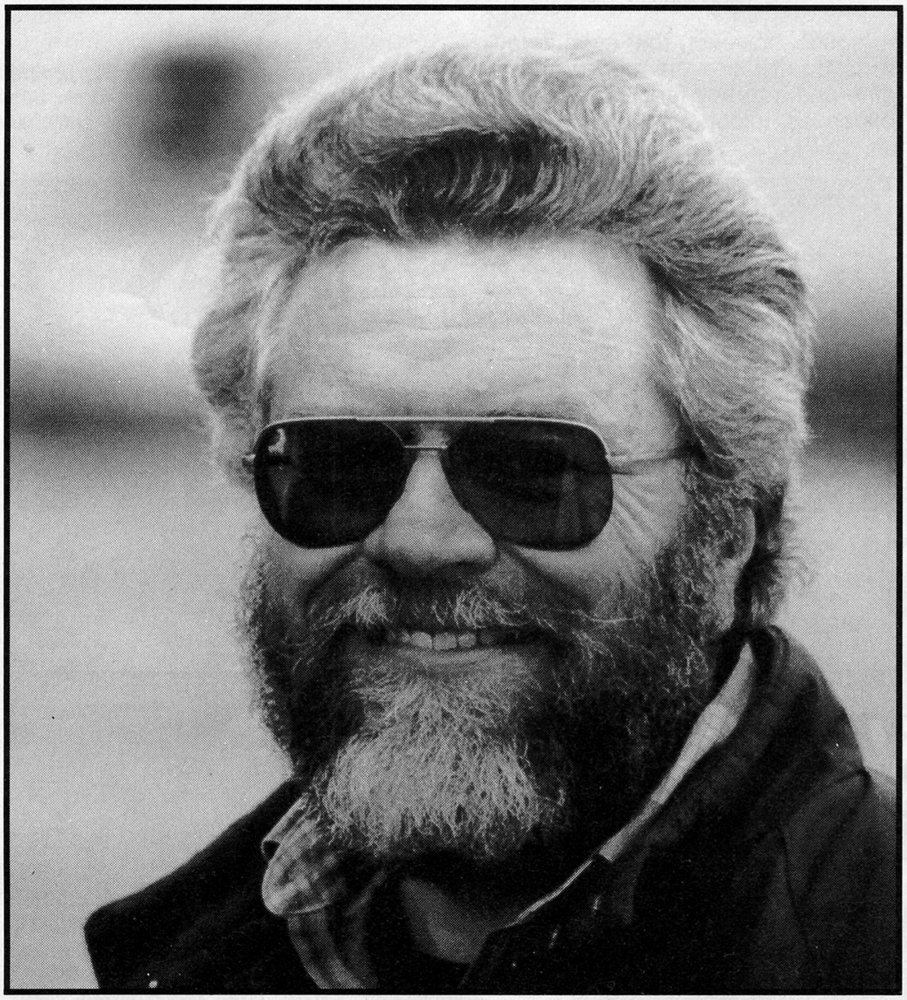
HERB ADAMS



Father of the Trans Am

A GENIUS WITH A FLAIR FOR STYLING AND ENGINEERING

By David Fetherston

Herbert Adams was not an average high school student; he excelled in his classes *and* at his hobby of building hot rods. These talents and his top grades at college won him a place at the prestigious General Motors Institute. Four years later he graduated with honors in automotive engineering.

With his degree from the GM Institute in hand, Adams was assigned to five GM divisions in as many years. He worked on the production line, in tooling and suspension design, in styling studios and with engineering design. This broad base of knowledge landed him in advanced design at GM, the division responsible for the direction of corporate design. It's also the division where all young, talented designers want to work but where only the cream of the crop get the chance.

From there Adams was posted to the Pontiac Division, where John DeLorean was chief guru. Those were the golden days: Chevrolet had released the Z28 Camaro in '67 and DeLorean countered with a Super Firebird.

The project was initially called the Pontiac Firebird Sprint Turismo (PFST). The idea was hatched at Pontiac engineering meetings, but none of the older Pontiac engineers wanted to touch it. Seeing an opportunity, Adams spoke up and accepted the challenge.

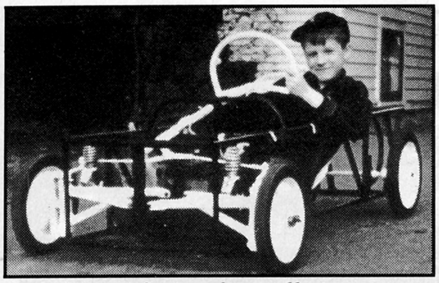
Starting with a base Firebird, he reengineered the suspension, building a machine with excellent handling and good ride quality: It's said that the first model ran the best-handling suspension of any American-built car that decade. Extensive R&D went into the car. Adams developed high-effort steering gear, which was based on standard power steering but gave a much better feel by eliminating the mushy lifelessness that standard GM power steering had at that time.

Adams had an open order to produce a car that was different from the Camaro, and he did. When the project was finalized, the PSFT Firebird was powered by the short-lived six-cylinder Pontiac overhead cam engine. He even built a Hemi head for the six before it was dropped. As a prototype vehicle, it was used as a mule for new ideas, and even though it was powered by a six-cylinder, Adams' good work was quickly translated into a V8 application.

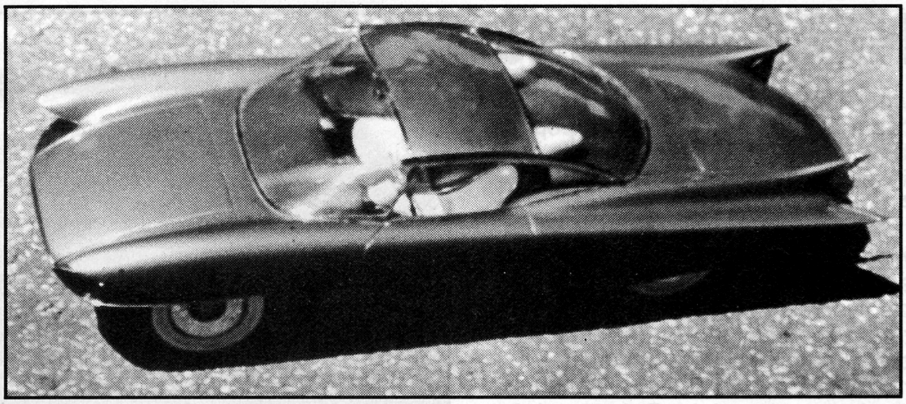
Another first for Adams was the Shaker hoodscoop. He devised, built and installed it on a prototype Trans Am model. The idea was picked up and converted for use on Pontiac V8 models, and Ford made the concept even more famous by installing the Shaker on the Mach I Mustang.

DeLorean liked the car and decided to build six second-generation V8 models. These were used as promotional units, and they toured the country. They were heavily track-tested and further refinements were included in the final package. DeLorean came up with the name Trans Am and promptly licensed it from the Sports Car Club of America (SCCA), which used it in a sports racing car series. DeLorean borrowed other race-related names including GTO and Le Mans for the Pontiac Division.

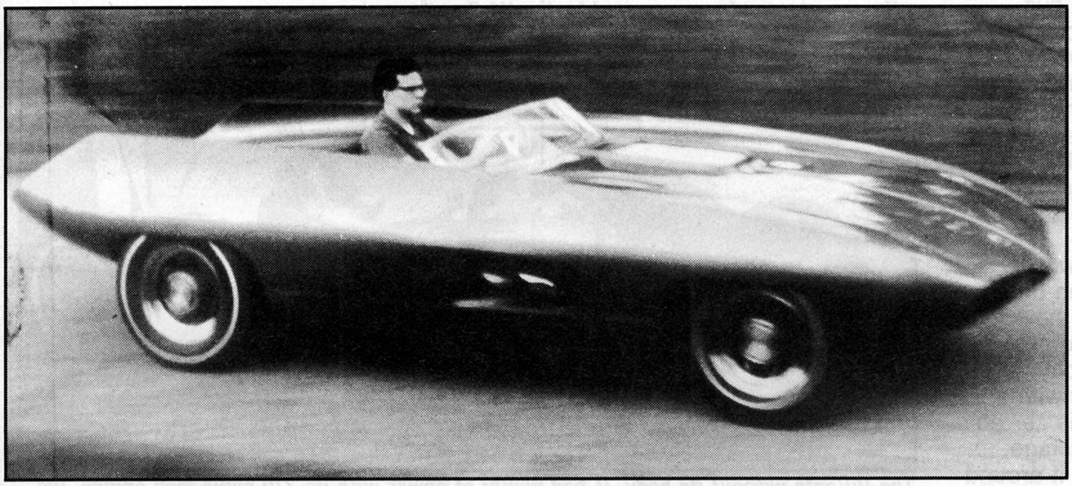
The Trans Am Pontiac hit the streets in mid-'69. It could be fully equipped with all the power options,



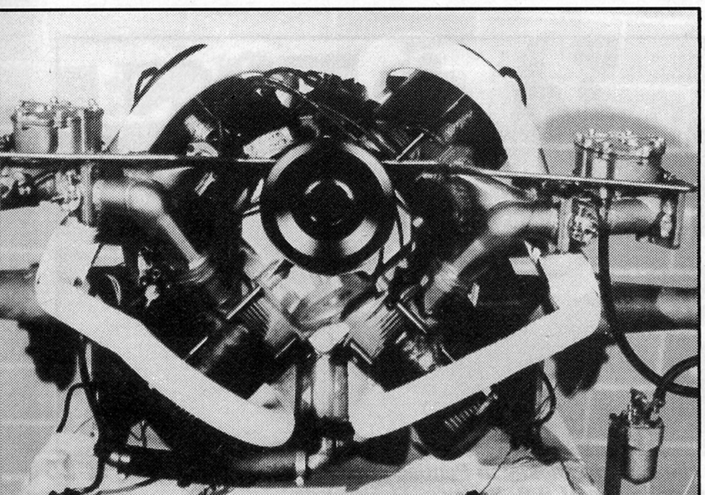
Herb Adams' first real car effort—an electric go-cart he made for his brother. It had a full tubular steel chassis and frame, with an electric motor and A-arm front suspension.



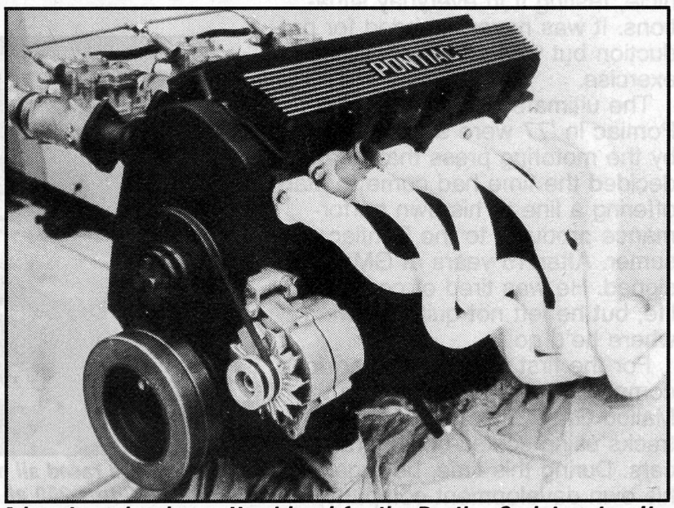
The model that won him the prize in the Fisher Craftsman's model building contest.



This beautiful two-seat sports car, called the ViVante, was designed by Adams, and he had it built for himself. It used a 370-cubic-inch Pontiac engine and four-speed transmission, along with Pontiac eight-lug wheels and a hand-formed aluminum body.



The Scotch Yoke X4-2 cycle, four-cylinder engine Adams designed and built for the commuter car project. The engine weighed 110 pounds and produced a very smooth 90 horsepower at 4000 rpm.



Adams' overhead cam Hemi head for the Pontiac Sprint motor. It was three inches lower, used dual rocker covers and produced better horsepower and fuel economy than the six, but it was dropped when Pontiac went to V8 power in all its performance cars.

including a 400-cube V8 and a state-of-the-art wheel and tire package. It sold only 697 copies. Built around the Camaro body shell, the Firebird was basically a sheetmetal revision of the Camaro. Pontiac changed the front body styling and rear lights and installed its own interiors and powertrains.

What set the Trans Am Pontiac apart from the others was its handling. A new body was introduced in 1970, and Adams' further development work made a superb handling car that was still selling in very small numbers. He wasn't just sitting in an engineering shop designing and building cars; he was out racing Pontiacs even though it wasn't corporate policy. He won the A/Sedan Championship in a Firebird, which in turn led him to build a group of ultimate Firebirds for Pontiac in 1977.

Pontiac sold 3200 Trans Ams in 1972, which represented 10 percent of Firebird sales. Even at this level it was considered a loss by many members of the senior design staff at Pontiac, but by 1979 its net percentage of sales had grown to 70 with 100,000 units sold.

The Trans Am has since become the division's number-one high-volume/high-profit model, and today it has a high public profile. The popularity of the Trans Am is directly linked to the reputation that Herb Adams built into the '69 model.

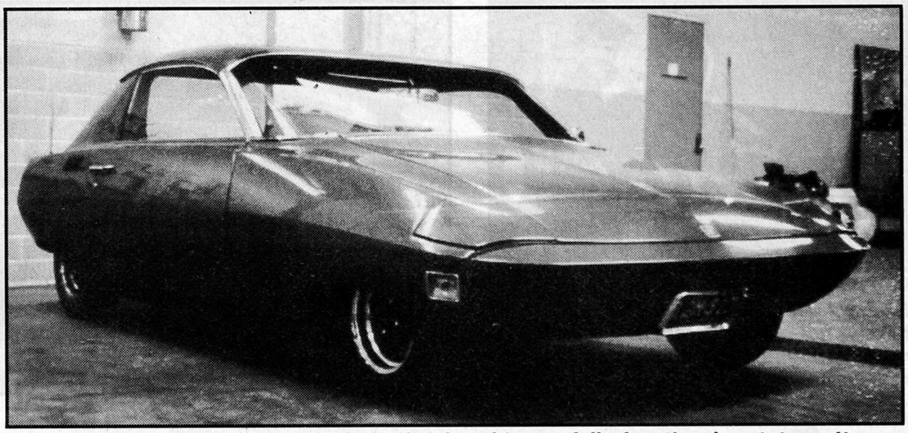
Adams' work extended far and wide with Pontiac. He was assigned an extensive array of projects during his five years in the advanced vehicle design section. He designed and built the first modern American hatchback on a GTO. Pontiac didn't like it, but when John DeLorean left for Chevrolet, he took the idea with him. The next year it was a successful production feature on the Chevy Nova. Adams also worked on engine development. He built experimental V8s—the 303 and the 366—that never saw production and worked on successes like the 455. He was also responsible for some of the body engineering on the '71 Judge.

Adams' last assignment was a clean sheet project, an open order to build a commuter car of the future. He designed the whole project—engine, suspension, body and interior. It was a two-seater with a two-cylinder engine, and this car actually got past the drawing stage. Adams built one and drove it around Detroit, putting miles on the little vehicle, testing it in everyday situations. It was never intended for production but was an advanced design exercise.

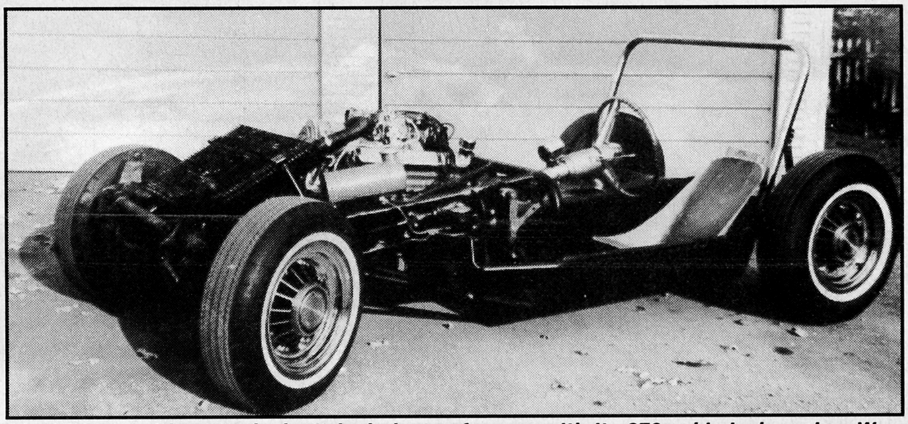
The ultimate Firebirds he built for Pontiac in '77 were so well received by the motoring press that Adams decided the time had come to start offering a line of his own performance products to the Pontiac consumer. After 15 years at GM, he resigned. He was tired of corporate life, but he left not quite knowing where he'd go.

For the first year he worked for a company that was developing the Malibu Grand Prix mini race car tracks using scaled-down Grand Prix cars. During this time, he organized his own development company, called Herb Adams Very Special Equipment (VSE).

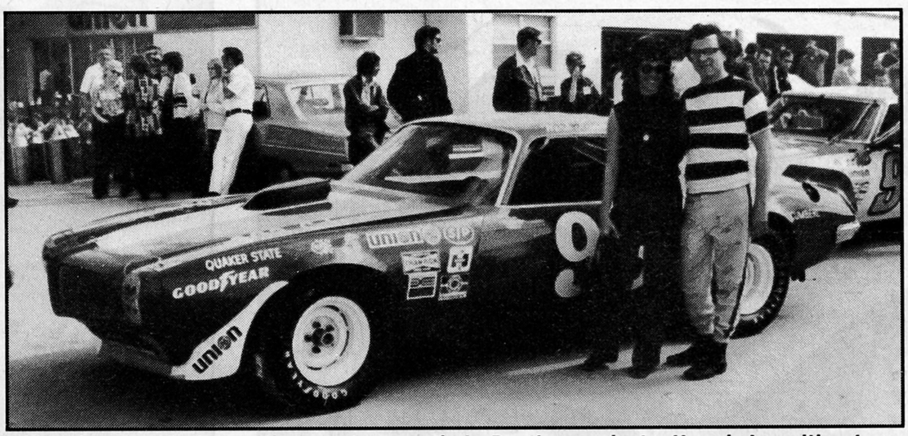
Today Adams consults on special projects. He has also done development work for Oldsmobile and Pontiac and acted as consultant to many other companies including Goodyear, and he even designed a new chassis for the aging Avanti. The production chassis runs a four-wheel independent suspension and



The famous commuter car that Adams developed into a fully functional prototype. It was a three-seater, and was powered by the X4-2 cycle engine.



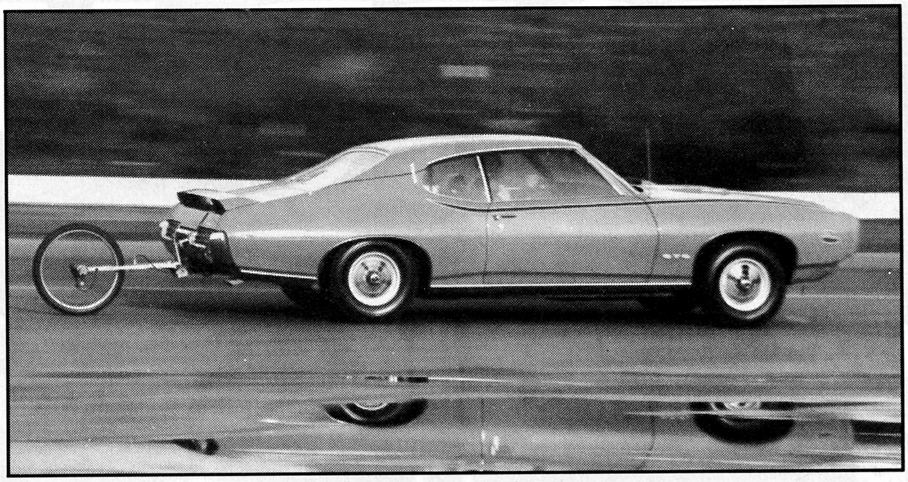
The ViVante without its body. It had plenty of power with its 370-cubic-inch engine. We wish we knew where this car is now!



