



Gear Head Limited Slip Differential Overhaul

Once in a while, it's fun to go through an unusual repair sequence—unusual in the sense that many of us never get a chance to actually perform this type of repair. Why? Because the component in question is so reliable, that's why. This article on limited slip differentials (LSDs) is a case in point.

The limited slip part of these differentials has a reputation for reliability that borders on "bullet proof." But what happens when you're suddenly asked to diagnose or repair one of the rare problems with one of these units? Do you look in the shop manual?

Unfortunately, the shop manual repair and adjustment procedures for the limited slip part of this Mazda differential are as bad as the LSD unit is good. We'll try to clarify the important repair and adjustment procedures involved. Maybe things will get a little clearer. Our donkey car for this article is a 1984 Mazda RX-7

GSL. It has well over one hundred thousand on the odometer, and the rear end had never been torn down for any reason. When all was said and done, a front pinion bearing and pinion seal were the only things that absolutely needed to be replaced. We did install new thrust washers between the side gears and differential case to bring us back to original specifications, although the old washers had not yet reached the wear limit.

General Hints

- **The best friend this LSD unit has is clean gear oil.** The Mazda owners manual recommends GL-5, SAE 90. And the repair manual suggests a "Special Lubricant for Limited Slip Differentials." Save yourself some trouble and drive over to the local GM dealer for their limited slip lube and additive.

• **There were some complaints about clutch chatter in these rear ends.** This chatter was most noticeable around tight corners and on the long sweeping curves found on interstate off ramps.

A change of gear oil and a few tight figure-eights in the parking lot to work the new lube between the discs cured every one I ever saw. But since customers are so darned reluctant to change the lube, we finally started adding the special posi-lube additive at every lube change. The use of GL-5 without the additive didn't seem to tear up the LSDs, but the chatter would always come back after the lube got some miles on it.

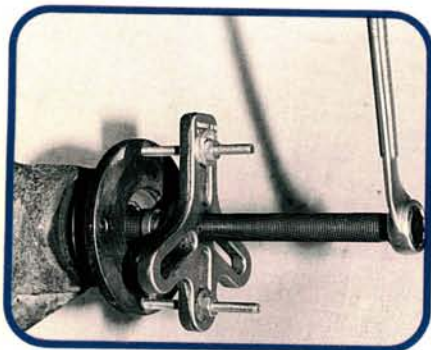
• **The only thing holding the rear axles in the axle tube are the brake rotor backing plates, and the press fit between the wheel bearing inner race and the axle shaft.** There are no clips or snap rings to worry about. If you don't have a slide hammer handy to remove the axles, try this:

• Remove the nuts from the backing plate bolts.

- Disconnect the hand brake cables.
- Disconnect the brake flexible line from the rigid line in the backing plate and remove the brake line retaining clip.
- Reinstall the wheel and tire, but leave the lug nuts loose. Then use the weight of the wheel to slide hammer the bearing loose. If there's a heavy build up of corrosion between the bearing and axle tube, you'll have to hunt for the slide hammer.
- After removing the companion flange bolts and the bolts holding the third member in the axle housing, give the third member a few good raps with a soft faced hammer to loosen it. **BE CAREFUL** when the third member comes loose. It's heavy. Your toes will thank you for the extra care.

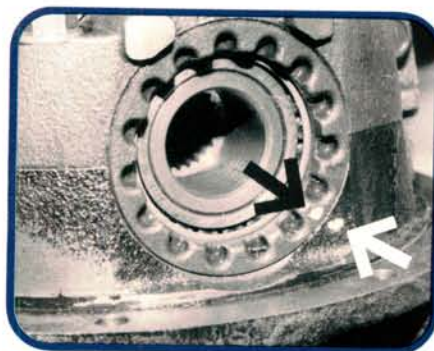
Our article starts with the differential unit already removed from the car.

—By Ralph Birnbaum



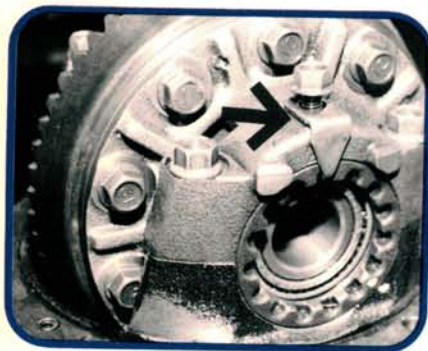
1

Over at the bench, hold the companion flange tight and unscrew the pinion nut. Then remove the large washer below it. This harmonic balancer puller and a couple of long bolts pulled the companion flange with ease, and didn't harm the threads on the pinion. Remove the old pinion seal.



