



Differential Repairs: The Forgotten Gears

By Mike Weinberg
Contributing Editor

Competition for market share in the transmission industry is getting tougher and tougher. Shops compete against other local shops for business, and now the car dealer is becoming a force to be reckoned with. Factory Reman programs with low prices and good warranties influence the price structure of this industry and divide the pie even further. It is critical for shops to become proficient at all of the services that they can offer to fatten up the bottom line. Standard-transmission repair and clutch replacement are a great way of increasing your gross sales, but the most overlooked profit center is differential repair. Many shops I speak with are uneducated about or afraid of ring-and-pinion work.

Diagnosing Differential Problems

Most rear-end complaints begin with noise. Carrier bearings, pinion bearings and axle bearings will make noise as they begin to fail and if left unattended will cause the ring and pinion to fail. One common cause of rear-end wear is lack of lube. Any time you have a vehicle on the lift for trans work or service, check the rear-end lubricant. This in itself is a service you can sell. Probably the most neglected part of the car, the differential should be checked for proper lube fill, excess backlash, leaks, loose pinion-yoke nuts (often the byproduct of worn U-joints or an out-of-balance driveshaft) and broken springs or

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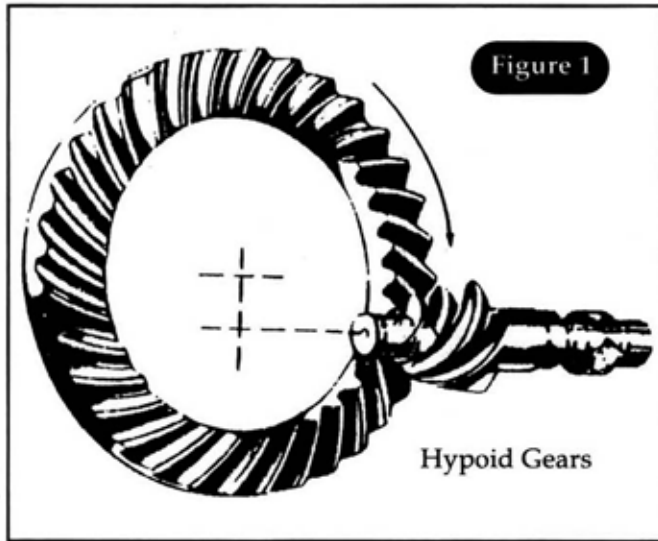