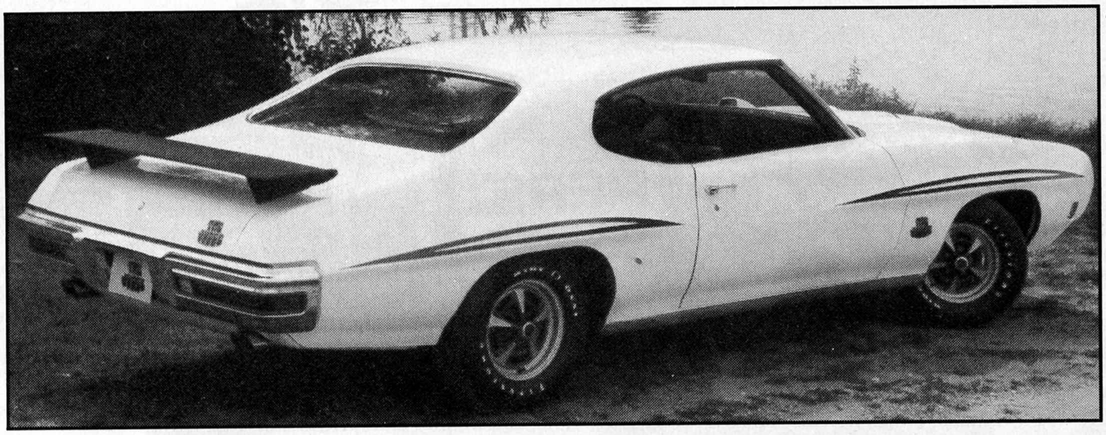
Adams has raced all over the country, mostly in Pontiac products. Here he's waiting to run the Citrus 250 at Daytona in one of H.B. Bailey's '71 Firebirds.

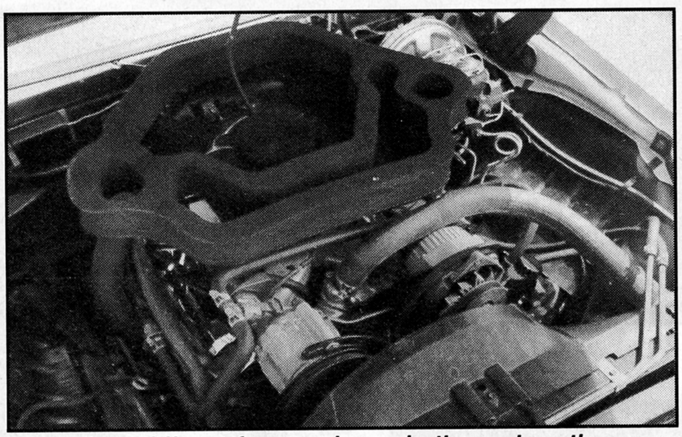
The Grey Ghost, a '64 Tempest that Mark Donahue loved to hate. With Bob Tullius at the wheel, it placed as high as second in a Trans Am race in the early Seventies.

Lead photo from a **Motor Trend** *story about seven Pontiac engineers who skirted the company policy of "no racing." The engineers used Adams' wife's Tempest with a 303 racing engine for competition.*

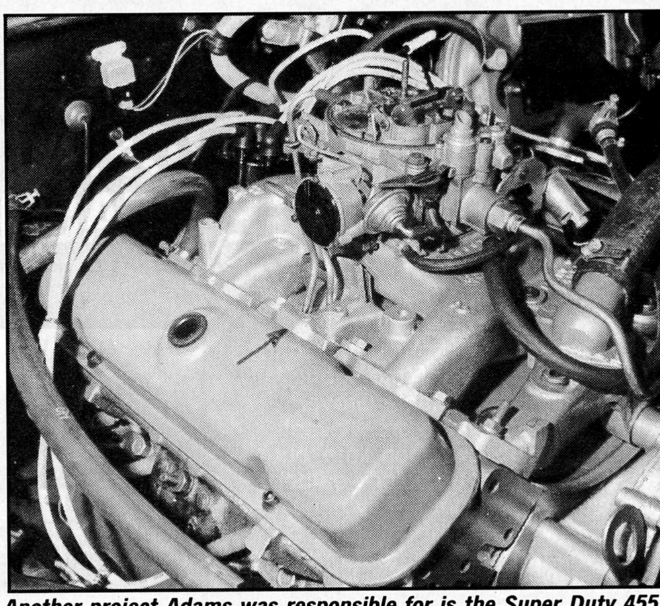


Adams was the product engineer on the '70 GTO Judge. Initially, the company didn't want another GTO, but when DeLorean saw the design, he gave the okay and selected the name Judge.





Externally no different from regular production engines, the experimental 303 was a test bed for the later production motors.



Another project Adams was responsible for is the Super Duty 455. This motor was the result of his development work with the racing 303 and 366 engines.

Adams developed a series of high-performance Firebirds. First came the PFST, or Pontiac Firebird Sprint Turismo, which was powered by the OHC six. This led to a series of show cars that resulted in the assignment to design the Trans Am Firebird for '69.

a 400-cube V8. He met these requirements by using a simple and very rigid central backbone tube and square box-section frame for the chassis.

In 1985 Adams built a GTP racer called the Escort, campaigning it with great success. It's a strange-looking device named after its sponsor, Cincinnati Microwave, which builds Escort Radar Detectors. The Escort races against factory teams and has done very well. It's different from other cars in the field because it's front-engined with rear-wheel drive, and the driver sits far in the back in the chassis. From the rear the body

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design is reminiscent of the Cheater racing cars of the Sixties, but from the front it's unmistakably the Escort. Adams designed the Escort to suck the ground. Its unique body is built like a surfboard—hand-shaped foam with a glass wrap.

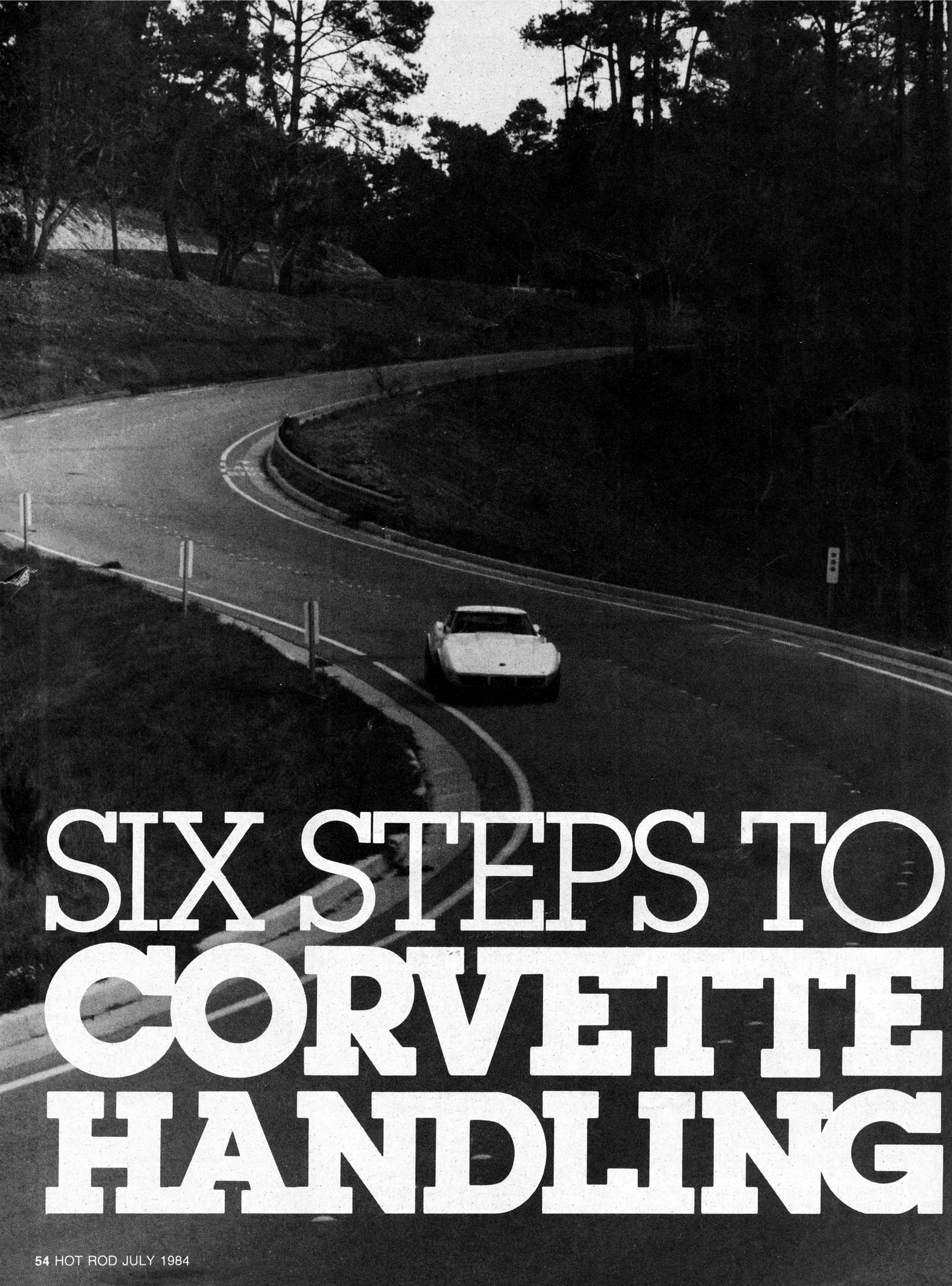
But Adams' expertise isn't limited to futuristic racing cars. He has a product line for the street and is a prolific writer of technical books on performance, handling and structural design. He publishes a quarterly newsletter on street performance and technology. He has worked mostly on the development of suspension kits for Pontiac and Chevy products, but is now developing a new range of product lines for Ford.

His book *Camaro-Firebird, The Complete Performance Handbook* is one of the best around on DIY performance. It's a no-nonsense way of getting to know suspension basics and how to make them work on the track and the street. Contained within the book is a short course in structural design that shows chassis design is possible in any home garage. For anyone thinking of building a performance car at home, this publication is a must.

Herb talks about setting up a garage before starting a project, and the step-by-step method of building a road racer. One of the most fascinating chapters in his book is the section on wheel alignment: A method of setting up front-end geometry at home is demonstrated, and Adams claims it's just as accurate as an optical wheel aligner. There's also a second publication, and for those lucky enough to own a Corvette, this book tells everything you could wish to know about its handling—and how to improve it dramatically. It's also a must for anyone interested in suspension design and modification, since it discusses esoteric details of fine suspension tuning.

Adams was a corporate maverick, working as a GM engineer during the week and successfully racing Pontiacs on the weekends. He can justly lay claim to being the father of the Trans Am, and he's still one of the best development engineers in the performance industry. Proof of that comes from Moroso, which now markets his suspension products.

Adams has moved to new projects that will turn the automotive spotlight on him once again, including a $3000 conversion that will transform a VW Rabbit/Golf into a snappy little sports car. He still races a Pontiac Firebird called the Fire Am, keeping his hand in racing and his mind and eyes as sharp as they've ever been. ***MC***



SIX STEPS TO CORVETTE HANDLING

Text & Photography: Rick Voegelin

Progress always has its price. In the case of Corvettes, the current price of progress is $24,000—the bottom line on the window sticker of a new 1984 model. No one would deny that Chevrolet's latest two-seater delivers a bundle of new-tech hardware in exchange for this princely sum. No, the problem for most prospective Corvette owners isn't making the decision to buy—it's making the monthly payments. For every computer company president who's just struck it rich with a new silicon chip, there are thousands of Corvette owners who still have to work for a living. And chances are the owner of a '63-'82 Stingray isn't quite ready to trade in a car he still loves for an LED dashboard, a rock-solid suspension, and the fat payment book that come with every new Corvette.

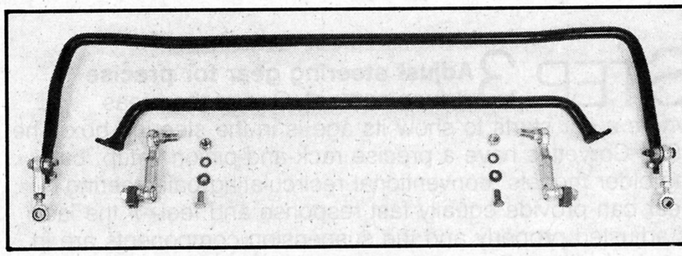
But suppose there was a way to update these older Corvettes. What if it were possible to apply some Eighties-style suspension science to Sixties-style Corvettes? After all, until the '84s started rolling off the assembly lines last spring, the last significant Corvette chassis revisions were made more than two decades ago.

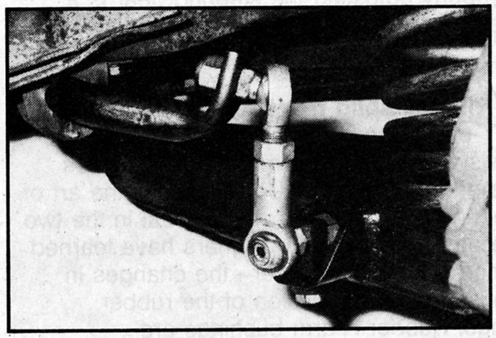
These were the thoughts that occupied Herb Adams' fertile mind when reports about Chevy's new *wondercar* first started filtering out of the Tech Center two years ago. Herb's handling and suspension expertise should be quite familiar to faithful HOT ROD readers by now, based on his suspension improvement program for Camaros and Firebirds, and his standout performances in HOT ROD's first and second "Suspension Shootout(s)." And now he's set down his plans for curing the '63-'82 Corvette's suspension shortcomings in his newest performance handbook, *Corvette Handling* (available from Herb Adams VSE, 100 Calle Del Oaks, Del Rey Oaks, CA 93940, 408/899-4859, for $9.95 postpaid).

Herb's first step was to analyze the chassis improvements that Chevrolet engineers designed into the new Corvette. Once you put aside the swoopy body panels, the *Star Wars* dashboard, and all the aluminum suspension forgings, you're left with three substantial chassis advances. Adams' list of genuine improvements found on the '84 Corvette included its front-mounted rack-and-pinion steering, its new rear suspension geometry, and its 16-inch-diameter wheels with 50-series Goodyear tires. Herb then sat down and devised a plan to provide older Corvettes with the benefits of these refinements, but without the high price. The result was the following six-step cure for Corvette handling ills.

Herb Adams Reveals How to Make Your '63-'82 Corvette Handle Like an '84—and Save $24,000 in the Process

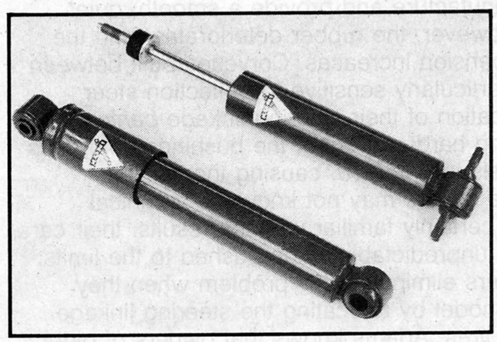
STEP 1 **Install front and rear stabilizer bars to control body roll.** Perhaps you may recall from past HOT ROD handling articles that Adams is an outspoken advocate of using stabilizer bars as the primary means of suspension control. Tires provide their best traction when they are perpendicular to the pavement, but body roll upsets this ideal relationship. Repeated trips to the skidpad and test track convinced Herb that 1⅛-inch-diameter front and rear bars provided the neutral handling characteristics he desired. Adjustable mounts for the rear bar accommodate both varying car weights and different driving styles. The front and rear bar attaching links feature spherical rod ends which quicken response by eliminating the "give" found in rubber bushings.





Adams believes in "big" stabilizer bars to control body roll. He engineered these 1⅛-inch-diameter front and rear bars for '63-'82 Corvettes.

Front stabilizer bar attaches to lower A-arms with spherical rod ends to provide instant handling response.

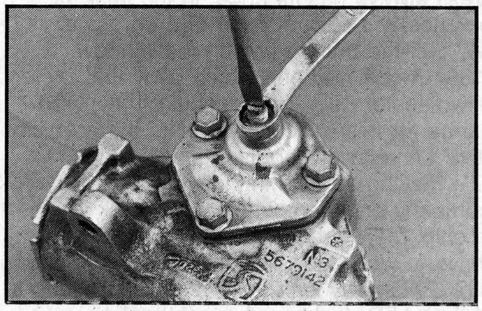


Adjustable Koni shock absorbers allow fine-tuning suspension for "critical dampening" after springs are trimmed.

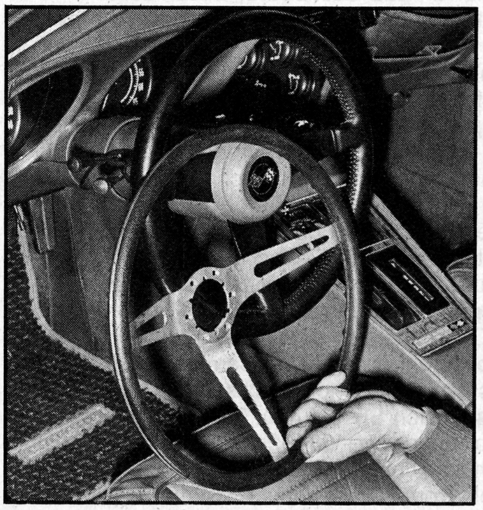
STEP 2 **Trim front springs to lower center of gravity and install adjustable shocks to control wheel movement.** In addition to his faith in big sway bars, Adams is also a believer in soft springs. By using the softest spring that still prevents the suspension from bottoming out, the wheels are able to follow irregularities in the road surface—which, in turn, allows the tires to provide maximum traction. Herb also reasoned that the comfortable ride provided by stock springs would make long trips more enjoyable for Corvette owners who really get out and drive their cars. By trimming half a coil from the stock springs, their rate is increased approximately 10 percent. This provides the correct stiffness, along with the added benefits of a lower center of gravity and a better aerodynamic angle of attack. For owners of Corvettes equipped with the rock-hard gymkhana factory suspension, Adams offers this advice: install the standard springs. Your kidneys will be forever grateful.

Shock absorbers play a critical role in Adams' "soft spring plan." They must be loose enough to allow the suspension to work, yet firm enough to control suspension motion. Achieving this goal of critical dampening is best done with adjustable shock absorbers. Adams selected Konis for his development Corvette, based on their quality and longevity.

CORVETTE HANDLING



Ten minutes spent adjusting lash in gearbox restores precision to steering.



Adams replaced stock steering wheel with 14½-inch-diameter, leather-wrapped VSE steering wheel. Reducing wheel diameter increases effort slightly.

STEP 3 Adjust steering gear for precise driver control.

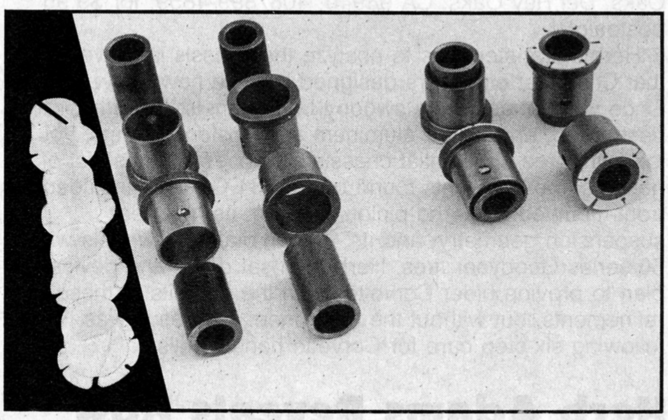
One of the areas where a car starts to show its age is in the steering box. The 1984 Corvettes have a precise rack-and-pinion setup, but the older models' conventional recirculating ball steering gear can provide equally fast response and feel—*if* the lash is adjusted properly and the suspension components are in good condition. Properly adjusting the steering gear is a no-cost, 10-minute procedure that's described in Herb's handbook.

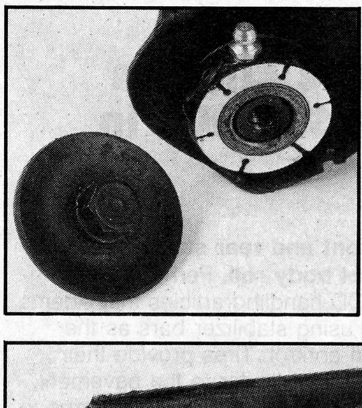
STEP 4 Install solid front A-arm bushings to eliminate deflection steer.

