THE SOFT RIDE VS. ROADABILITY

Influence from over the sea

BY ROGER HUNTINGTON

POOLE

THE PICTURE of a little 54-horsepower MG zipping through a section of winding road, leaving a tire-screaming 150-horsepower American sedan wallowing in its wake, was always good for a few yaks among the aficionados a few years back. "Detroit iron" in those days was nothing but lousy in the general roadability department.

The picture is a little different today. The Plymouth isn't necessarily out ahead of the MG now, but it's so close behind that any straight stretch more than 500 feet long could let it by. Then the MG could have to hustle to keep up. No, the story of the mini-powered imported sports car outrunning the big-inch American sedan on any road with a curve in it isn't as true as it used to be. More and more of the die-hard sports car drivers are realizing it every day. We might as well give the devil his due, and here's about how he did it:

To begin with, I think we should appreciate the fact that the science of designing and tuning an automobile chassis for predetermined roadability characteristics is a comparatively young science. It was less than 30 years ago (1931) when the brilliant Maurice Olley and his staff at Cadillac established the oversteer-understeer relationship, and pressed Goodyear to run side thrust and slip angle tests on tires. Before that time, auto engineers were mostly concerned with brutal problems like shimmy and tramp, spring interleaf friction, shock damper tuning, etc. Niceties like rear-end roll steer were for dreamers only. The Olley research was directly responsible for GM's independent front suspension in 1934, and it apparently influenced Chrysler's high-polar moment weight distribution at that time. These developments started the ball rolling.

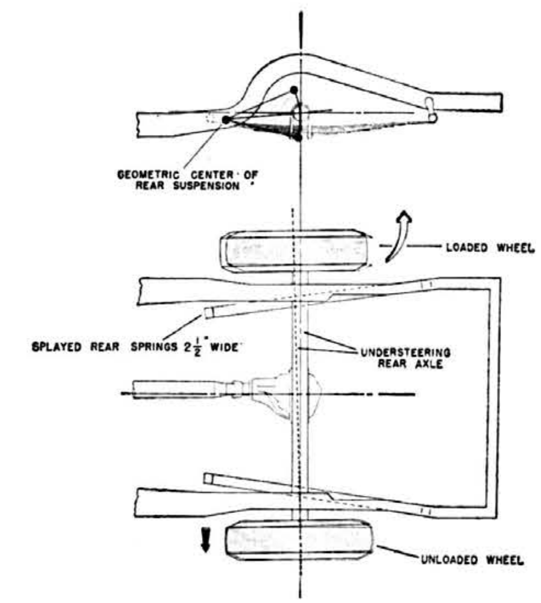
Actually, for nearly 20 years after that, Detroit proceeded at its own sweet pace on roadability development. There was no genuine popular interest in good handling among American motorists to goad the manufacturers. The public had never driven or ridden in a good-handling car, so how did it know what to demand? In those days, all the automotive emphasis was on loud styling, gimmicks, dynamic obsolescence and prestige buying. (Come to think of it, this sounds something like 1959.) It took the influx of imported sports cars and consumer automobile magazines in the early Fifties to wake us up. As soon as there was even a trickle of popular interest and demand for better handling, Detroit got to work in earnest. I think we agree that they have done a pretty good job in a reasonable length of time (and they're not done yet, by any means).

Let's pick up the story about 1950.

A car that did much to point up the need for improved roadability was the '49 Olds Rocket 88. Perhaps it's fortuitous that America's first really hot contemporary automobile engine was put in one of its poorest-handling chassis. Those early Rockets would get up to 60 miles per hour in less than 15 seconds and top 95 mph on the straight, but underneath all was trouble. The torque-tube, coil-spring rear end on trailing arms had crazy rear steering characteristics that were only aggravated by a rear anti-roll bar; the soft springs and nose-heavy weight distribution didn't help. It was becoming plain to the more observant at this point that engine performance was passing chassis performance. Detroit started to move.