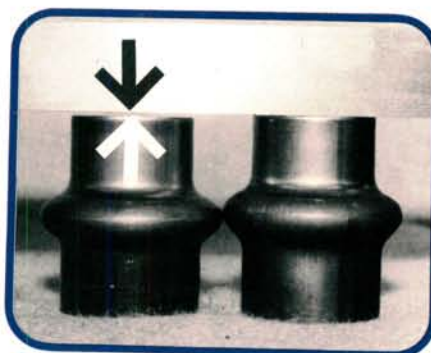
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Remove the differential case and ring gear. Take a punch and match mark the retaining caps so you don't mix them up later. I always add small punch marks on the adjustment collars too, showing where they align with the carrier. This gives you a good starting point for final adjustments later on.



3

Remove the lock plates on the adjustment collars. Unbolt the bearing caps and remove the adjustment collars. Remove the ring gear carrier from the housing. If you're reusing the carrier bearings, match the races to the bearings so they'll be matched to their original bearings at reassembly.



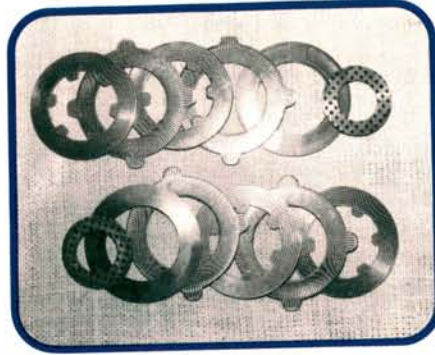
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Press the pinion shaft out of the front pinion bearing. Slide the old crush collar off the pinion shaft. Reusing the old collar is risky. We stood old and new crush collars side by side so you could see the difference. An already crushed collar may not properly preload the pinion bearing inner races.



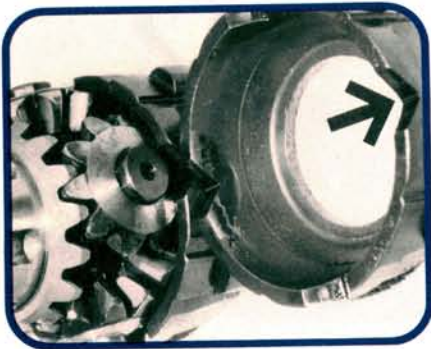
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Unbolt the ring gear bolts from the ring gear carrier. Remove the ring gear and turn the carrier over. There are four screws holding the two sections of the differential case together. Alternately back off the screws until the gap between the housing parts is about 3 mm.



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Separate the housing halves. Inside, you'll find the heart of the LSD. This photo shows the friction discs, friction plates, conical clutch tension washers, and the thrust washers. There are two friction discs and two friction plates on either side of the spider gears.



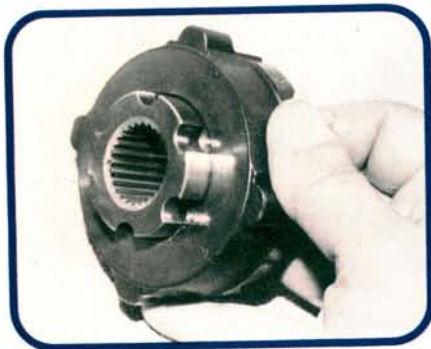
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Here's a better look at the spider gear housing. The spider itself sits in v-shaped notches in the pressure rings (right arrow). The splined side gears transmit drive to the axle shafts. Remove the side gears and test fit each side gear to the axle splines to check for wear.



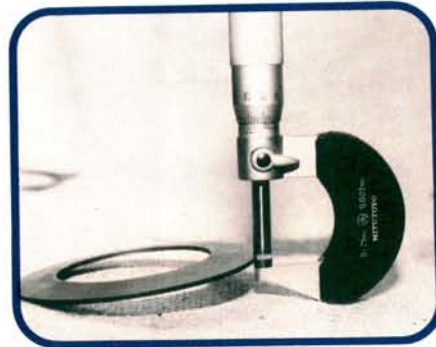
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Remove the spider gear assembly from the pressure rings and check the spider gears and the spider shafts for scoring or wear. Also check the spider gears and mating gears on the pressure rings for chipped or worn teeth. Clean and lube all parts as you reassemble them.