When the '63 Corvette chassis was introduced more than 20 years ago, it was a state-of-the-art design. Unfortunately, the art of automotive engineering has changed a great deal in the two decades that have passed. Chassis designers have learned about the importance of deflection steer—the changes in wheel direction caused by compression of the rubber suspension bushings. Rubber A-arm bushings are inexpensive to manufacture and provide a smooth, quiet ride. Over time, however, the rubber deteriorates, and the "give" in the suspension increases. Corvettes built between '63 and '82 are particularly sensitive to deflection steer because of the location of their steering linkage *behind* the front wheels. During hard cornering, the bushings compress and the front wheels turn *inward*, causing the car to oversteer. Corvette drivers may not know the technical terms, but they're certainly familiar with the results: their cars feel "twitchy" and unpredictable when pushed to the limits.

Corvette engineers eliminated this problem when they designed the '84 model by relocating the steering linkage ahead of the front tires. Adams knows that owners of older versions don't have that alternative, however. So he set out to get rid of deflection steer by eliminating the deflection in the suspension. This means getting *all* the rubber out of the front end. Herb rejected steel suspension bushings because of their noise; he passed on urethane because of their lack of precision and doubts about their long-term durability. Finally he decided on nyliner bushings, which consist of thin nylon bearings riding inside precisely machined steel sleeves.

A nyliner bushing has almost no deflection, yet provides smooth, quiet suspension motion. They also have provisions for grease fittings (a feature lacking in urethane bushings), which help banish suspension squeaks. Installing these bushings in a Corvette requires disassembly of the front suspension, but Adams reasoned that many older Corvettes were about due for a suspension rebuild in any event. These bushings also reduce camber changes, which aids the tires in producing maximum cornering power.





Herb replaced rubber bushings in front A-arms with nyliner bushings to eliminate deflection oversteer.

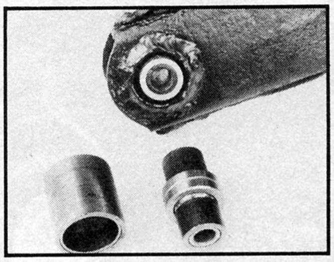
Steel sleeves for nyliner bushings must be welded to control arms. Grease fittings in sleeves allow lubrication of bushings to improve durability.

STEP 5 Install solid rear control arm bushings and rear strut rods to eliminate toe and camber changes.

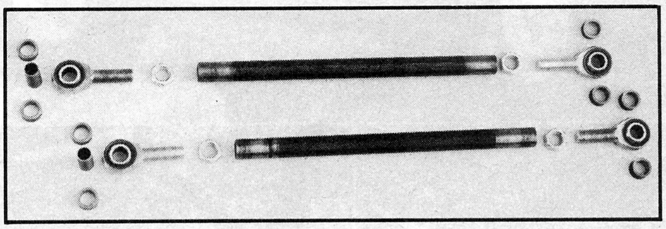
New Corvettes are outfitted with a sophisticated five-link rear suspension. Again, though, the owner of an older model Corvette has to work with what he's got. A Corvette's unique independent rear suspension requires the same attention as its front end—and for many of the same reasons. Rubber bushings in the rear

Complex motion of rear control arm requires spherical bearings to replace soft rubber bushings.

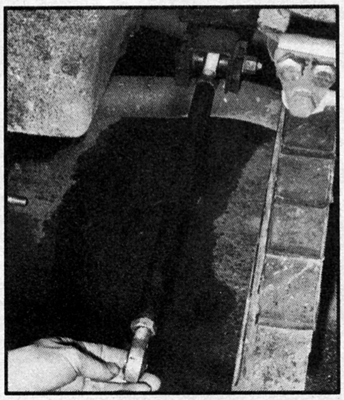
CORVETTE HANDLING



Adams has found that only aircraft-quality ball bearings with hardened races will withstand loads in rear control arm. Arm must be removed to permit welding of steel sleeve.

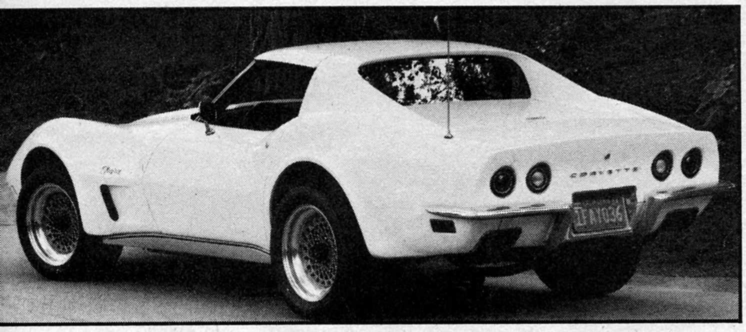


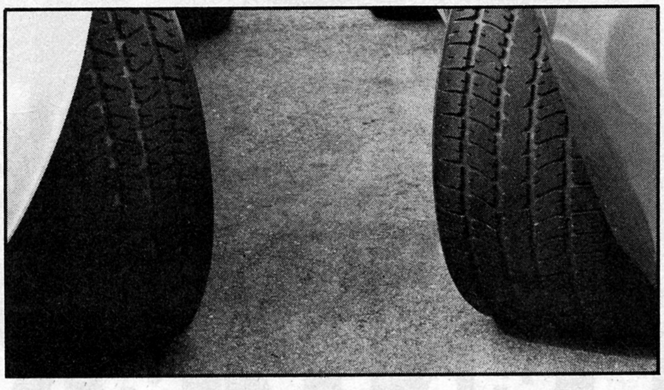
Heavy wall steel tubing and rugged rod ends used in VSE rear strut rods eliminate deflection found in stock pieces.



Stiff strut rods eliminate camber changes in rear tires during hard cornering.

16-inch-diameter Epsilon wheels and 50-series Goodyear "Gatorback" tires add Eighties high-tech styling to venerable fiberglass—as well as some serious road-holding abilities.





Uni-directional tread pattern on P255/VR50-16 tires (right) was developed from Formula One rain tire technology.

control arms deflect when the car is driven vigorously, causing continuous changes in the tires' camber and toe-in which the driver cannot control or predict. Eliminating these unwanted deflections in the rear suspension requires somewhat different equipment, however. Nyliner bushings aren't suitable for the complex motion of the rear control arms. The only bearings that meet Herb's specifications are aircraft-type spherical ball bearings with hardened races. Again, installation of these bearings requires removal of the rear control arms, but the work is warranted by the improvement in suspension control these bearings offer.

The camber of a Corvette's rear tires is controlled by strut rods mounted behind the leaf spring. Herb deposited the stock strut rods in the nearest trash can and built his own replacement strut rods using thick wall steel tubing and heavy-duty heim joints. These extremely stiff strut rods easily withstand the suspension loads during fast cornering, keeping the tires square to the pavement. They also make adjusting the rear suspension camber a simple (if not particularly enjoyable) pastime.

STEP 6 **Install 16-inch-diameter wheels and Goodyear "Gatorback" tires for greater traction and faster response.** Certainly a great deal of the credit for the 1984 Corvette's outstanding handling is due to its 8.5-inch-wide, 16-inch-diameter wheels and Goodyear P255/50VR-16 radial tires. All the high-tech suspension hardware under a new Corvette's fiberglass skin is really there to serve the contact patch between the tire treads and asphalt. Putting more rubber on the road increases traction, and reducing the width of the tire sidewall quickens the response to driver inputs. This is one time when the owner of an older Corvette doesn't have to give anything away to a new model. By carefully selecting wheel offsets, Adams was able to install the same Goodyear "Gatorback" tires used on new Corvettes on his '73 "mule car," mounted on 8.5-inch-wide, three-piece Epsilon modular wheels. And somehow this Eighties-style wheel-and-tire combination looks just right under the Sixties-style fiberglass of a Stingray Corvette.

Although it requires only a few paragraphs to summarize Adams' suspension plan, the actual research and development consumed more than two years. Of course, the test of Herb's efforts isn't how good this program looks on paper; it's how well an older Corvette equipped according to Adams' insight performs alongside one of the new '84 wondercars. Fortunately, HOT ROD has some impressive "real world" numbers to report. Tests at our favorite Southern California skidpad revealed that Adams' much-abused test car cornered at a phenomenal .90 g's after being outfitted with all the suspension refinements described above. For comparison, the best skidpad numbers produced by an '84 model under similar controlled conditions is .85 g's. Since no one spends his driving life circling a skidpad, HOT ROD's designated test driver also tried his hand at the Shelby Performance Center's standard handling course—and drove away with a new track record for his efforts!

As a result of his Corvette investigations, Herb has added all the suspension components described here to his growing catalog of handling hardware. Of course, not every Corvette owner may feel the need to have enough cornering power to win at Daytona. By following just the initial steps in Adams' suspension plan—stabilizer bars, shocks, springs, and steering adjustment—a Corvette owner will realize the biggest gains in road-holding power. Installing solid suspension bushings and 16-inch wheels can always come later—like when you want to humble the computer chip baron who thinks that a big checkbook is the only way to buy Corvette happiness. **HR**

CORVETTE HANDLING

A PERFORMANCE HANDBOOK

INFORMATION

The information contained in this publication is accurate and complete to the best of our knowledge. All recommendations on designs or modifications are made without any guarantees whatsoever on the part of the author or Herb Adams VSE, Inc. Because design matters, modifications, materials and methods of application are beyond our control, Herb Adams and Herb Adams VSE, Inc., disclaim any liabilities incurred in connection with the use of this information.

Throughout this guide, use of the term "Corvette" is for model identification only. All manufacturer's names, numbers, symbols and descriptions are used for reference purposes only.

Herb Adams VSE advises that certain parts and modifications described in this handbook may affect engine exhaust modifications. All such parts and modifications are therefore offered for sale or use in California and in states having similar emission regulations for racing and other off-road use only.

A PERFORMANCE HANDBOOK

CORVETTE HANDLING

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INTRODUCTION

Car enthusiasts looking forward to a "new" Corvette had to be patient for two decades, but the wait was worth it. The 1984 Corvette set new standards for handling, braking, and advanced design. Yet all this progress has its price—and unfortunately, for most Corvette enthusiasts, the cost of a 1984 model puts these benefits far out of reach.

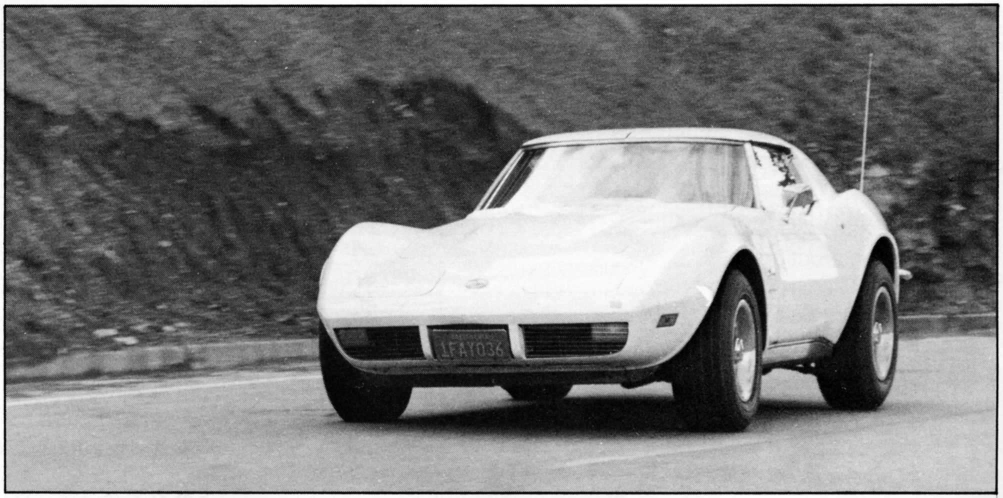
Suddenly there are thousands of Corvettes produced between 1963 and 1982 that seem terribly outdated alongside the latest version. But these are still attractive, appealing automobiles that command a high degree of owner loyalty. It makes no sense to shunt these Corvettes aside just because Chevrolet has released a more exotic successor. In fact, by analyzing the changes made in the 1984 edition to correct certain shortcomings in the earlier models, it is possible to improve the handling and over-the-road performance of the entire generation of Corvettes produced between 1963 and 1982.

That's what this performance handbook is all about. It's intended to be a guide for the Corvette owner who wants to experience the handling of an '84 model without paying $28,000 for the privilege. A '63-'82 Corvette prepared according to the recommendations in this handbook may not be able to drive around one of Chevrolet's new wonders, but it will certainly stay close. **Very** close.

Automotive engineers have learned much about the science of handling in the years since the '63-'82 Corvette chassis was first designed. Many Vette drivers complain that their cars feel "twitchy" and "unpredictable" when pushed to the limits; we now know the reasons for their unease. In these pages we'll examine the **causes** of these undesirable handling traits and explain the practical **cures** for these shortcomings.

In the "Handling Basics" chapter we define the terms that engineers use when they're talking about suspension systems. Road tests and reviews are often full of references to "oversteer" and "anti-squat," but very seldom are these concepts fully explained. Once you've become familiar with the language, you'll understand there is really no mystery about good handling.

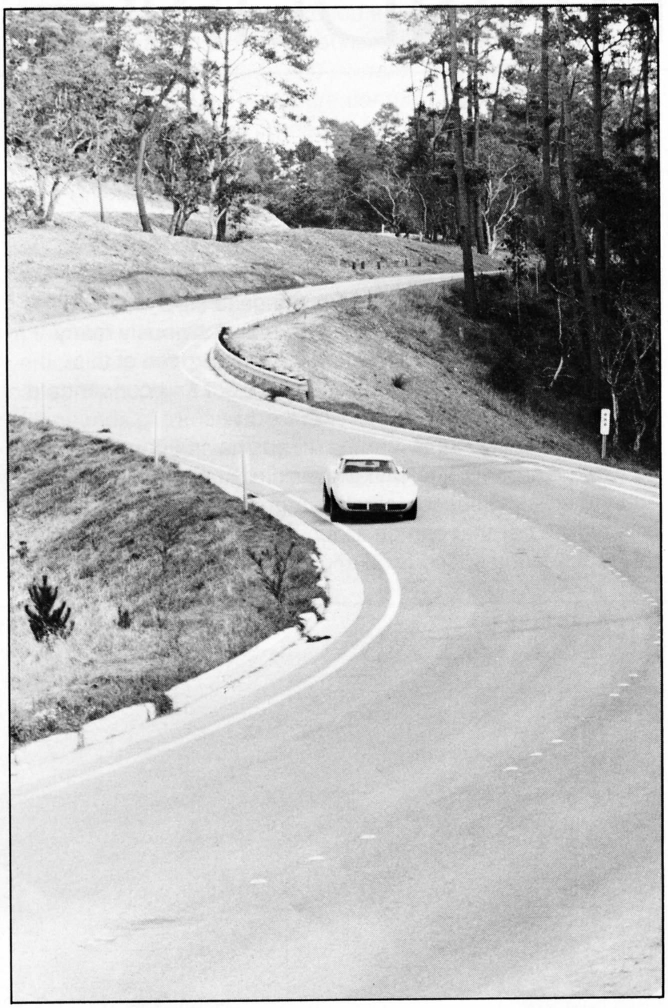
Next we'll take a look under the sleek skin of the 1984 Corvette, concentrating on the changes that set the new model apart from earlier versions. Then we'll get down to business in the chapter on upgrading '63-'82 Corvette suspensions. We'll see how the improvements made in the '84 Corvette's



chassis design can be applied to the earlier models. In addition, various approaches to improving a Corvette's handling are explored, with a special look at the hardware that will increase a Vette's cornering speed.

Next on the agenda is a comprehensive and entertaining section on preparing a Corvette for racing, written by champion driver Jerry Thompson. It's worthwhile reading for anyone who's ever wanted an inside look at what it takes to get a car ready for competition. If constructing a winning Corvette is beyond your ambition, then perhaps the quick and easy improvements outlined in our "Performance Tips" chapter will make your Corvette more enjoyable to drive.

The final section describes the components and kits which Herb Adams Very Special Equipment offers for '63-'82 Corvettes. It's always been our philosophy that an enthusiast should understand **how** the parts we recommend will improve his car's handling. We think that once an enthusiast understands how a stabilizer bar or solid bushing kit contributes to good handling, then he'll see that VSE parts are designed to produce improvements he can feel at a price he can afford.



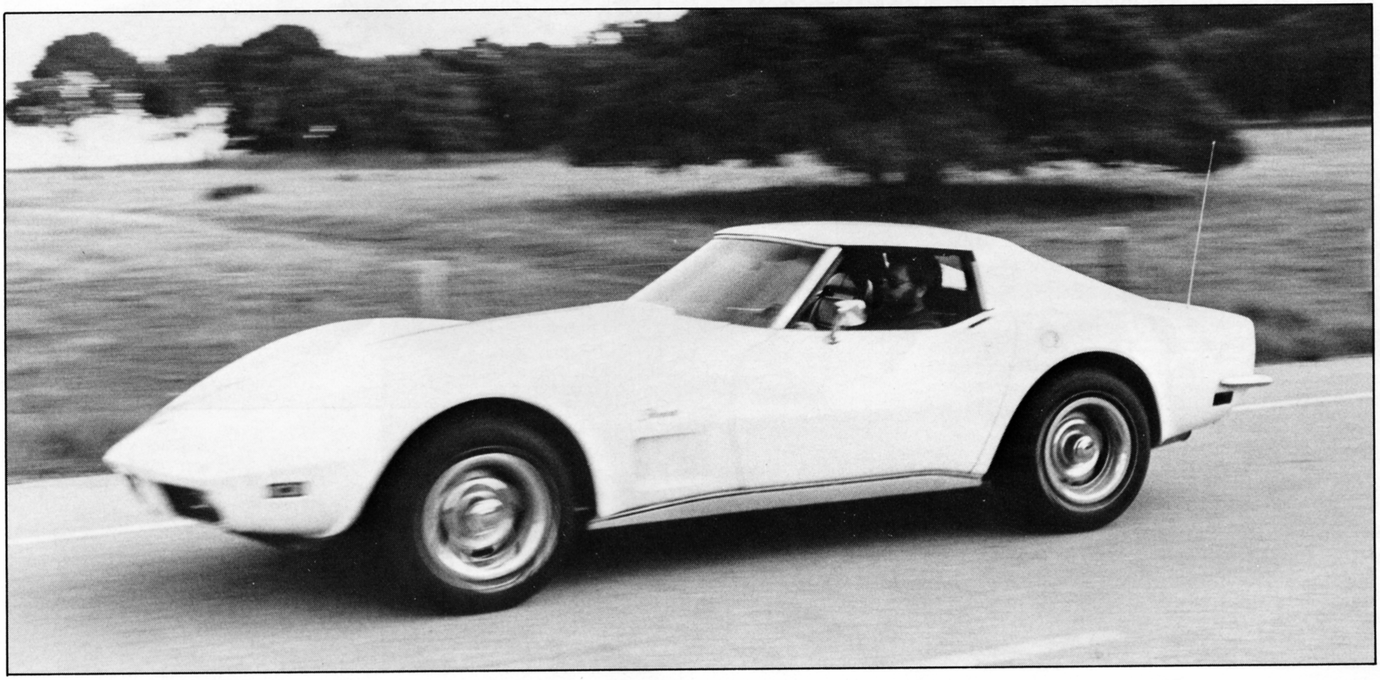
CHAPTER ONE

HANDLING BASICS

Good handling means different things to different people. The subject is very complex, so there are obviously many different views and explanations. For the purpose of this handbook, we will try to simplify the subject and concentrate on practical results rather than on theory.

Good handling in this context means having your Corvette go where you want it to with the maximum amount of control and the greatest speed potential. A good handling Corvette is not just a car that can go around corners at high cornering rates. Cornering speed is an important part of good handling but there are other factors that are just as important. If a Corvette is not comfortable to drive, it will be difficult for the driver to consistently make it go where he wants it to. If it has inconsistent and erratic behavior, it will be impossible to make it go where the driver wants.

In order to discuss the subject of Corvette handling, it is necessary to have some understanding of certain aspects of car equipment and behavior. This chapter covers some of the background information needed to appreciate the hows and whys of your Corvette's handling.