One of the first trends was a general switch by the industry to tubular dampers on the rear, set in "sea leg" fashion to give some resistance to lateral body sway. This didn't do much for cornering, but the car felt a little more stable at speed in a crosswind. Another important development came around 1952 when Chrysler products and Pontiac raised their front roll centers from *below* ground level to a couple of inches above it by changing the relative lengths and settings of front wishbone arms. This reduced the roll couple a little by shortening the effective lever arm; but, more important, it reduced the outward tilt (camber) of the front tires when the body rolled, thereby increasing their cornering power.

This was one of the early attempts to improve handling through minor changes in suspension linkage geometry. Since then there has been a lot of work on both the front and rear ends. Today most American cars have front roll centers 1 to 2 in. above ground level. With rear leaf springs they began putting the front pivot point below the axle center, so when the body rolled under a side force the different arcs, struck at both ends of the axle, would steer it *toward* the force a little, giving a roll understeer effect. This effect increased with passengers in the rear seat, which offset some of the increased oversteer tendency from the added weight. This rear geometry is now general among U.S. cars.



Conventional rear leaf spring layout that gives roll understeer. Added weight, passengers or luggage, increases effect. The Plymouth Sport Fury had to be literally "thrown" into the turn to get the moderate roll shown on the opposite page.

Two cars that boosted public interest in handling problems in the early Fifties were the Hudson Hornet and the Loewy-designed '53 Studebaker coupe (even though neither car handled particularly well in standard form). The Champion coupe, from 1953 on, handles remarkably better than the V-8 coupe (even though both are on the same body and chassis) due to better weight distribution. Loewy's design proved that you could lower the center of gravity a couple of inches and cut air drag 25% without sacrificing too much space or utility and at the same time improve styling. Hudson's reputation was earned on the AAA and Nascar stock car racing circuits; they proved that the suspension of a big American passenger car could be reworked to give genuine sports car cornering —at the sacrifice of ride. Lincoln seconded the motion in their development for the Mexican Road Races in that period. All this progress was heavily advertised (remember the Ed Sullivan shows back then?), and it apparently made a deep impression on the man in the street. Popular demand for better handling in family cars increased.

Two important innovations in this general period were Lincoln's ball-joint front suspension links and Chrysler's Oriflow damper. A ball joint to combine the pivoting motion of the front suspension links and steering knuckle had been the dream of auto engineers for 20 years; it would give smoother steering and ride because of less bind in the suspension, it would ease the lubrication problem, and the saving in lateral width would give more space in the engine compartment. The big problems were always in the areas of production cost, wear and lubricant sealing. Finally Lincoln engineers got together with Thompson Products and solved the problems. Today ball-joint front suspension is practically standard in the industry (with today's designs much better and less costly than the original '52 Lincoln layout).

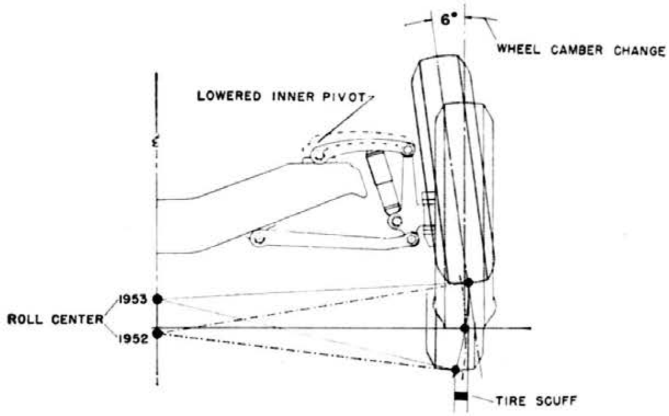
Chrysler ushered in an era of damper development with the 1950 Oriflow design. The principle here is to use long, narrow, laminar flow orifices in the damper instead of large, short passages with blow-off valves. The result is less damping on the boulevard at low wheel velocities and proportionally more resistance on hard bumps to prevent bottoming. Earlier dampers had too much damping at the low end and not enough at the high end. Furthermore, Chrysler broke new ground for American passenger cars by utilizing a jounce-rebound damping distribution of around 40-60 in the new Oriflow. Most previous cars had this distribution nearer 10-90 to keep the high damping at low wheel velocities from hurting the ride too much. The laminar orifice idea largely solved this, and the 40-60 distribution gave a much firmer feel in rough going. In the next few years a number of other cars began the move toward these principles. Several late models use jounce-rebound calibration in the 30-70 range, and substantial orifice control over much of the velocity range. And, of course, we have had other important damping developments like "two-stage" blow-off valves (Ford), hydraulic lock to replace bumpers for suspension stops (Lincoln), and Freon-filled bladders to take up volume changes and prevent oil foaming (Cadillac). We've still got a long way to go on dampers, too.

