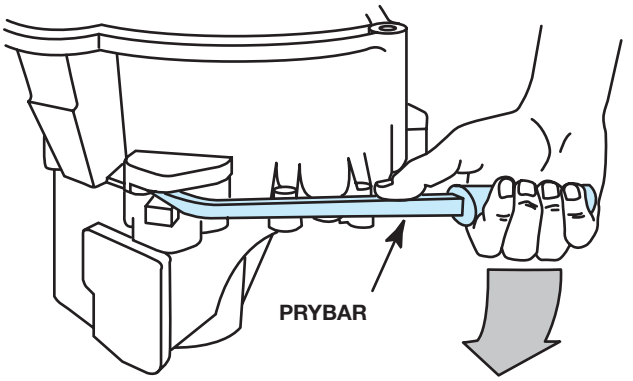


FIGURE 8-20 Most transaxles use formed-in-place gaskets that tend to glue the case and covers together. This unit has a slot to allow prying without damaging the gasket surfaces.

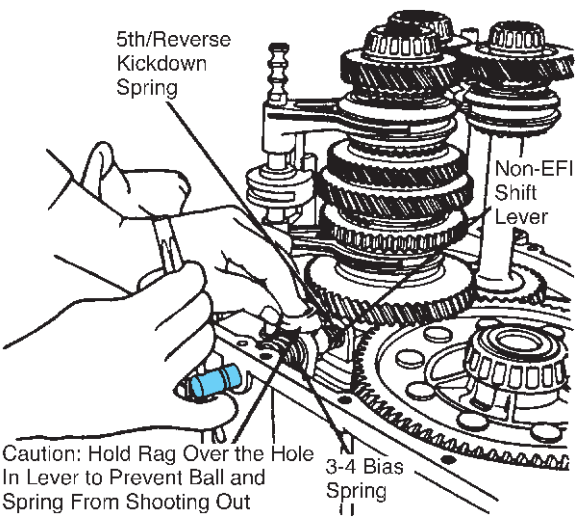


FIGURE 8-21 With some transaxles, the internal shift linkage is removed after the case cover has been removed. *(Courtesy of Ford Motor Company)*

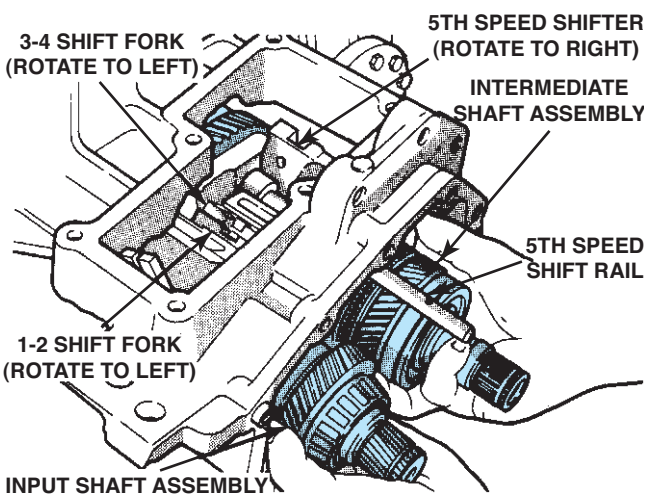


FIGURE 8-22 With the shift linkage disconnected, both shafts with gear assemblies can be removed. *(Courtesy of DaimlerChrysler Corporation)*

TECH TIP

A good rule to follow during bolt replacement is that each bolt should thread in by hand (no tools) a distance that is equal to or greater than the diameter of the bolt.

TECH TIP

If needed, a section of heater hose can be inserted into the differential to hold the side gears in place.

TECH TIP

After the unit is disassembled, the subassembly reconditioning steps can be performed. Most technicians will carefully check or recondition each part to ensure that with the exception of minor wear on the gears, the unit will perform like new when it is put back into operation.

7. If not done in step 1, remove the ring gear and differential assembly (Figure 8-23). The side gears of some differentials have rounded thrust faces so that they will rotate easily to the windows of the differential case and fall out (Figure 8-24). These gears are normally held in place by a special tool or wooden or plastic plug inserted into them when the driveshafts are removed.

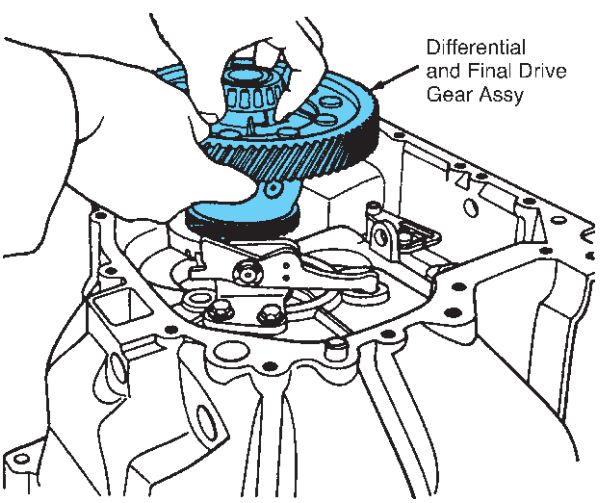


FIGURE 8-23 On this transaxle, the differential assembly is removed after the gear assemblies have been removed. *(Courtesy of Ford Motor Company)*

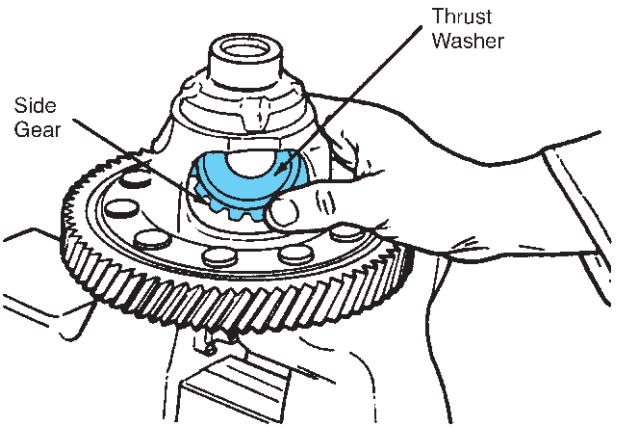


FIGURE 8-24 The side gears in some differentials have a rounded thrust surface and can roll out of position when the CV joints have been removed. *(Courtesy of Ford Motor Company)*

Transmission Disassembly

As with a transaxle, the procedure given here is general and intended to familiarize you with the service procedures and how they are performed (Figure 8-25). The exact procedure for disassembling a specific transmission is printed in various service manuals (Figure 8-26). The order of the disassembly steps will be different from that given here for many transmissions.

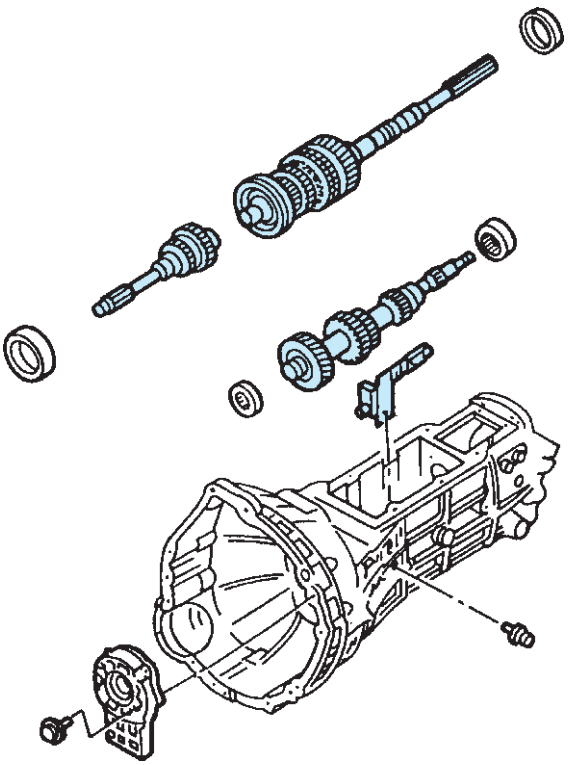
Synchronizer assemblies are normally left assembled until it is time to inspect the parts. Most sleeves and hubs are factory-matched sets and should be kept in their same position relative to each other. An experienced technician will use a permanent marker or small grinder to place index marks on both the sleeve and hub to speed up reassembly and prevent future problems (Figure 8-27). In most cases, if any part of this assembly is damaged, except for the blocker rings, replacement of the entire synchronizer assembly will be required.

To disassemble a transmission:

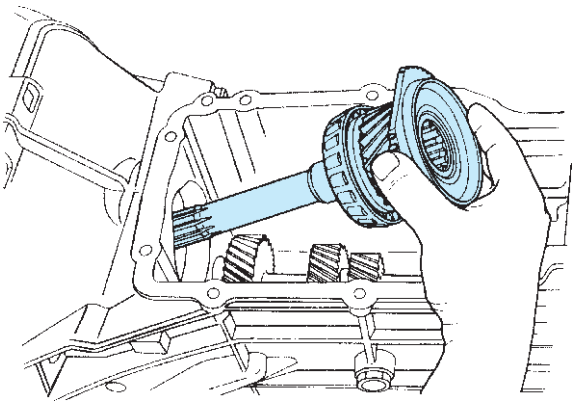
1. Clean all of the oil, dirt, and grease from the outside of the unit.

TECH TIP

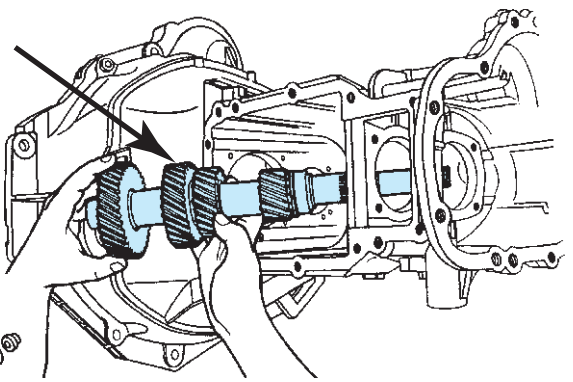
Always remove the fill plug to ensure that it is not seized and does not have damaged threads.



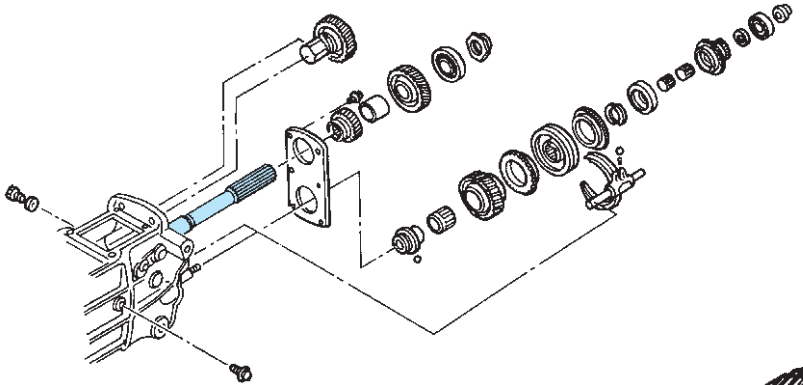
(a) Disassemble Transmission



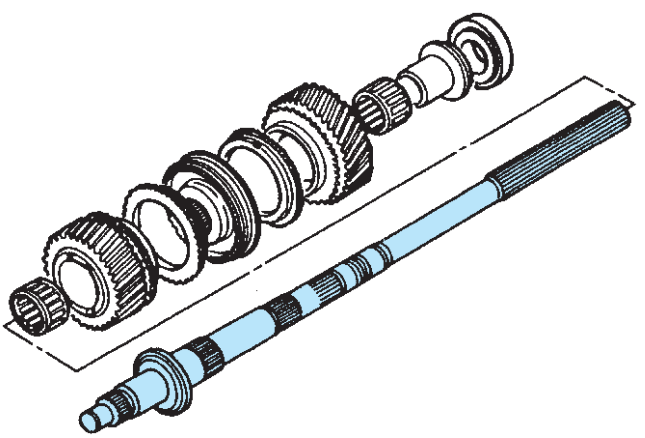
(d) Remove Main Drive Gear



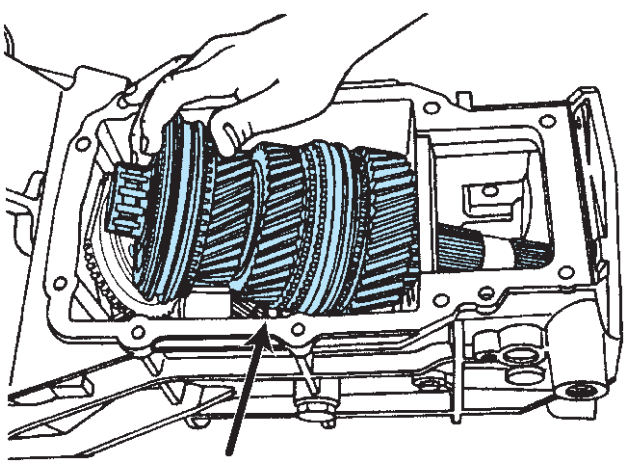
(e) Remove Cluster Gear



(b) Remove Extension Housing and Internal Parts



(f) Disassemble Mainshaft Assembly



(c) Remove Mainshaft Assembly

FIGURE 8-25 The procedure to disassemble this transmission (a) is to remove the extension housing and internal parts (b), remove the mainshaft (c), remove the main drive gear (d), remove the cluster gear (e), and disassemble the mainshaft (f).

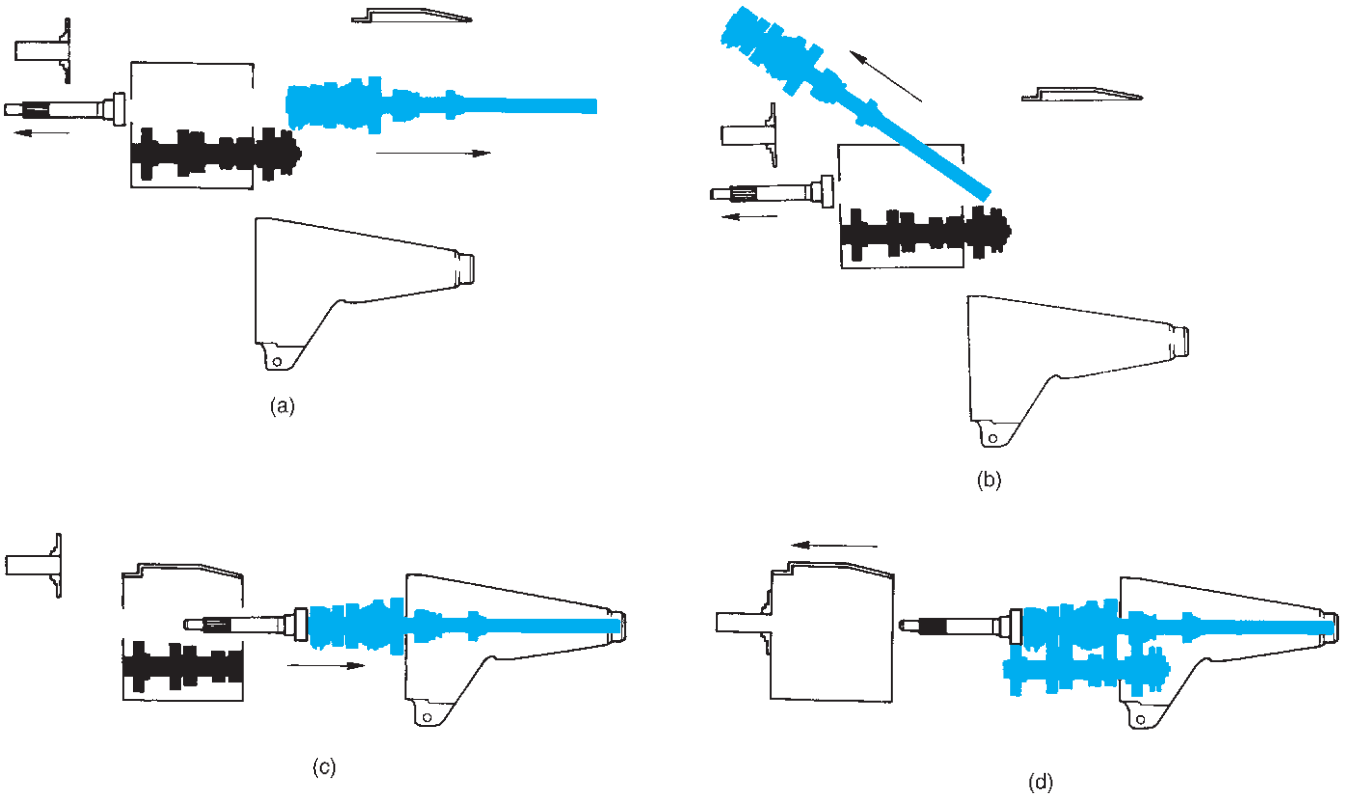


FIGURE 8-26 The disassembly procedure varies depending on the transmission. The clutch shaft and mainshaft may be removed from each end (a), the mainshaft may be removed through the top (b), the clutch shaft and mainshaft may be removed from the rear (c), or all the shafts may be removed from the rear (d).

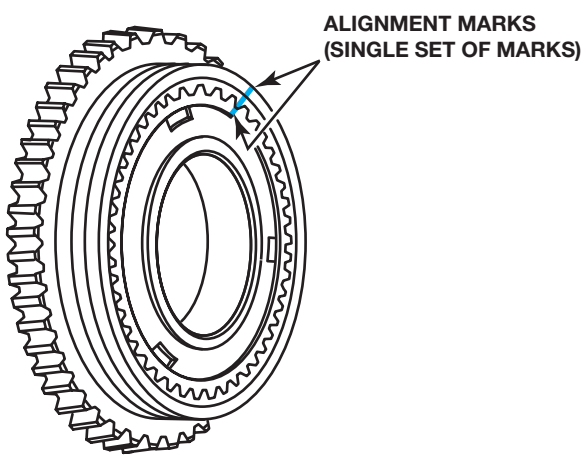


FIGURE 8-27 A synchronizer sleeve should never be removed from its hub without first checking for alignment marks or adding alignment marks if there are none. A mispositioned sleeve can cause hard shifting.

2. Remove the drain plug and check the quantity and condition of the fluid.
3. Remove the case cover or case cover with shift mechanism.

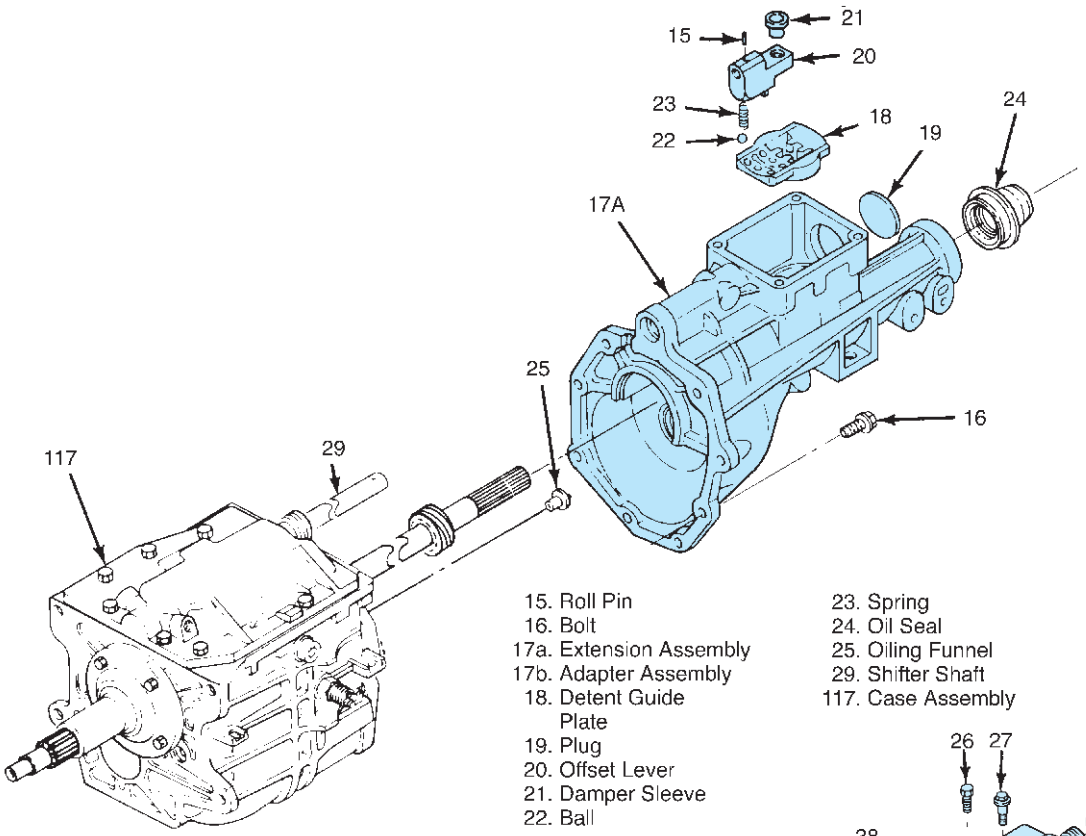
   On some units, it is necessary to disconnect the shift shaft in the extension housing, remove the extension housing, and then remove the case cover and shift mechanism (Figure 8-28). Most tunnelcase transmissions do not have a case cover.
4. Remove the input bearing retainer, and note the top and bottom of this unit (Figure 8-29).

TECH TIP

Some transmissions need to be shifted into a certain gear to allow removal of the shift forks.

TECH TIP

Some technicians will make index marks on the bearing retainer to expedite alignment during reassembly.



15. Roll Pin
16. Bolt
17a. Extension Assembly
17b. Adapter Assembly
18. Detent Guide Plate
19. Plug
20. Offset Lever
21. Damper Sleeve
22. Ball
23. Spring
24. Oil Seal
25. Oiling Funnel
29. Shifter Shaft
117. Case Assembly

(a)

FIGURE 8-28 Disassembly of this transmission begins with removal of the extension housing (a) and case cover with shift linkage (b). *(Courtesy of BWD Automotive Corporation)*

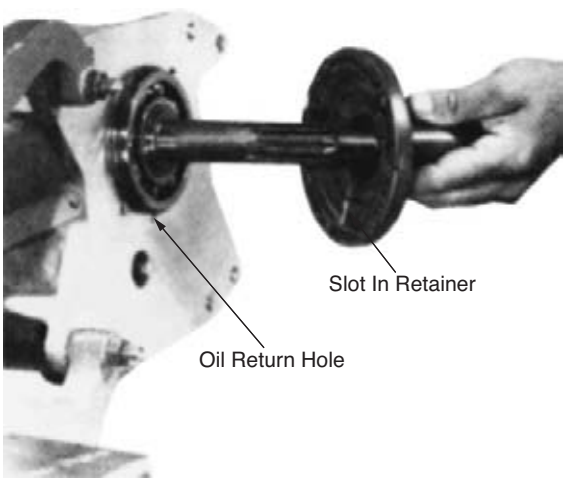
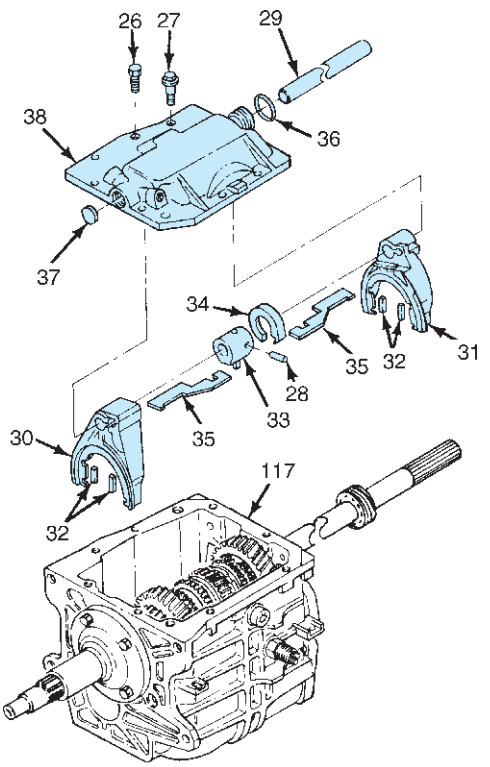
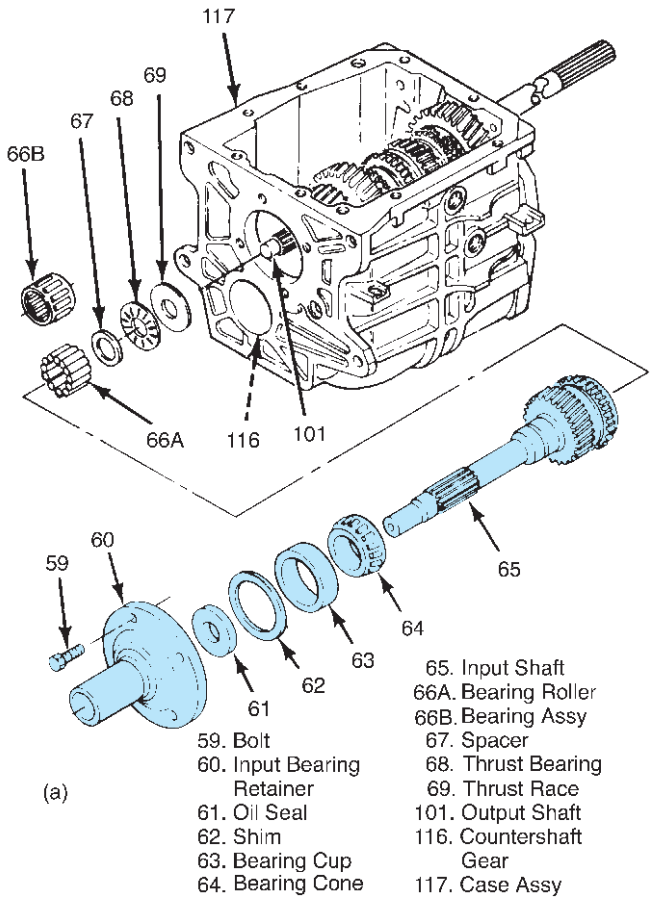


FIGURE 8-29 When the front bearing retainer is removed, it is a good practice to note the location of the oil return groove. *(Courtesy of Ford Motor Company)*



26. Bolt
27. Bolt
28. Selector Arm Pin
29. Shifter Shaft
30. 3-4 Shift Fork
31. 1-2 Shift Fork
32. Insert
33. Selector Arm Assembly
34. Interlock Plate
35. Selector Plate
36. O-Ring
37. Plug
38. Case Cover
117. Case Assembly

(b)



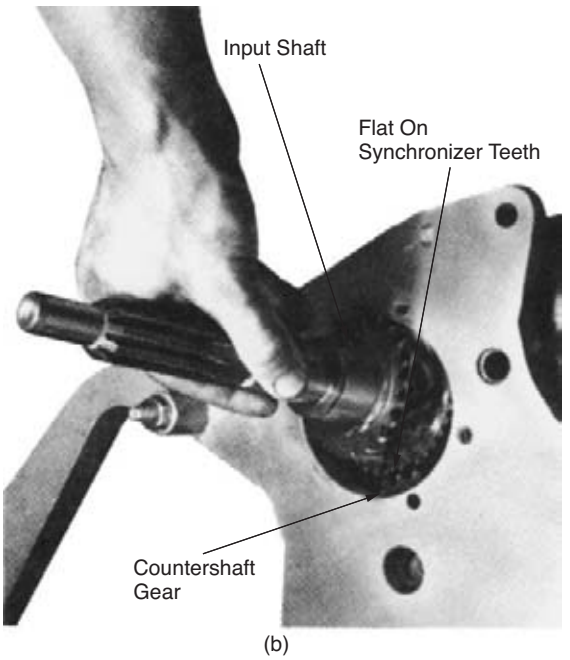


FIGURE 8-30 This input shaft bearing includes a set of shims used to adjust transmission end play and an oil seal (a). The synchronizer clutching teeth are cut away in one section of some input shafts to allow removal of the gear once the bearing retainer has been removed (b). *(a is courtesy of BWD Automotive Corporation; b is courtesy of Ford Motor Company)*

TECH TIP

Some main drive gears have the clutching teeth removed from one section and this section must be aligned with the cluster gear to allow removal (Figure 8-30).