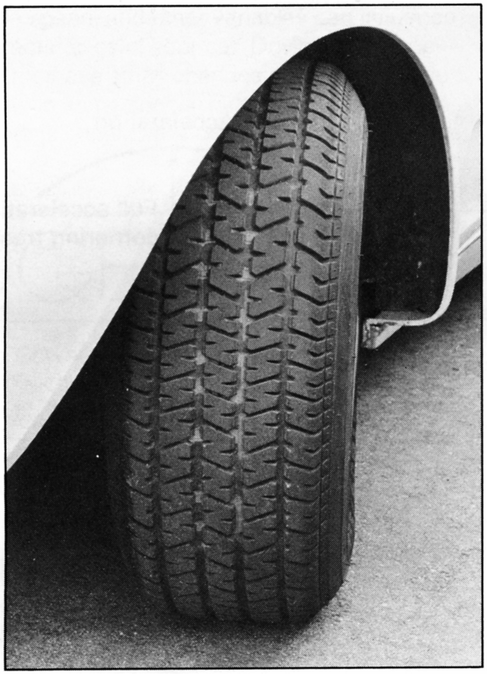
TIRE CHARACTERISTICS

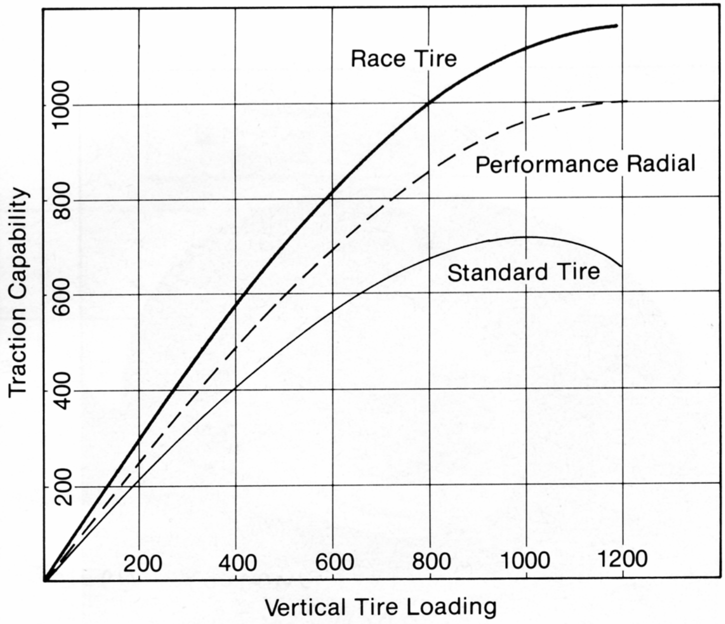
When analyzing a car's handling, it is convenient to concentrate on the tires' input and output characteristics: How much traction do the tires offer at a specified load? Variables like slip angles and aligning torques are important to tire engineers, but they are not important for the Corvette enthusiast who just wants to improve his Vette's handling.

The accompanying tire curves are representative of three distinct types of tires—a regular production type tire, a high performance street tire such as the Goodyear Eagle NCT and a racing tire. Note that, as vertical loads on the tires increase, all three provide increasing traction capability up to a point. Obviously the standard tire has less traction capability throughout its load range than the performance oriented tires, and, at very high vertical loads, its traction capability actually decreases. In contrast, the race tire has considerably greater traction capabilities at the same vertical loads. This is why the race tire is "stickier," and accounts for the higher cornering speeds permitted by racing rubber.

As the curves indicate, racing tires often have traction capabilities which actually exceed a given load. For example, a racing tire may have 1000 pounds of traction capability with a vertical load of only 800 pounds. This means that the tire's coefficient of friction is greater than 1.00—which is why a race car can develop cornering forces that exceed one "g" of lateral force. The NCT street radial closely approaches the race tire's traction capabilities. Further, its traction curve does not drop off at the higher vertical loads like the standard tire does, which makes the NCT an excellent high-performance tire for Corvettes.

All these tires lose some of their relative traction capabilities at the higher loads. Examine the race tire's curve: when the vertical load doubles from 500 to 1000 pounds, the traction capability is only 1120 pounds. Thus the race tire has "lost" 160 pounds of traction capability relative to the ratio it exhibited at a 500 pound vertical load. Understanding this phenomenon of diminishing traction return is essential to understanding why a car handles the way it does.



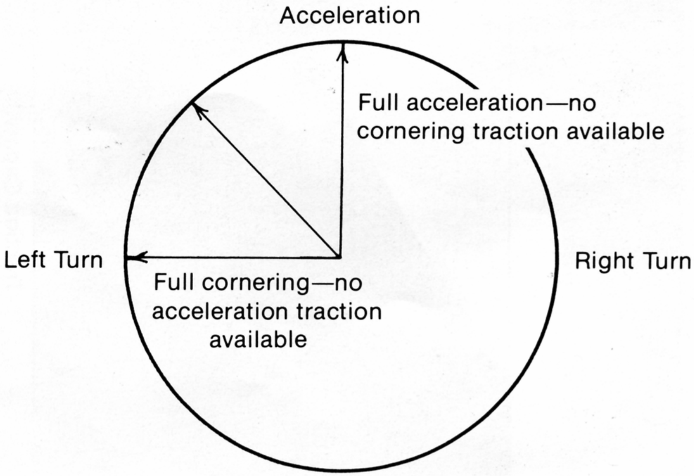


THE CIRCLE OF TRACTION

Every tire has a well defined capability to produce traction. This available traction can be applied to accelerating, braking or cornering maneuvers up to the limit of the tire's load capacity. Very seldom does a car just accelerate or just corner. Usually the car is undergoing a variety of changes in speed and direction simultaneously. How these changing forces affect tire performance (and thus handling) is represented by the "circle of traction."

A typical NCT tire, for example, might have a total traction capability of 960 pounds of force at a vertical loading of 1000 pounds. Naturally, this traction capability depends on a host of variables, including the pavement composition, tire pressure, temperature, suspension camber angle, and so forth. For purposes of analysis, however, we can assume that the tire's total traction capability is a constant 960 pounds. This figure represents all the traction available for any given horizontal loading. For instance, if all this traction capability is being used to circle a skidpad as fast as possible, there is none left for braking or accelerating. If you tried to brake or accelerate under these conditions, a portion of the total traction would be applied to this purpose, and less would be available for cornering power. The same is true if you are using all the traction capability for braking or accelerating—there would be none available for cornering side loads. This is why a car will fish-tail under hard acceleration, or spin out under severe braking. All of the tire's available traction is being used in the fore-and-aft direction, and there is none left for the side loadings needed to keep the car moving straight.

If we could view the tire contact patch as it moves along the roadway we could see how this "circle of traction" operates. The total traction capability can be represented by an arrow on a circular graph. This arrow—the available traction—may be positioned in any direction. If it points straight ahead, there is no traction reserve for cornering forces; if it points to the 10 o'clock position, the available traction could be used for both acceleration and for cornering. This is the typical situation produced when accelerating out of a corner. Applying more throttle causes the back of the car to start to come around because more of the traction is being used for acceleration. This leaves less for cornering, so the back of the car begins to break loose.

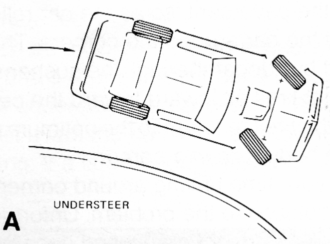


OVERSTEER AND UNDERSTEER

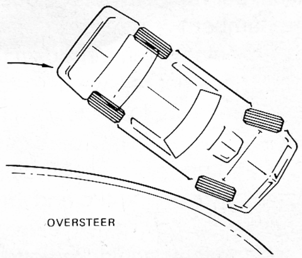
One reason we recommend larger, more effective stabilizer bars for Corvettes is the bars' ability to control a car's understeer characteristics. Standard Corvettes are produced at the factory with a great deal of understeer built into their suspensions.

Anyone who has driven a Corvette hard into a corner has probably experienced understeer. The car "plows" or "pushes" through the corner. Regardless of the term used to describe the condition, the front tires must be pointed more into the turn to keep the car on its line (see diagram A). Oversteer is the opposite effect: the front tires are pointed outward, and the car is said to be "loose" or "hanging out" (as in diagram B). Neutral steer is the middle ground between oversteer and understeer. Both the front and rear tires are running at the same angle to the road. A Corvette set up for neutral steer will be faster in steady state cornering than one which over- or understeers because all four tires are sharing the cornering loads equally. By using the recommended stabilizer bars, your Corvette will become very close to the desired neutral steering attitude.

Factors such as the number of people in the car, road conditions, vehicle speed, and other variables can influence the handling characteristics of your car. Driving technique can compensate for these small changes if the car is close to the neutral state. In some special circumstances a slight degree of oversteer is beneficial. Certain autocross courses, for example, favor a car which oversteers somewhat. In general, though, you will probably be most comfortable in street driving conditions with a car set up to corner with a very slight amount of understeer.



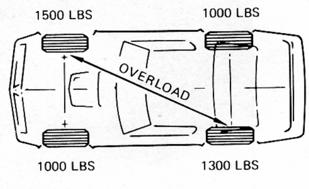
A



B

WEDGE

Occasionally a Corvette will understeer in one direction and oversteer in the other. This is caused by unequal static loading across the corners of the car (see diagram C). Adjusting the length of the stabilizer bar links can eliminate wedge so the car will handle the same in both right and left hand turns.



A "WEDGED" CAR

C

BODY ROLL

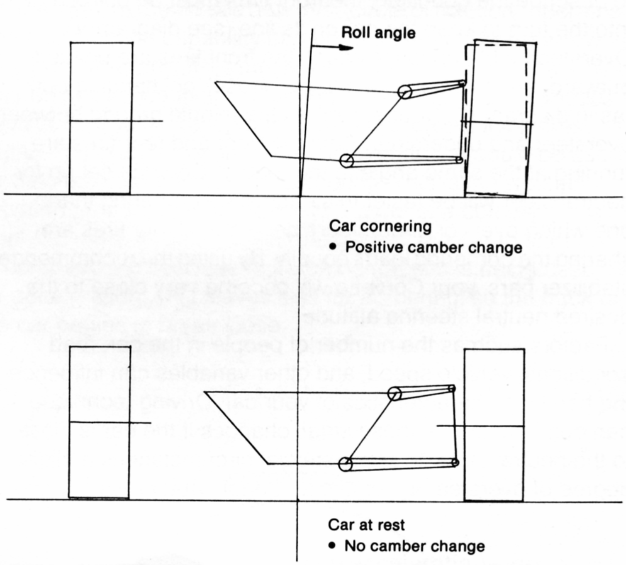
As a car travels around a turn at speed, forces acting on the vehicle make the body roll toward the outside of the turn. When the body and frame roll, the wheels roll with it, and the tires are no longer perpendicular to the road surface. Tires generate their maximum cornering power when they are perpendicular to the pavement, so as the car rolls, they lose their ability to pull the car around the corners. This condition can be countered by "decambering" the suspension so that the tops of the front tires tilt inward toward the center of the car. This permits the tires to return to the optimum perpendicular position when the body rolls in a corner.

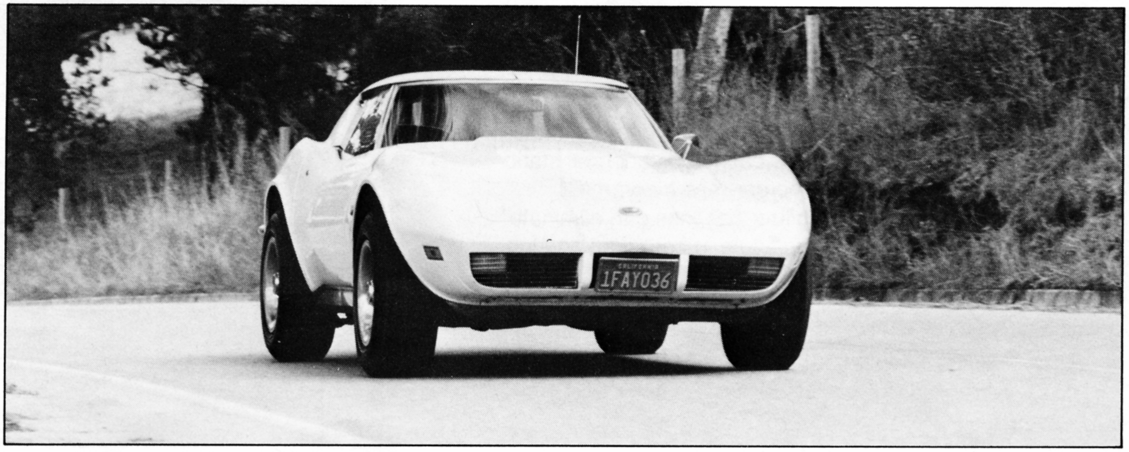
If you spent all your time driving around corners, this would be a satisfactory solution to the problem. Unfortunately, the real world is full of straight roads, and decambered tires will wear quickly on their inside treads. The practical limit for a street-driven car is one degree negative camber. (As a point of comparison, our race cars are aligned with 2 to 3 degrees of negative camber.)

Since the tires and wheels will remain closer to perpendicular to the road, if the body does not roll, we use stabilizer bars to control the chassis' tendency to roll toward the outside of a turn. Larger, more effective stabilizer bars minimize body roll, and thus improve cornering power by helping to maintain the proper relationship between the tire and the roadway.

Stabilizer bars which limit body roll are also effective in negating the roll steer that is built into Corvette suspensions. Roll steer is a condition where the front and rear suspensions are designed to steer the wheels as the body rolls; this makes the car feel "safe" to novice drivers. This same self-steering tendency is unwanted in a high-performance automobile, and the stabilizer bars we recommend help minimize this trait.

Camber Change in Cornering Due to Body Roll Angle





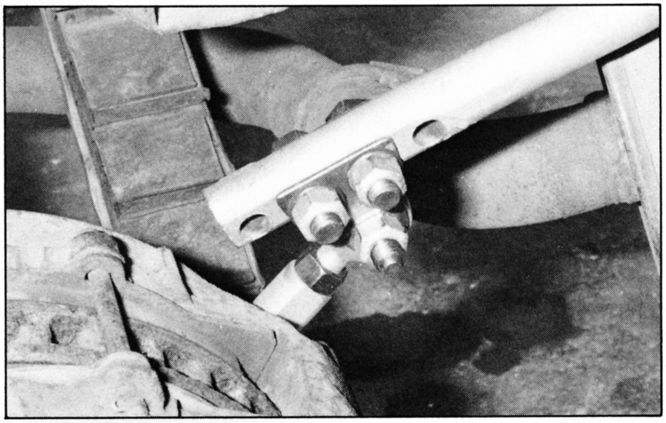
STABILIZER BARS

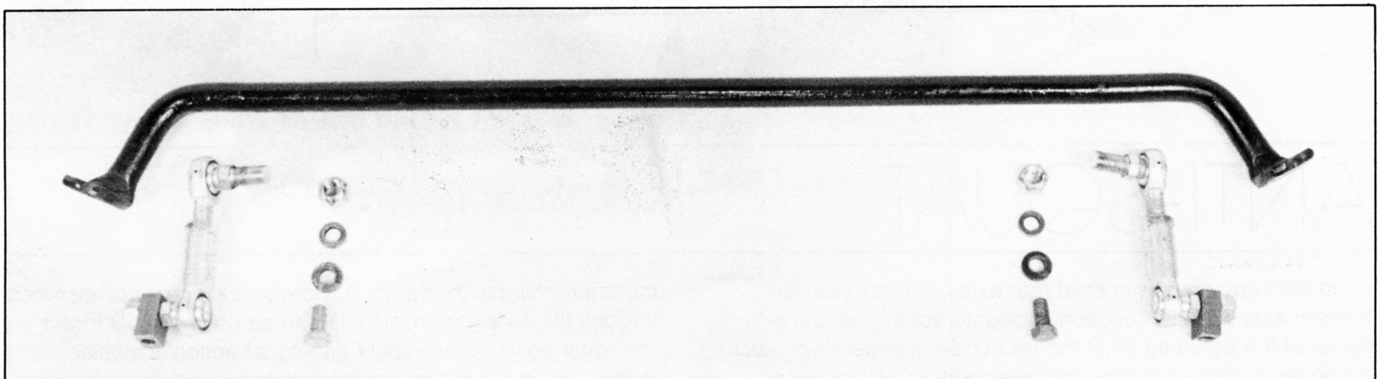
It is necessary to control body roll on cars with independent suspensions because there is little anti-roll effect built in. Stabilizer bars control body roll by requiring the bar to be twisted if the body is to roll. Since larger diameter bars are harder to twist, they are more effective in limiting body roll. Stabilizer bars are used to control body roll because they have little effect on the up and down motions of the suspension. Stiffer springs can also be used to control body roll, but they also decrease the suspension's ability to absorb bumps so the ride quality is poorer.

Some of the reasons it is necessary to control body roll in cornering are for driver and passenger comfort, to limit the effects of roll steer, and to limit the loss of cornering power due to camber change. If a car rolls at too great an angle driving around a corner, like a Renault, the passengers feel like the car will tip over. Since the Corvette suspension has a considerable amount of roll-steer built in, this unwanted steering effect is reduced if body roll is reduced (roll steer is that part of the suspension geometry that causes the wheels to steer toward understeer as the body rolls.) G.M. always builds this into their cars on the premise that it makes them safe in spite of the driver's abilities. Performance minded drivers don't need much protection for themselves, so they don't need much roll steer.

The camber effects of body roll are caused by the fact that, as the body rolls, the tires roll with it. This causes the camber to increase on the outside tires, which reduces their cornering power. If body roll is minimized, the outside tires can remain perpendicular to the ground and deliver maximum cornering traction. The best way to limit body roll is to install bigger (and therefore stiffer) stabilizer bars. It is also an advantage to connect the stabilizer bars to the control arms with steel joints to eliminate lost motion.

If a car, such as a Corvette, is equipped with both a front stabilizer bar and a rear stabilizer bar it is possible to control the amount of understeer and oversteer. When a larger rear stabilizer bar is used, the car will move toward the oversteer side of handling. If a large enough rear bar is used, the car will oversteer.





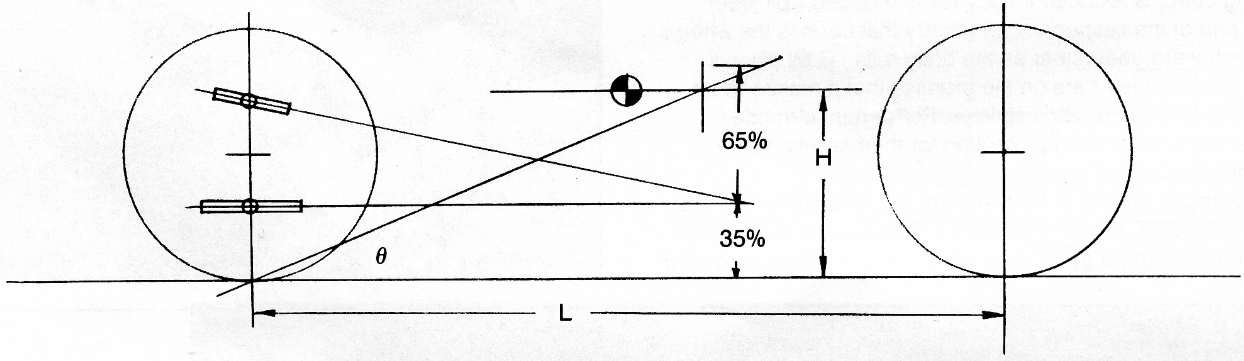
ANTI-DIVE

Anti-dive is that characteristic of a suspension, usually the front, which resists the tendency of the car to dive forward under braking. Anti-dive is produced on a Corvette by angling the upper control arms, with front pivots higher than the rear. As braking forces are absorbed by the control arms, they exert a force on the front of the car which tends to raise it. It is possible to have 100 percent anti-dive, but the resulting wheel travel patterns are not correct for other considerations. The amount of anti-dive built into your Corvette is a good compromise for both the street and the race track. On high speed oval tracks, it has been found that less anti-dive is an advantage because the cars don't brake very often, and it eliminates caster change which is a by-product of the anti-dive geometry.

For 100% anti-dive (60% on front)

$$\tan \theta = \frac{H}{.6L}$$

For sample shown, anti-dive is 35%



ANTI-SQUAT

On cars equipped with solid rear axles, it is possible to use the rear axle's torque reaction to counteract the natural tendency of the car to squat at the rear under acceleration. Such suspension characteristics are called anti-squat because they are used to prevent this action. Since a Corvette uses independent rear suspension, the axle torques are fed through the differential into the frame. The torque reaction is not absorbed through the suspension, so little can be done to counteract the squat action. Some slight anti-squat action is available in the Corvette rear suspension, but its magnitude is not large enough to try to optimize it.