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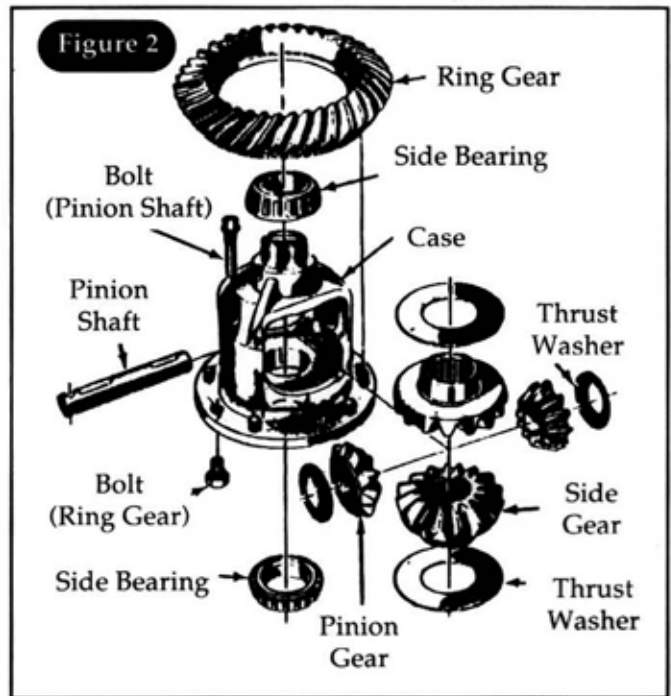
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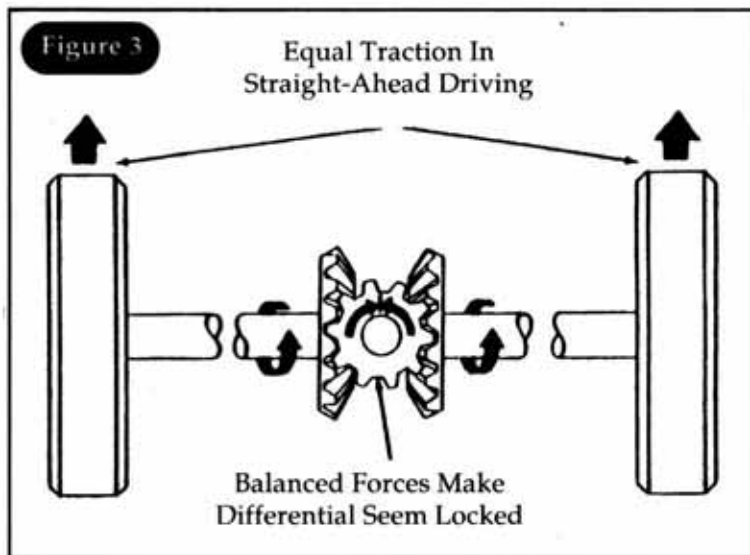
enough noise that you will be afraid to drive it too far. Jerking or skipping in the driveline usually is indicative of missing teeth on the pinion or the ring gear. Grinding and chattering while in a turn are symptoms of worn side and pinion gears, stripped axle splines, worn-out limited-slip clutches or cones, or a need for fresh posi-traction fluid. Any of the symptoms mentioned mean that the rear cover should be removed and the rear inspected carefully. Always check for worn, loose or broken differential cross pins.

mounts. Using an evacuator, servicing diffs becomes quick and easy. Please note that on limited-slip rears you will have to use the proper gear lube or add a bottle of limited-slip additive to the gear oil.

If the vehicle is drivable you can learn a lot about what is wrong by using just your hearing. Bearing noises usually fall into one of two categories. Carrier and axle bearings will make a constant noise that increases with rpm and rarely is affected by throttle changes or steering inputs. Pinion bearings will show up as noise that will change pitch on throttle changes. A worn ring and pinion will sound much the same, with noise on either acceleration or coasting that varies with throttle input. This usually is caused by the gears running off centerline because of worn bearings or loose pinion lock nuts. If the ring and pinion is severely damaged it usually will make



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Theory Of Operation

In a transmission the gears are set in parallel to each other and are helical or spur cut. This is because power enters the front of the transmission and leaves through the output in a straight line. In a rear-end gearset the power enters the pinion gear and then makes a 90° turn to get to the axles. For quiet, cool operation and less friction, rear-end gears are usually of hypoid design (See Figure 1). The numerical ratio of the gearset is determined by dividing the number of teeth on the pinion into the number of teeth on the ring gear. A low numerical ratio will provide less torque multiplication but will give the vehicle a

higher top speed. A high numerical ratio will give better acceleration but less top-end speed. The pinion gear being at a 90° angle to the plane of the ring gear makes position critical. This is called "setup" and is accomplished through precision shims to control pinion depth and preload and side-to-side placement of the ring gear and differential carrier. Properly positioned, the ring and pinion will multiply torque to the rear wheel silently. An improper setup will be noisy, generate excessive heat and fail the gearset prematurely. The ring and pinion are manufactured as a matched set and are finish lapped and patterned for quiet, smooth operation. They always must be replaced as a matched set (See Figure 2).