TECH TIP

On some transmissions, the shaft-to-bearing snap ring is removed, and the input shaft bearing is removed by prying forward on the outer snap ring. The gear is left in place (Figure 8-31).

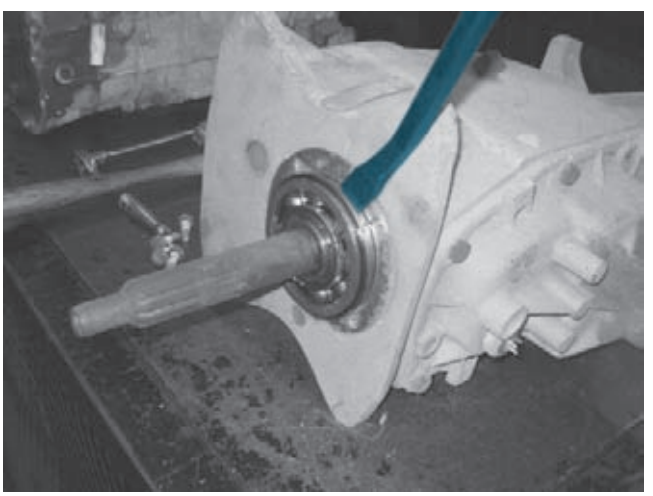
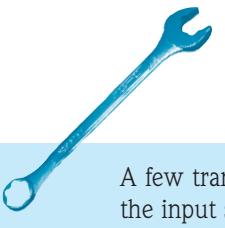


FIGURE 8-31 On this transmission, the bearing is pried off the main drive gear so that the gear, along with the mainshaft, can be removed through the rear of the case.

On units that use tapered roller bearings, remove the shims and bearing cup (Figure 8-30). The input shaft/main drive gear can now be removed.

5. Remove the extension housing (if not done in step 2); the rear of the mainshaft will be exposed (Figure 8-32).

A puller is required on the T56 transmission to remove the speedometer rotor. After removing the reverse speed gear and synchronizer assembly, a puller is required to remove the 5–6 driven gear (Figure 8-33). The countershaft extension with the fifth and sixth drive gears and the synchronizer assembly along with the shift fork can now be removed (Figure 8-34).



TECH TIP

A few transmissions use a special nut to lock the input shaft/main drive gear into the front bearing. This nut is removed by shifting the transmission into two gears—third and first, for example—to lock up and hold the gear set while the nut is removed using a special wrench.

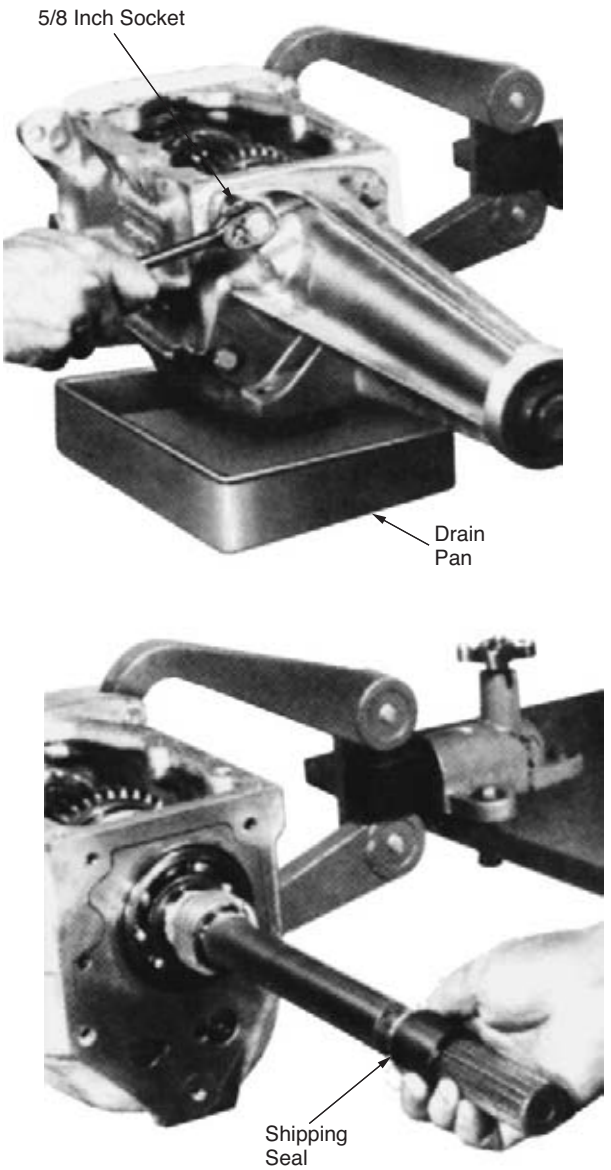
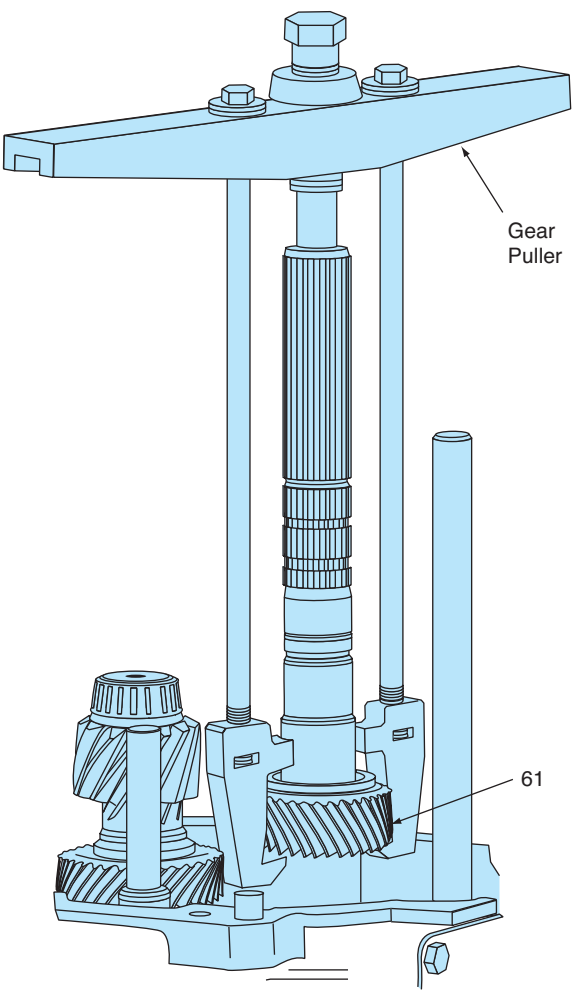
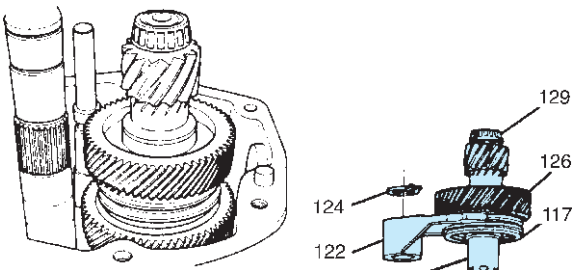


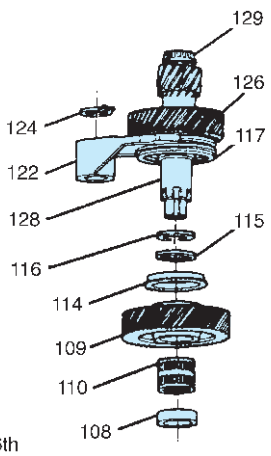
FIGURE 8-32 On many transmissions, the extension housing can be removed to gain access to the rear of the mainshaft. *(Courtesy of Ford Motor Company)*



61 Gear, 5th/6th Driven

FIGURE 8-33 A gear puller is used to remove the 5–6 driven gear. *(Courtesy of Transmission Technologies Corporation, TTC)*





108 Washer, Thrust
109 Gear, 6th Drive
110 Bearing, 6th Gear Needle
114 Ring, 6th Gear Blocker
115 Spacer
116 Ring, Snap
117 Synchronizer Assembly, 5th/6th
122 Fork, 5th/6th Shift
124 Ring, Snap
126 Gear, 5th Drive
128 Extension, Countershaft
129 Bearing, Countershaft Extension Tapered

FIGURE 8-34 With the 5th/6th driven gear removed, the countershaft extension with the 5th and 6th drive gears and synchronizer assembly can be removed. *(Courtesy of Transmission Technologies Corporation, TTC)*

TECH TIP

Shifting into two gears is also used to lock up the output shaft when a nut is to be loosened or tightened.

TECH TIP

On some units, parts of the shift linkage will need to be disconnected during extension housing removal (Figure 8-35).

TECH TIP

On some transmissions, the mainshaft assembly is removed along with the extension housing, and then the extension housing is removed from the mainshaft (Figure 8-36).

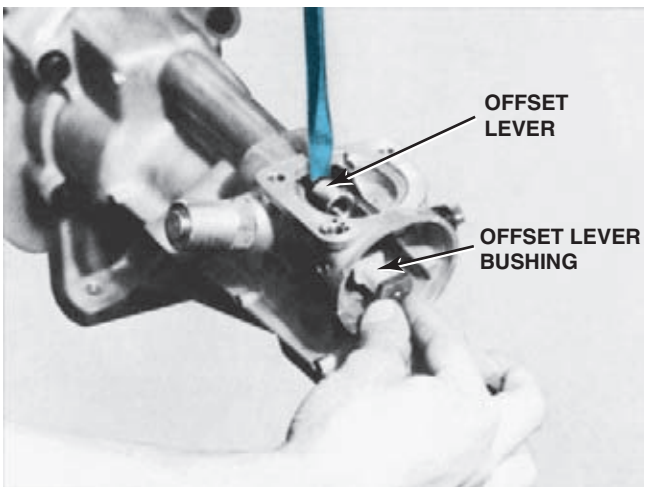


FIGURE 8-35 On this transmission, it is necessary to disconnect a part of the shift linkage before removing the extension housing. *(Courtesy of Ford Motor Company)*

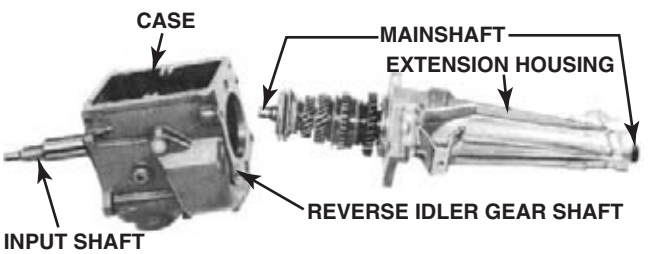
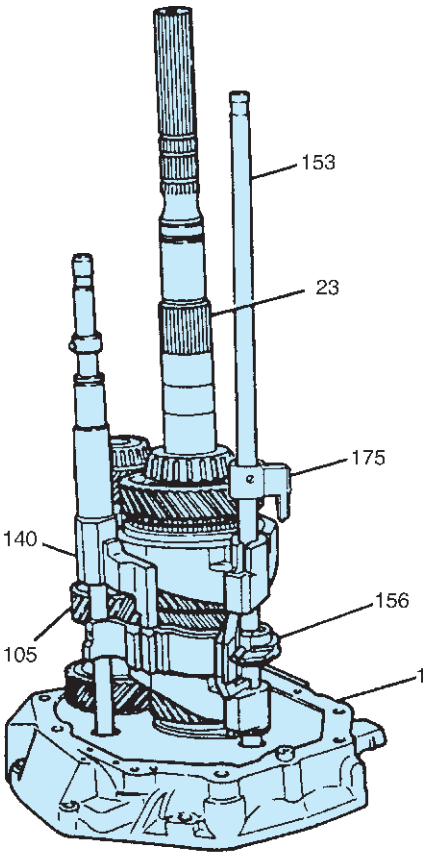


FIGURE 8-36 With this transmission, the extension housing is removed along with the mainshaft assembly. The main drive gear can be separated and removed at this point.

TECH TIP

On some tunnel-case transmissions, the extension housing and all of the internal gears are removed as a unit (Figure 8-37).

6. Remove the rear bearing, and then remove the mainshaft assembly (if not done in step 5) (Figure 8-38). This usually involves using a puller to remove a ball bearing or sliding the cup of a tapered roller bearing out of the case and then moving the mainshaft forward, upward, and out of the case.
7. Remove the cluster gear and countershaft (if not done in step 5). On one-piece tapered roller bearing units, remove the rear bearing retainer and slide the countershaft to the



1. Transmission Front Adapter
10. Shaft, Input
23. Mainshaft
105. Countershaft
140. Rail Assembly, 5th/6th and Reverse Shift
153. Rail Assembly, 1st/2nd 3rd/4th Shift
156. Plate, Interlock
175. Lever, Skip Shift

FIGURE 8-37 On tunnel-case transmissions, both the mainshaft and countershaft with their gear assemblies are removed from the case at the same time. The extension housing portions have been removed from this T56 during earlier steps. *(Courtesy of Transmission Technologies Corporation, TTC)*

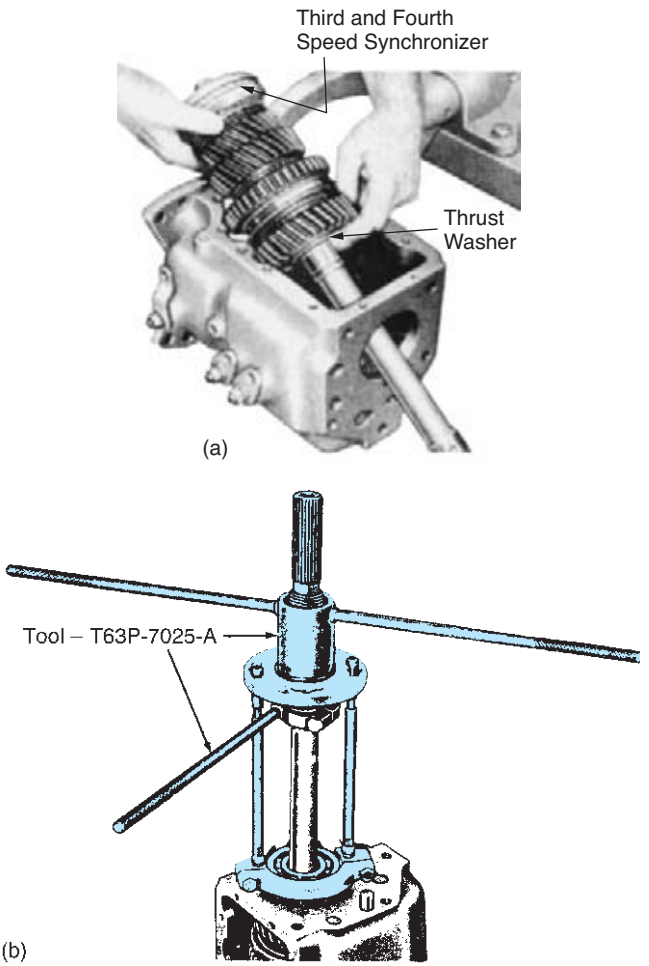
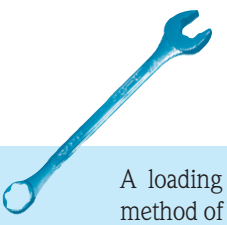


FIGURE 8-38 The mainshaft is removed through the top of the case (a) of this transmission after the output shaft bearing has been removed (b). *(Courtesy of Ford Motor Company)*

rear of the case to remove the rear bearing cup, then move the shafts forward and upward for removal (Figure 8-39).

On two-piece needle-bearing units, locate the lock that keeps the countershaft from rotating; this is usually a key or pin. The pin will need to be removed; a key will fall out as the countershaft is removed (Figure 8-40). Next, use a brass punch or commercial loading tool/dummy shaft, to drive or press the countershaft out of the case; this will usually be toward the rear (Figure 8-41).



TECH TIP

A loading tool/dummy shaft is the preferred method of pushing out the countershaft because the needle bearings can be kept in place in the cluster gear. A loading tool can be made by cutting a piece of smooth plastic rod or tubing, metal tubing or pipe, or wooden dowel to a length slightly longer than the cluster gear. The diameter of the loading tool should be the same size or slightly smaller than the countershaft.

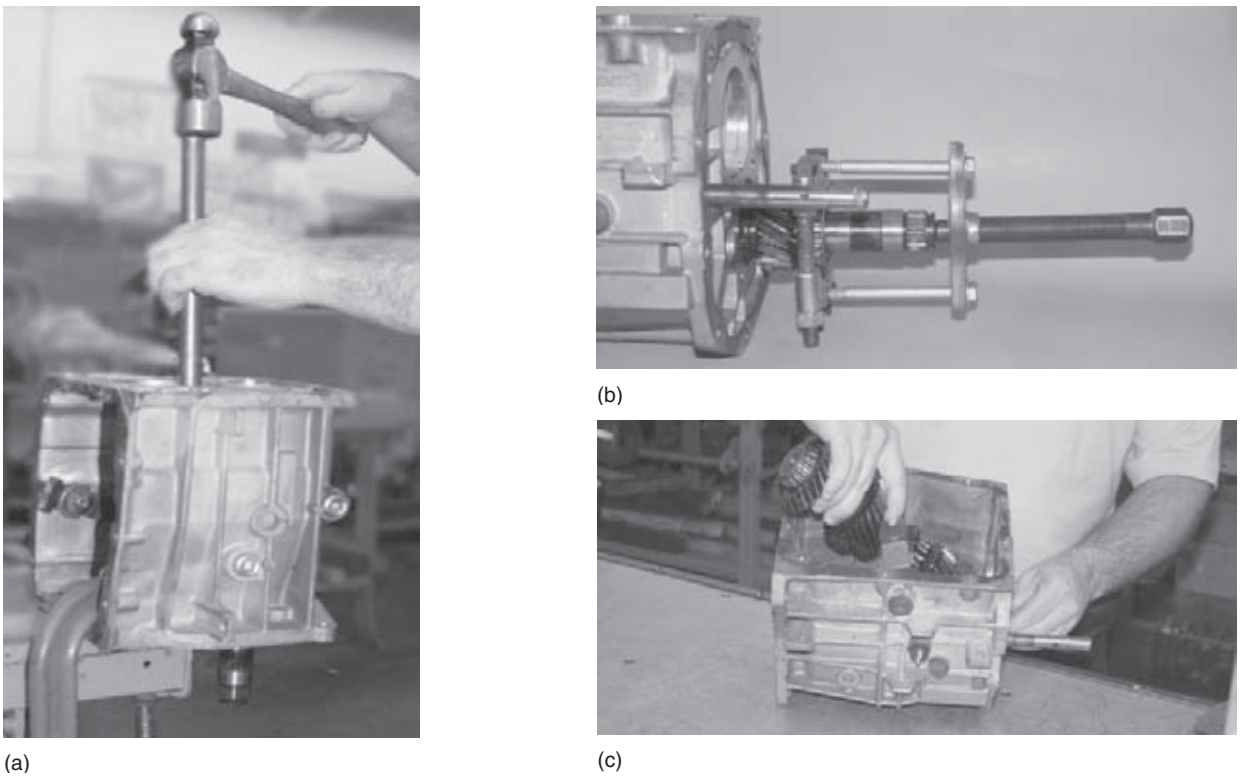


FIGURE 8-39 A T5 cluster gear is removed from the case by pushing the cluster gear downward so the rear bearing is out of the case (a), removing the rear bearing (b), and lifting the cluster gear from the case (c). Note that a brass punch is used to push on the cluster gear.

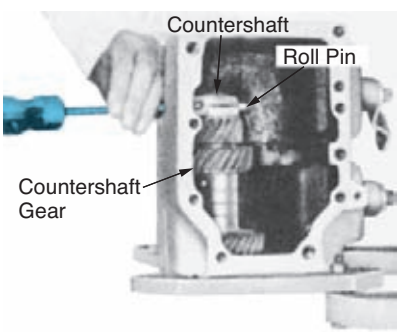


FIGURE 8-40 Transmissions with separate cluster gears and countershafts use a pin or key to locate the countershaft in the case. *(Courtesy of Ford Motor Company)*

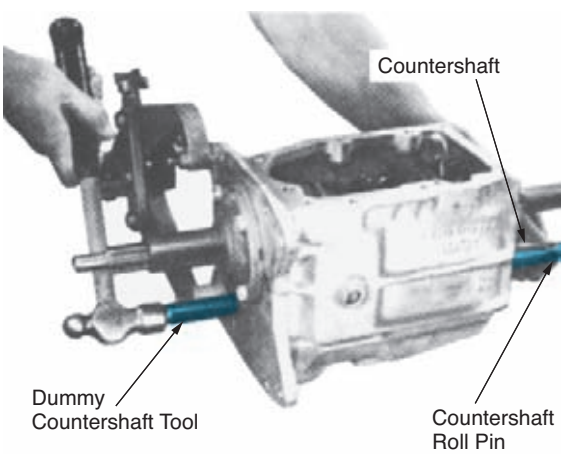


FIGURE 8-41 The dummy countershaft tool is being used to drive the countershaft out; it will stay in the cluster gear to hold the needle bearings in position until the gear is removed. *(Courtesy of Ford Motor Company)*

Remove the cluster gear and thrust washers from the top of the case (Figure 8-42).

8. Locate and remove the reverse idler gear shaft locking device, and remove the shaft, gear, and any thrust washers or O-rings (Figure 8-43).

On some units, the idler gear shaft must be driven out using a long tapered punch; the end of the shaft has a recess to keep the punch located properly (Figure 8-44).

On other units, the idler gear shaft must be pressed out (Figure 8-45).