DEFINING G FORCES

One "g" is simply the force equal to gravity here on Earth. If an object is said to weigh 100 pounds, the force of gravity on it equals 100 pounds. If this object is subjected to a second force of 80 pounds, we would say it has a .8g force acting on it. This system of describing forces affecting common objects—like automobiles—is more convenient than using pounds of force as measure, since it eliminates the need to recognize the weight of the object. (For instance, a 3000 pound cornering force acting on a 3000 pound car would be one "g" load. The same 3000 pound force on a 4000 pound car would be only a .75g load.) By describing cornering forces in g's, we can compare various cars equally regardless of their individual weights.

Many magazine road tests include a car's cornering power measured on a skidpad and expressed in g's. A typical late-model stock Corvette can corner at .81g—a very respectable figure. A road racing sedan, however, does considerably better. Our Trans Am racer produced 1.15g in skidpad testing.

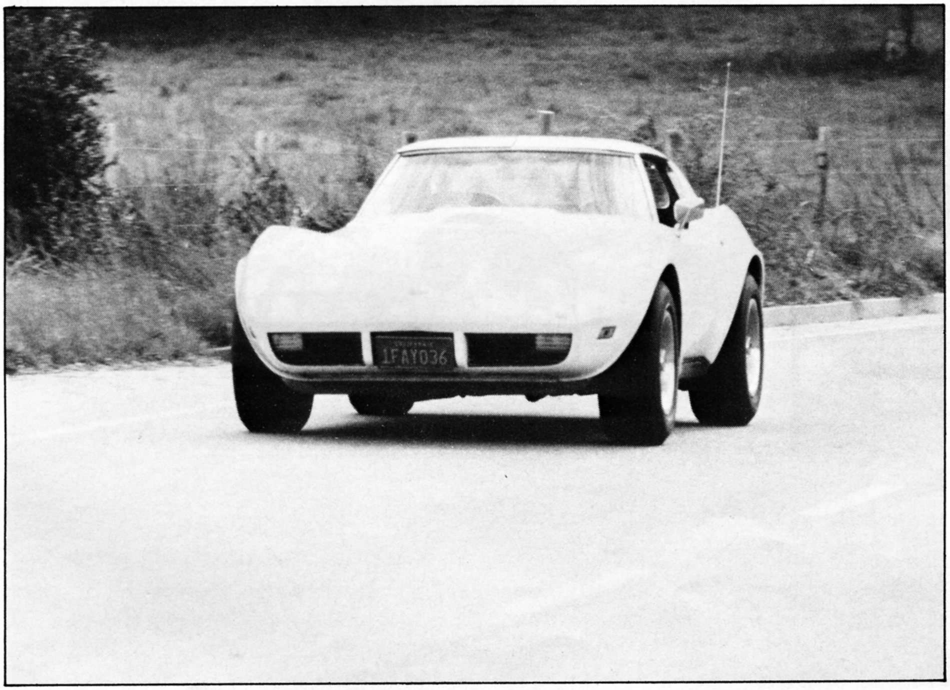
A simplified formula for determining a car's cornering power on a skid pad is:

$$g = \frac{1.225 \times \text{radius}}{T^2}$$

Where **radius** = radius of the turn in feet
T = time in seconds required to complete a 360 degree turn

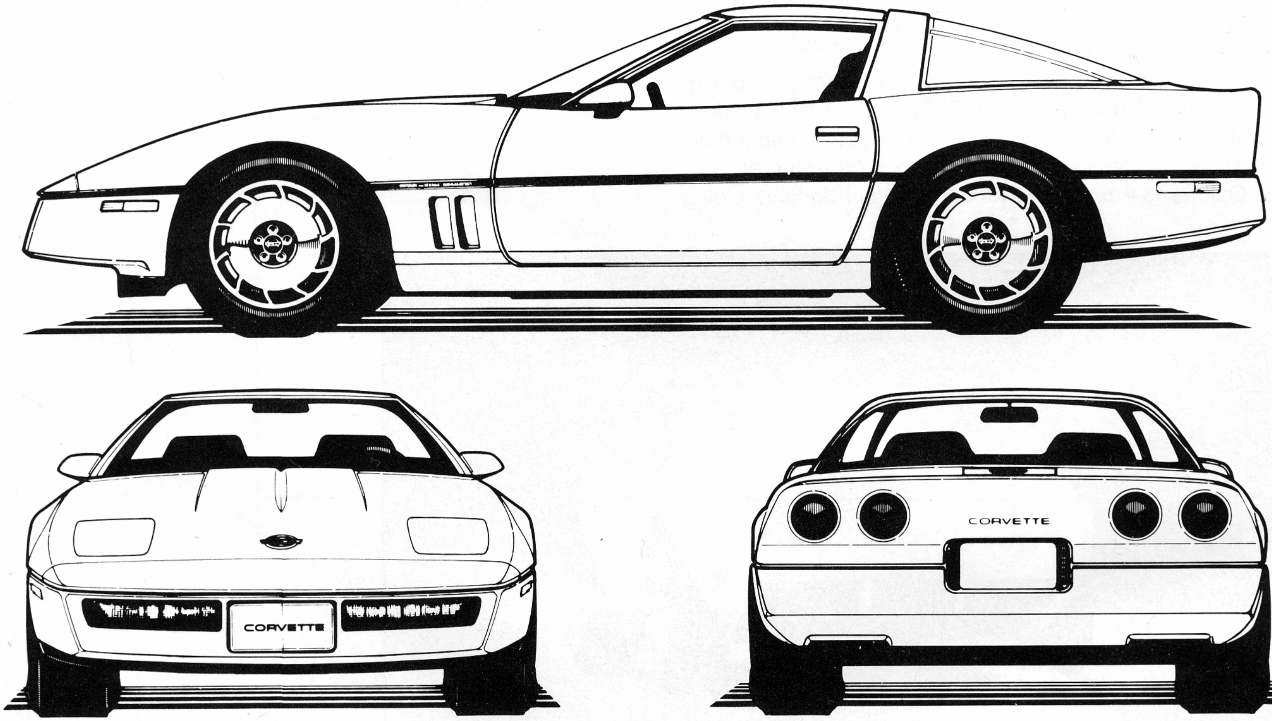
Plugging in some "real world" numbers shows how the formula works. For example, if a car takes 12 seconds per lap on a 100 foot radius skidpad, the computation is as follows:

$$g = \frac{1.225 \times 100}{12^2} = .85g$$



CHAPTER TWO

1984 CORVETTE TECHNICAL ANALYSIS



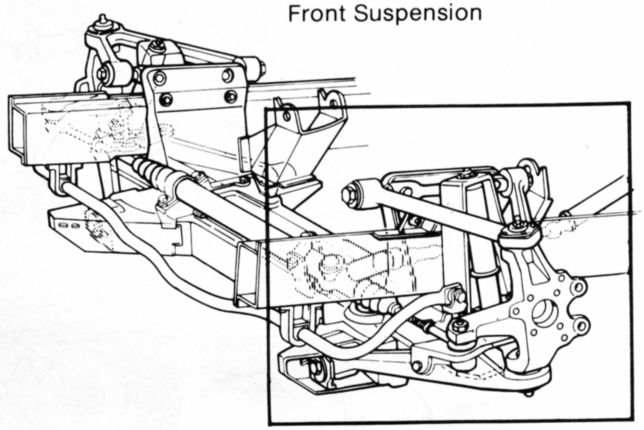
After 20 years (1963-1982) of building the same basic chassis, Chevrolet has developed an all new chassis for the 1984 Corvette. During this 20-year period there has been a considerable increase in chassis design knowledge and the new Corvette takes advantage of this increase.

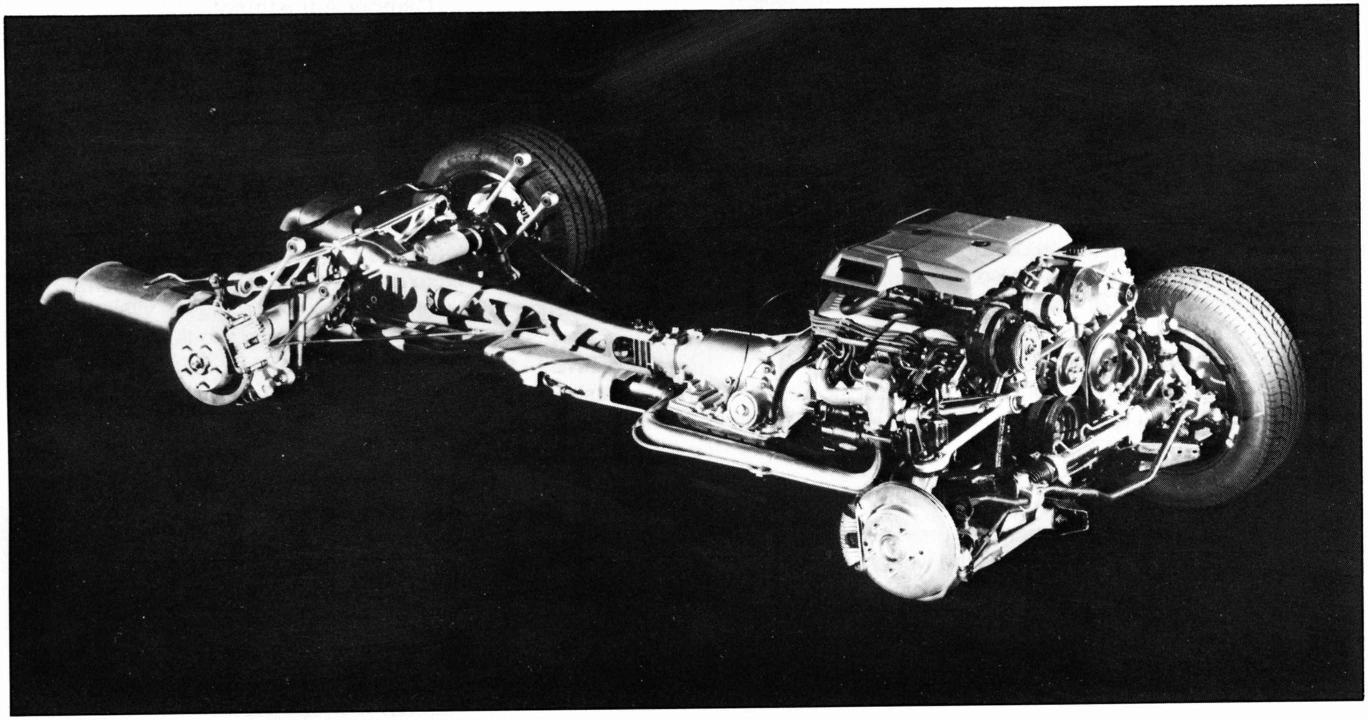
The major improvement in the overall design is the way Chevrolet engineers have arranged the components so that rubber-bushing deflection results in understeer rather than oversteer. This makes the new car much more steady feeling and predictable.

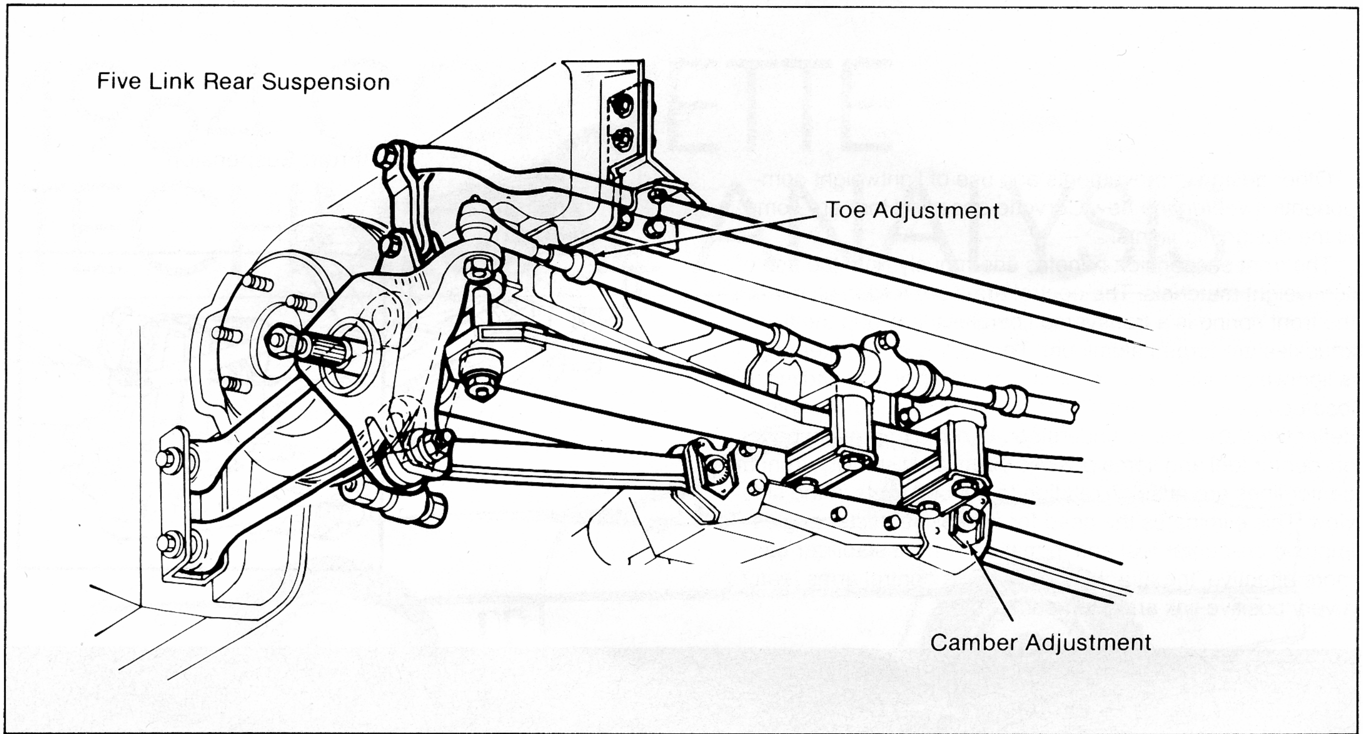
Other design improvements and use of lightweight components sweeten the new Corvette chassis. Here are some of the design highlights:

The front suspension benefits enormously from the use of lightweight materials. The control arms are forged aluminum, the front spring is a transverse fiberglass leaf, and the front knuckles are forged aluminum. The rack & pinion steering is lightweight also, and, more important for good handling, it is located ahead of the front axle, so the control arm bushing deflections are toward understeer. In order to provide better on-center feel and some positive directional stability, front axle center lines are offset in relation to the ball joints in the side view. This eliminates the need for excessive caster angles. To improve on-center feel and to make the front stabilizer bar more effective, the attaching links to the control arms feature a very positive link arrangement.

Front Suspension







Lightweight materials are central to improvements in the rear suspension as well. Again the spring is a fiberglass transverse leaf and all the control arms are aluminum. The rear knuckles are also aluminum, as are the axle shafts.

The five-link rear suspension design used on the 1984 Corvette is a superior design to the older setup. Basically the five links are:

Link One — The drive axle

This is a carryover from the previous design. It locates the wheel hub axially and forms the top link in the suspension as viewed from the rear.

Link Two — Camber rod

This link is also carried over from the previous design. It, together with the drive axle, positions the wheel hub as viewed from the rear. This link can be adjusted so the rear wheel camber angle can be changed. Since this link has rubber bushings, there will be deflections during hard cornering which will let the camber go positive and cause some deflection oversteer.

Links Three and Four — Upper and lower trailing links

These two links replace the radius arm used in the previous design. This is an improvement because it feeds the brake torques into the chassis in a fore and aft direction. The older design radius rod fed brake torque into the chassis as a torque which tended to cause some wheel hop and erratic behavior under hard braking.

Link Five — Rear tie-rod link

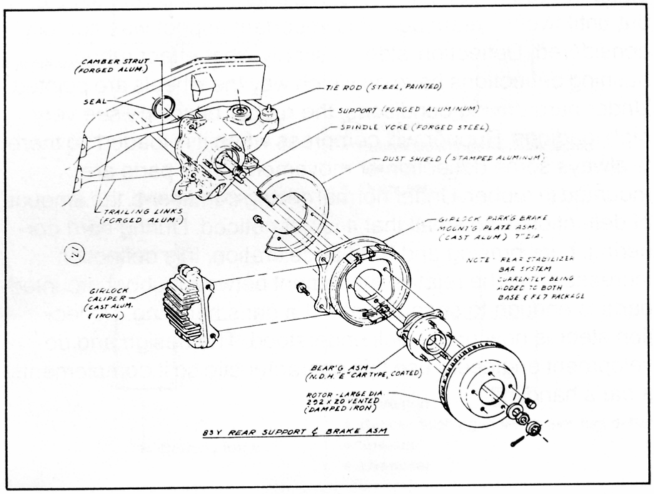
This is a new link for Corvette and is one of the reasons the new car has such a progressive feel. Since this link is mounted behind the rear axle, any deflection of the suspension under hard cornering will result in a toe-in change at the rear wheel. Toe-in at the rear is understeer, so, as cornering forces build, the driver feels more understeer. This is an easily controlable situation, so the driver feels comfortable. Since the older design rear suspension does not have this link, the only way to duplicate the handling and feel is to eliminate the rubber bushings. If the rubber is eliminated, there won't be any deflection and the toe-in will at least remain constant.

The lightweight theme is continued on the rear suspension where the differential and its mounting crossmember are aluminum.

The 1984 Corvette sustains the model's tradition of excellent braking equipment. There are again four-wheel disc brakes, but now there are aluminum calipers to save weight. The master cylinder is also aluminum, as is the pedal assembly.

The 1984 Corvette uses the most advanced tire and wheel combination available for street driven vehicles. The tires were specially developed for the Corvette by Goodyear. These tires are the result of many years of work on high performance street tires. Their tread pattern is a result of Formula One racing tire developments. The new tires, 50-series radials, are mounted on 9-inch wide, 16-inch diameter wheels. Optional wheels are designed to pump cooling air over the brakes.

The advanced technology shown on the 1984 Corvettes makes older Corvettes seem outdated. This is partially so, but with a careful look at the 1984 features, it will be possible to update some aspects of older Corvettes. It won't be economically feasible to include all the aluminum parts, but the use of new tires and wheels is a natural. If we can also control the bushing deflection of older models, their handling characteristics will be like those of newer Corvettes.

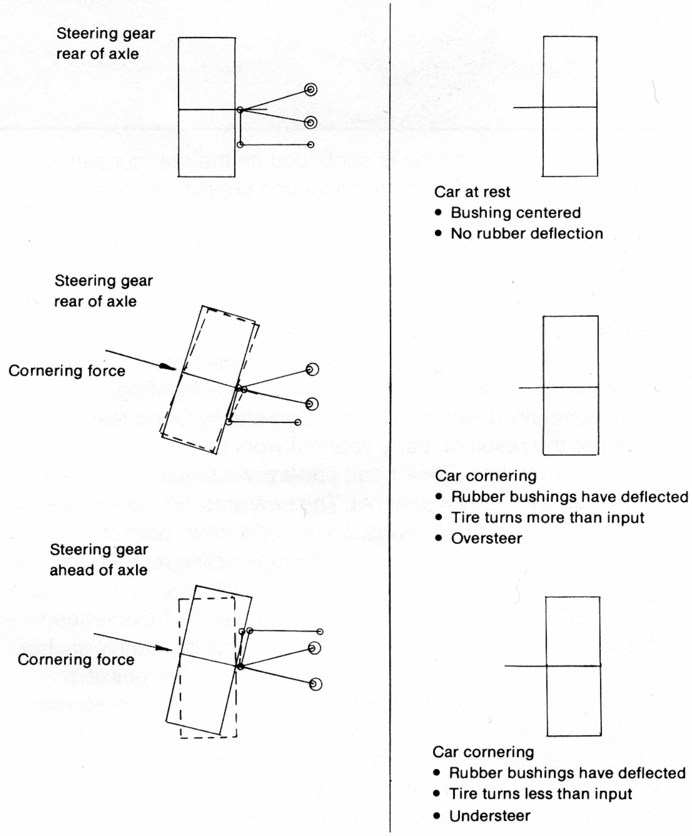


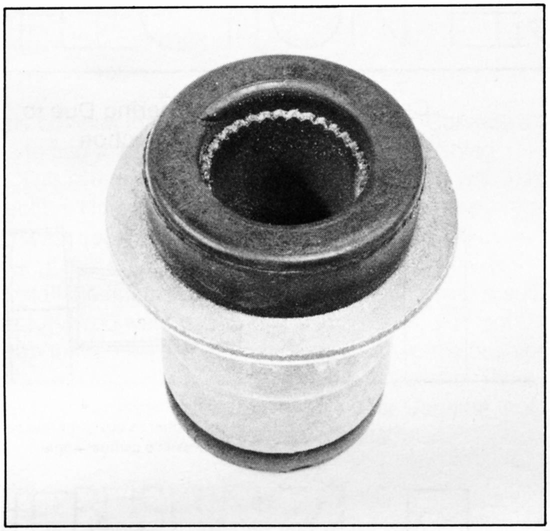
CHAPTER THREE

1963-82 CORVETTE SUSPENSION MODIFICATIONS

When the 1963 Corvette was designed and developed it represented the "state of the art" in suspension design. In order to make it economical, Chevrolet made some compromises, but basically it was a modern suspension for the time. Since that time, production-car engineers and race-car engineers have learned a few things about suspension design. Probably the most important design parameter that was not greatly understood in 1960 is deflection-steer. It might sound very simple, but until twenty years ago, this important aspect was not fully considered. Deflection-steer is simply what effect rubber bushing deflections have on which way the wheels are pointed. Under hard driving conditions, the rubber bushings see very high loadings. Rubber will compress when it is loaded so there is always some deflection or movement when parts are mounted in rubber. Under normal driving conditions, the amount of deflection is so small that it is not noticed. During hard cornering, hard braking and hard acceleration, this deflection increases and the relative movement between rubber mounted parts is enough to seriously affect a car's handling. Deflection steer is now pretty well understood. The design and development engineers use this characteristic so it complements a car's handling.