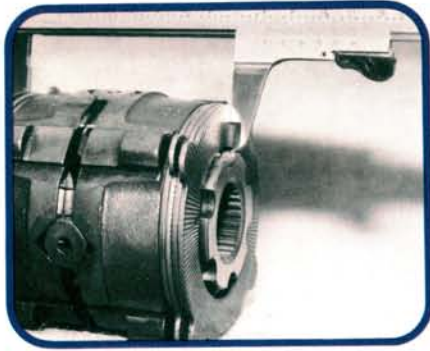
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Place each side gear in its respective pressure ring and check for a snug fit. Turn each gear in each ring to see if there's any sticking or binding. All parts should slide freely, but fit snugly. The external notches in the side gear match tabs on the friction discs.



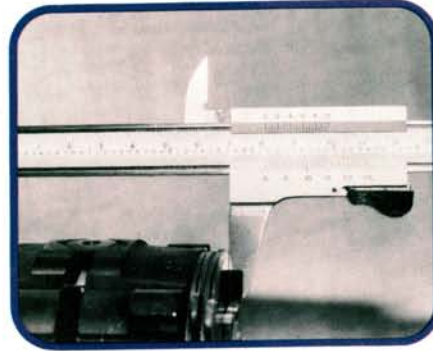
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The conical washers compress as the two sections of the gear carrier are screwed together to keep a constant pressure on the friction discs and plates. If you measure their thickness with a standard micrometer, measure at the edge, or the curve of the washer will give you a higher reading. Jot down the readings.



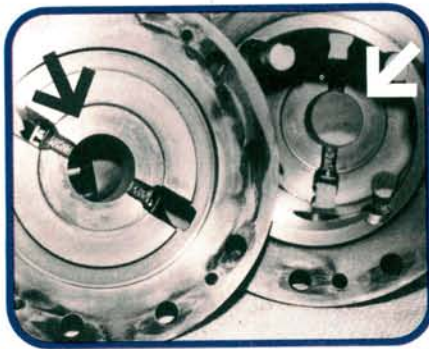
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Leave the conical washers on the workbench. Measure across the carrier with all plates and discs installed. Write down your reading (in this case it was 80.50 mm). Our conical washers measured 1.70 mm each or 3.40 mm together. Add this to 80.50 and subtract that from the manufacturing constant of 84 mm.



12

Here's what we get. (80.50 mm plus 3.40 mm equals 83.90 mm which is only 0.10 mm less than 84 mm.) That's the amount of space left between the clutch packs and the case when everything is screwed together. Since our spec is zero to 0.20 mm, this gear stack falls right in the middle.



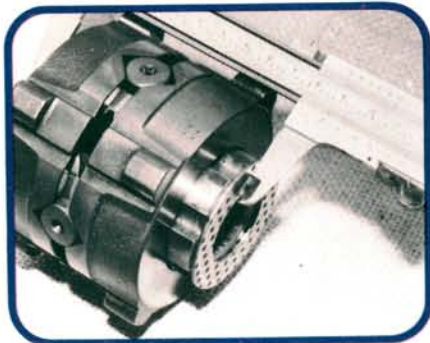
13

What about the clearance between the side gears and the case? This photo shows where the thrust washers ride in the two case sections. The design constant for the distance between these recesses is 88.2 mm. We'll need to know this distance to measure the end play, and select the correct thrust washer.



14

Use your micrometer to measure the thickness of each thrust washer. Standard thickness is 1.6 mm with a wear limit of 1.4 mm. These original washers showed only slight wear, about 0.10 mm. In addition to the standard 1.6 mm washers, an oversized 1.8 mm washer is available.