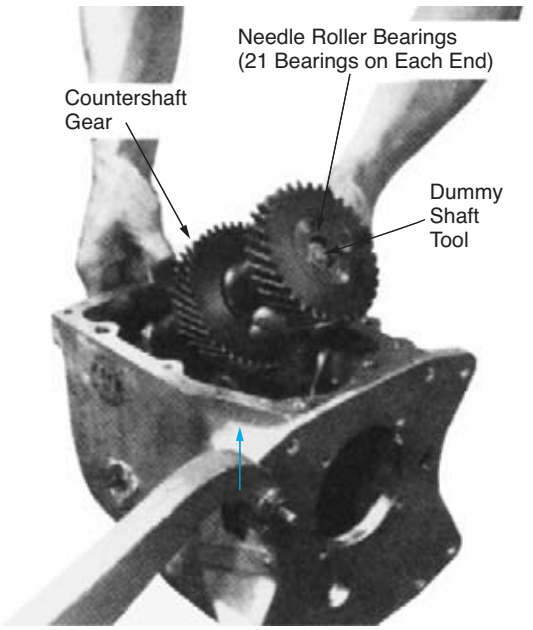
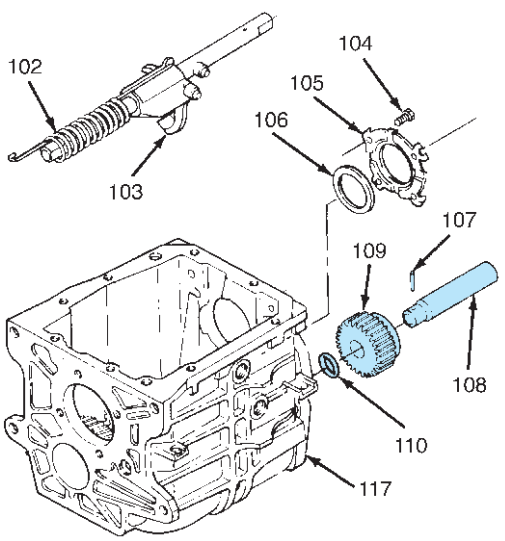


FIGURE 8-42 This cluster gear is being removed from the case along with the dummy shaft tool and needle bearings. *(Courtesy of Ford Motor Company)*

FIGURE 8-44 A recess is provided in the end of this reverse idler gear shaft so that a punch can be used to drive it out of the case.



102. Spring
103. Fork, Pin and Roller Assembly
104. Bolt
105. Rear Retainer
106. Shim
107. Roll Pin
108. Reverse Idler Shaft
109. Reverse Idler Gear
110. O-Ring
117. Case Assembly

FIGURE 8-43 Reverse idler gear assembly showing the relationship of the various parts. *(Courtesy of BWD Automotive Corporation)*

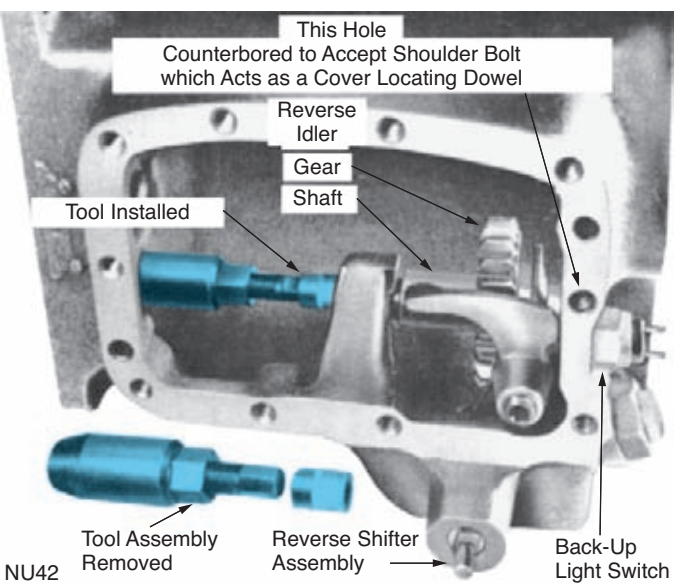


FIGURE 8-45 A special tool is being used to force this reverse idler gear shaft out of the case. For this purpose, a shop-made tool can be made from a nut, bolt, washer, and short piece of pipe. *(Courtesy of DaimlerChrysler Corporation)*

At this time, the transmission should be disassembled and the subassembly reconditioning steps can be performed.

Parts Cleaning

The first step in cleaning is to check the debris attached to the magnet located in the bottom of the case (Figure 8-46). This will provide an important clue to the internal damage you may find. Large, irregular-shaped particles are probably chips from gear teeth. Small, fine, sandlike or powderlike particles indicate material worn off a bearing, gear, or synchronizer assembly.

REAL WORLD PROBLEM

Imagine that you are working in a transmission repair shop and you encounter these problems:

Case 1

The customer's concern was no second gear, and as you disassembled the transmission, you found the second-gear teeth stripped off the cluster gear. You should completely inspect the transmission to determine what new parts to install, but with this much information, what parts should be replaced?

Case 2

The customer is concerned that the transaxle has no third or fourth gear. During your road test, you find a normal first, second, fifth, and reverse, but the shift is blocked for third and fourth. What do you think is causing this problem? What parts should you check carefully during the disassembly of this unit?

FIGURE 8-46 This case magnet has been removed from a badly worn transmission. Imagine where all this metal came from and the damage that occurred as it passed through the transmission.

SAFETY TIP

Use care if cleaning with petroleum-based solvents. Some of these can cause skin or respiration problems and should not be inhaled or allowed to remain in contact with your skin. There is also a fire hazard when the solvent is blown into the air as the parts are dried.

TECH TIP

Parts should not be wiped dry with shop towels; this could leave lint, which later could block an oiling funnel or passage.

The cleanup of most of the internal parts is done by dipping them in a safety solvent while scrubbing them with a cleaning brush or by running them through a hot-water washer. After cleaning, the parts are dried using compressed air and if necessary, then rewashed and redried until they are clean.

When drying bearings, hold the bearing, or direct the air blast, so as not to spin and possibly damage the bearing. Thick deposits and caked-on debris can often be removed by scraping, using care not to damage the metal surfaces, especially the sealing surfaces.

Old sealant is normally removed with an aerosol sealant-removing solvent or a small sealant-removing brush or pad mounted in a drill motor.

Gear Inspection

In some cases, gear damage is quite obvious and easy to locate (Figure 8-47). There is no need to clean up some of the unusable gears shown in Figure 8-48. With other gears, however, a close inspection is necessary to determine if there is a problem with the teeth or thrust or bearing surfaces.

Each of the gears, along with their clutching teeth and their inner bore, should be inspected for wear or damage. Close inspection of a gear tooth will often show a smooth metallic sheen with a duller, cleaner area; this indicates the gear's contact pattern with its mating gear. Many gear teeth

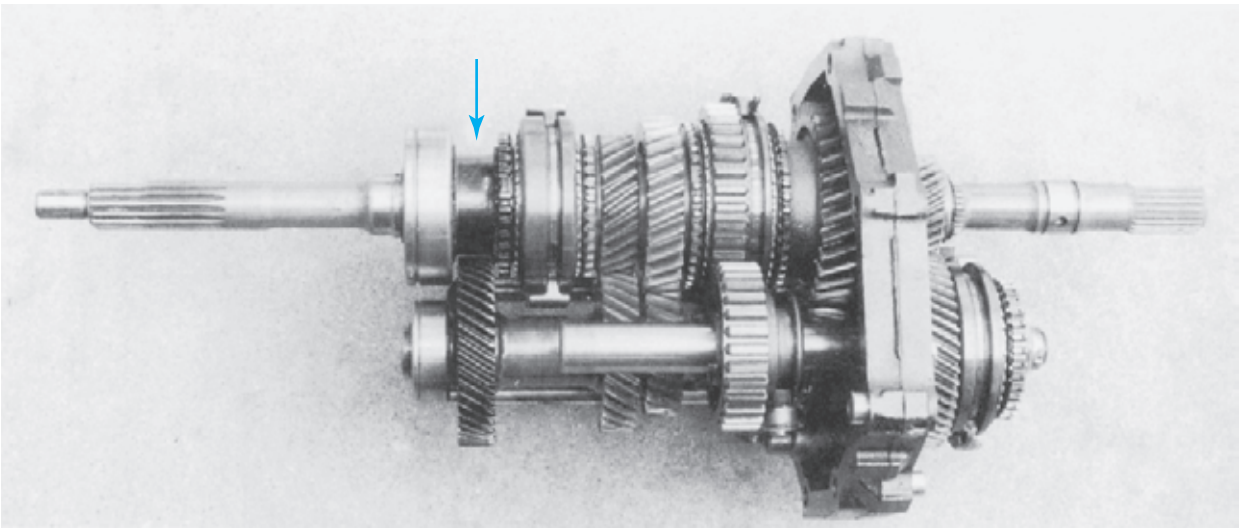


FIGURE 8-47 This transmission has been severely overheated; note the main drive gear and the blackened gear on the cluster that it was meshed with.

TECH TIP

Overheated cluster and main drive gears are caused by low lubricant level. Remember that the average motorist never checks standard transmission oil level. The technician must make sure that all transmission seals are in good shape and educate the customer to have the gear oil checked at regular intervals.

TECH TIP

If one gear of a set has a broken tooth, be aware that a tooth on the mating gear encountered the same load and is probably damaged. The broken gear and its mate are replaced as a set.

will also show underlying machine marks from when the gear was originally made; these marks are normal (Figure 8-49). The contact area should occur in the vertical center of the tooth and be almost as long as the tooth. Figure 8-50 shows acceptable contact patterns and patterns that require replacing the gear(s). Improper contact patterns are especially important when checking for gear noise problems.

The cluster gear used in the Tremec TR-3550 transmission is a three-piece unit (Figure 8-51). It can be disassembled to allow replacement of its parts.

Gear damage occurs in many forms. The terms used by Borg Warner Automotive to describe damage are as follows:

- **Burr:** local rise of material forming a protruding sharp edge
- **Chip:** area from which a small fragment has been broken off or cut
- **Crack**: surface break in the nature of a line, indicating partial or complete separation of material
- **Excessive wear:** heavy or obvious wear beyond expectations, considering conditions of operation
- **Galling:** breakdown (or buildup) of metal surface due to excessive friction between parts; particles of the softer material are torn loose and welded to the harder material
- **Indentation:** displacement of material caused by localized heavy contact
- **Nick:** local break or notch; usually, displacement of material rather than loss
- **Scoring:** tear or break in a metal surface from contact under pressure; may show discoloration from heat produced by friction
- **Step wear:** heavy wear that produces a step that can be seen or felt between adjacent contact and noncontact surfaces
- **Uneven wear:** condition of localized, unevenly distributed wear; includes hollows, shiny spots, uneven polish, and other visual indications

FIGURE 8-48 Some faulty parts, such as the damaged gears (a, b, and c) and broken countershaft (d), are rather obvious; others are also easy to spot, such as the mainshaft (e) or countershaft bearing (f). Some faulty parts, however, look almost normal, like the synchronizer hubs that are broken (g) or have a worn thrust surface (h) or the input bearing retainer that has worn through the hardened surface (i).

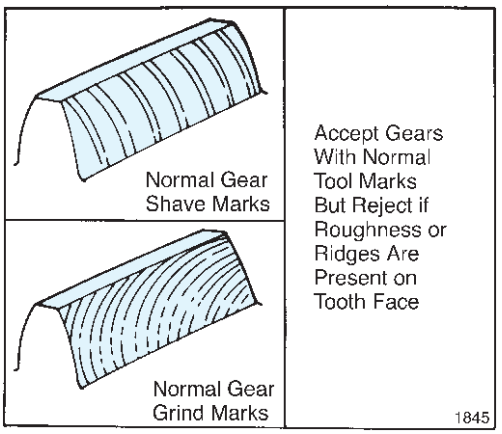


FIGURE 8-49 Normal machine marks on gear teeth are not cause for gear replacement. *(Courtesy of BWD Automotive Corporation)*

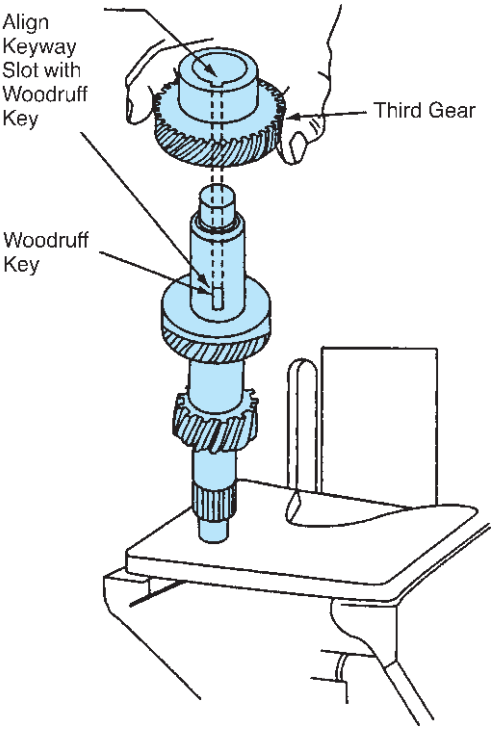


FIGURE 8-51 Third gear should be aligned with the key before pressing it onto the TR-3550 cluster gear. *(Courtesy of Transmission Technologies Corporation, TTC)*

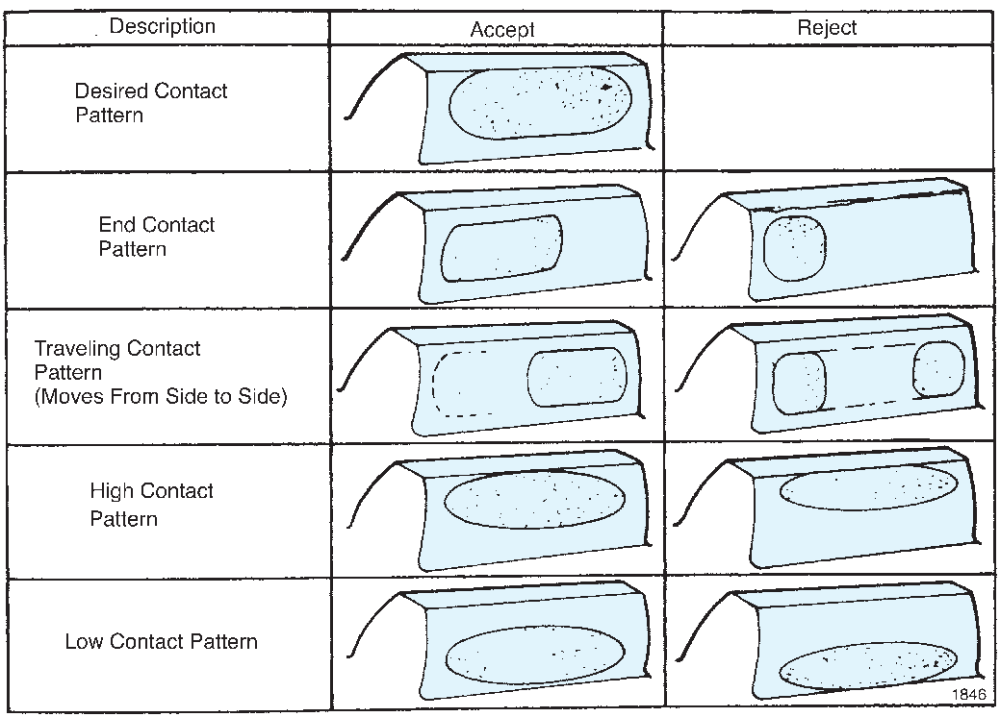


FIGURE 8-50 Worn gears will often show a contact pattern on close inspection. Good and bad patterns are shown here. *(Courtesy of BWD Automotive Corporation)*

REAL WORLD FIX

A 1992 Toyota MR2 (99,000 mil) had a problem of fifth-gear jump-out. After confirming the problem, the technician disassembled and inspected the transaxle. A loose fifth driven gear retaining nut and a damaged fifth-gear clutch hub were found. The unit was re-assembled, using a new fifth-gear hub, sleeve, keys, and springs. The transaxle worked fine for about 1,500 mil, and then the problem returned.

The transaxle was disassembled again, and it was determined that a damaged fifth driven gear was overlooked during the original repair. Replacement of this gear fixed this transaxle. A thorough inspection during the first repair would have caught the other problem and would have saved pulling the transaxle a second time.

TECH TIP

A technician often has to decide whether to reuse or replace slightly worn or damaged parts. Some cluster gears, for example are very expensive, and replacement can raise the cost of a rebuild significantly. Normally, chips that do not extend into the contact area do not require gear replacement (Figure 8-52). They can, however, cause a slight noise or be the base of a stress crack or further chipping. Small burrs and chips can be removed or blended into the gear surface using a high-speed grinder with a small abrasive stone (Figure 8-53). Worn, rounded, or burred clutching teeth can also be corrected by grinding.

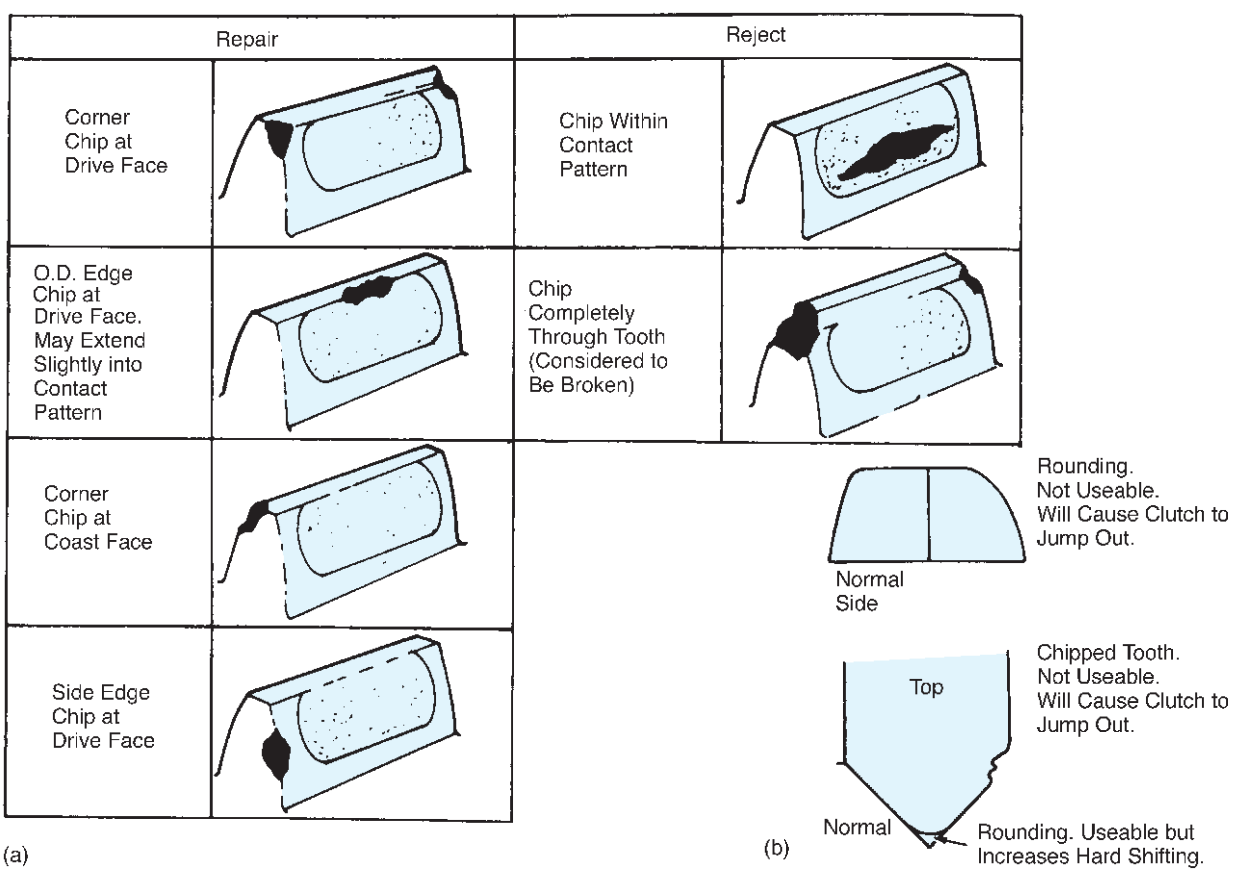


FIGURE 8-52 Some gear tooth (a) and clutch tooth (b) chipping is acceptable, and in these cases, the gear can be reused. If the chip extends into the contact pattern or is completely through the tooth, the gear should be replaced. *(Courtesy of BWD Automotive Corporation)*

Bearing Inspection and Service

Immediately after cleaning, an antifriction (ball, roller, or needle) bearing should be dipped in a clean, lightweight lubricant and covered to keep it clean and dust free. Inspection of a bearing is normally done by sight, feel, and sound. Visual inspection of a worn bearing can reveal a broken cage or pitted, spalled raceways (Figure 8-54).

The cone of a tapered roller bearing should be pushed into its cup so that there is pressure between the two as they are rotated. If the bearing feels or sounds rough, rewash, air dry, lubricate with thin oil or ATF, and repeat this check. If it still feels rough, give it one more chance by recleaning, lubricating, and rechecking it; replace it if it is still rough. If there is any doubt that the bearing is not in perfect condition, most technicians will replace it to prevent the possibility of noisy operation or comeback.

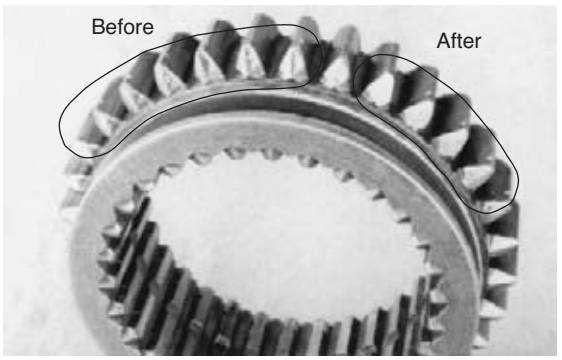


FIGURE 8-53 Teeth of a reverse gear before and after being touched up with a grinder.

TECH TIP

Holding the bearing in a vertical position by the outer race while spinning the inner race by hand allows you to feel and listen for damage not easily seen. Many technicians place the shaft inside the inner race, giving it a slight load and a much better turning handle (Figure 8-55). The weight of the shaft also makes any bearing problem more evident.

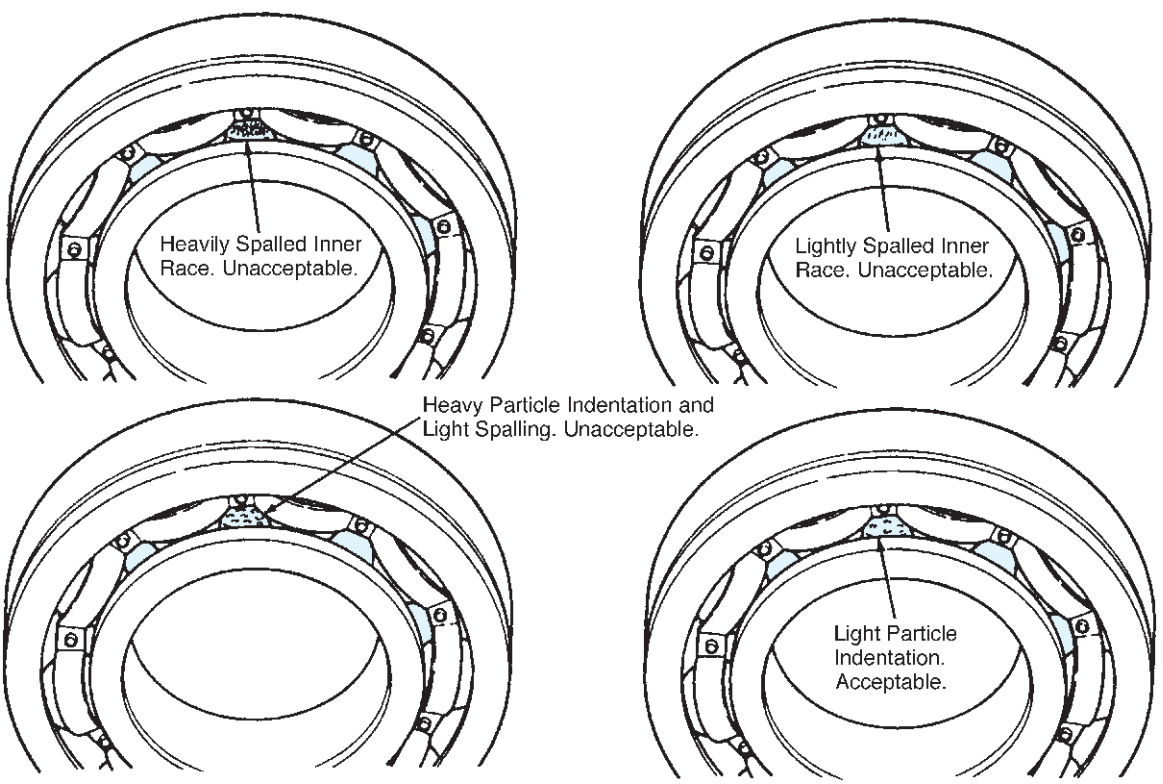


FIGURE 8-54 Bearing damage can often be seen under close inspection. *(Courtesy of Ford Motor Company)*

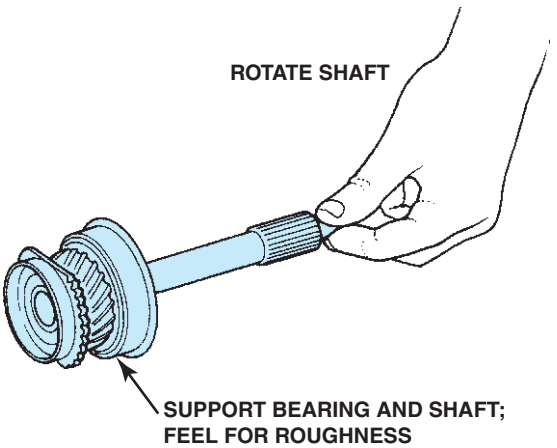


FIGURE 8-55 If you rotate the shaft while supporting it by the bearing race, you can feel any roughness that would indicate a faulty bearing.