Effect of Steering Location on Deflection Oversteer and Understeer Because of Rubber Bushing Deflection

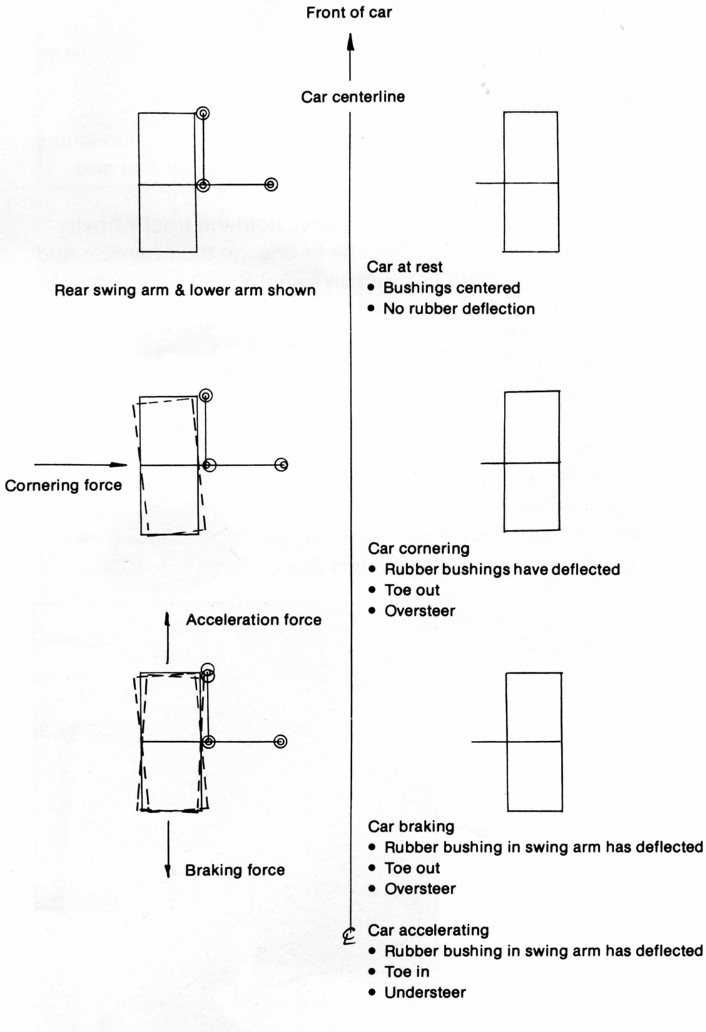




All but the 1984 Corvettes do not benefit from this technology, so their handling qualities are sometimes erratic. Under normal driving situations, a Corvette is a predictable and smooth handling car. If you have ever made an abrupt maneuver with your Corvette, or if you ever tried to test your Corvette at the limit, you know its handling characteristics are twitchy and unpredictable. A Corvette that is thrown into a corner is very difficult to keep on a precise course. If you brake or accelerate during hard cornering, you have a very difficult time keeping the car under control. The major reason for this poor handling is deflection steer. 1963-1982 Corvettes have a considerable amount of deflection steer in both the front suspension and the rear suspension.

Bushing deflection on a newer car is solely a problem of the hardness of the rubber. Obviously the softer the rubber, the more deflection. The Corvette engineers have always used reasonably hard rubber to minimize deflections. Unfortunately, as a car gets older and the bushings fatigue, the amount of deflection increases and the handling becomes more erratic.

Effects of Cornering and Driving Loads on Rear Suspension Toe in and Toe out



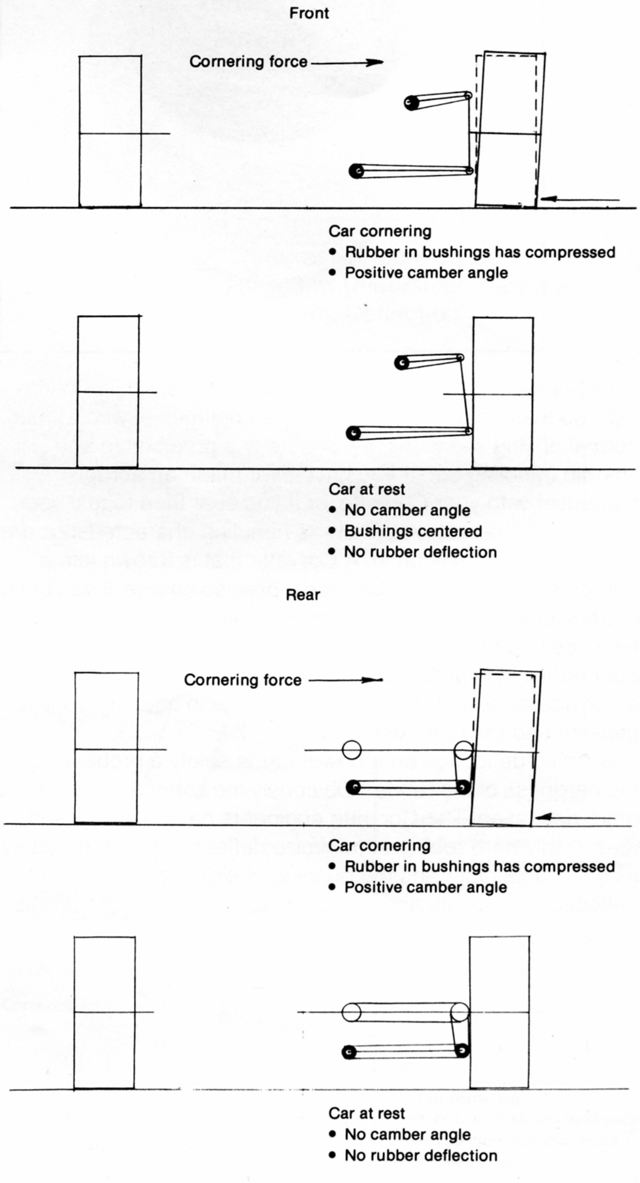
CAMBER CHANGE

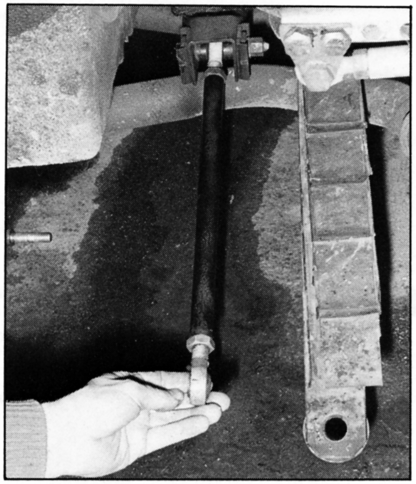
So far we have only considered the effect of suspension bushing deflections on the steering response of a Corvette. Bushing deflection also has a considerable effect on a Corvette's cornering power because it allows the wheels to also change camber under hard driving situations. If we look at the accompanying diagram it is evident that, during hard cornering, bushing deflection will allow the outside wheels to lose camber. When a wheel cambers, the tire does not run square with the ground and it loses its ability to develop cornering power. This loss of cornering power is proportional to the cornering load, so again we have an unstable condition where the car's response is changing with road irregularities and with driver input.

Bushing deflection therefore allows both the front wheels and the rear wheels of a Corvette to change their camber and their toe settings in a continuously variable pattern that the driver cannot control or predict.

Some Corvettes are driven slowly because their drivers do not want to get tickets, but probably most Corvettes are driven slowly because, without knowing it, the driver loses confidence in the car's handling as the speed is increased. It should also be noted that modern high performance radial tires make the bushing deflection problem worse because they provide more traction, which increases the cornering and braking loads. Increasing these loads causes more bushing deflection, so the handling becomes more erratic.

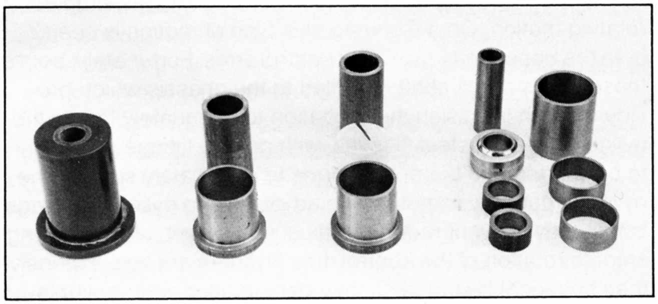
Camber Change in Cornering Due to Rubber Bushing Deflection





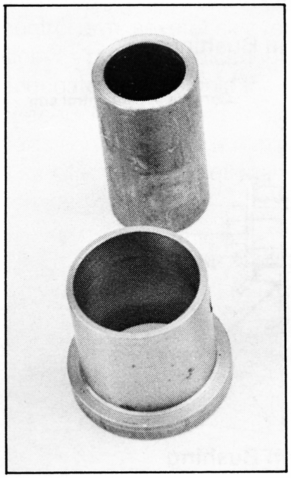
DEFLECTION ELIMINATION

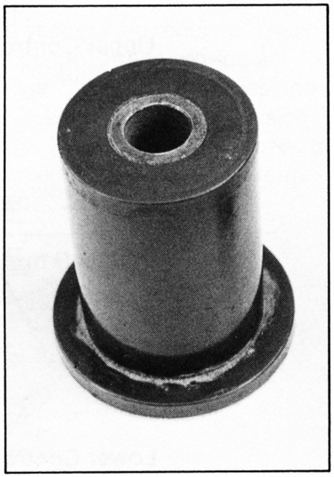
It is pretty obvious that the way to improve your Corvette's handling is to find a way to eliminate suspension bushing deflection. This is usually done by installing a bushing with less, or no deflection. Unfortunately, changing bushings is an involved project because the control arms must be removed from the car. If this amount of work is to be done, it makes sense to install the finest possible bushings, so the final results are satisfactory. You want a durable bushing so you do not have to change them every year, and you also want a bushing that is quiet, so you don't introduce rattles and sqeaks. There are several types of bushings available for your Corvette, but only a few of them will give satisfactory results.



STEEL BUSHINGS

This type of bushing is used on some race cars to replace the stock rubber bushings. Race cars have open exhausts, so chassis noise is not a problem. Simple "steel on steel" bushings are noisy because a certain amount of clearance is needed between the bushing sleeves to allow for assembly and for smooth operation. This clearance, usually about .005 inch, results in a terrible amount of noise as the control arms are moved about by bumps and road irregularities. Simple "steel on steel" bushings are inexpensive, but because of the noise they produce they are not suitable for normal street operation.



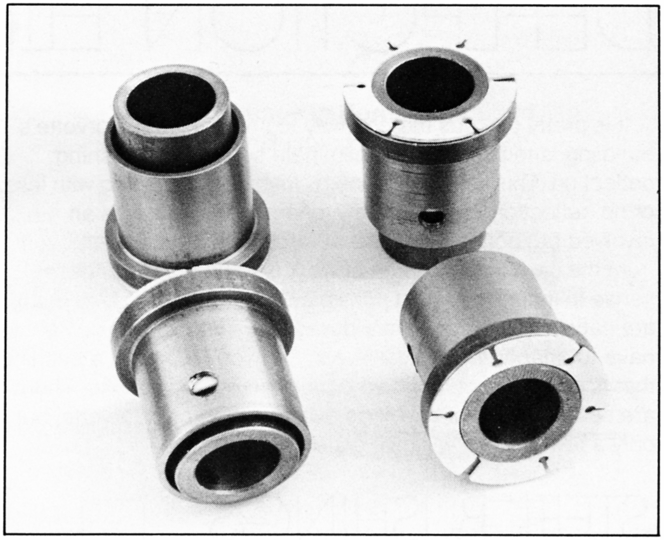


URETHANE BUSHINGS

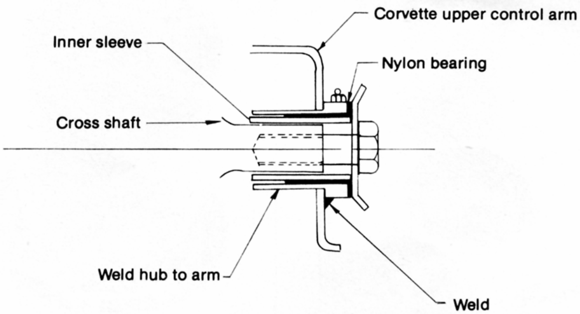
In the past few years there have been a number of companies selling urethane bushings to replace stock rubber suspension bushings. Urethane is a plastic that is quite durable and reasonably hard. When urethane bushings are used to replace stock rubber bushings, they effectively reduce deflection. Unfortunately, there is no magic and although the urethane bushings are cheap to buy, they do not do an adequate job. In order for a suspension bushing to work, it must allow rotational movement without any slop in either the radial or axial directions. A piece or urethane plastic in place of a rubber bushing cannot be fitted tightly enough in the radial and axial planes and still be loose enough to allow smooth rotation. If you fit the bushings tightly, the control arms will not move freely and the suspension will be bound up. If you fit them loosely enough to allow for proper suspension movement, they will rattle and squeak. Even the graphite impregnated urethane bushings are unsatisfactory because there is not enough precision in the parts to correctly control tolerances. Thick sections of plastic are also known to cold-flow under prolonged loading so urethane bushing is unable to give satisfactory long term service. The chief advantage to a urethane bushing is its low cost. Considering the labor involved in changing the bushings, installing a cheap part is hardly worth the trouble.

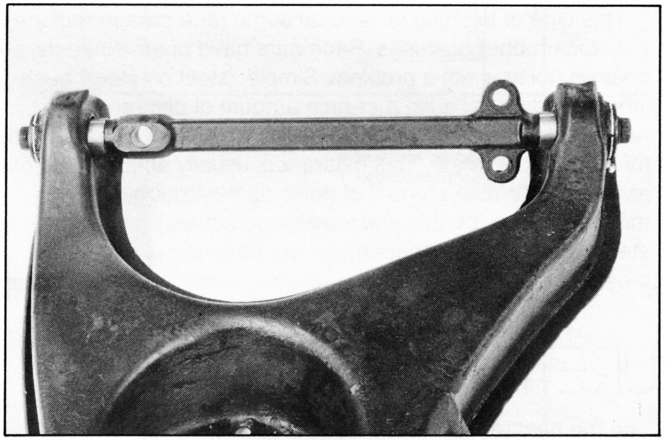
NYLINER BUSHINGS

Nyliner bushings are made from nylon. They are a precision molded part that has very high load carrying capacity. Because the sections are kept thin, cold-flow is not a problem. Nyliners can only be used when a control arm has simple rotating motion. On a Corvette, this type of motion is seen on both the upper and lower front control arms. Fortunately, both of these pivots use a shaft mounted to the chassis which provide enough precision in its location to adequately locate the nyliners. Special steel sleeves, with grease fittings, need to be welded into the control arms to adequately support the nyliner's outside diameter. The advantage to nyliner bushings is that they prevent radial and axial movement, while allowing smooth rotation of the control arm. Nyliners are less expensive than spherical bearings so they can be used where simple rotating motion is all that is required. Properly installed nyliners that are greased every 10,000 miles will last several years.

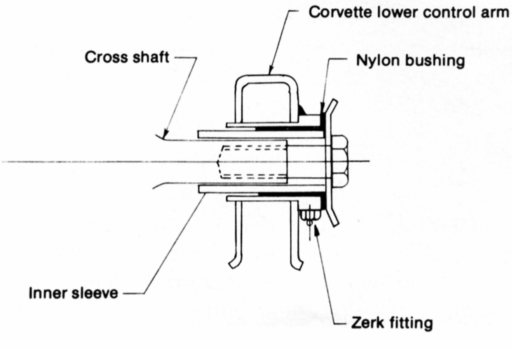


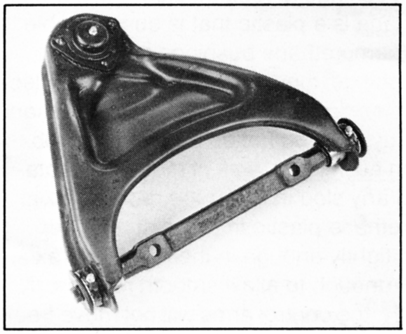
Upper Control Arm Bushing

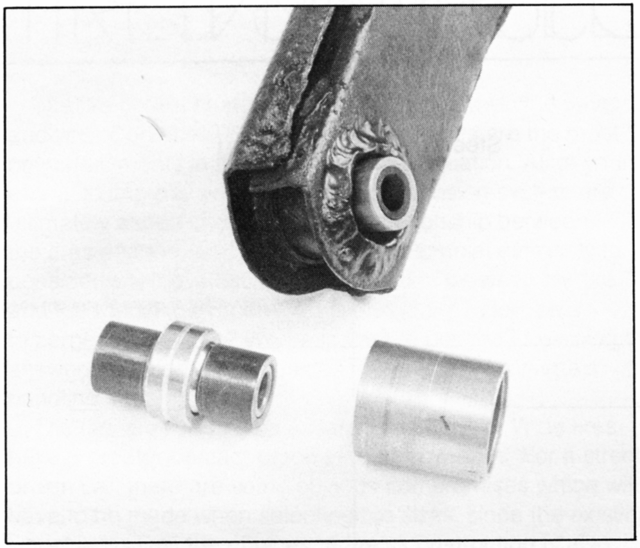


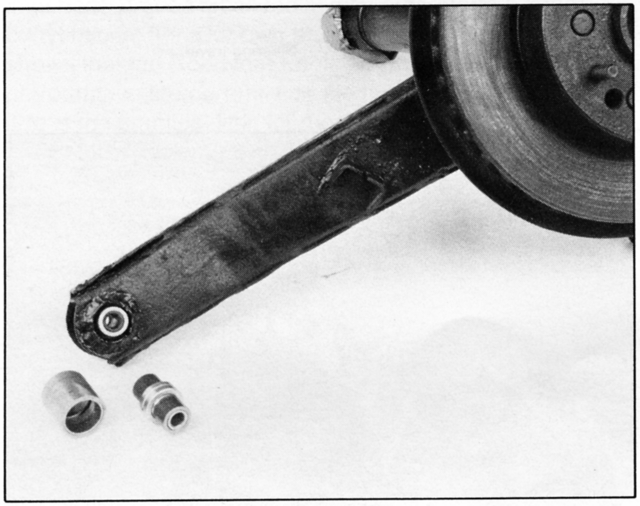


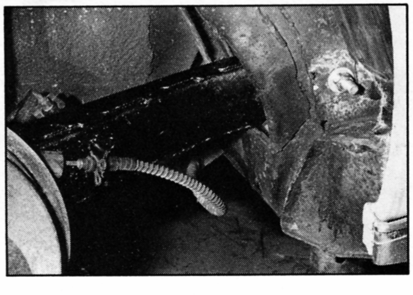
Lower Control Arm Bushing









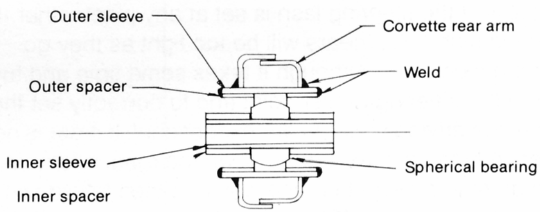


SPHERICAL BEARINGS

Spherical bearings are needed whenever the control arm movement is needed in more than one plane. A Corvette's rear arm is in such a location because the arm has to rotate slightly in the rear plane as it moves up and down. This complex movement cannot be accomplished with a simple bushing without bending something. The rubber bushing that is used on a stock Corvette can handle this motion, but of course we know that rubber bushings also allow for unwanted deflection steer. Spherical bearings are available from many sources and for various prices. We have found that the only ones that hold up are the expensive aircraft type that use a hardened steel ball and a hardened steel race. All the less expensive types will pound out after a few thousand miles. We have run cars with hardened steel spherical bearings over 60,000 miles without problems. Spherical bearings do require grease every 10,000 miles, so fittings should be installed.