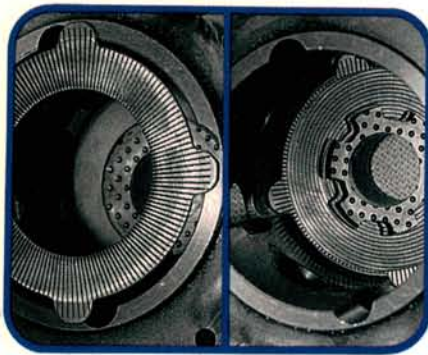
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Install both thrust washers on the clutch assembly. Measure across the outer faces of the thrust washers. Ours measured 87.65 mm. Subtract this from the design constant of the assembled case, 88.2 mm. In this instance we end up with 0.35 mm, within the 0.16-0.42 mm specification.



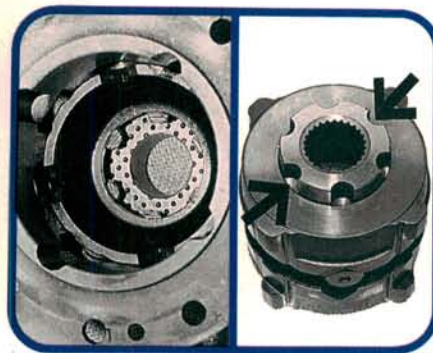
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Let's put her back together. Set the "bucket" end of the differential housing on the bench. Drop in the thrust washer and conical washer. The domed ends of the conical washers point toward the thrust washers. Another way to think of it, is that the dome faces away from the clutch packs.



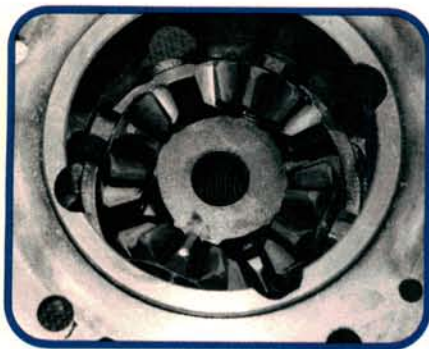
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Drop in the first friction plate. The friction plates have four external tabs that slide into machined grooves in the case. Then add a friction disc (internal tabs), followed by another friction plate and another friction disc. Each pack has two plates, and two discs.



18

Install the pressure ring (left photo). We flipped the pressure ring/side gear back over so you could see the six notches in the side gears. These notches engage the internal tabs on the friction discs. Drop the side gear into the pressure ring and turn it until the tabs and notches align.



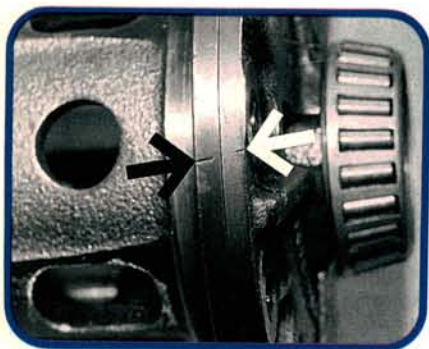
19

If the side gear properly engages both friction discs, it will sit all the way down on the thrust washer. Then install the spider gear assembly, making sure the pinion gears mesh with the friction ring and that the spider fits all the way down in the v-shaped grooves in the pressure ring.



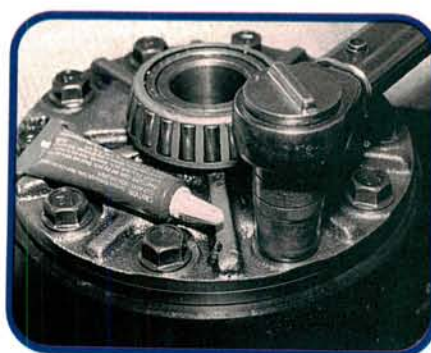
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Install the top pressure ring/side gear assembly on the spider gear assembly. Stop here and look through the hole in the case. Both v-shaped notches should sit right on the spiders if everything is installed properly. Install the remaining clutch pack, conical washer and thrust washer as you did on the other side.



21

Reinstall the cap on the differential housing. Align the factory match marks on the housings and start the four taper screws in their holes. Apply a little thread lock compound to the screws. Alternately tighten the screws to draw the cap down evenly against the tension of the conical washers.