Packard's torsion bar suspension of 1955, in some ways, was like an oasis in a desert of technical conformity. It wasn't the torsion bar springing that made it special; it was the unique linkage that interconnected the front and rear suspensions, so a bump (upward wheel travel) at the front would cause the *rear* of the body to raise a little. This design gave very desirable pitch characteristics, and an excellent ride and handling on choppy roads. The idea was dropped with the demise of that Packard model, but the principle has been resurrected on GM's new Firebird III experimental car, combined in a beautiful air-oil springing system with an inertia lockout valve to prevent brake dive and acceleration squat. Packard's clever '55 torsion suspension system could well prove to be a prototype for the future.

Another significant development of the 1955 period was the swing of several manufacturers to rear leaf springs mounted outboard of the frame rails. This was done primarily to lower the body without pinching rear seat room, but there were secondary benefits. Other factors equal, suspension roll stiffness is proportional to the *square* of the lateral springbase. Thus a few inches more width between those rear leaf springs will substantially reduce the roll angle without greatly affecting the ride. Spreading tread width also helps, of course. Some '59 models have 5 in. more tread and 8 or 10 in. wider springbase than corresponding models of five years ago. This, coupled with the downward trend of the center of gravity, is one of the most important factors in the reduced roll angles of modern

U.S. cars. Take a quick numerical example: compare a '54 model with CG height of 25 in., tread of 58 in., and rear springbase of 40 in. with a '59 with respective measurements of 23, 62, and 48 in. With equal rear spring stiffness, the effective roll stiffness would be 44% higher on the '59. And, in a normal 0.4-G turn, the lateral weight transfer due to centrifugal force would be 17.2% on the '54 and 14.8% on the '59.

Still another important '55 development was anti-brake dive front-end geometry. By slanting the upper A-frame downward toward the rear you can utilize brake torque reaction to *lift* the front of the body. (A friend recently



The roll center on Chrysler products was raised by changing front suspension geometry (see text). Solid line represents the later suspension geometry.

told us he ran across a private patent for this device dated 1937!) The body lifting doesn't make the brakes work any better, but the car looks and feels a little more graceful when it stops.

The 1957 Detroit model crop saw several important suspension innovations, some obvious (and advertised) and some less obvious and largely unsung. There were noted four key developments: 1) Chrysler's torsion bar front end: 2) GM's trailing-arm rear-end linkage; 3) rear leaf springs with very short front sections to resist axle torque, and 4) more extensive use of rubber bumpers to increase the effective spring rate over a substantial portion of total wheel travel. Chrysler ad men boomed the TorsionAire principle as the greatest thing to hit the auto industry in 20 years; they do have a beautiful-handling front end, but it seems pretty well established now that the torsion springs themselves have little to do with it. Just the right combination of tread width/CG height ratio, roll stiffness, roll center height, shock calibration (more low-speed control than earlier models), fore-and-aft flexibility and variable spring rate was the secret. The fact that such a combination could happen at all in the American car market—only eight years after the '49 Rocket 88—was the real miracle. The '57 Plymouth Fury, with its low CG and heavy-duty suspension, was one of the best handling and cornering U.S. passenger cars in history. The other manufacturers have not matched it yet.