In order to correctly install spherical bearings in a Corvette control arm, several sleeves and spacers are required. These sleeves must be welded into the control arm to provide an adequate cage to hold the bearings. Since these sleeves and spacers must be held to close tolerances, they are precision parts and they are not inexpensive. The final result, however, is a satisfactory non-deflecting bushing that will give long term service.

Rear Control Arm Bushing

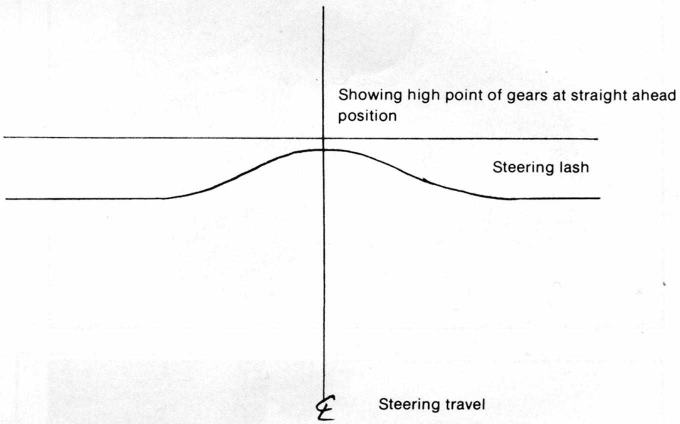


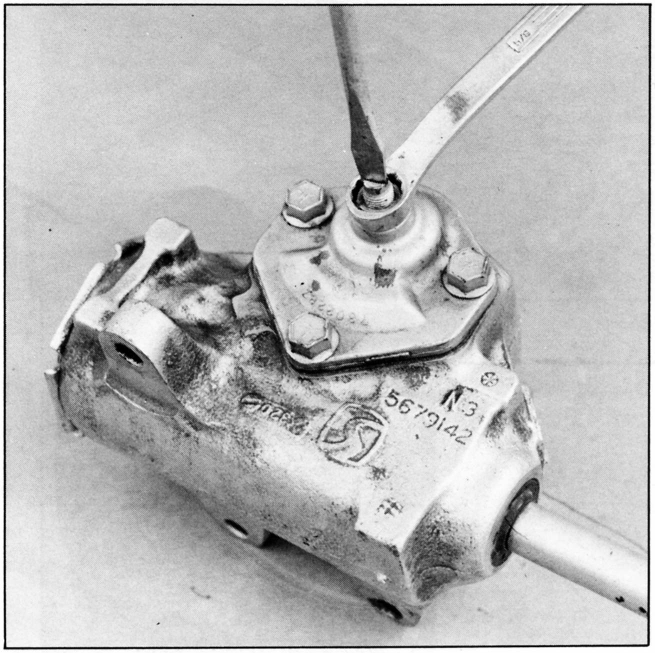
STEERING LASH ADJUSTMENT

In order to maintain a precise feeling in the steering, it is necessary to keep a minimum of lash between the gears in the steering box. As a car gets older, there is some wear in the steering box and lash can increase. The lash can easily be adjusted on a Corvette steering box by loosening the lock nut and turning the adjustment screw clockwise. Turn the screw carefully until you feel it start to tighten, and then back it off about a quarter turn. This will set the gears tightly together but not cause them to bind. The steering lash can only be set with the gear in the straight ahead position. Finding your steering gear's center position is a little tricky, but it is extremely important. Fortunately, most cars are set in the mid-position. If you have had damage, or swapped parts, however, it might be necessary to reestablish your steering center point. The gears in a Corvette steering box are ground so that they fit tighter together at the exact center location. This is done to get a firm feel as the car is driven down the road without causing excess steering effort during turns. The steering center point, or high point, can be felt in steering wheel effort if the steering linkage is disconnected from the pitman arm. By turning the steering wheel slowly and smoothly, you can feel the steering high point as the gears get closer together. A small scale can be used to measure the increased torque on the steering wheel at the steering center. Most GM cars have a small mark on the end of the steering shaft, under the horn button, which is straight up when the gears are at midpoint.

Obviously, if the steering lash is set at any place other than the steering high point, gears will be too tight as they go through the high point. Although it takes some time and fuss to confirm the steering center point and to correctly set the gear lash, the driving rewards are exceptional. If a car is not on the steering high point as it goes down the road, it feels like it has to go over a hill to turn one way and then falls down the hill to turn the other way. When the steering center and lash are correct your Corvette will be a joy to drive. The steering will feel precise on center and the effort to turn in either direction will be the same.

Steering Gear High Point





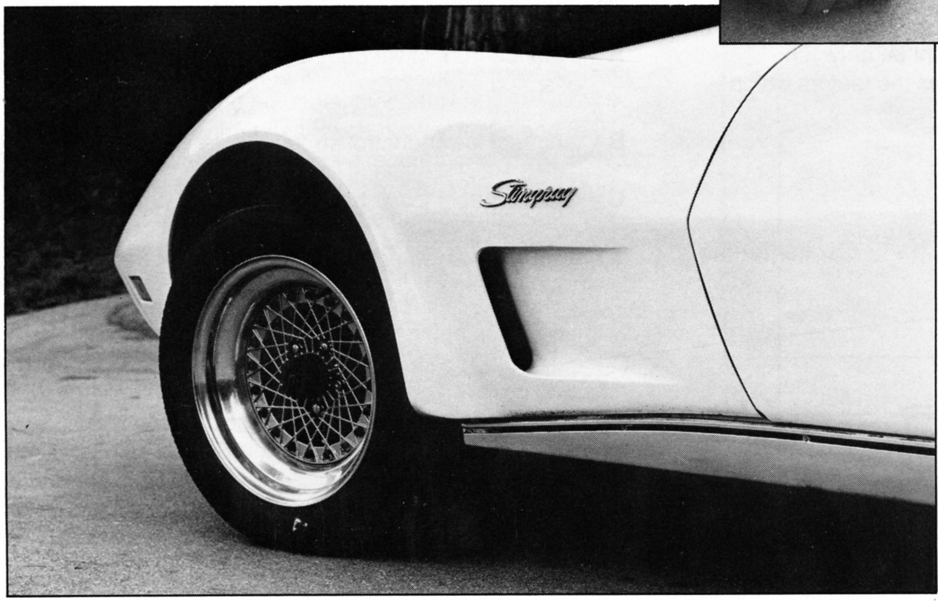
TIRES & WHEELS

The tire contact patch is the only link between the pavement and your Corvette. These few square inches are the most critical elements in the entire handling equation. All of your efforts to improve your Corvette's suspension system are ultimately aimed at optimizing the relationship between the tires and the road. There are three crucial elements to consider when evaluating the interaction between the tire and the road: How much load is on the tire? How close to perpendicular is it? Where is the tire pointed? Learning the answers to these questions can improve any Corvette's handling capabilities.

The tire itself should be as large as possible. Wide tires have a greater contact patch than narrow ones. For a street-driven car, there are some obvious compromises which will have to be made when selecting tire sizes, since the existing wheel wells limit the choices. A tire's construction is also important. A good small radial may outperform a larger conventional tire. Our own testing programs have repeatedly shown that the Goodyear Eagle NCT tire is the best all-around performance tire currently on the market. The P255-60-15 size is the practical limit for most street-driven Corvettes.

The taller, wider 265 size can be made to fit, but wheel well modifications are required. Additionally, the P255 NCT tires require the use of standard 8-inch wide Corvette wheels, while the P265's perform best with 10-inch wide wheels. More cornering power is available from the 265 tires and wider wheels if you want to step up to flaring the fenders.

The 1984 Corvette will use a 255-50 series radial on 9-inch wide, 16-inch diameter wheels. These will fit on older Corvettes with little modification, so they can be considered in an ultimate handling package if costs are no object. VSE has both the wheels and tires available for sale.



SPRING LOAD VS. SPRING RATE

Occasionally car enthusiasts become confused about the difference between spring load and spring rate. The spring load is the amount of weight, or force, that is required to compress the spring to a given height. The spring rate is the force required to compress the spring an inch. Thus if a spring has a rate of 100 pounds-per-inch, it would take a spring load of 1000 pounds to compress the spring 10 inches.

These two terms are important for Corvette owners who want to fine-tune their car's handling. If the car is too low, springs with a higher load rating are required; they will compress less distance under the weight of the car, and thus the car will ride higher. A higher rate spring will not raise the car unless it is also a higher load spring. It will just offer more resistance to compression and make the car ride more harshly. In fact, a higher rate spring with shorter overall length will have a lower load rating, so it will actually lower the car.

SPRING RATE VS. WHEEL RATE

Depending on the type of suspension used, the spring rates and the wheel rates can vary relative to each other. '63-'82 Corvettes use a single leaf spring at the rear. With this type of suspension, the wheel rates are almost one half the spring rates. This is because, for every inch of wheel movement, there is an inch of spring movement, and the spring handles both wheels. If the spring rate is 200 lb./inch, the wheel rate is 100 lb./inch.

The coil spring front suspensions found on Corvettes have a more complex relationship between wheel travel and spring travel. A car with this type of suspension might have a spring rate of 300 lb./inch, but the wheel rate might be only 100 lb./inch. The accompanying diagram shows the factors which affect the ratio between wheel rate and spring rate on a car having this type of independent front suspension.

The wheel rate can be found in the formula:

$$R_W = R_S \left(\frac{A}{B}\right)^2 \times \left(\frac{T}{C}\right)^2$$

Where

R_W = rate at wheel

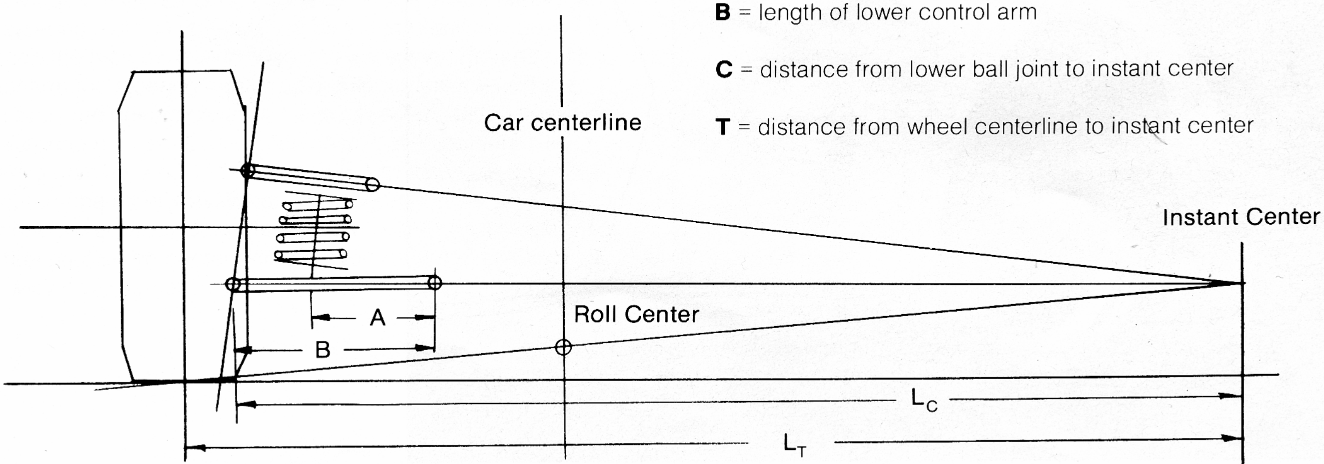
R_S = rate at spring

A = distance from lower control arm pivot to centerline of spring pad

B = length of lower control arm

C = distance from lower ball joint to instant center

T = distance from wheel centerline to instant center



MODIFYING SPRING RATE

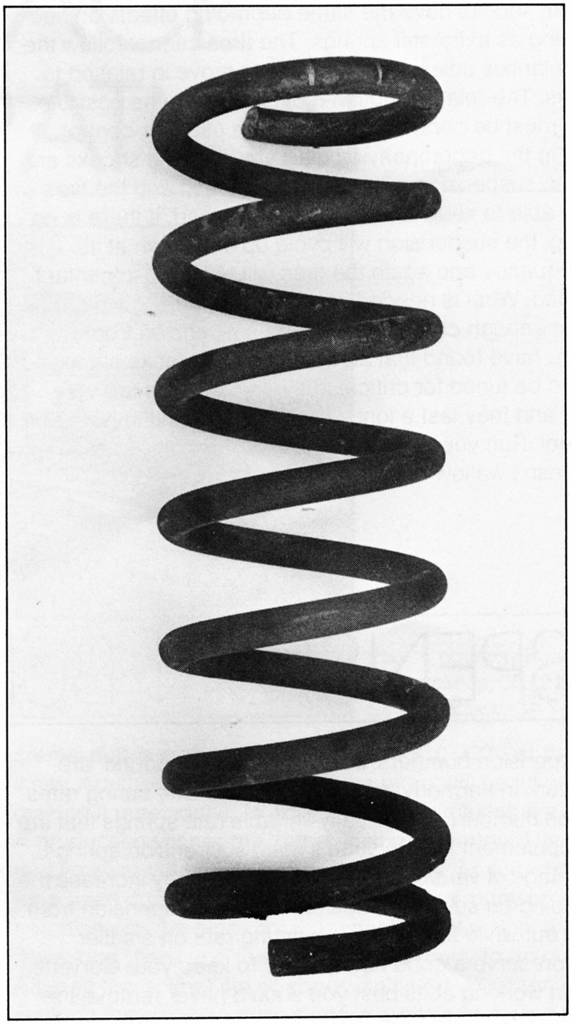
The purpose of suspension springs is to hold the car steady while allowing the wheels to follow road irregularities. In general, the softest possible springs will do this job best. Softer springs will allow each individual wheel to move in relation to the chassis while having the minimum effect on the driver's compartment. This translates into a soft ride, noise isolation and good handling. In an effort to control the inherent deflection steer problems of the Corvette chassis, some people advocate the use of higher rate springs.

All stiffer springs do is make the car ride hard. They have no capability to make a significant improvement in handling. As long as the springs on a car are stiff enough to keep the car from bottoming out, they are adequate. If a car is lowered, a slight increase in spring rate can be used to compensate for the reduced ride travel.

Some car enthusiasts have the mistaken belief that if 300 lb./in. coil springs are good, then 600 lb./in. springs have to be better. They're wrong. Optimum road holding demands that the tires be in contact with the pavement; a soft spring lets the wheels follow road irregularities so that the tires can generate maximum adhesion. And, of course, there's driver comfort to consider; springs which are too stiff will have you looking for a kidney belt in short order.

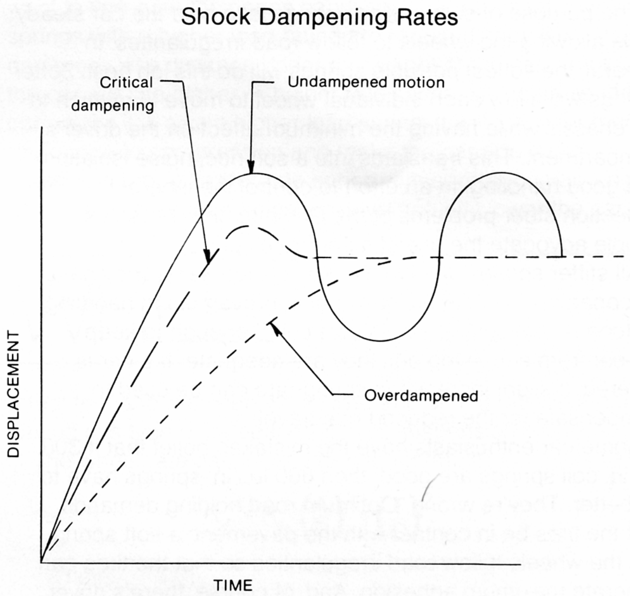
Our recommendation for Corvette front springs is to use the standard factory coils. For street use you can trim one half coil off the top of the spring with an acetylene torch to lower the car slightly. Let the hot metal air cool slowly.

Most Corvette spring rates range between 300 and 350 lb./in. Trimming the coils as we've recommended will increase the rate approximately 10 percent. The true purpose of trimming the front springs is to lower the car for improved aerodynamics and better handling. (If your Corvette has the gymkhana springs, they are too stiff for normal street use. We recommend you replace them with standard Corvette springs. This will produce a vast improvement in ride quality with no loss in handling performance if you use VSE equipment.) Subsequent changes aimed at improving handling should concentrate on swaybars, tires, and reducing deflection steer rather than incompressible springs.



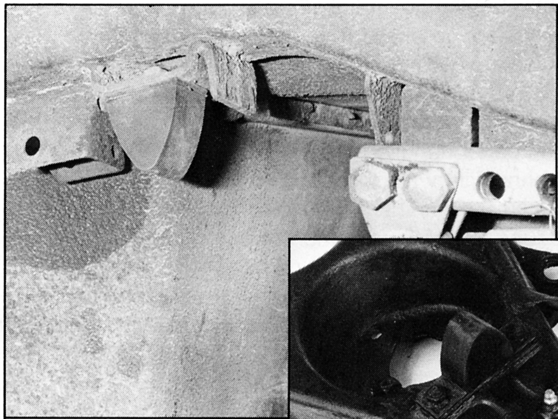
SHOCKS

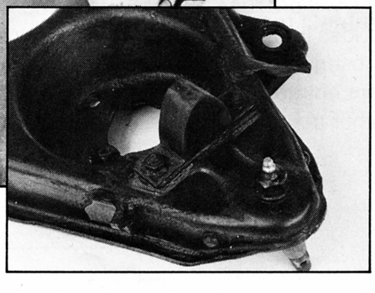
Extra firm shocks have the same degrading effects on ride and handling as extra stiff springs. The tires cannot follow the road irregularities unless they are free to move in relation to the chassis. The relative motion must be as free as possible, but it also must be controlled. Shocks are used for control. As shown in the accompanying diagram, i.e. if the shocks are too firm, the suspension will be overdampened and the tires will not be able to keep in contact with the road. If there is no dampening, the suspension will cycle up and down at its natural frequency and again the tires will not keep in contact with the road. What is needed is critical-dampening which means just enough control to keep the suspension from cycling. We have found that adjustable Koni shocks allow each car to be tuned for critical dampening. Konis are very well made and they last a long time, so your initial investment is well spent. Run your shocks as soft as possible—just so the car doesn't wallow over bumps.