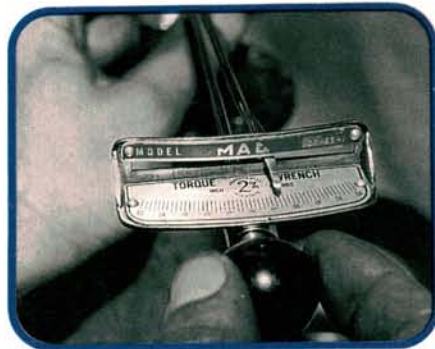
22

Reinstall the ring gear. Clean the ring gear, the threaded holes in the ring gear, and the threads on the ring gear bolts. Apply some thread locking compound to the bolts and torque them in a star pattern, and in three steps. Final torque on the bolts is 70-85 Nm (51-61 ft-lb).



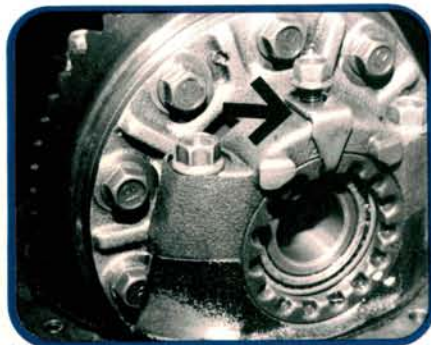
23

Before we set the pinion bearing preload, we need to measure the drag between the seal and companion flange. Lube and install the seal, the pinion (with bearings), the companion flange, washer, and pinion nut. Tighten the pinion nut just far enough to remove bearing end play. Then measure break-away torque.



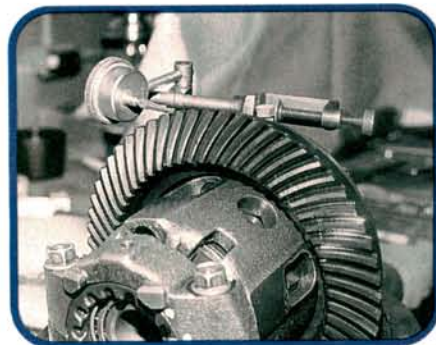
24

Remove the pinion and install the new crush spacer. Tighten the nut just far enough to remove bearing play. Check breakaway torque. Keep tightening and checking until breakaway torque is 7.8-12.2 in-lb, plus the seal torque determined in the last step. If you go too far, start over with a new spacer.



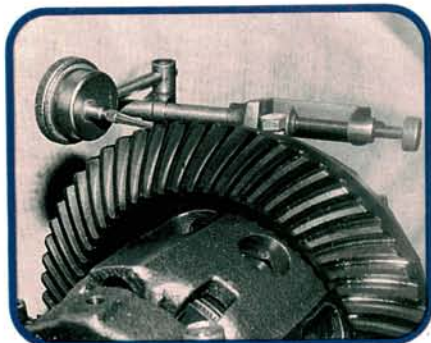
25

Reinstall the ring gear assembly and adjustment collars. Bolt on the bearing caps but don't final torque them. Tighten the collar on the ring gear side until the ring gear just touches the pinion and the punch marks we made in step 2 line up. Tighten the other collar just enough to remove bearing end play.



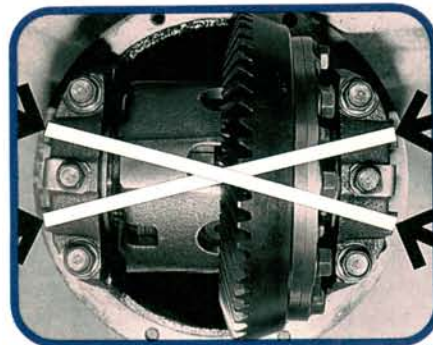
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Make an initial check of backlash. Keep the dial indicator needle at a right angle to the ring gear teeth and measure at four points, 90 degrees apart. Adjust backlash by loosening one collar and tightening the other the same amount. Look for a backlash of 0.09-0.11 mm (0.0035-0.0043 in).



27

Check the ring gear at several points to make sure it's running true. If we kept things clean, and torqued the ring gear bolts gradually and evenly, there should be no problem. Make sure that none of your backlash readings goes below 0.05 mm, and that your highest and lowest readings are within 0.07 mm of each other.



28

Set carrier bearing preload. Tighten each adjustment collar in equal amounts until the diagonal distance between the bosses on the bearing caps is 185.43-185.50 mm. Recheck backlash. If it's still okay, tighten the bearing cap bolts to 38-53 Nm (27-38 ft-lb) and reinstall the locks on the adjustment collars.