The differential carrier positions the ring gear and contains the side gear into which the axles are splined. The pinion or "spider gears" are set at 90° angles to the side gears and are retained by a cross pin. This allows the axles to turn at different speeds in a corner (different being the root of the name differential). Because the inside wheel will cover less distance than the outside wheel, the axles must be able to turn at different speeds to prevent wheel hop and skidding (See Figure 3). If the inside wheel turns 50% in a corner, the outside wheel must turn 150%. This is called an "open differential." A limited-slip diff will contain clutches, cones or gears to control the rotation of the side gears to make both wheels transmit some power through a corner. In racing it is common to use a "locked differential" where both side gears are locked to the carrier and both wheels turn at the same speed through the corners (See Figure 4). This is accomplished because high speeds create slip

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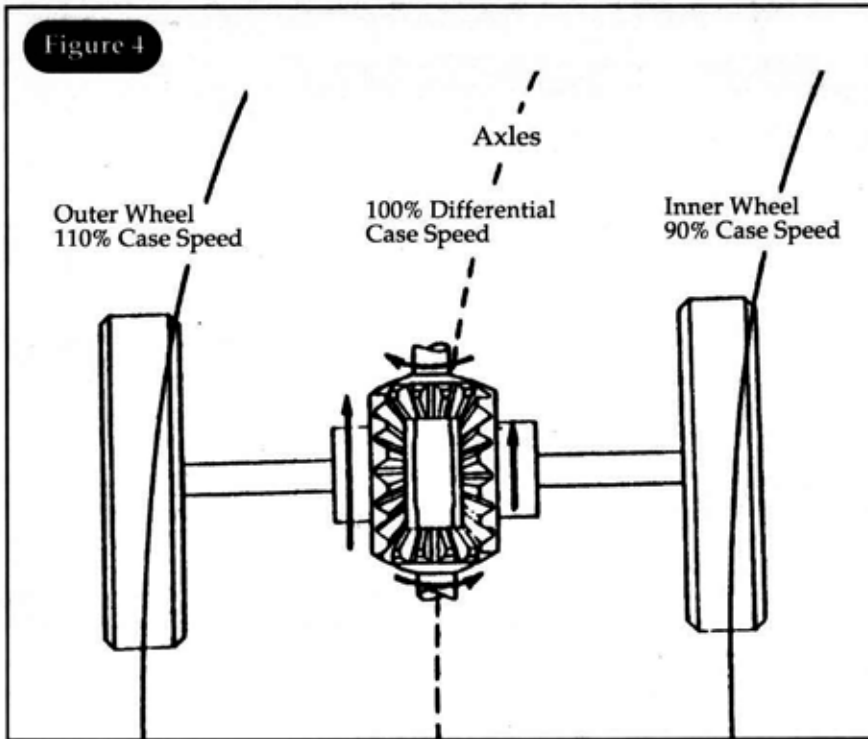
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angles for the tires and the car drifts or slides through the corner. This is not something to be tried on a snowy day going to the supermarket. The operation of the differential gears puts constant stress on the cross pin and carrier. Careful inspection of this area is critical whenever you inspect a rear. A weak or broken cross pin will cause catastrophic failure of the rear end. A typical scenario occurs in winter driving. Joe Customer spins the wheels trying to get out of the driveway in six inches of snow and ice. Because the car is not moving, Joe doesn't look at the speedometer; he just adds power. The speedometer now reads between 60 and 100 mph. Now Joe manages to creep forward until the spinning wheels hook up on a hunk of dry pavement. The wheels go from 60 mph to zero, shockloading the entire drivetrain. The weak link is the bolt that retains the cross pin in the diff. It shatters and the cross pin now hits the speed of light as it tries to bore a hole through the rear-end housing. It ricochets around in the diff like a ball on a roulette table, and you have a very profitable repair if you want to do ring-and-pinion work.