Bearing damage occurs in many forms. The terms commonly used to describe bearing damage are as follows:

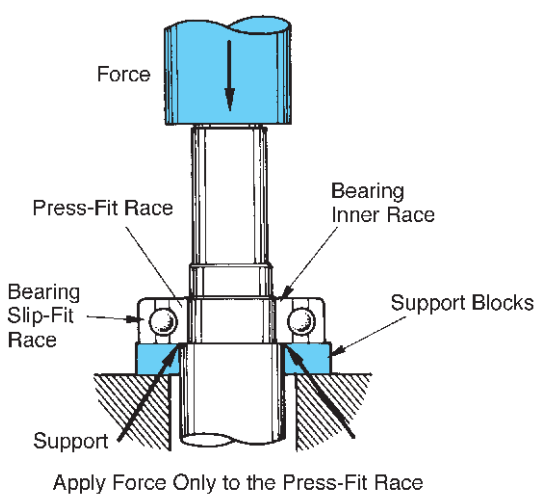
- **Brinelling**: a series of indentations pressed or worn into a race
- **Contamination**: scratches, pitting, or scoring in a scattered pattern on the ball or roller surfaces
- **Electric arcing**: a series of small burn marks or grooves across the raceways
- **Fretting**: small particles that decay and break off the bearing races
- **Misalignment**: a diagonal polish of the stationary race while excess wear occurs all over the rotating raceway from a bore and shaft that are not correctly aligned
- **Peeling**: a light scraping away of the surface of the bearing race
- **Seizing**: caused when balls or rollers fail to roll; causes damage to cage and end of rollers with evidence of excessive heat
- **Spalling**: an advanced stage of decay with flaking away of particles from the bearing race

To protect themselves as well as the bearing, technicians should exercise care when removing or replacing bearings. A pressing force through or across a ball or roller bearing will ruin the bearing and could cause the bearing to explode. This is encountered, for example, when removing a front input shaft bearing or many rear axle bearings. Their inner races are pressed onto the shaft, and the gear or axle head often prevents you from gripping the inner race; thus you have to attach the pulling tool or press adapter to the outer race. The pressing force is then transmitted from the outer race through the balls to the inner race; excessive force can damage (brinell) the balls and races and can cause explosive forces to build up in the outer race (Figure 8-56).

REAL WORLD FIX

A 1996 Pontiac Sunfire (255,000 kilometers) has a vibration along with a growling noise problem while decelerating from 30 to 10 kph. This cannot be duplicated with the vehicle on the hoist. The technician asked for assistance.

Following advice, the transaxle was removed and disassembled. A worn differential bearing was found, replaced, and adjusted. This fixed the noise and vibration.



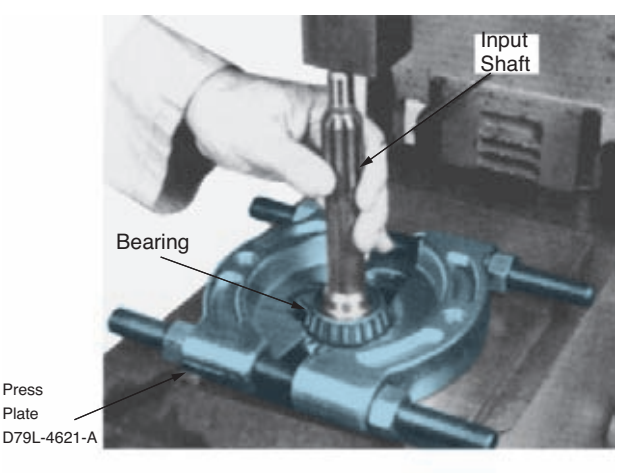


FIGURE 8-56 When a ball bearing is pressed off a shaft, the bearing should be supported by the inner race (if possible) so that the force is not exerted on the outer race by the balls (a). The bearing is often supported by a bearing separator, as shown here (b). *(a is courtesy of CR Services; b is courtesy of Ford Motor Company)*

TECH TIP

When installing a tight-fitting bearing over a shaft, heat the bearing in an oven or hot oil. A temperature of 300 to 400°F will expand the bearing about 0.001" per inch of bearing diameter. If you can't heat the external part, sometimes you can cool the internal part to make it smaller. Parts can be chilled by placing them in a freezer or immersing them in a container with dry ice and acetone. Either of these methods can change a press fit into a slip fit.

TECH TIP

When pressing a bearing, an experienced technician will always place some form of a shield over the bearing to contain possible flying parts. He or she will always replace or carefully check any bearing that requires this type of removal. It is often possible to remove a bearing with a gear so that the gear will press against the bearing's inner race, saving the bearing. When installing a bearing, it is always a good rule to apply pressure on the race that is making contact at that time (Figure 8-57). Some shops make it a practice to heat any bearing that is pressed onto a shaft; the expansion makes installation easier, with less possibility of damage to the bearing.

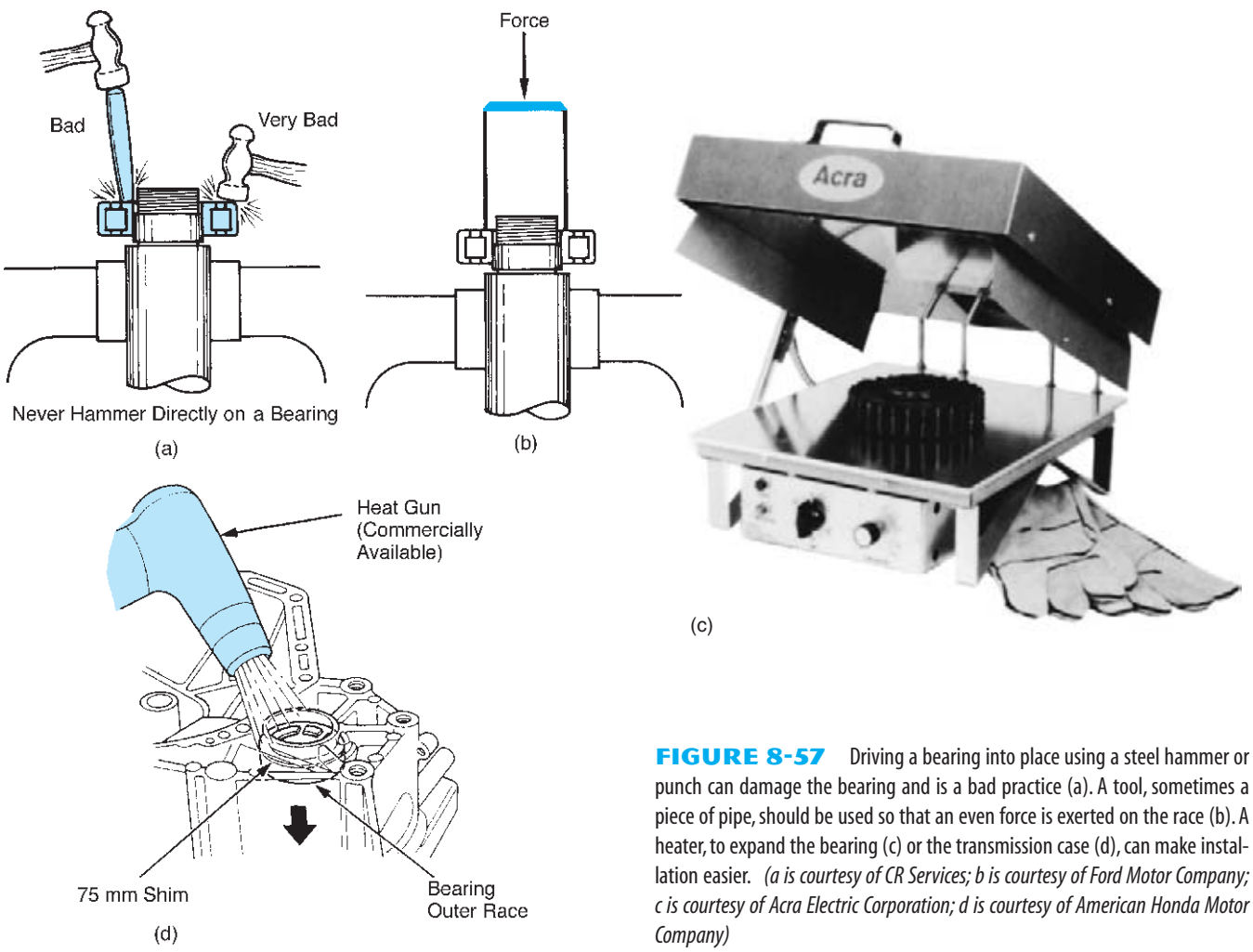


FIGURE 8-57 Driving a bearing into place using a steel hammer or punch can damage the bearing and is a bad practice (a). A tool, sometimes a piece of pipe, should be used so that an even force is exerted on the race (b). A heater, to expand the bearing (c) or the transmission case (d), can make installation easier. *(a is courtesy of CR Services; b is courtesy of Ford Motor Company; c is courtesy of Acra Electric Corporation; d is courtesy of American Honda Motor Company)*

Mainshaft Disassembly

Transaxle/transmission mainshafts are disassembled to allow a thorough inspection of the journals and bearings where the gears are mounted and for access to the synchronizer assemblies. In some cases, this is simply a matter of removing snap rings and sliding the various parts off the shaft; in most cases, the parts must be removed using a press or puller. All of these parts have a front and back; some technicians place a small index mark using a die grinder on the front of each part as it is removed. This mark will ensure that the part is positioned correctly during reassembly (Figure 8-58). Another aid is to place the parts in a holding fixture to keep the parts in the proper order.

Bearing Lubrication. Some bearings, like those on a transmission cluster gear, are lubricated by an oil bath. Other bearings, like those of a main-shaft speed gear, must have oil brought to them. Speed gear lubrication is often fed through passages in the mainshaft. Sometimes a trough or funnel is used to direct oil into a bearing or shaft (Figure 8-59). During a transmission rebuild, these oiling devices should be cleaned and checked to ensure that they will work properly.

Remember that each gear next to a synchronizer assembly has a center bearing and a thrust surface on each side of

TECH TIP

Early bearing failure that results in a pitted bearing can be caused by poor electrical grounds. The pits are often completely around the bearing races. Current flow for the engine's electrical systems must return to battery ground. Poor engine ground straps will force this current to pass through the transmission and across the bearings, and this can cause an arc at the bearing races. Adding an inexpensive ground strap to the transmission case eliminates this problem.

FIGURE 8-58 The technician used a die grinder to place the V-shaped marks on these synchronizer sleeves. They show the front or the position of the particular part.

TECH TIP

An experienced technician will always check a parts blow-up illustration to locate the snap rings and to determine the direction and order in which the parts are removed. Some mainshafts are stepped with reduced spline and journal diameters. Some have synchronizer hubs that are installed permanently on the shaft. Others have a thrust surface or flange that is part of the shaft (Figure 8-60). Any of these features will determine how the parts are removed and replaced.

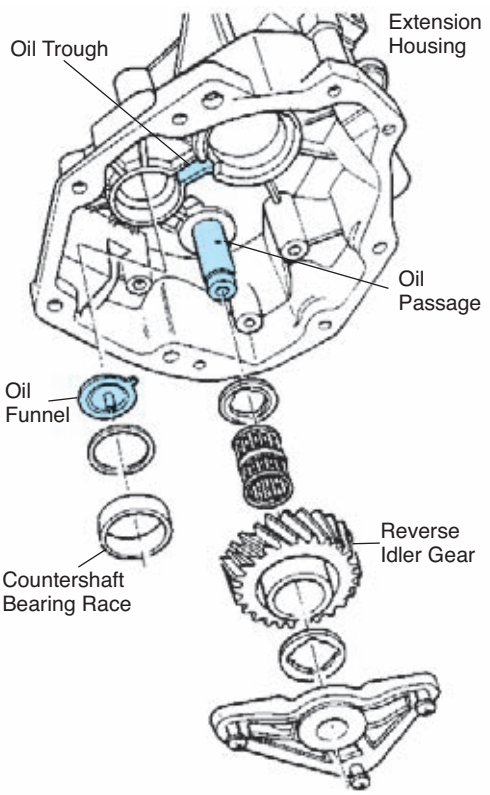
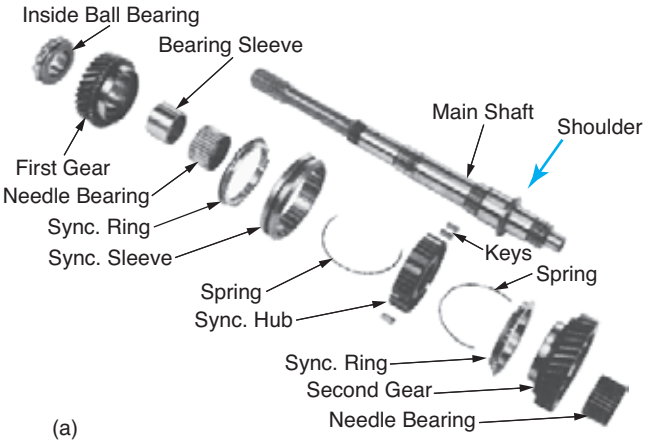
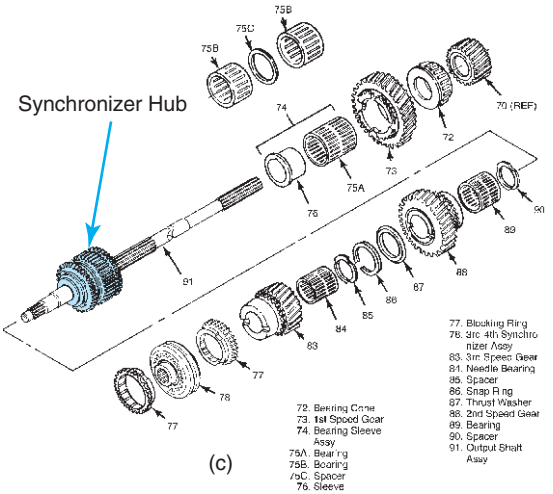


FIGURE 8-59 The oil trough feeds oil to the oil funnel and oil passage in the reverse idler shaft. The oil funnel feeds oil into the countershaft and sixth-speed gear, and the oil passage feeds oil into the reverse idler gear bearing.





Item	Description
1.	Bearing - Mainshaft Front
2.	Shaft - Main
3.	Gear - 1st Speed
4.	Ring - Synchro Blocker
5.	Spring - Synchronizer
6.	Hub - 1st/2nd Synchro
7.	Insert - Synchro Hub - 1st/2nd
8.	Gear - Reverse Sliding
9.	Spring - Synchronizer
10.	Ring - Synchro Blocker
11.	Ring - 1st/2nd Synchro Retaining
12.	Gear - 2nd Speed
13.	Ring - 2nd/3rd Thrust Washer Retaining
14.	Washer - 2nd/3rd Gear Thrust
15.	Gear - 3rd Speed
16.	Ring - Synchro Blocker
17.	Spring - Synchronizer
18.	Hub - 3rd/4th Synchro
19.	Insert - Synchro Hub 3rd/4th
20.	Sleeve - 3rd/4th Synchro
21.	Spring - Synchronizer
22.	Ring - Synchro Retaining
23.	Ring - Retaining
24.	Gear - 4th Speed
25.	Bearing - Mainshaft Rear

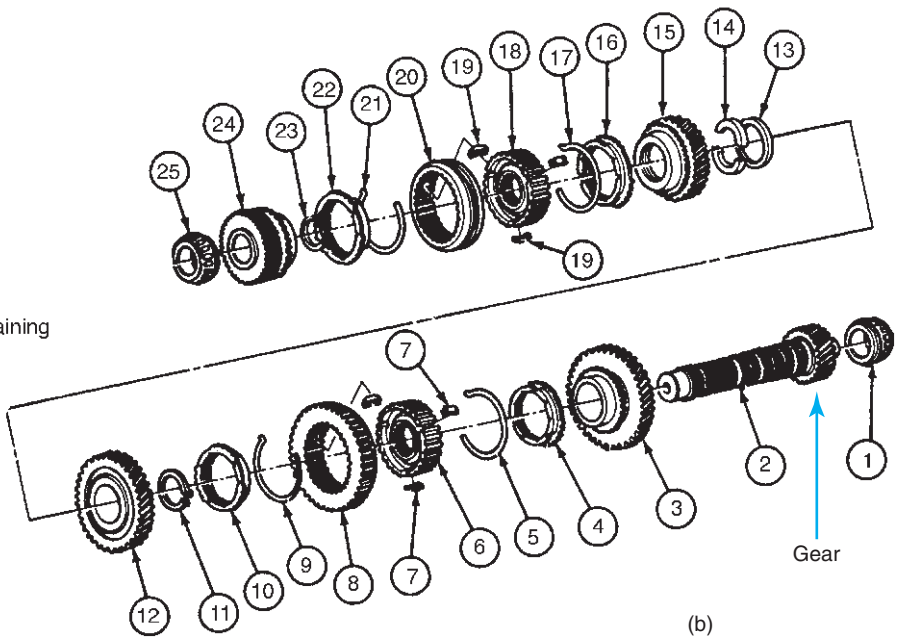


FIGURE 8-60 Some mainshafts have a thrust shoulder that requires disassembly from each end (a). Some shafts have a fixed gear at one end that requires disassembly from the other end (b). Some have a synchronizer hub that must not be removed (c). *(a and b are courtesy of Ford Motor Company; c is courtesy of BWD Automotive Corporation)*

it. The center bearing is either the smooth bore of the gear, a sleeve, or a set of needle bearings; and these operate on the mainshaft journals. The thrust surfaces are the smooth sides of the gears that can run against the smooth side of the synchronizer hub or a thrust washer. Each of these surfaces' possible wear areas are normally checked as the parts are disassembled.

TECH TIP

Gears that are not secured to the shaft should rotate easily and smoothly on the shaft and have a few thousandths of an inch of end float. Rough or sloppy motion indicates a problem with the gear or shaft (Figure 8-61).

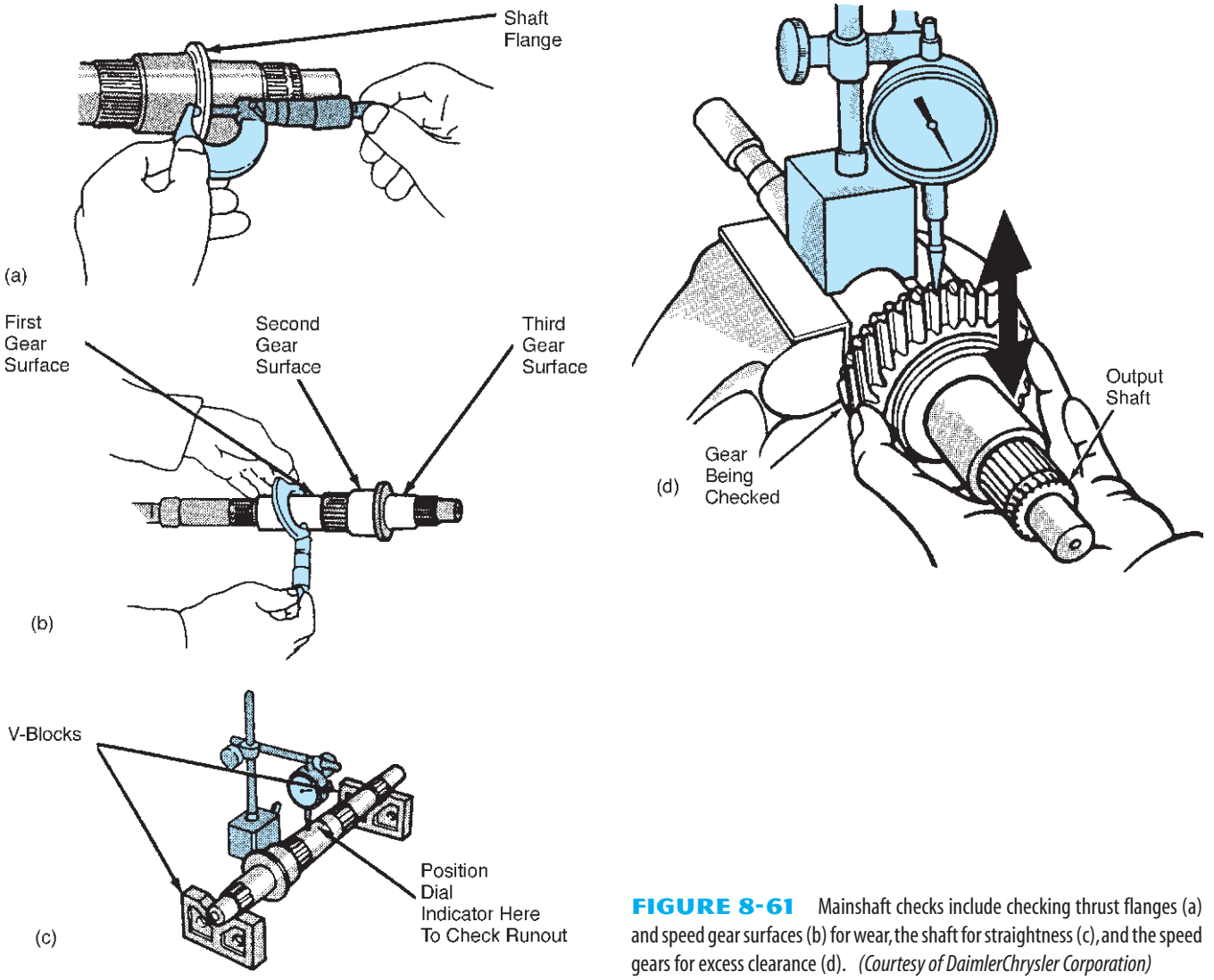


FIGURE 8-61 Mainshaft checks include checking thrust flanges (a) and speed gear surfaces (b) for wear, the shaft for straightness (c), and the speed gears for excess clearance (d). *(Courtesy of DaimlerChrysler Corporation)*

To disassemble a mainshaft:

1. In some cases, slide the end gear off the shaft. In other cases, the end gear will be held in place by a bearing that must be pressed off the shaft. Most technicians will install a bearing separator onto the gear and press the shaft out of the gear and bearing (Figure 8-62). Since the gear will contact the inner bearing race, this should remove the bearing with no damage to it. A puller can also be used.
2. Remove the blocker ring and the synchronizer hub retaining ring; install a bearing separator onto the gear next to the synchronizer assembly; and press the shaft out of the gear, blocker ring, and synchronizer assembly (Figure 8-63).
3. Continue this disassembly procedure to remove any remaining gears, thrust washers, synchronizer assembly, and bearings.

Synchronizer Disassembly, Inspection, and Reassembly

Synchronizer assemblies are disassembled for cleaning, inspection, and occasionally for deburring the ends of the splines in the sleeve. As mentioned earlier, the sleeve and hub are factory matched so that index marks need to be placed on them before disassembly.

Some synchronizer sleeves have notches for the inserts only in certain areas, and some assemblies include a detent ball and spring in addition to the inserts and energizer springs (Figures 8-64 and 8-65). Other assemblies use winged inserts or keys, which will remain in place as the sleeve is removed. Most inserts have straight sides and will pop out of place as the sleeve is slid off.

To disassemble a synchronizer assembly, remove the energizer springs and slide the sleeve off the hub. The inserts will either fall or slide out of their grooves.

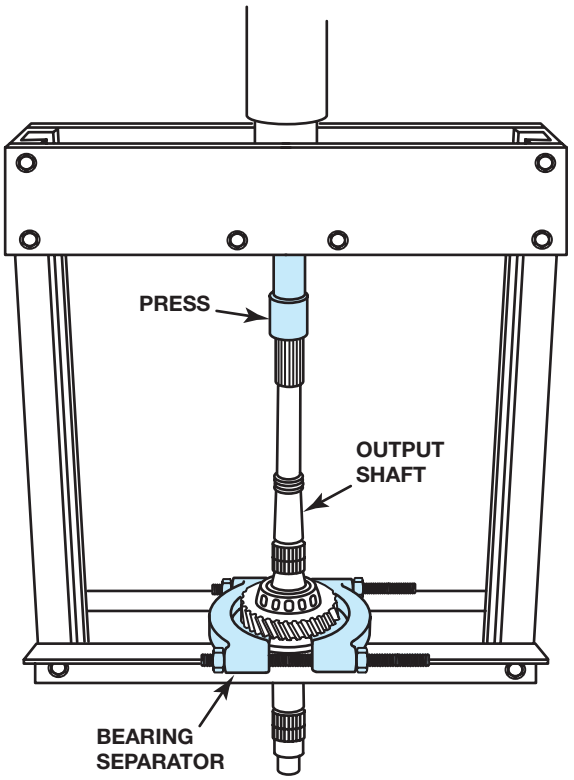


FIGURE 8-62 After the snap ring has been removed, the mainshaft will be pressed out of the gear and bearing. The gear will support the bearing by its inner race.

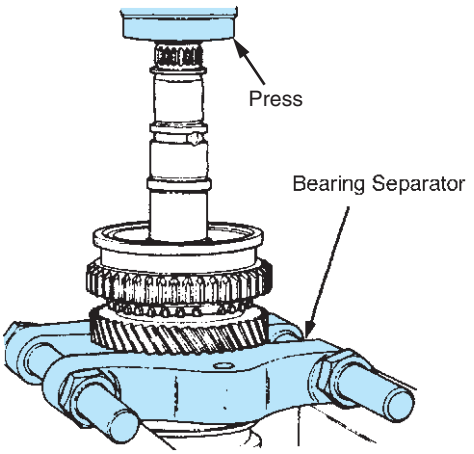


FIGURE 8-63 The bearing separator supports the speed gear, which, in turn, supports the synchronizer assembly as the mainshaft is pressed out of them.

