The new top of the line Audi A8 certainly doesn’t scrimp on grandiose luxo-appointments. Sitting behind the wheel, as much fine leather and burled walnut surrounds you as if a blue-ribbon Holstein foddered on birds’-eye-grain riflestocks had gulped you down. The engine compartment decor masks any hint of machinery within: virtually no nuts or bolts, nor wires or fluid lines. Only the various filler caps and the dipstick handle suggest internal combustion under all that plastic upholstery.

But amid all the “gracious living” upper crust splendor, the most interesting aspect of this new car, and of the Audi A4 a price-notch down, is the complex front suspension, a radical departure from previous geometries. Alignment mechanics with years on the job, seeing it for the first time, wonder aloud whether “set the toe and let ‘em go” might be a reasonable approach, after all. And once you see the peculiar numbers your alignment machine tosses up for caster and SAI, that inclination will grow on you. But don’t plan an early lunch just yet; on this system even setting the toe is not a familiar twist of the sleeve, as we will see.

Because of space limitations, I can’t cover everything. So if you need reminders to check spring sag and tire pressure first, you should probably learn alignment on a simpler, easier car.

**Balls and Arms**

What strikes you first about the front suspension are the four ball joints and four aluminum control arms on each side. Top and bottom, the arms form flexible trapezoidals with the narrow outboard side at the steering knuckle. The car’s weight rides through the tower bracket down the coaxial spring and strut to the forward lower control arm, with its ball joint loaded in compression, and then to the knuckle, hub, wheel, tire and road. Except for the spring’s determining ride height, this strut does not otherwise affect the alignment geometry; it is not part of the steering knuckle, has no top bearing and so is not a MacPherson strut.
The load-carrying front lower arm controls the primary knuckle geometry, with the rear and the top directing the “shift” of the steering axis. The upper arms pivot (in different planes) from the tower bracket.

What’s the Point?

What does this complicated geometry—surely the suspension with the highest “contraption factor” on any car—do for the driver? Alignment geometry doesn’t pump up ownership pride like the gnarled wood and tanned hides or the V8’s cubes. It doesn’t fit into bells-and-whistles or bragging rights categories. Not one percent of the well-heeled Audi A8 owners understand their suspension. But you can: It cancels all perceptible torque and bump steer as well as the steering lurch when a driver releases the accelerator in a turn (torque steer backwards, as it were). With the more powerful engines now available in expensive Audis, these effects would otherwise become all too perceptible, even dangerous, in a FWD car.

The point is to put the steering axis so close to the center of forces at the tire treadpatch that the driver never feels any unexpected change in steering feedback. This is tricky, because the treadpatch center of forces is a moving target: It changes with steering angle, load and braking; so the multilink geometry changes the virtual SAI to match. It also cancels squat or dive under acceleration or braking since the accel/deceleration torque twists the ride height opposite squat or dive. Let’s see how the whole arrangement works.

The steering arm for each knuckle is at the top, and the rack is, of course, at the same height. Why doesn’t the knuckle just flop around loose with all those joints? Because a line between the upper ball joints is never parallel to a line between the lowers (so they can’t flop in the same direction), and because the tie rod holds the steering arm, as on all steering. As the steering rack moves the arm, the knuckle moves in an epicyclic path, as though it were on the edge of a small wheel rolling around a large one, keeping the working SAI vertical above the treadpatch center of forces.

Bump steer occurs when the front toe changes excessively as the suspension travels from jounce to rebound and back. As the knuckle and steering arm move up and down, the tie-rod pivots inboard at the rack, changing toe in and out. On this suspension, you can adjust the horizontal angle between the tie rod and the steering arm. What looks like an ordinary cylindrical or conical stud at the outboard end is actually a threaded shaft. If you loosen the pinch clamp, you can turn that shaft to raise or lower the tie rod end relative to the steering arm, as I’ll explain. When the adjustment is right, toe change with suspension travel stays within a narrow range.

Virtual and Vanished Angles

There is no caster dimension or even definite steering axis in the normal sense. Since the steering knuckle moves in a shallow epicyclic arc around the four ball joints, the system has what Audi calls a “virtual steering axis.” At any steering angle this acts as though the caster were zero and the steering axis were vertical through the middle of the treadpatch. The variable pivot axis will confuse most alignment machines’ software until you get the ’97 updates, so until then ignore any caster and SAI numbers your machine stammers out. Using a Hunter machine with ’96 software, they weren’t even the same from
side to side on this press car. Zoom-zoom journalists probably thrashed the car through the pot-holed streets of Gotham.

This geometry makes for neutral steering at all angles, so an aligner who understands his work will immediately wonder what centers the steering after a turn. The answer will surprise you and give rise to some very hard questions: the elasticity of the bushing rubber. That means, of course, that vague or wandering steering should immediately point you to a close examination of all the bushings. It also means you must conduct special measurements and perform a different procedure when replacing them, as we’ll get to a bit later. If you don’t follow these exactly, the steering will not self-center. And if you didn’t know about the bushings, you won’t know why.

Replacing an original equipment bushing with a new part with different elasticity characteristics could have unpredictable effects on the car’s handling. My personal inclination would be the one I learned on the late, unlamented ’70s Capris: if one bushing is bad, recommend replacing all of them. This is the safest, though not the cheapest, route.