The GM and Ford trailing-arm rear suspensions were designed primarily for two reasons: to use rear air springs effectively and, in the case of the GM divisions, to utilize the X-type frame with rear-seat foot wells in the floor. The only real advantage over the conventional Hotchkiss rear end is in resisting axle torque (in fact, Chevrolet and Pontiac have control linkage geometry that *lifts* the rear end on acceleration). Meanwhile there remain problems of linkage flexibility and rear-end steering. Pontiac felt compelled to carry their arms on outriggers to give parallelogram lateral geometry (plan view) compared with Chevy's splayed arms—and Thunderbird engineers threw out the trailing arms altogether this year and went back to leaf springs, to stop axle torque hop with stick-shift cars. These rear-end layouts may be only a passing fancy. Note that other makers are nicely resisting axle torque by carrying the rear axle only about ⅓ of the way back on the leaf spring, so the short, stiff front section will resist bowing. Some have tried auxiliary torque braces on one side, but this doesn't appear vital for normal driving.

In my opinion one of the more significant recent developments in suspension science—unsung, to be sure—is the increasing use of rubber blocks to boost the effective spring rate over a substantial part of the wheel travel, instead of only as a suspension stop for hard bumps. You see it especially on Chrysler products. As you know, a steel spring normally has a linear load-deflection curve; that is, if 120 lb of force will deflect it 1 in., 360 lb will deflect it 3 in. This is not the best set-up for a suspension spring because we want a low rate on the boulevard and a progressively stiffer rate on hard corners or rough roads.

In the past we've gotten a certain rate increased by juggling leaf spring shackle geometry, but the effect was limited. The thought of just using a simple rubber block to do the job was apparently too crude to contemplate. But the breakthrough came in '57—and today rubber block reinforcement of steel spring rate in our passenger car suspensions is very popular throughout the industry. Incidentally, Studebaker tried another tack with their front coil spring and wound the coil with a varying helix angle, so some coils would bottom out before others and give more stiffness. This seems to work fine, though it costs more than rubber blocks. At any rate, there's no doubt that the new emphasis on variable rate in our suspensions has been an important factor in the handling of late U.S. cars.

Some other developments—like air springs, 14-in. tires with 22 pounds per square inch, improved power steering systems, etc., though they're all vital parts of a trend, have really done nothing to improve the general handling of our cars. All the above might suggest that the age-old battle between ride and handling is being eliminated. It's not, and may never be. Gimmicks like air springs and 22-psi tires, that have radically improved the ride, have generally *hurt* handling. U.S. engineers have done a brilliant job to get improvements in *both* fields in the last 10 years.

In conclusion, no chassis article would be complete without some mention of brakes. The average braking system on U.S. cars today is probably 50% better than it was five years ago. Some of the important developments that brought this about would include the trend to flanged and ribbed drums to improve heat dissipation and reduce drum distortion; solving space problems to allow wider linings, in turn to maintain lining area with limited drum diameters; Chrysler's "center-plane" brake with intentional shoe distortion to maintain more nearly equal lining pressure around the drum; Buick's aluminum drums; grooved linings for lateral heat equalization over the drum; the '59 emphasis on more air circulation around the drum, by setting the drum away from the wheel and venting the wheel disc to pull air across the drum. All these were vital improvements. But there are still weak spots; our U.S. passenger car brakes are barely up to their job yet. We badly need higher-quality factory linings; this is a cost problem that Detroit can't seem to face. (Maybe a couple less chrome ornaments would cover it!) A trend back to 15-in. wheels and 12-in. drums would help. Better balancing of the braking work between front and rear brakes would improve things. A device to prevent wheel lockup on hard braking would save many lives.

Well, Detroit hasn't yet made Ferraris and Astons out of its Buicks and Chryslers, but next time you feel frisky with that MG and you run into a late-model Plymouth with dual pipes, better think twice!