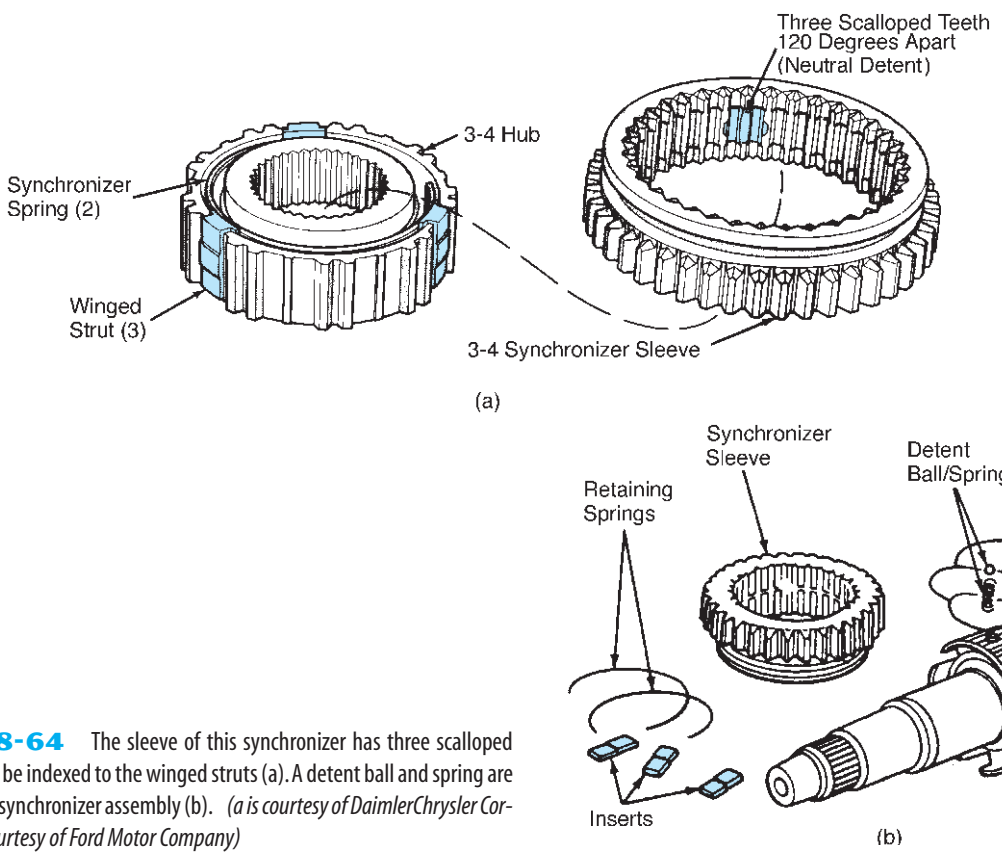
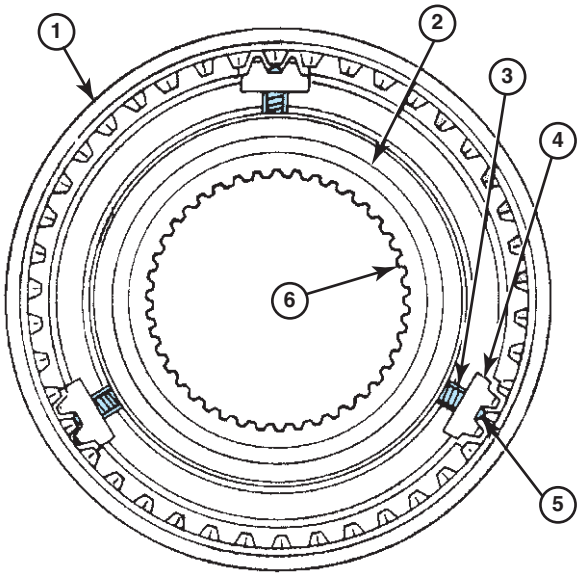


FIGURE 8-64 The sleeve of this synchronizer has three scalloped teeth that must be indexed to the winged struts (a). A detent ball and spring are included in this synchronizer assembly (b). *(a is courtesy of DaimlerChrysler Corporation; b is courtesy of Ford Motor Company)*



1. SLEEVE
2. HUB SHOULDER
3. SPRING (2)
4. STRUT (3)
5. DETENT BALL (3)
6. HUB

FIGURE 8-65 This synchronizer uses three coil springs (#3) and three detent balls (#5) to locate the struts (#4) to the sleeve (#1). *(Courtesy of DaimlerChrysler Corporation)*

TECH TIP

Some technicians prefer to disassemble synchronizer assemblies over a shop cloth or towel so that the small balls or springs won't roll away.

TECH TIP

The parts should be washed in solvent and air dried. While cleaning and checking the hub, do not let it drop; the hub is relatively soft and damages easily.

Inspection includes checking the inserts for wear or breakage, checking the sleeve for burrs, and checking the fit of the sleeve to the hub (Figure 8-66). A hub should fall freely through the sleeve. A tight-fitting sleeve will cause hard shifts. Usually, a fault with any part of the assembly will require replacement with a new synchronizer assembly.

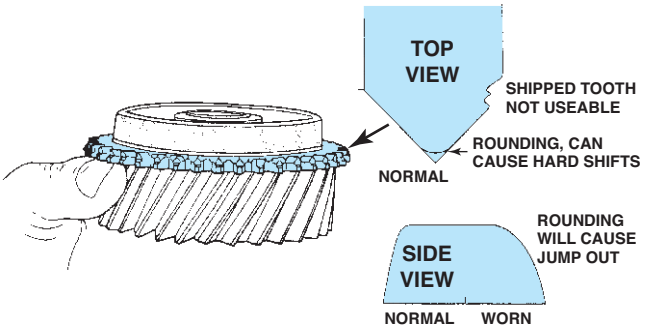


FIGURE 8-66 The clutching teeth are common speed gear wear points.

REAL WORLD FIX

A Muncie four-speed was overhauled about 500 mil ago. Now there is gear clash on 4–3 downshifts. The transmission worked well except for this problem.

Close inspection of the keys/inserts from the 3–4 synchronizer showed them to be severely worn in the center, raised area. Replacement of these keys, two blocker rings, and energizer springs fixed this shift problem. A more thorough inspection of these synchronizer parts during the overhaul would have prevented this problem.

To reassemble a synchronizer assembly:

1. Place the sleeve over the hub with the index marks aligned. If there are no index marks, locate the sleeve over the hub in a position where it moves freely and in the correct front-to-rear position. When aligned properly, the sleeve will free-fall over the hub. Many technicians will set the sleeve and hub on a shop cloth placed on a benchtop with the front/engine ends upward.
2. Slide an insert into each of the grooves.
3. Set an energizer spring in place. A common spring style has a tang that enters one of the inserts and a tail that is placed under the other inserts in a clockwise direction (Figure 8-67). Other spring styles are positioned in a similar manner.
4. Turn the assembly over and place the tang of the second spring into the other end of the same insert, and place the spring under the other insert in a clockwise direction. In

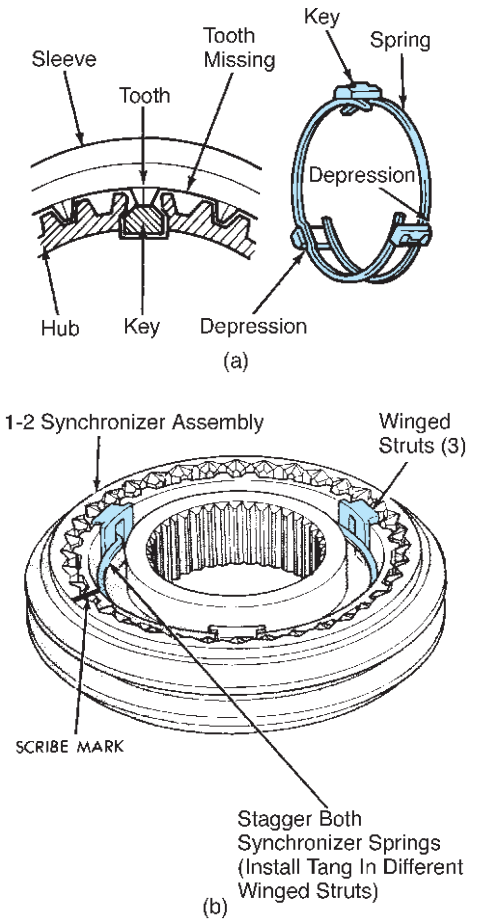


FIGURE 8-67 Some energizer springs have a depression to locate them to the keys (a). Other energizer springs have a tang to position them in a strut (b). The springs are usually staggered to different keys/struts and wrapped in opposite directions. *(a is courtesy of Ford Motor Company; b is courtesy of DaimlerChrysler Corporation)*

this way, the two springs are running in opposite directions. It should be noted that some manufacturers recommend placing the spring tangs into different inserts.

The purpose of the energizer spring placement is to obtain equal spring pressure under each of the inserts. When other spring styles are used, they are also positioned so as to distribute their force equally.

Although separate from the assembly, this is a good time to check the blocker rings and cone clutch area of the gear (Figure 8-68). Blocker ring problems commonly encountered are burred clutching teeth, broken rings, worn insert grooves, and wear on the inner cone surface.

The next check is to place the ring over the gear's cone and measure the clearance (Figure 8-70). Some manufacturers specify a minimum clearance of about 0.020 in. (0.5 mm). *Blocker ring clearance* is also called *ride height or synchronizer reserve.*

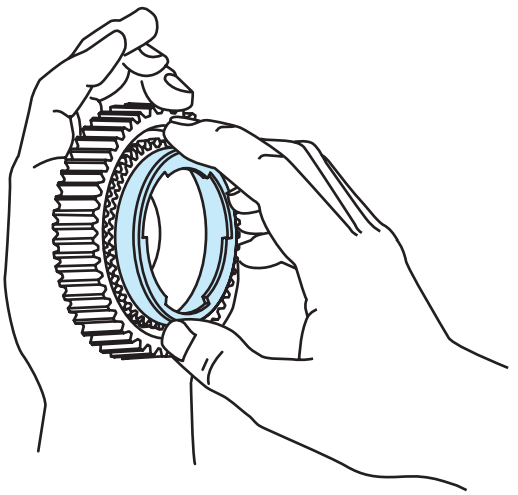


FIGURE 8-68 When pushed against its cone, a blocker ring should grab the speed gear but release cleanly and easily.

TECH TIP

A good metal blocker ring will have a thread-like inner surface with the threads coming to a sharp point; the edges will not reflect light (Figure 8-69). A worn blocker ring will have flattened rings around the inner surface.

TECH TIP

After a quick visual check for damage, a technician will drop a metal blocker ring onto a bench top from a short distance. A good blocker ring will make a bell-like ringing noise; a cracked or broken ring will make a dull, flat sound.

TECH TIP

Paper-lined blocker rings should be checked for glazing of the friction surface and discoloration, which often indicates glazing.

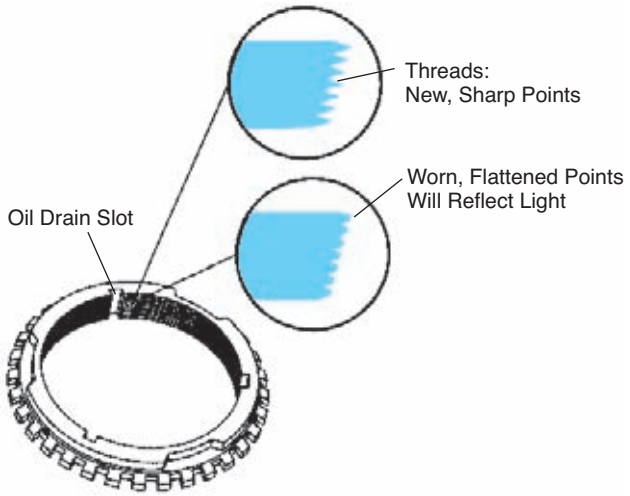


FIGURE 8-69 The threadlike grooves of a new blocker ring are sharp so they cut through the lubrication film. They become flattened as they wear, and the edges will reflect light.

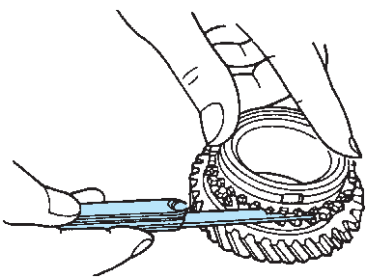


FIGURE 8-70 When the cone is pushed against the gear, there should be a minimum amount of clearance between the blocker ring and gear clutching teeth (feeler gauge). *(Courtesy of Ford Motor Company)*

REAL WORLD FIX

The five-speed, world-class transmission in a 1994 Mustang (75,000 mil) was rebuilt after a failure of the reverse gears. The cluster gear, second-speed gear, and 1–2–reverse synchronizer were replaced. The vehicle came back with a complaint about second-gear jumpout. There was also a nonrelated problem with the clutch, so the transmission needed to be removed.

The replacement 1–2–reverse synchronizer was designed for a non-world-class transmission. Installing the correct parts fixed this problem. Complete identification of the transmission when ordering the parts would have prevented this comeback.

REAL WORLD FIX

A 1994 Jeep Wrangler (131,000 mil) transmission pops out of reverse. A road test confirms this, and during this test it popped out hard enough to damage the case. The transmission was removed and sent to a rebuilder for repair. After repair, the transmission worked okay, but it then started popping out of first gear. The transmission was sent to another rebuilder, but after reinstallation and a couple of months use, the problem reappeared.

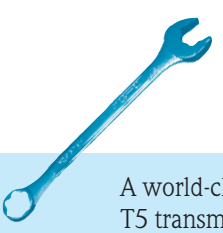
The transmission was removed once more, and the transmission shop owner went through it. He found that the 1–2 synchronizer sleeve was put in backwards, and this misaligned the detent balls on the shift rail. Proper reassembly of the 1–2 synchronizer fixed this problem.

Placing index marks on the parts as they were disassembled and checking for proper operation as the transmission was assembled would have saved a lot of excess work.

REAL WORLD FIX

Another Jeep Wrangler (165,000 mil) will not make a 5–4 downshift. With the vehicle sitting still, the shift lever moves normally from 4 to 5 and 5 to 4, but the 5–4 shift is blocked when driving. A 5–3 shift is okay. Otherwise, the transmission is quiet and works properly. This is a replacement, rebuilt transmission. An internal inspection of the transmission shows the dents and interlocks are good.

Following advice, the technician inspected the fourth-gear blocker ring and found that it was the wrong one and would rotate too far on downshifts. Replacement of this blocker ring fixed this problem.



TECH TIP

A world-class (WC) or non-world-class (NWC) T5 transmission can be identified by looking at the front of the case near the cluster gear bearing. On a WC unit, you will notice a bearing race, and you can read the part number. On a NWC unit, you will be looking at a flat, plain soft plug.

TECH TIP

There are several ways to check a blocker ring. If specifications are not available, you can measure the clearance using a new ring as a guide. The cone surface of the gear should be smooth and polished with no metal buildup (usually brass from the old ring). Metal buildup can be removed using fine emery cloth and polished using crocus cloth. Another check is to push the ring onto the cone as you rotate the gear. The ring should lock to the gear and rotate, but it should also pull right off the gear without sticking.

TECH TIP

An experienced technician will check each part for proper operation as it is assembled, knowing that it is possible to get the wrong part and that some new parts are faulty.

Mainshaft Reassembly

After the used parts cleaned and checked and any new parts needed available, the mainshaft is ready for reassembly.

A small parts kit may be obtained for reassembly. This usually includes new snap rings (old snap rings become weak, stretched, and should not be reused), thrust washers, and needle bearings; often, it also contains blocker rings, bearings, gaskets, and seals (Figure 8-71). During assembly, every moving part should be lubricated with gear oil, petroleum jelly, or transmission assembly lube.

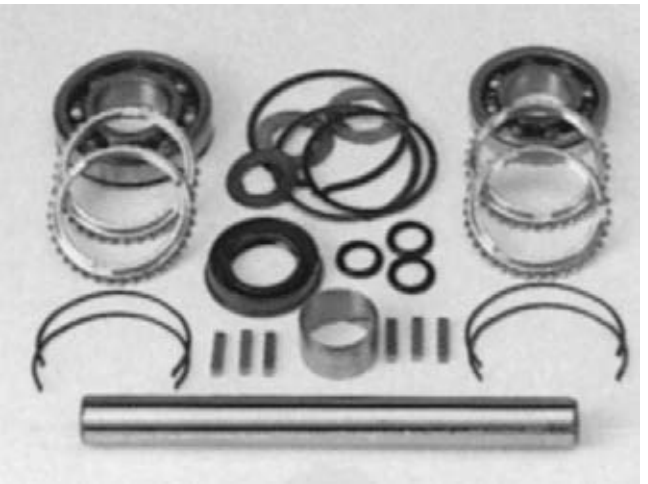


FIGURE 8-71 A transmission rebuild kit includes the parts that are normally replaced during a transmission rebuild.

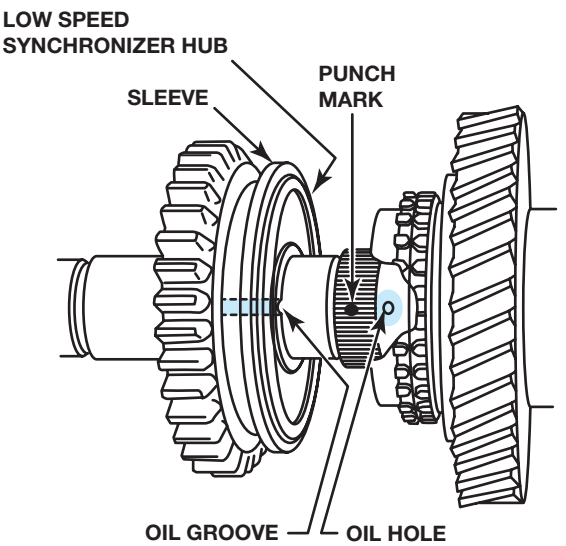
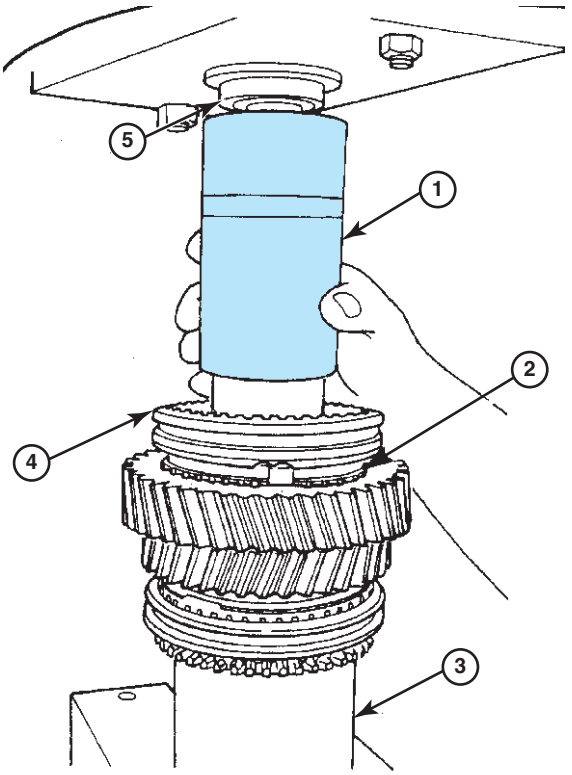


FIGURE 8-72 This synchronizer hub has an oil groove that must be aligned with the oil hole in the mainshaft during assembly.

To reassemble a mainshaft:

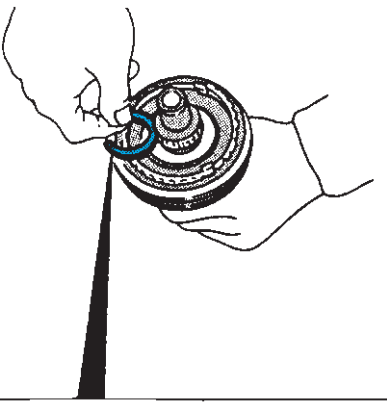
1. Place the first gear to be installed (with its sleeve, bushing, or bearing, if used) onto the mainshaft along with its blocker ring. Set the synchronizer assembly in place, making sure that it is facing the proper direction. Turn the mainshaft so that the gear is above the synchronizer, align the blocker ring so that its notches engage the inserts, and shift the synchronizer sleeve to engage the gear's clutching teeth to keep the blocker ring aligned. Some synchronizer hubs have oiling grooves that must be aligned with an oil hole in the shaft (Figure 8-72).
2. Press the shaft into the synchronizer hub and install the snap ring to retain it (Figure 8-73). It is good practice to place wooden blocks or a shop cloth onto the press plates to protect the hub from becoming burred.
3. Shift the synchronizer sleeve to neutral, and check the gear and blocker ring for *end float* and free movement.

   In some cases, *selective-fit* snap rings or thrust washers are available to adjust the clearance, if necessary.
4. Place the next blocker ring and gear in place, making sure the blocker ring notches engage the inserts, and shift the sleeve to keep them aligned. Depending on the mainshaft, this will be followed by a thrust washer(s) and retaining



1. SUITABLE SIZE PIPE
2. SYNCHRO RING
3. SPECIAL TOOL
4. 1-2 SYNCHRO ASSEMBLY
5. PRESS RAM

FIGURE 8-73 A pipe of the proper size is used to press the synchronizer assembly in place. Note that the blocker/synchro ring must be kept aligned with the synchronizer keys. *(Courtesy of DaimlerChrysler Corporation)*



I.D. Mark	Snap Ring Thickness	MM (In.)
A	1.80 - 1.85	(0.0709 - 0.0828)
B	1.85 - 1.90	(0.0728 - 0.0748)
C	1.90 - 1.95	(0.0748 - 0.0768)
D	1.95 - 2.00	(0.0768 - 0.0787)
E	2.00 - 2.05	(0.0787 - 0.0807)
F	2.05 - 2.10	(0.0807 - 0.0827)
G	2.10 - 2.15	(0.0827 - 0.0846)

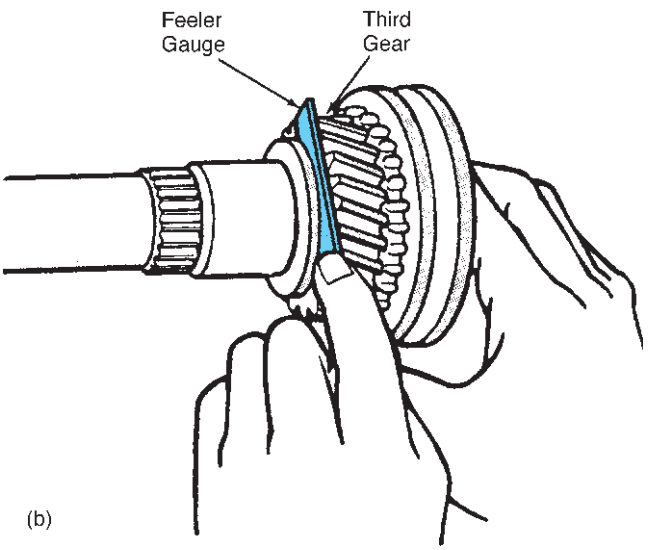


FIGURE 8-74 Some transmissions have selective snap rings available (a), and the proper snap ring should be installed so the speed gear end clearance is correct (b). *(Courtesy of DaimlerChrysler Corporation)*

TECH TIP

A blocker ring should rotate slightly. Each floating gear should have about 0.004 to 0.010 in. (0.1 to 0.25 mm) of end float (Figure 8-74).

ring or snap ring or a bearing and snap ring (Figure 8-75). The retaining/snap ring will often be the base for a thrust washer and another gear set, and this is usually a repeat of step 1. Pressing the shaft into a bearing normally completes the buildup of that end of the shaft.

5. After installing all the parts, check the assembly by shifting the synchronizer sleeves into neutral.

TECH TIP

Each of the floating gears should rotate freely and smoothly with a slight end float. Each of the blocker rings should be loose and have a slight end float.