The Alignment Sequence

As with all wheel alignments, after you set up the heads and compensate for wheel runout, start in back. Just want to do a two-wheel alignment? Then find a two-wheeled car. As I mentioned earlier in this series, there are no two-wheel alignments; that’s cheating the customer out of half a job.

Next set the rear camber to specs. There are three different rear axles on these cars. The simplest, on the FWD A4, is a beam and trailing arm. The official story is that camber is not adjustable and an out-of-spec car possibly needs a beam axle inspection and replacement. Chances are once these cars become more plentiful, tapered shims or eccentric bolts will become available, too. If the toe is wrong, Audi says, you may at least be able to center it by slightly shifting the beam on its slotted brackets.

Check with your alignment equipment supplier. By the time you see one of these out of rear spec, something will probably be available. Quattro A4s use a double-A-arm, A8s use a lower A-arm and upper single, with somewhat (if not easily) adjustable camber and toe through eccentrics.

Back to the Front

Now for the fun, front part. Start by setting a brake pedal depressor. After checking that the steering wheel is in the middle of rack travel and horizontal at straight ahead, clamp it in place. Audi uses the same sort of multiple-spline steering shaft as VW, so you can correct steering wheel position in increments of 4.5 degrees by removing the wheel and re-installing it one or more notch from the original position.

The easy parts are caster and SAI. There’s no need to swing the wheels side to side for the machine to calculate: there are no such
angles here. Camber, however, is still conventionally measurable, and it’s the first thing to correct if wrong. While Audi approves no means to adjust an individual wheel’s camber setting, they do recommend shifting the subframe with a special tool (VAG 1941) to equalize the camber on both sides. You loosen the subframe attachment fasteners and use the special tool to slide the entire unit slightly one way or the other. Audi does not approve other methods (so I can’t suggest them in writing), but most experienced aligners will already have thought of alternatives that could work.

Toe is the problem adjustment on these cars, particularly if someone changed the adjustment at the joint between the outer tie rod and the steering arm. But let’s assume happy talk to begin with and look at ordinary toe, what Audi calls “unladen” toe. “Unladen” means with nothing in the car but the spare tire, jack and tools and a full tank of gas. It does not mean with the wheels off the alignment slip plates; we want ordinary curb height with no vehicle load or passenger weight. Measurement is straightforward, and you make any needed adjustments at the inboard side of the tie rod, removing and replacing the bellows clamp once finished. If all your numbers so far are within spec, you can now release the steering wheel clamp and check toe-out-in-turns for any indication of damage.

But that’s not the only toe adjustment, just the easy one. The stud from the outer tie rod to the steering arm, as we saw, is a threaded one, locked in position by the pinch clamp. This changes the angle between the tie rod and the steering arm, and thus the susceptibility of the car to bump steer as explained before. Audi wants you to use special tools and a special procedure to measure this, an angle they call “raised toe,” and it will be more difficult to avoid getting this equipment than the previous. Besides checking “raised” toe if someone loosened the tie rod end adjustment, you should also check it after an accident that causes axle, suspension or dimensional body damage or if the car shows bump steer either on bumpy roads or during hard braking. Checking raised toe is part of every thorough alignment of these cars.

The special tools required are VAG 1925 and VAG 1925/3. They will allow you to `bounce’ the wheels up 60 mm from the unladen position. VAG 125 connects to the front subframe bolts on each side. You unscrew the threaded spindles until they just touch the subframe bolts, and then jack the car up at the front jacking points about 70 mm (2-3/4 in). Next you push the cylinder up from the threaded spindles and secure them with the locking bolts. Finally you lower the car onto the adapter, VAG 1925/3. At this point, you measure toe at each wheel again. There should be 12’ more toe-in on each side than in the unladen position. If the readings are correct, stop; you’re done. If they are not, loosen the clamp on the tie rod end and unscrew the threaded stud about 4 mm (5/32 in) and push the joint down until there is no more motion. Then screw the stud in until you get the specified unladen toe, plus a 12’ correction factor. Finally, you tighten the clamp bolt to 33 ft. lb. (45 Nm) and the adjusting bolt to 62 in. lb. (7 Nm) and recheck all the readings after bouncing the car several times on the springs. See why you don’t want to loosen the clamp or adjuster if you don’t have to?

A Pass, Perhaps?

Think this suspension geometry is just too much trouble to learn or the tools too expensive, that it would be more sensible to just blow off any Audi A8s and A4s that roll into your shop? Think again. The next car scheduled for this system is the 1998 Passat. Gonna blow off all the VWs? Think of it this way instead: if you can properly align this most complicated suspension system on the road, yours is the best steering and suspension shop in town, bar none.

But you can’t do these by mindless instinct and time on the job; you can’t do it by randomly twisting things until the display numbers turn green and the steering wheel centers. A responsible alignment involves consciously applied science, not mystic obscurantism. You have to clearly understand how the geometry works and what the adjustments do if you’re to do a safe job. And that’s true for every alignment, even the most familiar, because steering is the most important control on any vehicle. There are no minor steering failures.

—By Joe Woods

Thanks to Michelle and Mark at the Huntington NY Goodyear shop for letting me in to shoot the pictures.