Repairing A Rear

After you have inspected the rear and determined the extent of damage, it is critical to get all the information you can to order parts. On the ring gear will be stamped a part number and a ratio. If it is not readable, divide the tooth counts to determine the ratio, count the number of bolts retaining the ring gear to the carrier and measure the diameter of the ring gear. Determine whether it is an open rear or a limited-slip, and on late models see whether there is a tone wheel for ABS brakes. There are a number of quality places to buy rear-end gears and parts but none of them has a crystal ball. It is up to you to help them with as much info as possible so that they can get you the right parts the first time. Note: Ratios are super critical. For instance, it is a must that the front and rear ratios match on 4WD vehicles. A mismatch in those ratios will have the vehicle hopping down the road like a frog when in 4-wheel operation. Customers often will ask you to change a rear-end ratio for better performance. This is fine as long as you make the customer understand that such a change may alter the vehicle's drivability and you



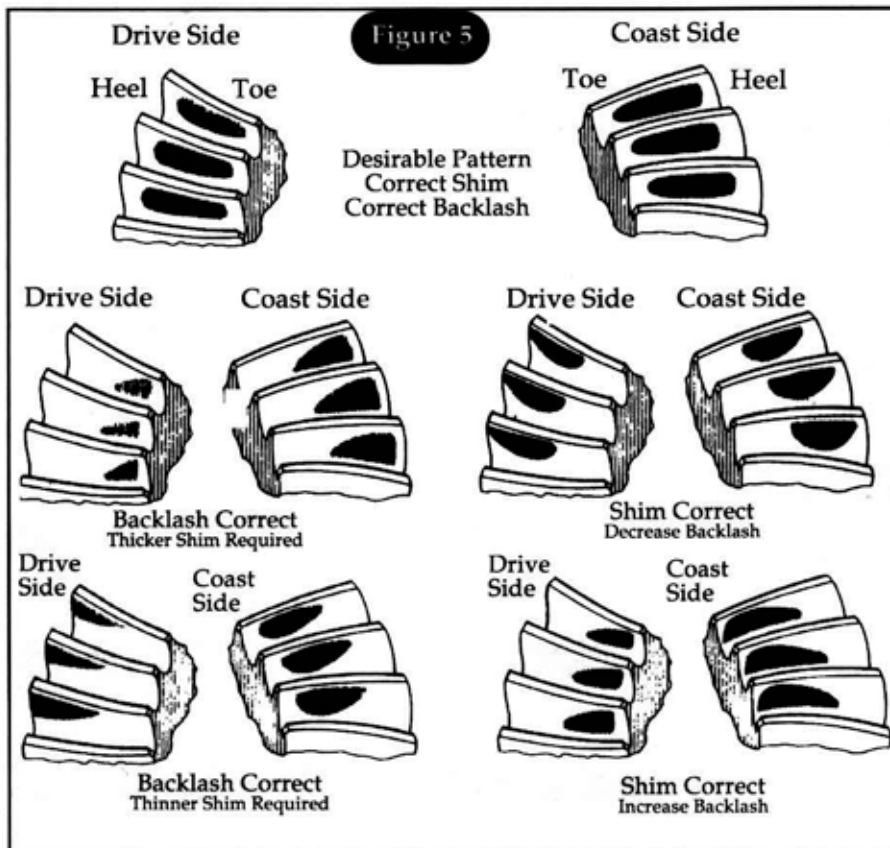
make them take responsibility for the results.

Disassembly is relatively simple on most rears, but care must be taken to mark and retain all components. Mark the diff bearing caps (right or left) for future reassembly. Mark and retain all shims in

sides of the gear. The shims you took out, measured and retained will be the starting point for setting up the rear. Some ring-and-pinion sets will have a pinion depth marked on the head of the pinion gear. This usually is a fractional number with a plus or

minus next to it, indicating that more or less pinion-depth shim is required from the centerline. Using a white grease as a pattern to check tooth contact will allow for proper pinion-depth and backlash adjustment. Figure 5 will help as a reference.

Understanding how the rear works will make repairs simpler. A micrometer and a dial indicator are really the only tools you need to go into rear-end repair. You couldn't ride a bike until you tried it as a kid. This is a valuable addition to your ability to coin profits for the shop and keep your customers coming in for service. **TD**



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