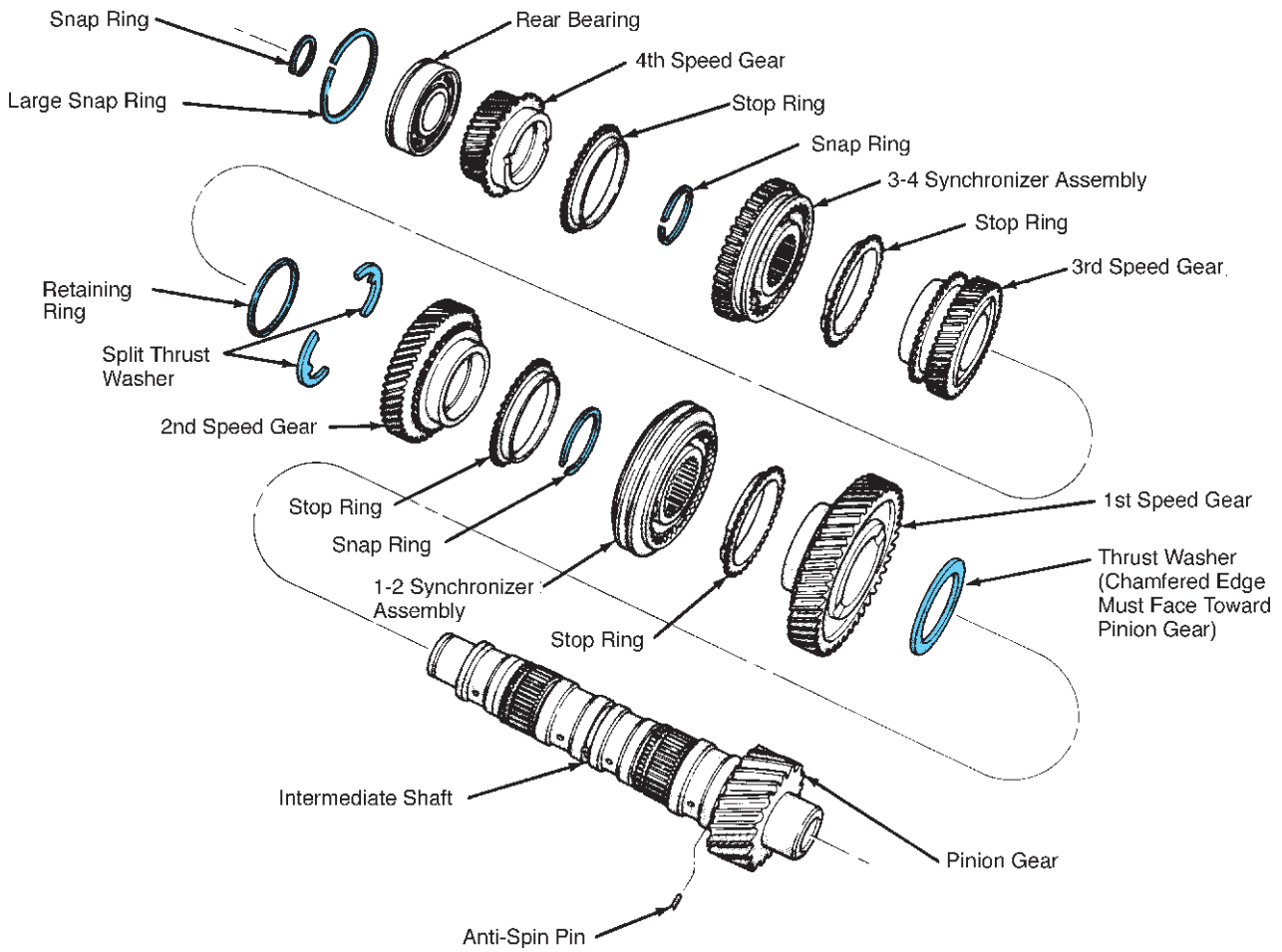


FIGURE 8-75 The first-speed gear floats between the thrust washer and the synchronizer assembly, which is positioned by the snap ring. The second- and third-speed gears float between the split thrust washer and retaining ring and their synchronizer assemblies. The fourth-speed gear floats between the rear bearing and the synchronizer assembly. *(Courtesy of DaimlerChrysler Corporation)*

REAL WORLD FIX

A 1996 Chevrolet S10 pickup (123,000 mil) came in because it was popping out of fifth gear deceleration. The transmission was disassembled, and a worn fifth gear synchronizer assembly was found. The fifth gear, synchronizer, and blocker ring were replaced as the transmission was reassembled. The transmission was reinstalled, but it still popped out of fifth gear. The transmission was disassembled, and a bad rear bearing was found. The transmission was reassembled with a new bearing, and the bearing endplay was adjusted. The transmission still popped out of fifth gear.

The transmission was disassembled for the third time, and a closer inspection showed that fifth gear had too much play on the mainshaft. Replacement of the mainshaft fixed this problem.

Differential Disassembly, Inspection, and Reassembly

Transaxle differentials need to be partially or completely disassembled to replace the bearing cones, ring gear, or differential gears (Figure 8-76).

Differential clearance can be checked using one of three methods; the method used is determined by the access

TECH TIP

Excessive clearance in the differential gear set- can cause a clunk as the lash is taken up when the clutch is engaged. This is especially noticeable when changing direction, low to reverse or reverse to low.

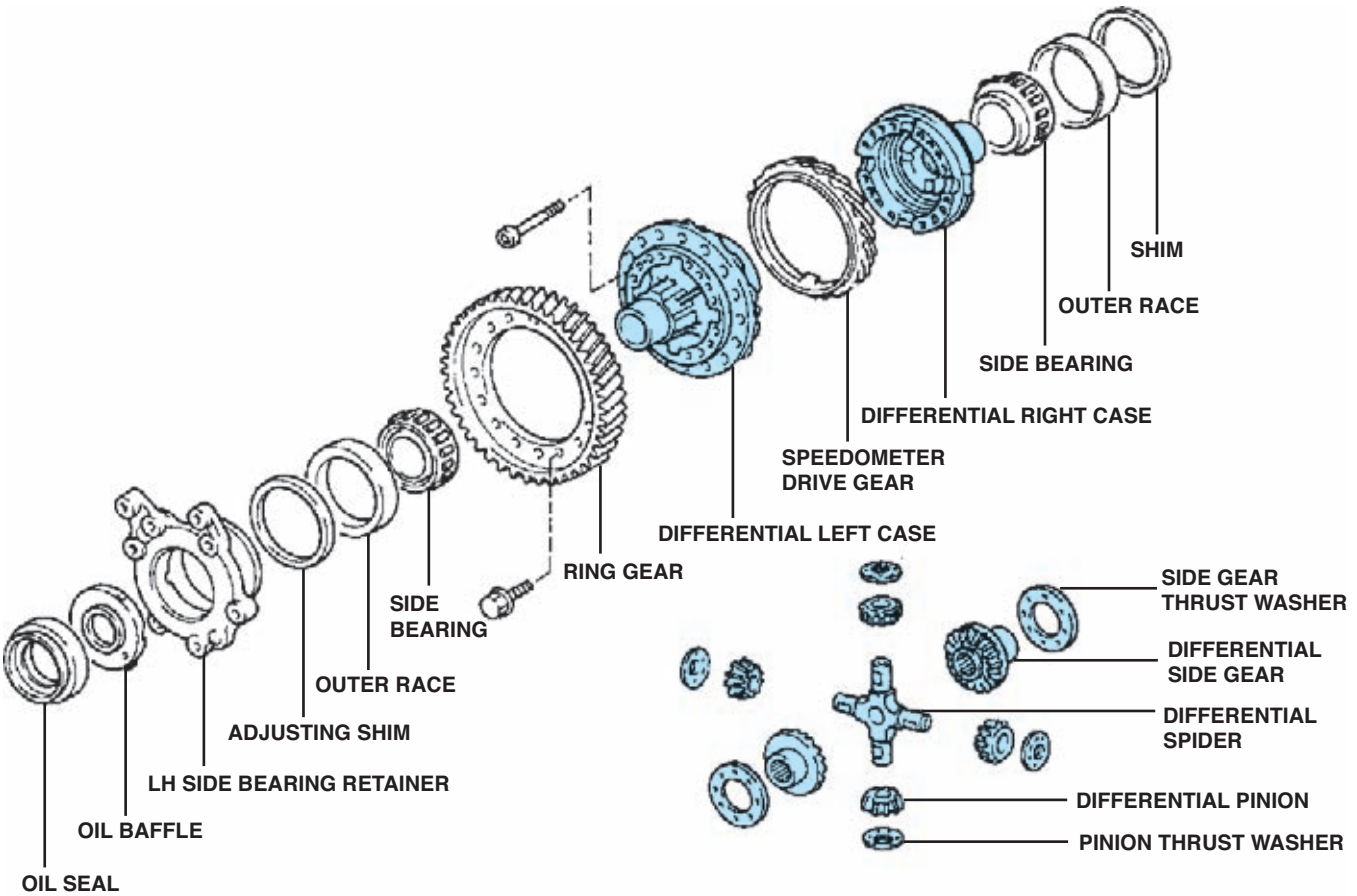


FIGURE 8-76 Exploded view of a differential. *(Courtesy of Toyota Motor Sales USA, Inc.)*

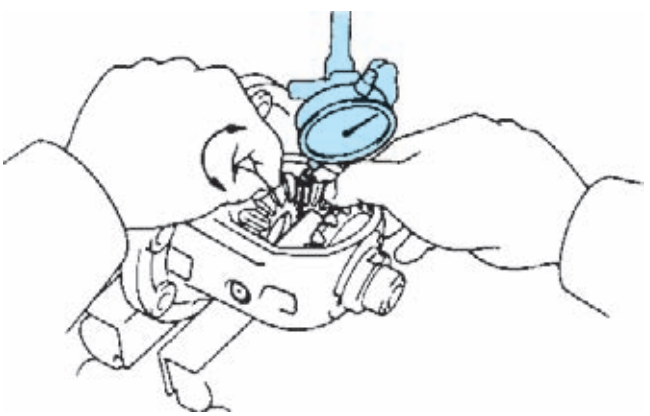


FIGURE 8-77 Differential wear can be checked by measuring the side gear backlash using a dial indicator. *(Courtesy of Toyota Motor Sales USA, Inc.)*

to the gears and how the specifications are given (Figure 8-77). The quickest and simplest method of checking differential clearance is to slide the largest feeler gauge that will fit between the axle side gear and case. Another method is to insert a strip of Plastigage between two of the gears as you rotate them and then measure the thickness of the crushed Plastigage. The third method is to set up a dial indicator with the stylus on a tooth of one of the side gears. Hold the other side gear stationary as you move the first gear back and forth against the lash. The amount of lash is shown by the amount of dial indicator needle movement. One manufacturer gives a specification of 0 to 0.009 in. (0 to 23 mm) for this check; some technicians use a judgment call. Too much clearance can be reduced in some differentials by using larger thrust washers behind the differential pinion and side gears. Other differentials do not use thrust washers, so the only way to reduce the clearance is to replace the differential.

To disassemble a differential:

1. Remove the pinion shaft lock pin (Figure 8-78).
2. Slide the pinion shaft out of the case and check it for step wear (Figure 8-79).
3. Roll the pinion gears to the case window(s) and remove the pinion gears and thrust washers and the side gears and their thrust washers (Figure 8-80).
4. Inspect the gears, thrust washers, and case surfaces for scoring and wear.

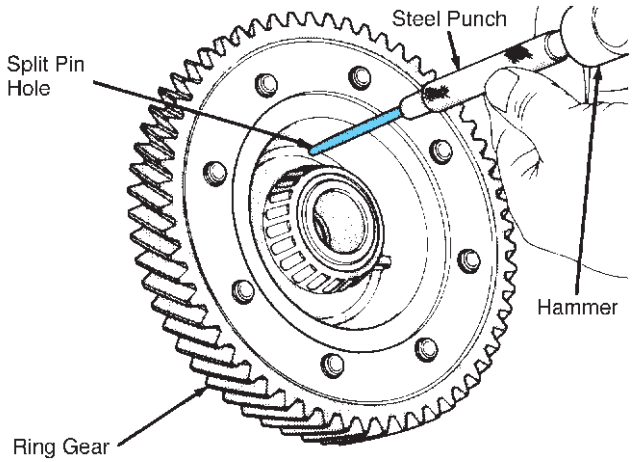


FIGURE 8-78 The first disassembly step for most differentials is to remove the pinion shaft lock pin or screw. *(Courtesy of DaimlerChrysler Corporation)*

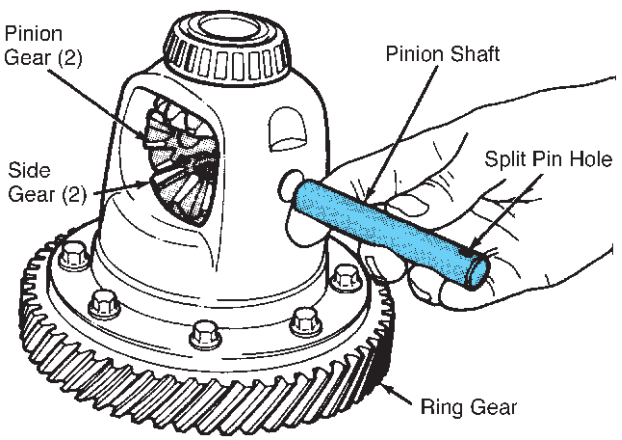


FIGURE 8-79 With the lock pin removed, the pinion shaft can be slid out of the differential case. *(Courtesy of DaimlerChrysler Corporation)*

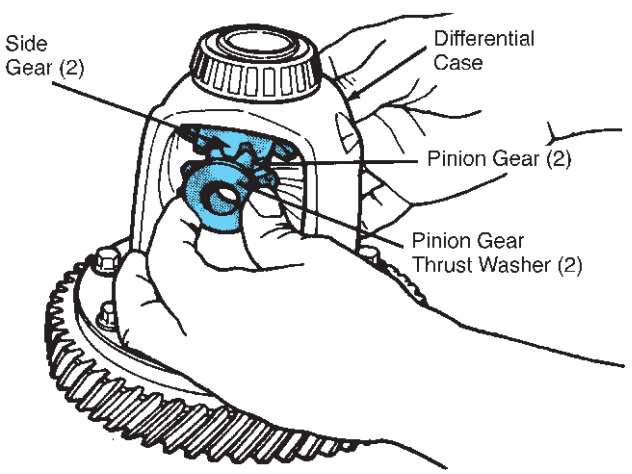


FIGURE 8-80 With the pinion shaft removed, the pinion gears can be rolled to the case windows and removed; then the side gears can be lifted out of the case. *(Courtesy of DaimlerChrysler Corporation)*

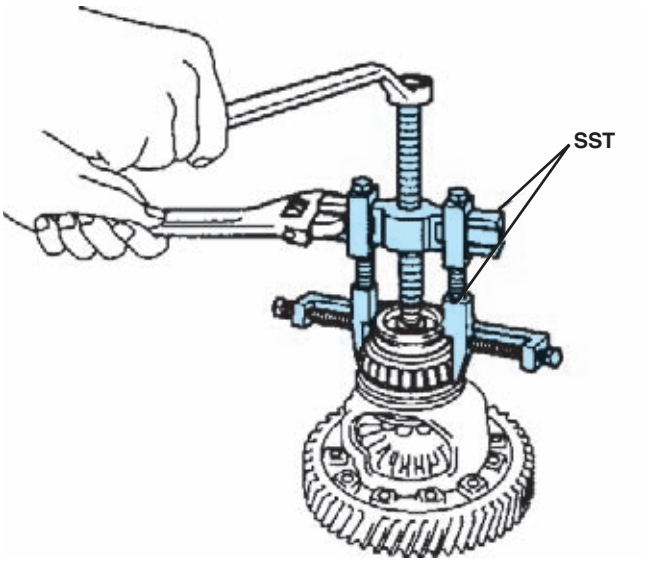


FIGURE 8-81 A faulty differential case bearing can be removed using a two-jaw bearing puller with an attachment for the puller to push against. *(Courtesy of Toyota Motor Sales USA, Inc.)*

Reverse this procedure to reassemble the differential.

A puller is normally required to remove the side bearings. Some manufacturers recommend the use of a special puller; others use a sturdy two-jaw bearing puller and a step-plate adapter (Figure 8-81). The new bearing is installed using a special bearing installer. Many shops will use a section of iron pipe of the correct diameter that fits the inner bearing race.

Ring gear replacement on most differentials is a matter of removing the bolts and then the gear. In some cases, heating the gear is required to seat it properly onto the case. The ring gear mounting bolts must be tightened to the correct torque. It is a good practice to tighten them in an alternating pattern, back and forth across the gear. Sometimes the ring gear is installed using rivets. These are normally removed by drilling through the rivet head, cutting the remainder of the head off

REAL WORLD FIX

The differential in a 1998 Saturn SL (105,000 mil) five-speed transaxle blew apart and destroyed the transaxle. An inspection showed a repaired portion of the engine block indicating this had happened before. The technician had located a low-mileage used transaxle but was concerned about possible failure in the future.

A check revealed a TSB describing an updated differential pin and gears. Installation of these parts into the good, used transaxle ensured a long-lasting repair.

REAL WORLD FIX

A 1992 Acura Legend (153,000 mil) would not move when put in gear and made a loud grinding noise. A visual inspection with the vehicle on a lift showed no obvious problem.

Disassembly of the transmission revealed the shaft that transfers power to the front drive axle was stripped. Replacement of this shaft fixed this problem.

with a chisel, and driving the rest of the rivet out using a punch (Figure 8-82). Replacement ring gears have threaded holes and are furnished with bolts.

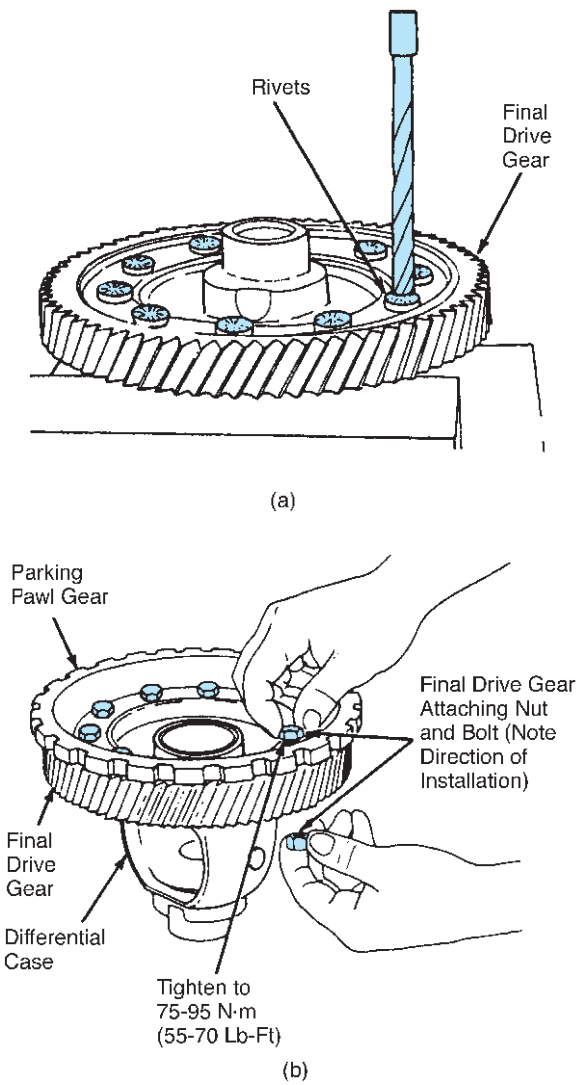


FIGURE 8-82 This final drive ring gear is riveted to the differential case. To replace it, the rivet heads are removed using a drill and chisel (a), and the new gear is installed using bolts and nuts (b). *(Courtesy of Ford Motor Company)*

Shift Mechanism

There is a large variety of shift mechanisms. Some are contained in one assembly, such as the side cover of an open case transmission. Others are spread throughout the transmission. This spread-out shift mechanism is more common with transaxles (Figure 8-83). This wide variety often creates a problem when rebuilding a particular transaxle/transmission for the first time. It is easy to forget where and how each part goes for reassembly. Following service manual illustrations helps greatly, especially if the technician relates the part to its name and function. Many technicians lay the parts out in order as the transmission/transaxle is disassembled; the parts are often marked for direction and location. Understanding what each part is and what it does leads to a successful repair.

Each mechanism set contains a fork for each synchronizer sleeve or gear to be shifted, and each fork is mounted on a rail or lever that moves it through its travel. Each shifter includes one or more springloaded detent balls or cams and some form of interlock that allows only one shift fork to move at a time.

To visually check shift mechanism:

- **Shift fork:** distortion and bends, cracks, step wear at both the sleeve contact and cam contact areas, broken or worn inserts (Figures 8-84 and 8-85)
- **Shift rail:** distortion and bends, burrs, scores, grooves, elongated pinholes
- **Detent springs:** breakage
- **Detent cam (sometimes part of a rail):** wear, scoring
- **Interlock plates:** burrs, wear, scoring
- **Selector plates:** burrs, wear, scoring
- **Reverse lockout mechanism/solenoid:** proper operation (Figure 8-86)

As the transaxle/transmission is assembled, each of these parts should be checked for complete movement and smooth operation.

REAL WORLD FIX

A five-speed transaxle in a Pontiac Grand Am (35,000 mil) was rebuilt because of chipped teeth on the reverse gears. An upgraded gear set was installed. The transaxle now hung up in two gears.

Close inspection revealed a missing interlock pin, and the missing pin was blamed for the chipped reverse gear teeth. Installation of the interlock fixed this transaxle. As a unit is repaired for a problem, always look for a cause of that problem.

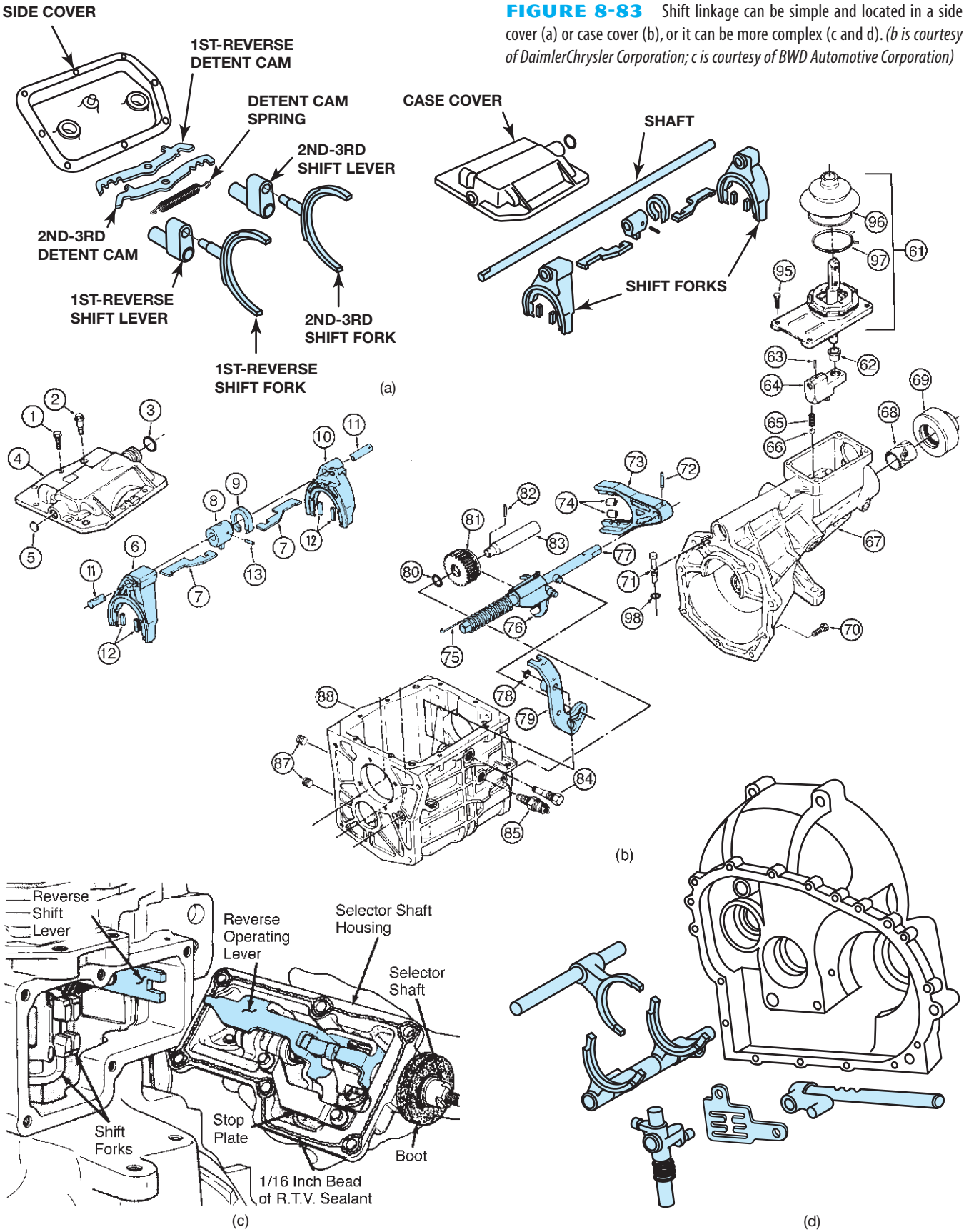


FIGURE 8-83 Shift linkage can be simple and located in a side cover (a) or case cover (b), or it can be more complex (c and d). *(b is courtesy of DaimlerChrysler Corporation; c is courtesy of BWD Automotive Corporation)*

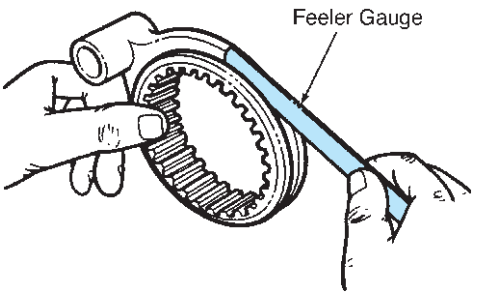
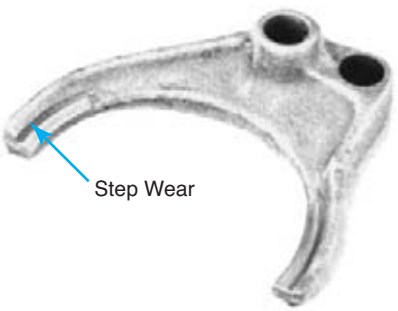
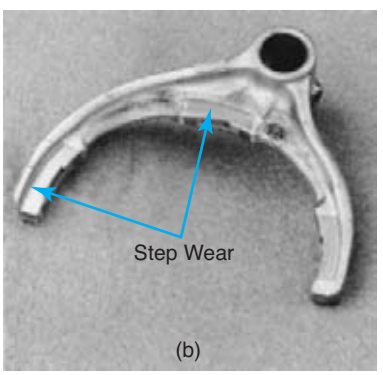


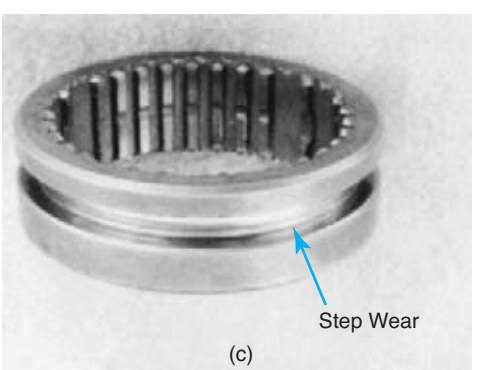
FIGURE 8-84 There should be a specified clearance (about 0.030 in.) between the fork and the groove in the sleeve; excess clearance indicates a worn fork or groove. *(Courtesy of Ford Motor Company)*



(a)



(b)



(c)

FIGURE 8-85 Close inspection of these shift forks shows a step caused by wear. Step wear and rubbing can also be seen in the synchronizer sleeve groove.

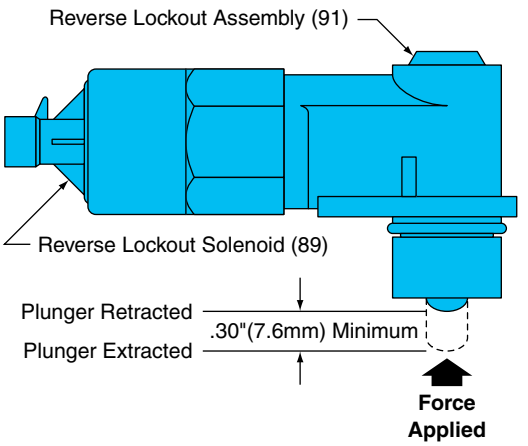


FIGURE 8-86 The reverse lockout plunger should move at least 0.300 in. when it is connected to a 12-V power source. *(Courtesy of Transmission Technologies Corporation, TTC)*

REAL WORLD FIX

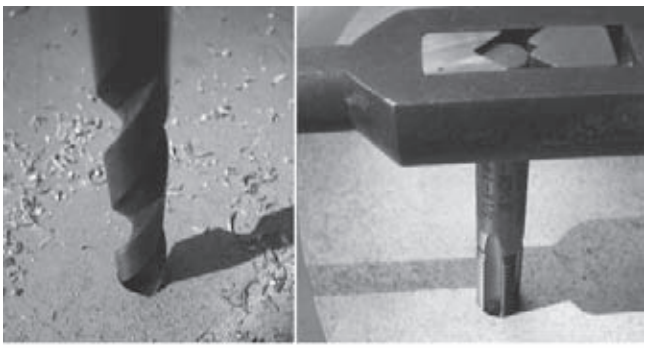
A 1995 BMW 318is (113,000 mil) had a problem of first-gear jump-out. The transmission was removed and rebuilt, and a new 1–2 guide sleeve and first gear was installed along with new transmission mounts and rubber shifter mounts. But, this did not fix the problem.

Following advice, the shift fork was measured for wear as this fork tends to wear in a very smooth manner. The shift fork measured at 0.145 to 0.170 in., and the dimension of a new fork was 0.190 in. Replacement of this fork fixed this transmission.

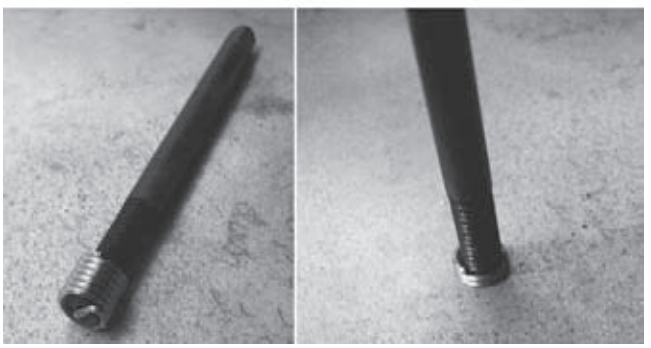
REAL WORLD FIX

A 1998 Camaro (92,000 mil) made a dry, grinding noise in fifth gear when it was cold and went away after it warmed up. The noise also occurred with the clutch depressed and the transmission in fifth gear.

Following advice, the transmission was disassembled, and inspection revealed that the plastic pads on the fifth-gear shift fork had disintegrated. Replacement of the fifth-gear shift fork and the plastic pads on all the shift forks fixed this problem.



(a) (b)



(c) (d)

FIGURE 8-87 Step 1 in repairing damaged threads is to drill a properly sized hole for the special tap (a). Step 2 is to use the special tap to cut new threads (b). Step 3 is to put the thread insert on the installing tool (c). Step 4 is to screw the insert into the new threads (d). The final step (not shown) is to break off the insert's installing tang.

Case and Covers

The case and all covers should be thoroughly cleaned and carefully checked for cracks, distortion or wear of bearing bores, stripped bolt threads, and worn throwout bearing supports. Damaged cases are normally replaced; however, they can be repaired, depending on the skill of the technician and the availability and cost of a replacement. Some rebuilders machine the case and insert steel sleeves for worn bearing bores or throw-out bearing supports to return them to the original diameter and provide stronger-than-new material.

Stripped bolt threads are normally repaired by installing a thread insert (Figure 8-87).

To install a thread insert:

1. Using the correct tap, cut new threads in the damaged hole. It is often necessary to drill out the old threads using the tap drill sized to the special tap.
2. Place the insert onto the installing tool, and thread it into the hole until the outside end of the thread enters the case threads (Figure 8-88).
3. Break off the tang that is incorporated in some inserts, or stake or resize the insert to lock it in place.

Damaged Threads Repaired Threads

FIGURE 8-88 The damaged threads (left) have been repaired (right) by installing a thread insert. They are better than new because of the hardness of the insert.

TECH TIP

Many modern gear cases are cast from aluminum and, in a few cases, magnesium. Aluminum and magnesium have very similar properties except that magnesium burns. The metal will ignite at approximately 1,600°F (872°C) and burn with an intense white flame. Once combustion begins, it is extremely difficult to stop. Unpainted magnesium cases can be identified by a dull battleship-gray coating of magnesium oxide.

Most cases include one or more seals, which are normally replaced during a rebuild. These seals include:

- Each shift shaft that passes through the case,
- One or two output shaft seals, and
- Sometimes an input shaft seal.

Old seals are normally removed by prying them out using a seal puller or pry bar, or by driving them out from behind. New seals are driven into place using a seal driver that fits against the entire outer surface of the seal to prevent seal distortion (Figure 8-89).

Transaxle/Transmission Reassembly

The procedure used to assemble a transmission or transaxle is normally the reverse of the procedure used to disassemble it; the last thing removed from the case is usually the first thing replaced. Unit assembly varies widely, and it is recommended that the manufacturer's information be reviewed for specifications and the specific procedure to follow. Each moving part should be lubricated as it is installed, and checked for free and

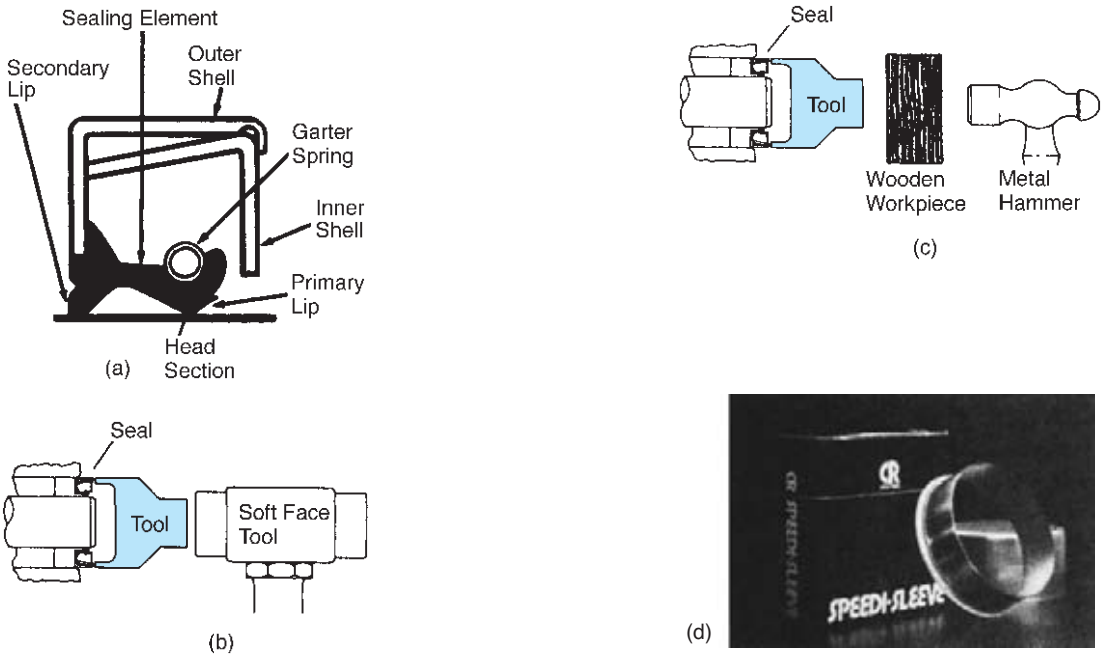


FIGURE 8-89 Improper installation can damage the outer shell of a seal or dislodge the garter spring (a). A new seal should be driven straight in using a seal driver and a soft-face hammer or block of wood to cushion the impact of the driving tool (b and c). If the sealing surface on the shaft is damaged, a thin sleeve can be installed over it (d). *(Courtesy of CR Services)*

smooth operation. Petroleum jelly, transmission assembly lube, or gear oil should be used for the lubricant.

To assemble a transaxle:

1. Set the differential assembly into the case.
2. Place the input shaft and mainshaft together and set them in the case.
3. Install the shift forks and rails.
4. Install the reverse idler gear, shaft, and fork.
5. Apply sealant to the case mating surface.
6. Install the case cover and tighten the bolts to the correct torque.
7. Install the exterior parts.
8. Check the operation in neutral and all gears.

NOTE: After assembly, the input shaft should rotate smoothly and easily in neutral and have no drag when trying to turn the output shafts; each gear range should also rotate smoothly without excess drag.

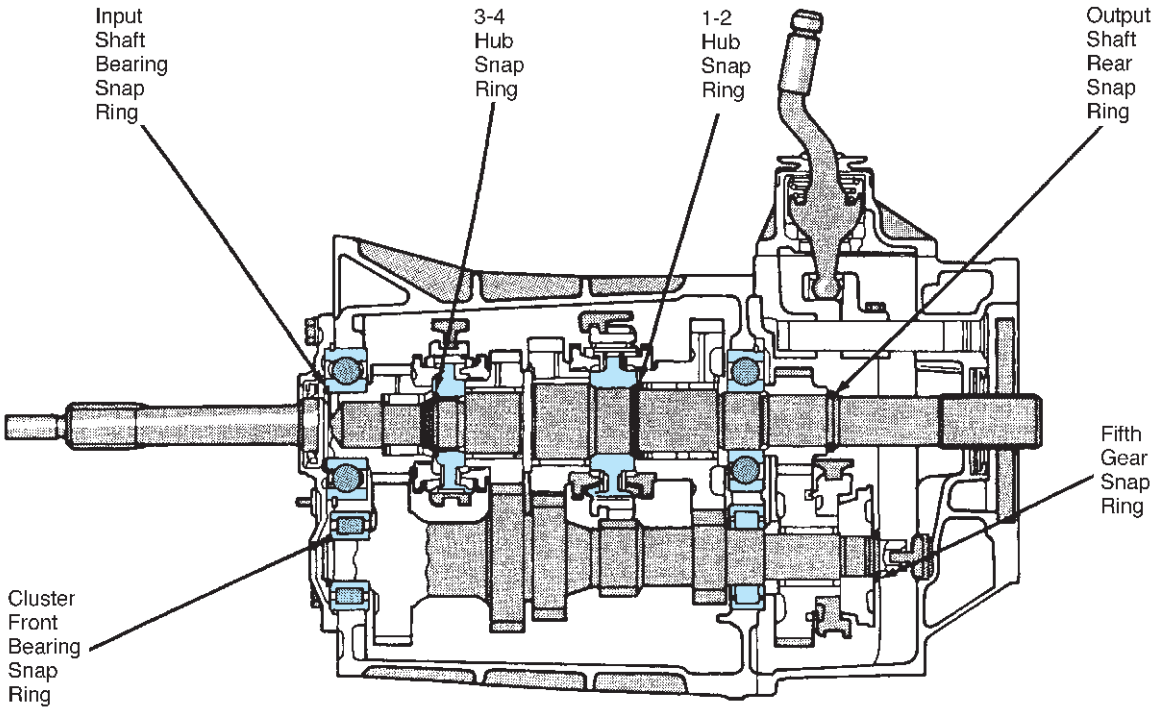
During the reassembly of a transaxle/transmission that uses tapered roller bearings, the **preload** or **end play** of each shaft should be checked. A selective **shim** is located at a bearing at one end of each shaft, and the thickness of this shim controls the amount of preload or end play (Figure 8-90). Preload causes a slight drag as a shaft is rotated; it is usually measured using a torque wrench or spring scale. End play is a free, lengthwise movement of the shaft; it is usually measured using a dial indicator or feeler gauge.

Gauging fixtures are available for some transaxles that allow for setting the clearance on all three of the shafts at one time (Figure 8-91). Without special fixtures, most shops will need to check the clearance on each shaft, one at a time. This must be done if a bearing, shaft, bearing retainer/case cover, or case has been replaced.

To check and adjust bearing clearance/preload on a transaxle:

1. Place the shaft to be checked with its bearings in the case. If new parts are used, adjustment is necessary. Use an adjusting shim that is too small, so there will be end play. A shim that is about 0.010 in. (0.25 mm) smaller than the one that was originally used, or the smallest one available, is normally used as a starter.
2. Install the bearing retainer or case cover, and tighten all bolts to the correct torque. Rotate the shaft several times as the bolts are tightened to seat the bearings.
3. Install a dial indicator with the indicating stylus at the end of and parallel to the shaft (Figure 8-92). Move the shaft up and down through its free travel several times while reading the end play or clearance on the dial indicator.

NOTE: Check end play at least three times or until you get consistent readings.



Input Shaft Bearing Snap Ring

I.D. Mark	Thickness
A	2.10-2.15 mm
B	2.15-2.20 mm
C	2.20-2.25 mm
D	2.25-2.30 mm
E	2.30-2.35 mm
F	2.35-2.40 mm
G	2.40-2.45 mm

1-2 Hub Snap Ring

I.D. Mark	Thickness
B	2.35-2.40 mm
C	2.40-2.45 mm
D	2.45-2.50 mm
E	2.50-2.55 mm
F	2.55-2.60 mm
G	2.60-2.65 mm

Cluster Front Bearing Snap Ring

I.D. Mark	Thickness
A	2.00-2.05 mm
B	2.05-2.10 mm
C	2.10-2.15 mm
D	2.15-2.20 mm
E	2.20-2.25 mm

Output Shaft Rear Snap Ring

I.D. Mark	Thickness
A	2.75-2.80 mm
B	2.80-2.85 mm
C	2.85-2.90 mm
D	2.90-2.95 mm
E	2.95-3.00 mm
F	3.00-3.05 mm
G	3.05-3.10 mm
H	3.10-3.15 mm
I	3.15-3.20 mm
J	3.20-3.25 mm
K	3.25-3.30 mm
L	3.30-3.35 mm

3-4 Hub Snap Ring

I.D. Mark	Thickness
A	1.80-1.85 mm
B	1.85-1.90 mm
C	1.90-1.95 mm
D	1.95-2.00 mm
E	2.00-2.05 mm
F	2.05-2.10 mm
G	2.10-2.15 mm

Fifth Gear Snap Ring

I.D. Mark	Thickness
A	2.80-2.85 mm
B	2.85-2.90 mm
C	2.90-2.95 mm
D	2.95-3.00 mm
E	3.00-3.05 mm
F	3.05-3.10 mm
G	3.10-3.15 mm
H	3.15-3.20 mm

FIGURE 8-90 This transmission uses selective snap rings at six different locations to adjust end play or preload. *(Courtesy of DaimlerChrysler Corporation)*

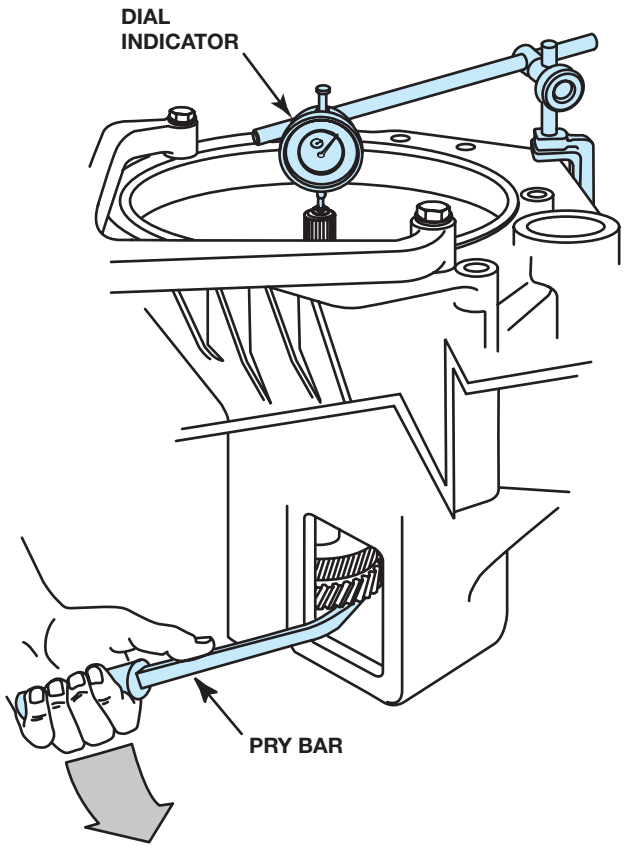


FIGURE 8-91 The dial indicator is set up to measure input shaft end play as it is lifted and dropped using the pry bar.

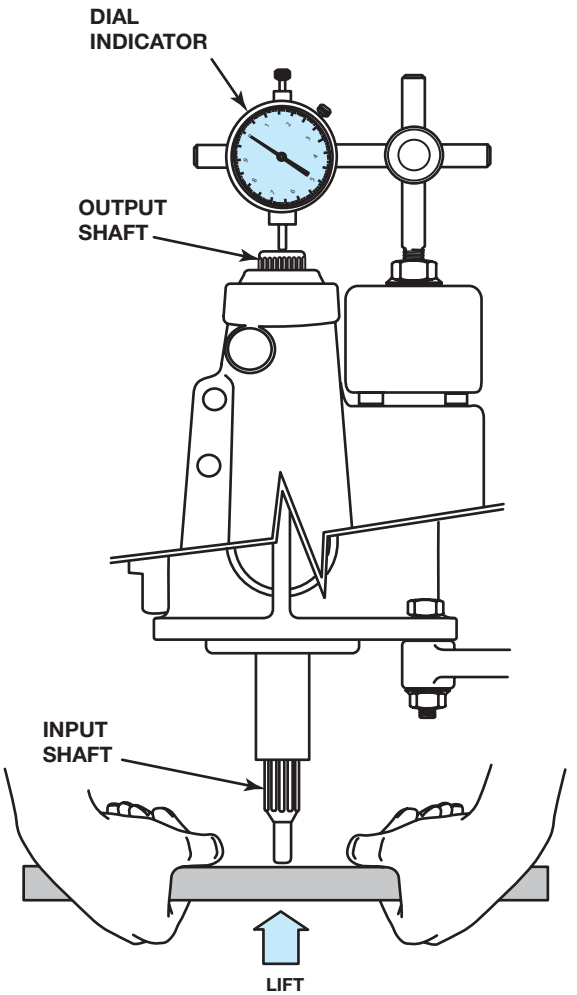


FIGURE 8-92 A dial indicator has been set up to measure the end play that occurs as the cluster gear is lifted and dropped.

4. Compare the measured travel to the specifications. If a clearance is specified and the travel is within the specifications, no adjustment is required. If a clearance is specified and the travel is more or less than the specifications, an adjustment is required.

TECH TIP

If there is too much end play, the shim size usually needs to be increased. For example, 0.010 in. (0.25 mm) of travel with a specification of 0.001 to 0.003 in. (0.25 to 0.07 mm) is corrected with a shim that is 0.008 in. (0.2 mm) larger than the one used during the check. Too little travel is corrected in the same way but with a thinner shim.

TECH TIP

If a preload is specified, the shim size needs to be increased by the amount of clearance plus a preload factor of about 0.003 or 0.004 in. (0.07 to 0.1 mm), depending on the manufacturer. For example, 0.010 in. of travel is corrected with a shim that is 0.010 + 0.003 (or 0.013) in. (0.3 mm) larger that the one used during the check. If a preload is specified and there is no clearance, check the preload as described in step 6.

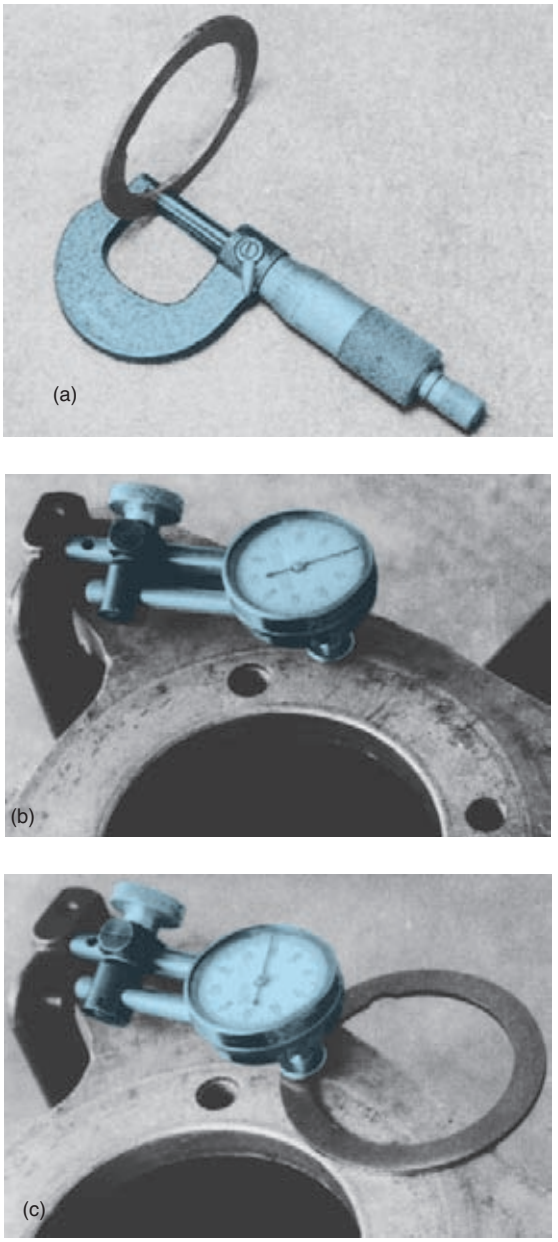


FIGURE 8-93 A selective shim can be measured using an outside micrometer (a) or by setting up a dial indicator to read zero on the case (b) and then sliding the shim under the indicator and reading the size (c).

5. If a shim change is required, remove the bearing retainer/case cover and remove the old shim. Measure the thickness of the shim. Add that size to the amount of change you measured in the last step (Figure 8-93). Select and install a shim of the correct size, replace the bearing retainer/case cover, tighten the bolts, rotate the shaft to seat the bearings, and feel for end play. On preloaded shafts, there should not be any end play.
6. Using a torque wrench or spring scale and adapter, measure the torque required to keep the shaft rotating, not the breakaway or starting torque (Figure 8-94).

TECH TIP

An alternative method of measuring the distance between the case and the bearing cup is to place two very thin strips of solder in place of the shim between the case and the bearing cup, install the shaft and bearing, install the case cover, and tighten the bolts to the correct torque. Disassemble the unit, and measure the thickness of the solder using a micrometer. This will be the shim size before adjusting for preload or end play.

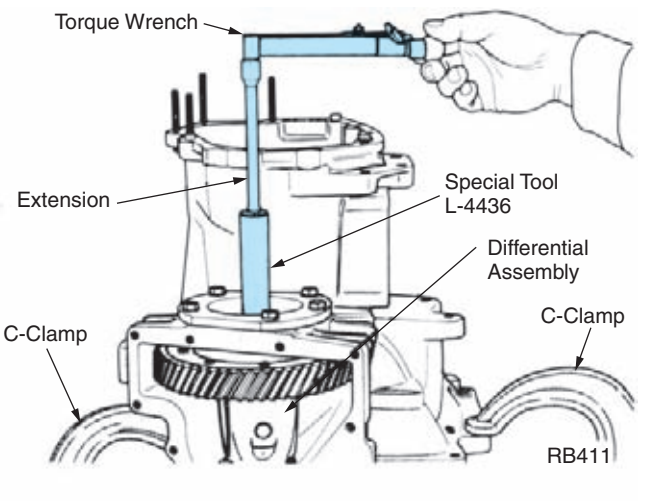


FIGURE 8-94 The preload or turning torque required to rotate a shaft can be measured using a torque wrench. *(Courtesy of DaimlerChrysler Corporation)*

NOTE: An oversized socket can be used on splined shafts by placing cardboard or cloth over the shaft so a pressure is required to slide the socket in place.

Compare the preload reading to the specifications; if they are within the specifications, you have the correct shim. Readings that are too high or too low indicate the wrong shim. In these cases, use the next larger or smaller shim to correct preload.

7. When the clearance/preload is correct, remove this shaft, and repeat this check on the next shaft.

To assemble a transmission:

1. Install the reverse idler gear and shaft.
2. Install the cluster gear and countershaft.

REAL WORLD FIX

A 1999 Nissan Altima (113,000 mil) came in with a loud driver's side wheel bearing noise. The wheel bearings and driveshafts were replaced on both sides, and this took care of the noise problem. The five-speed manual transaxle was low on fluid so it was filled to the proper level. The vehicle returned the next day with a fluid leak at the output shaft seal. The seal was replaced, and a test drive showed no seal leak. The vehicle returned two days later with a fluid leak at the output shaft seal. The transaxle was disassembled and a bad differential bearing was found and replaced. All the other bearings were good. The transaxle was assembled and reinstalled, and a test drive showed no seal leak. The vehicle returned four days later with a slow fluid leak at the output shaft seal.

The technician was advised to try moving the output shafts up and down, and they found vertical movement, free play. After the transaxle was disassembled and the differential bearings adjusted to the proper preload, this play was gone. Proper bearing adjustment stopped the excess movement and fixed this problem.

TECH TIP

Petroleum jelly can be used to stick the thrust washers in position.

TECH TIP

If loading the needle bearings in a cluster gear and no loading tool is available, a common manila folder can be used. First, put a layer of grease inside the cluster gear to help hold the needle bearings in place. Cut the folder to the same length as the cluster gear. Roll it into a tube so there is at least two or three thicknesses, and then cut off the excess. Slide the tube inside the cluster gear and use it to hold the bearings.

3. Install the mainshaft.
4. Install the input shaft and retainer.
5. Install the extension housing.
6. Install the side cover with shift mechanism.
7. Check the operation in neutral and all gears.

As the transmission is assembled, the end play of the cluster gear and the clearance or preload of the mainshaft and main drive gear should be checked and adjusted, if necessary.

To check the end play on two-piece cluster gear and countershaft assemblies:

1. Place a loading tool inside the cluster gear and load the needle bearings and thrust washers (Figure 8-95).
2. Place the gear assembly into the case and push the countershaft into place, pushing the loading tool out of the other end of the case (Figure 8-96).
3. Move the cluster gear to contact the front of the case and using the largest feeler gauge that will enter, measure the clearance between the gear and thrust washer or case

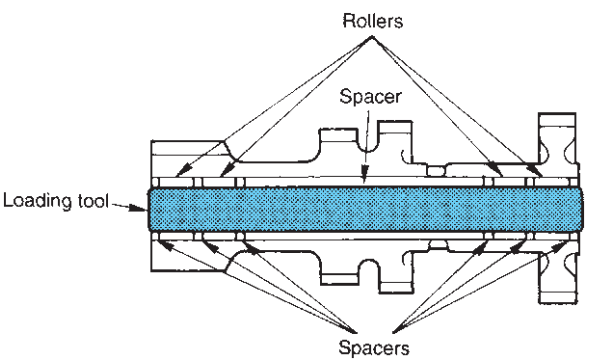


FIGURE 8-95 A loading tool should be used to hold the needle bearings and spacers in position while the cluster gear is installed in the transmission. The loading tool is a shaft that is the same diameter as the countershaft and the same length as the cluster gear.

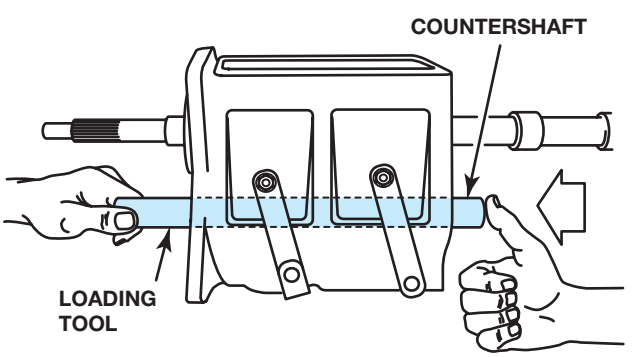


FIGURE 8-96 The loading tool/dummy shaft is pushed out as the countershaft is installed. Note that the roll pin is temporarily installed so that the hole in the countershaft can be aligned with the hole in the case.

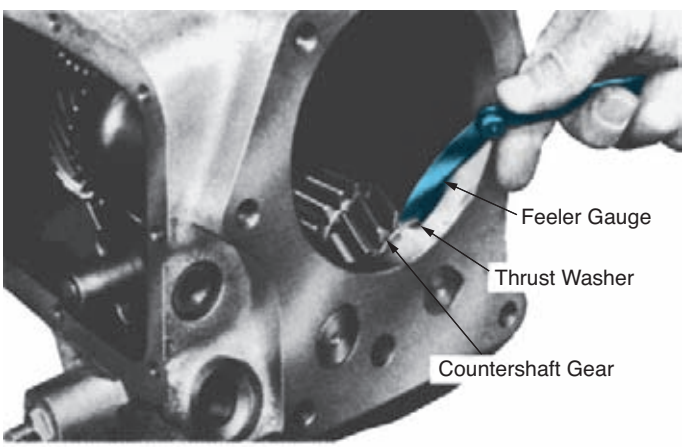
(Figure 8-97a). An alternate method is to mount a dial indicator at the front of the case with the indicator stylus on the cluster gear and parallel to the countershaft (Figure 8-97b). Move the cluster gear up and down and read the travel/clearance.

4. Compare the feeler gauge or dial indicator reading to the specifications. You can use 0.004 to 0.020 in. (0.1 to 0.5 mm) as a guide if specifications are not available. Excessive end play is an indication that the thrust washers are worn.

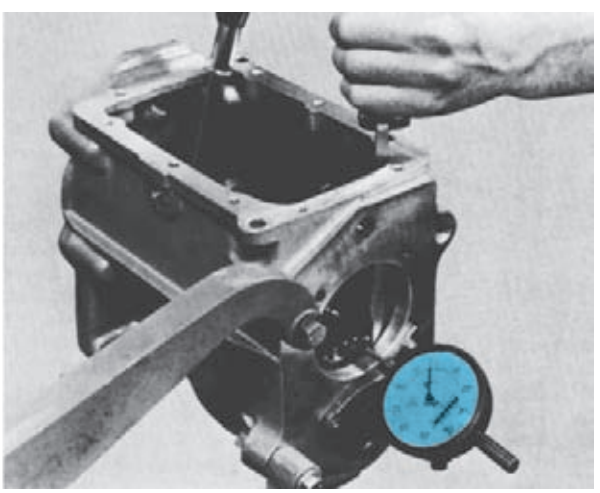
The procedure used to adjust the bearing preload/clearance on a one-piece cluster gear/countershaft using tapered roller bearings is the same as that used to adjust the shaft bearing clearance on a transaxle. For example, the countershaft gear of a T5 transmission should be adjusted to provide end play of 0.0005 to 0.004 in. (0.013 to 0.102 mm); the shim for this is at the rear bearing retainer (Figure 8-98).

The input shaft and mainshaft on the T5 transmission also use tapered roller bearings that are adjusted to provide zero free travel and preload. The selective shim for this is at the input bearing. Two different methods can be used to select the correct shim. One is to assemble the transmission, place it in a vertical position (output shaft up), rotate the shafts to seat the bearings, and measure the end play at the end of the mainshaft using a dial indicator (Figure 8-99). If there is more than zero end play, the shim thickness should be increased the same amount as the end play. For example, if there is 0.006 in. (0.15 mm) of end play, a 0.006-in.-larger shim needs to be installed.

The second method of adjustment is to assemble the transmission except for the input bearing retainer. With the transmission vertical (input shaft up), rotate the input and mainshaft to seat the bearings while pushing downward on the input bearing cup. Then measure the distance from the front of the bearing cup to the case using a depth micrometer (dimension A) and the depth of the bearing cup recess in the

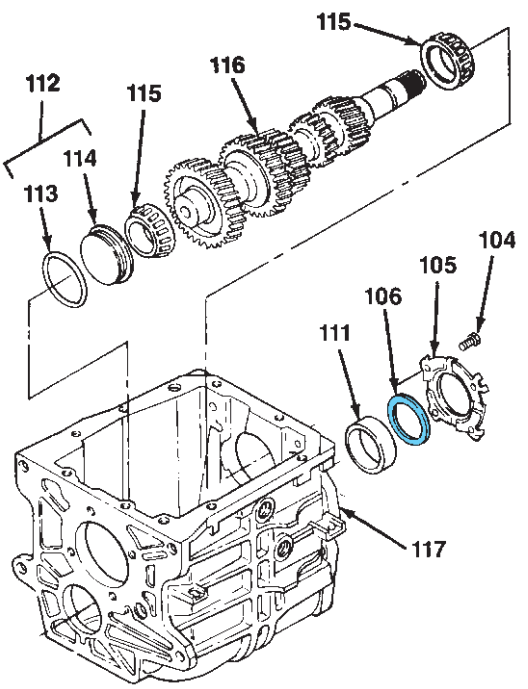


(a)



(b)

FIGURE 8-97 Cluster gear end play can be measured by prying the gear to one end and using a feeler gauge to measure the gap between the end of the gear and the thrust washer (a), using a dial indicator to measure the travel as the gear is pried from one end to the other (b). *(a is courtesy of Daimler-Chrysler Corporation; b is courtesy of Ford Motor Company)*



104. Bolt
105. Rear Retainer
106. Shim
111. Bearing Cup
112. Bearing Cup Assembly
113. O-ring
114. Bearing Cup
115. Bearing Cone
116. Countershaft Gear
117. Case Assembly

FIGURE 8-98 This transmission uses a shim (106) to adjust countershaft gear end play to 0.0005 to 0.004 in. (0.013 to 0.102 mm). *(Courtesy of BWD Automotive Corporation)*

front bearing retainer (dimension B) (Figure 8-100). Subtract dimension A from dimension B, and add 0.003 in. (0.07 mm) for the overall thickness of the shim (B − A + 0.003 = shim thickness). After the proper shim is selected and installed along with the front bearing retainer, check the rotation of the input and mainshaft. They should turn with only a very slight drag and have no end play.

As the cover, extension housing, and front bearing retainer are installed, a gasket or sealant—usually RTV or anaerobic sealant—should be used to prevent lubricant leaks (Figure 8-101). Following the manufacturer's recommendations, the retaining bolts should be tightened in an alternating fashion, back and forth across the cover (Figure 8-102). Tighten each bolt to the proper torque.

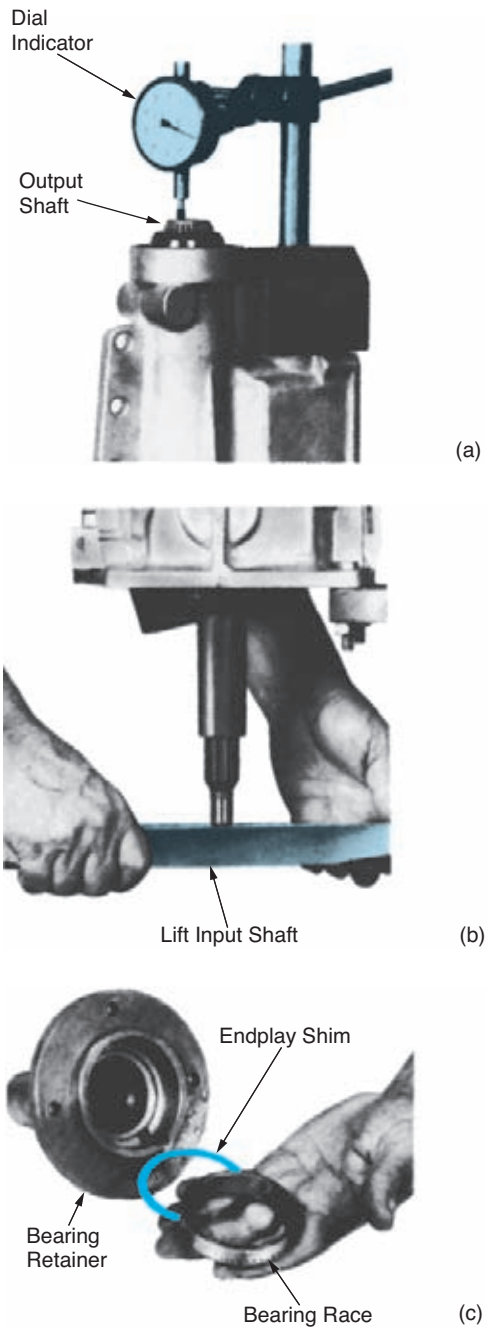


FIGURE 8-99 One method of selecting the proper shim to get the correct input/output shaft bearing preload on a T5 transmission is to assemble the transmission and mount and adjust a dial indicator at the output shaft (a) to read the end play as you lift the input shaft (b). Change the end play shim as needed to compensate for too much or too little end play (c). *(Courtesy of Ford Motor Company)*

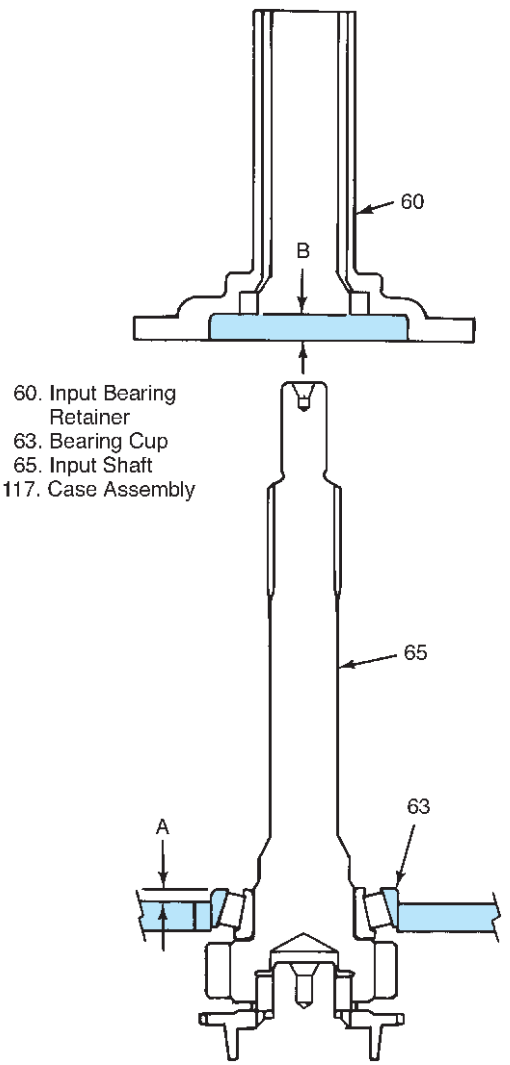


FIGURE 8-100 A second method of adjusting input/output shaft bearing preload on a T5 transmission is to push the input bearing cup into the case and measure distance A, measure distance B in the bearing retainer, and subtract A from B. The shim should be this size + 0.003 in. *(Courtesy of BWD Automotive Corporation)*

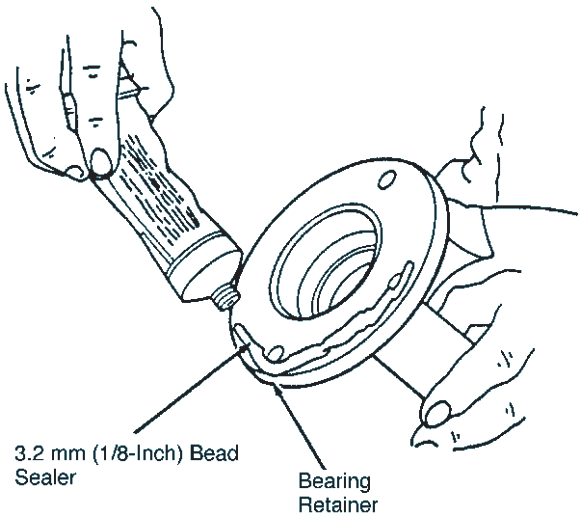


FIGURE 8-101 A bead of anaerobic sealant is used to prevent leaks between this front bearing retainer and the case. *(Courtesy of Transmission Technologies Corporation, TTC)*

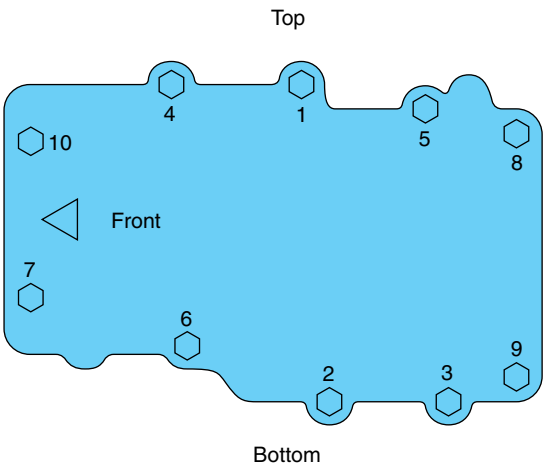


FIGURE 8-102 The case-to-cover bolts of this TR-3550 transmission should be tightened to 18–22 lb-ft (24.4–29.8 N-m) using this sequence. Note that it starts with the center bolts and works to the ends. *(Courtesy of Transmission Technologies Corporation, TTC)*

REAL WORLD FIX

The transmission in a 1992 Explorer (150,000 mil) was rebuilt 5,000 mil ago. A damaged input shaft and all of the bearings were replaced using OEM parts. The end play was adjusted as shown in the Ford service manual.This transmission was repaired before for the same problem, a seized front bearing. It came back because of the same problem.

It was determined that the damage was caused by a fluid loss. The leak was through three loose rubber plugs at the back of the top cover. Replacement of the damaged input shaft bearing and the three rubber sealing plugs fixed this transmission. Experience teaches us that it is always a good practice when making a repair to determine what caused the problem. If you don't fix the cause, the problem can return.

After a transmission is assembled, the input shaft should turn freely in neutral with no drag when turning the output shaft. Shifts into each gear should be smooth, and the shafts should rotate easily and smoothly in each gear.

REAL WORLD PROBLEM

Imagine that you are working in a transmission repair shop and you encounter these problems.

Case 1

You are repairing a four-speed transaxle with clash complaint during the fourth gear shift. The vehicle is an 8-year-old compact that is fairly worn. When checking the blocker ring-to-speed gear clearances, you find these clearances: first gear, 0.020 in.; second gear, 0.065 in.; third gear, 0.60 in.; and fourth gear, 0.0 in. You can't find any specs. So for this transaxle you measure a new blocker ring and find that its clearance is 0.085 in. With the cost of these blocker rings at $23.95 each and a limited budget of the customer, which should you replace?

Case 2

You've just about finished rebuilding a five-speed transmission by bolting the main drive gear bearing retainer in place, but when you turn the clutch shaft, you find that there is no neutral. The output shaft turns a little slower than the clutch shaft. What is probably wrong? What should you do next?

SUMMARY

1. Transmissions must have clean gear oil at the proper level and of the proper type.
2. Faulty shift linkage can cause problems.
3. The cause of improper transmission operation is determined using several diagnostic steps.
4. Internal transmission problems require that the transmission be removed from the vehicle. Transaxle removal is generally more difficult.
5. Transmission and transaxle disassembly and reassembly varies between different makes and models.
6. Presses and pullers are often required for complete disassembly.
7. A thorough cleanup is done so parts can be inspected.
8. Gears, bearings, synchronizer assemblies, shift forks, and transaxle differentials are the major wear components.
9. Synchronizer assemblies require careful assembly.
10. Shafts that use tapered roller bearings require end play adjustments as the unit is assembled.

REVIEW QUESTIONS

1. To check the fluid level in a transmission or transaxle, a _____ plug or _____ stick is usually provided.
2. The fluid level should be at the bottom of the _____ plug hole.
3. A transmission or transaxle that shifts hard could be caused by a _____ clutch or binding in the _____ linkage.
4. A transmission that is noisy in neutral and all reduction gears could be caused by worn _____ bearings.
5. A pair of _____ _____ can be used to help support the weight of the transmission during removal and installation.
6. Transaxle removal may require the use of an engine _____ fixture.
7. The first thing that should be disconnected when removing a transmission is the _____ _____ _____.
8. _____ marks should be placed on the synchronizer sleeve and hub during disassembly.
9. Excessive friction between parts will cause _____.
10. Inspection of a bearing is done by _____, _____, and _____.
11. A _____ or special _____ may be required to dissemble the mainshaft.
12. _____ _____ snap rings or thrust washers are available to adjust bearings and gear clearances.
13. Old oil _____ can be removed by prying them out using a seal puller or screwdriver, or by driving them out from behind.
14. Bearing preload is measured using a _____ wrench or _____ scale.
15. After a transmission or transaxle is assembled, the input should turn freely in _____ with no drag when trying to _____ the output shaft.

CHAPTER QUIZ

1. While discussing transaxle gear lubricant, Student A says that the fluid level should be even with the bottom of the filler hole. Student B says that it should be in the hatch-marked area of the dipstick. Who is correct?
   a. Student A
   b. Student B
   c. Both A and B
   d. Neither A nor B

2. Student A says that an improperly adjusted shift linkage can cause a transmission to jump out of gear. Student B says that clutch drag can cause hard shifting. Who is correct?
   a. Student A
   b. Student B
   c. Both A and B
   d. Neither A nor B

3. A transaxle shifts easily through all the gear ranges with the engine shut off, but with the engine running, the shifts into all forward gears are hard and there is a clash when shifting into reverse. Student A says this problem could be caused by a worn shift fork. Student B says there could be worn countershaft bearings. Who is correct?
   a. Student A
   b. Student B
   c. Both A and B
   d. Neither A nor B

4. An engine support fixture is usually required when removing a (A) transaxle; (B) transmission. Which is correct?
   a. A only
   b. B only
   c. Both A and B
   d. Neither A nor B

5. Student A says that the shift linkage should be checked for proper adjustment after a transmission has been replaced. Student B says that you should be careful not to catch a wire or hose between the clutch housing and engine when replacing a transaxle. Who is correct?
   a. Student A
   b. Student B
   c. Both A and B
   d. Neither A nor B

6. Student A says that synchronizer sleeves can be replaced onto the hub in any position. Student B says that blocker rings should be snug and not wiggle around when installed. Who is correct?
   a. Student A
   b. Student B
   c. Both A and B
   d. Neither A nor B

7. While discussing a transaxle that makes a loud clunk as the clutch is engaged, Student A says that this could be caused by a worn differential pinion shaft. Student B says that it could be caused by a worn clutch disc. Who is correct?
   a. Student A
   b. Student B
   c. Both A and B
   d. Neither A nor B

8. When working with a cluster gear supported by a counter-shaft, a loading tool
   a. holds the needle bearings in place during installation.
   b. contains the needle bearings during teardown.
   c. is used to push the countershaft out of the case.
   d. all of these.

9. A faulty blocker ring (A) makes a dull sound when tapped by a metal object; (B) has less than 0.040 in. (1 mm) of clearance. Which is correct?
   a. A only
   b. B only
   c. Both A and B
   d. Neither A nor B

10. All of the following should be observed carefully when checking bearings except that
    a. bearings should be air-dried by spinning them with compressed air.
    b. a rough bearing should be cleaned, dried, and rechecked.
    c. a bearing is checked by rotating it as you feel and listen for roughness.
    d. bearing should be lightly oiled before checking.

11. Student A says that all gears with chips on their teeth should be replaced. Student B says that burrs on the clutching teeth can be cleaned up using a small grinder. Who is correct?

a. Student A

b. Student B

c. Both A and B

d. Neither A nor B

12. Student A says that blocker ring clearance can be checked using a feeler gauge. Student B says that synchronizer energizer springs are usually placed in the hub running in opposite directions. Who is correct?

a. Student A

b. Student B

c. Both A and B

d. Neither A nor B

13. Student A says that each gear next to a synchronizer hub should have a few thousandths of an inch of end float after it is installed. Student B says that new snap rings should always be used during transaxle reassembly. Who is correct?

a. Student A

b. Student B

c. Both A and B

d. Neither A nor B

14. Student A says that all cluster gears should have about 0.010 in. (0.25 mm) of end play after installation. Student B says there should be this same amount of end play on an input shaft. Who is correct?

a. Student A

b. Student B

c. Both A and B

d. Neither A nor B

15. The bearing on many transaxle input shafts and mainshafts is adjusted using (A) selective shims; (B) threaded adjusters. Which is correct?

a. A only

b. B only

c. Both A and B

d. Neither A nor B

16. You've replaced the third-speed gear and the 3–4 synchronizer assembly on the clutch shaft of a five-speed transaxle and installed the retaining snap ring. The end float of the third-speed gear is sloppy—0.35 mm of float (the specification is 0.06 to 0.21 mm). Seven retaining rings are available between the sizes of 1.80 and 2.10 mm; their size will increase 0.05 mm in each step. Remove the snap ring, measure it, and determine that its size is 1.85 mm. What size of retaining ring do you need to get the correct end float?

17. What are the largest and smallest shim sizes that you could use to correct the end float in question 16?

18. The gear train is assembled in the five-speed transmission, and you need to replace the main drive gear bearing retainer. The distance from the front of the bearing to the case is 0.06 in., and the recess in the bearing retainer is 0.105 in. with the gasket in place. The specification is 0.0 to 0.004 in., and there are seven spacers available from 0.032 to 0.060 in. (0.004-in. increments). What size spacer do you need?