SUSPENSION BUMPERS

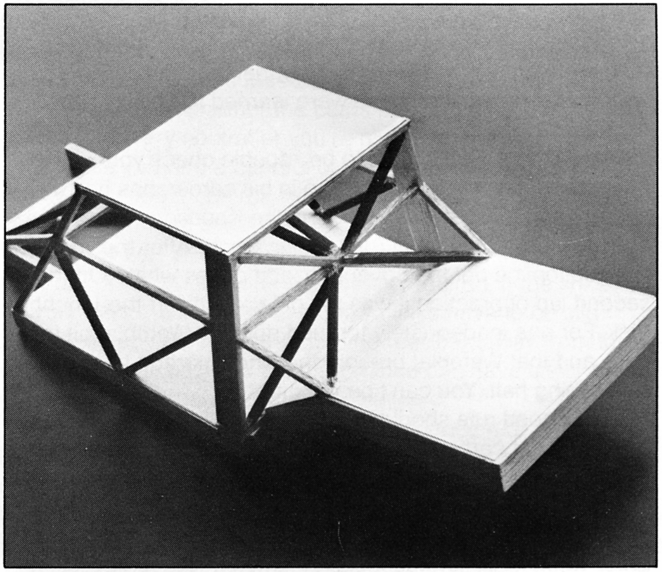
The suspension bumpers, both jounce and rebound, are tuned to work in harmony with the stock Corvette spring rates. Suspension bumpers are actually variable rate springs that are used to supplement the Corvette's main suspension springs. The advantage of variable rate springs is that they increase the rate of loading on severe bumps to keep the suspension from bottoming out while allowing a low spring rate on smaller bumps to preserve a good ride quality. To keep your Corvette suspension working at its best you should never remove the jounce bumpers or cut them down. Jounce bumpers that have been cut down lose their ideal characteristics for a variable rate. If the rate transition into the jounce bumper is too fast, the suspension will experience a jolt that can upset the car and cause a loss of wheel traction.

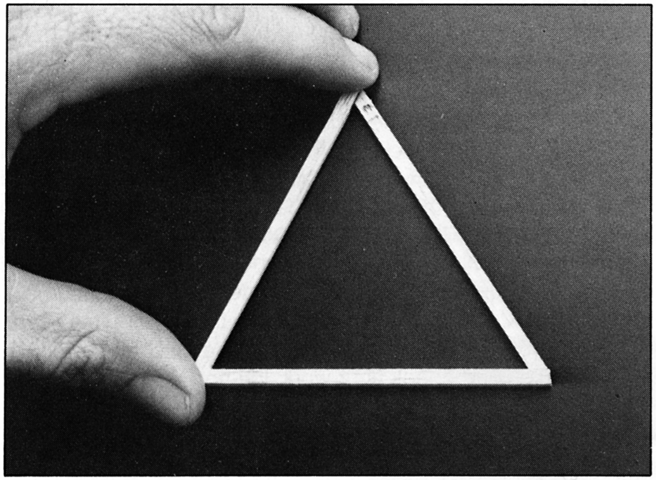




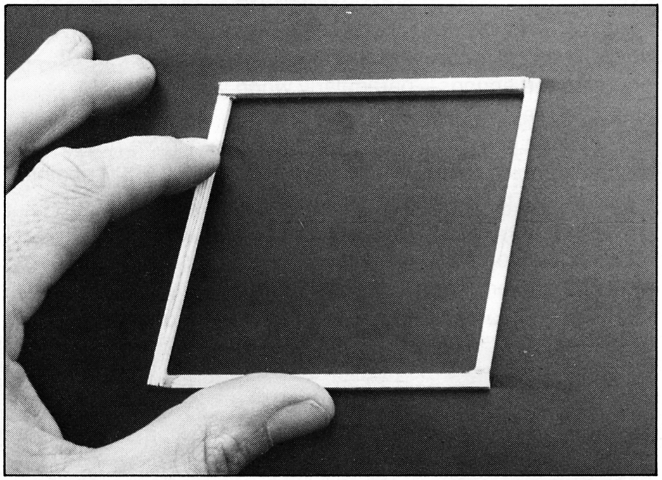
SHORT COURSE ON STRUCTURE

There are certain basic structural considerations which apply to any race car chassis. A maze of chrome moly tubing may be visually impressive, but unless the tubes are arranged so that they produce maximum chassis rigidity, they might as well be made from cardboard. The elements of structural design are not difficult to master. The automakers rely on computers and finite element analysis to produce chassis designs; we do it with balsa wood and paper. You can demonstrate the basics of chassis design for yourself in an evening with this method. By watching how certain shapes are inherently rigid and others flexible, you can visualize how a race car chassis deflects and bends under severe loads unless it is properly braced and triangulated.

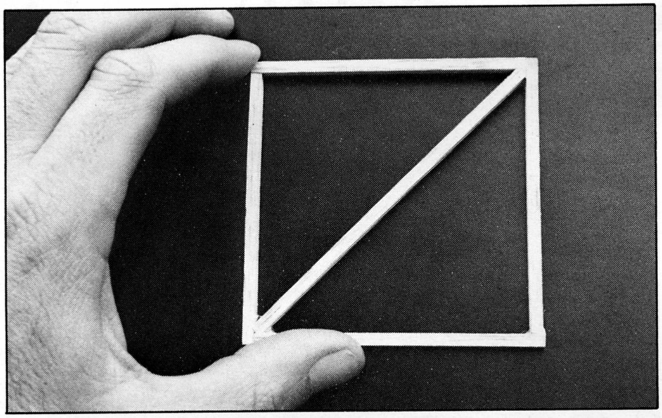




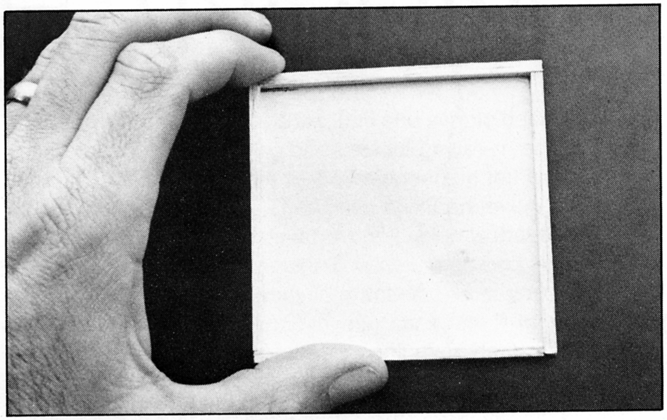
The triangle is the basic shape for creating rigid structures. Its dimensions cannot change unless one of its three legs is broken. There are two vital considerations in automotive structural design: Will the structure break, and will it deflect under load?



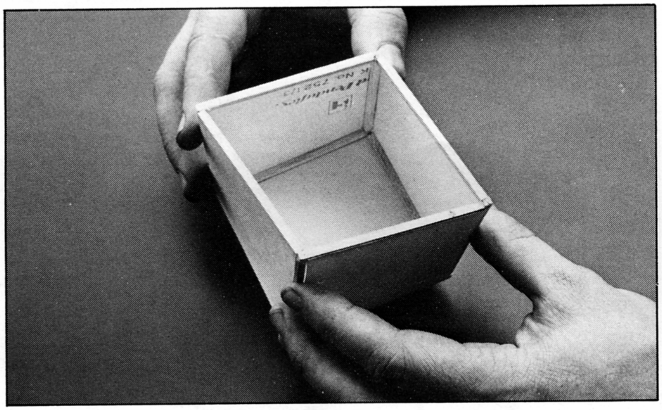
This common arrangement of tubes—either rectangular or square—is very weak diagonally. Only the strength of the joints is available to resist movement.



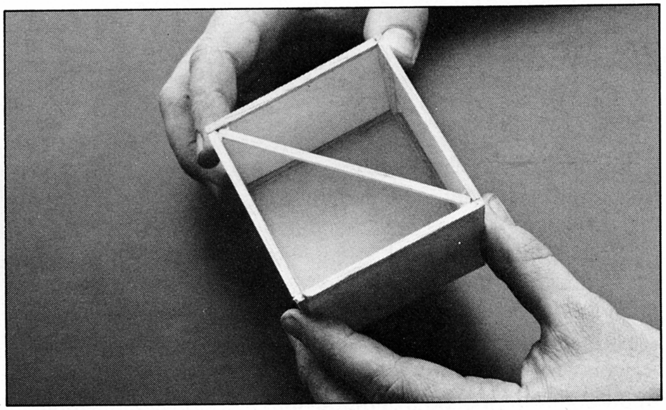
Here the basic rectangular shape is braced with a diagonal member. This divides the rectangle into two triangles—thus a shape which was very weak becomes extremely rigid. Double diagonals can be used (which creates four triangles) for still more rigidity, but these additional members are usually unnecessary unless very high loadings are anticipated.



Here a panel of thin metal (well, actually, cardboard in our model) is used to give the rectangle diagonal rigidity. This is called a "shear plate," and its effect is the same as a diagonal brace. Shear plates can be used to advantage in race cars because they can function as firewalls, floorboards and bulkheads, thus eliminating the weight and complexity of diagonal tubes.

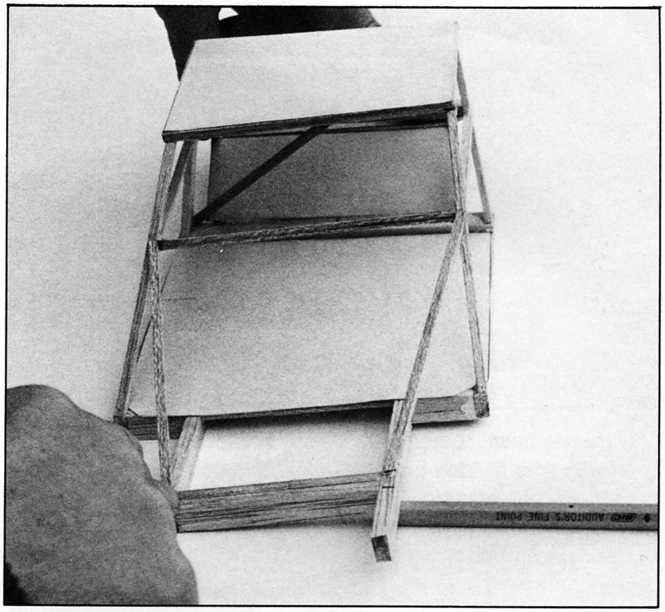


Applying our rigidity analysis from the two-dimensional examples above to this three-dimensional box reveals how the basic structure of a car can be improved. The most difficult forces to counter in a chassis are the loads that put the frame in torsion. If these torsional loads can be handled, then the bending loads are usually handled as well. Twisting this open box clearly shows how poorly it absorbs torsional loads. This is exactly what happens to areas of an automobile that are not triangulated. Note that even though five or its six sides are rigid, the one open side makes the whole assembly very weak.

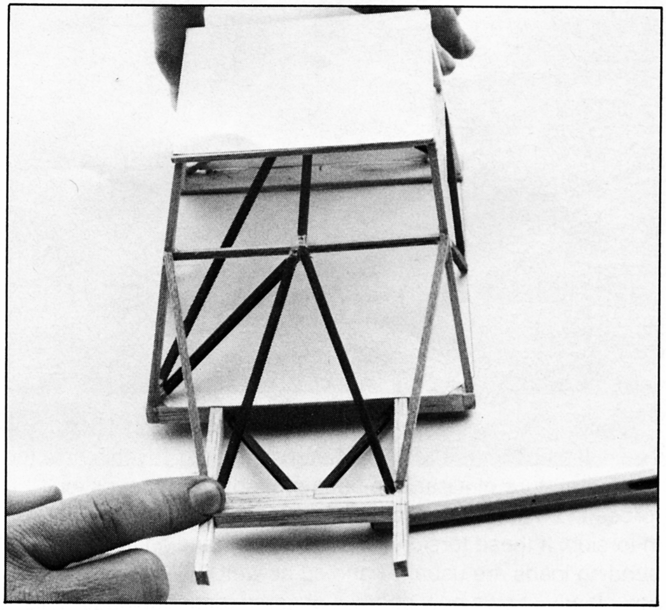


Just as a single diagonal brace strengthens a two-dimensional rectangle, a diagonal across the open box makes the total package torsionally rigid.

STRUCTURE (CONT.)



This model represents a typical roll cage added to a basic sedan chassis. It's evident from twisting the model that the roll cage does improve the torsional stiffness of the chassis to a degree, but torsional flex is still apparent. By carefully observing the very small amounts of relative movement between the balsa wood "chassis members" we can determine where tubes must be added to resist this deflection. This will increase the overall torsional stiffness of the model—and, ultimately, of the full-size car.



Here tubes have been added to those areas where movement was observed in the roll cage model. It is quite apparent from twisting this model that it is significantly more rigid than the preceding designs. If we use this model as a guide for placing tubes in a race car roll cage, the product will be a stiff, unyielding chassis which can then be "tuned" for the desired handling characteristics. The underlying concept in any rigid chassis design is the same idea demonstrated in the simple geometric shapes earlier: **Triangulation is necessary in every possible plane.**

CHAPTER FIVE

ADVANCED HANDLING

Automobile suspensions are very complex. Engineers have spent their lifetimes studying and learning about suspension systems and how they interact with a car in motion. Our concern, however, is to understand the more limited subject of how we can optimize a car's suspension system for racing. Although you should continue to try to learn all that you can about suspension systems in general, we will present here only those aspects which are related to converting an existing production car's suspension for racing use. The suspension systems on cars today are the result of many years of development by the auto industry, and, as a result, the basic system on your Corvette is fundamentally sound. Pretty good, even.

You don't have to worry about instant center height, swing arm length, and the many other conditions which must be considered in building a suspension from scratch. The engineers in the auto industry are aware of all these conditions, and they have evolved their designs to produce the best compromise for the total combination. Your main concern when making modifications for racing should not be to undo what has already been done correctly.

For instance, if you hear the story that a higher front roll center will decrease the effects of roll on camber change to the front wheels at the contact patch, and that you can accomplish this by moving the suspension pivots at their mountings, you might reason that you can improve on what General Motors has given you. It might be that this is true—however, it might also not be true. If your Vette's front roll center is at ground level, moving it up two inches might, or might not, make your car handle better. It's true that raising the roll center will give you a faster camber curve—but are you sure you want a faster camber curve? The only way to really tell is to build a car each way then test them against each other. You probably don't have the facilities, time or money to make this comparison, so you are stuck, like the rest of us, with the choice of guessing based on other people's advice and experience.

During the past two decades, this one simple design aspect, front roll center height, has been studied by everyone from Formula One constructors to the engineers at the world's leading auto companies. They have built cars every way you can imagine, and their collective conclusion is that the front roll center should be somewhere between ground level and maybe an inch or two above. In practical terms, you probably can't measure the difference in your car's handling by raising the front roll center. You probably can't even determine which position is better than the other.

The point is that there are some aspects of the suspension system that are best left as they are. Spend your time working on those areas where you know you can make an improvement and leave well enough alone on the others.

Since you are starting with a production car, one that is basically well designed, don't upset the combination until you are sure of what you are doing. If possible, make the changes one at a time, and let your driver test the car after each one. If you start with the car in its stock condition, you are starting from a known base. Each deviation you make from stock should be tested to be sure you have made an improvement. Sometimes what you think is a step in the right direction will turn out to be the opposite.

If you start out building the car with all sorts of tricks in the suspension, and it doesn't perform well during track testing, you won't have any idea where to start improving it. Each change from stock can have unexpected side effects. If you make too many changes without testing each one individually, you'll end up with a muddle of overlapping side effects, and you won't be able to get a true idea of what the car is doing. The modifications we will describe here are all proven to help in making your car handle better for racing. You can build them into your car and be assured that you are making improvements without wandering into a maze of unknown side effects. You will have to test to optimize the settings, but at least you'll be off on the right foot (or tire?) at the start.

SPRING SELECTION

The springs installed on your Vette at the factory were chosen to provide the best compromise of ride quality and acceptable handling. In general, they are considered to be soft because the wheel rates are in the order of 100 pounds-per-inch. We have all heard how stiffer springs will improve the handling characteristics of a production car. To some extent this is true because they might keep the car from bottoming out and they will increase the roll stiffness of the car.

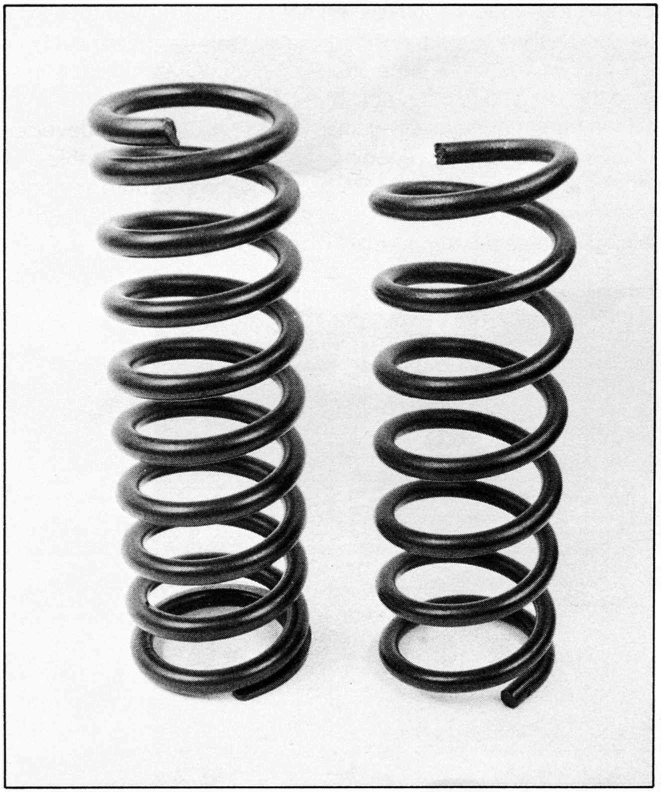
Both of these factors make the car feel like it's handling better, but the actual improvement in cornering may be slight. The popular mistake in selecting springs for a race car is to reason that if slightly stiffer springs are better, really stiff springs must be really good. Unfortunately, this line of logic is not valid. The same criteria used for choosing the production car springs are employed to pick race car springs. In order for the tires to develop any cornering forces, they have to be on the ground. If the springs are too stiff, the tires will spend more of their time off the pavement, so cornering power is reduced. This is especially true on bumpy, rough road surfaces.

If stiffer springs were better, no springs at all would be the best—and we all can appreciate how this setup would handle on a rough track. The softest springs will keep the tires on the ground the highest percentage of the time, so they are preferred. The limiting factor is that the springs must be stiff enough to keep the suspension from bottoming out over the bumps. Actually, driving the car is the best way to determine if this is happening, so final spring selection is best done at a test session. Since race cars are customarily lowered, the normal ride travel is reduced. This condition will make it easier for the suspension to bottom out because the control arms will have less travel before they hit the jounce bumpers. Herein lies the reason that racing cars have slightly higher spring rates than production cars. In order to keep the suspension from bottoming out with the reduced ride travel, stiffer springs are required. In most cases, the springs in a racing car are 10 to 30 percent stiffer than the equivalent production car. On some tracks, such as the banked turns at Daytona, the spring rates must be raised to make them 50 to 100 percent stiffer because the car is subjected to twice the vertical "g" forces on the 30 degree banking. In other words, the car effectively weighs twice as much.

One solution to the spring/suspension travel problem is to figure out a way to lower the car without reducing the ride travel. This is not always easy to do, but it has the advantage of taking the best of all conditions without compromise. One way to accomplish this trick is to obtain or fabricate front steering knuckles with a raised spindle location. This lowers the car but does not change the ride travel, so soft springs can be used without bottoming out the suspension. Other methods, such as moving the ball joints on the control arms, can have the same effect, but make these modifications only after thoroughly reviewing all the other complications that might result. For aerodynamic reasons, a race car's front should usually be lower than the rear. This means that the rear of the car will be trimmed higher, so that the ride height is no problem, and relatively soft springs can be used in back.

Finding slightly stiffer springs is always a problem for backyard racers because we don't have the money or facilities to get custom made springs. Here is where a little ingenuity and a cutting torch can be used to advantage. Since you probably are going to remove some weight from the front of your car, and because you are going to want to lower the front end slightly, you will need a spring with less load. (Spring load is the force that it takes to compress the spring to installed height.)

For example, you might need a spring that gives 1000 pounds of force at its installed height of 10 inches. This same spring might have a rate of 300 pounds-per-inch. This means that the spring must be compressed 3 1/3 inches to get it down to the 10 inch height at 1000 pounds. Since we are deal-



ing here with a known spring and are simply trying to increase its rate by a percentage, some quick calculations will point the way. A spring's rate is inversely proportional to its length—in this case, to its number of coils. This means that a spring with 12 coils and a rate of 300 lb./inch will have a stiffer 360 lb./inch rate if two coils are cut off. The calculation is as follows:

$$\frac{\text{New spring rate}}{\text{Old spring rate}} = \frac{\text{Original length}}{\text{New length}}$$

Substituting the figures for our sample spring, the proportion becomes:

$$\frac{360}{300} = \frac{12}{10}$$

The spring rate increase of 60 lb./inch is a gain of 20 percent, so if you need a spring that is two coils shorter than stock to lower the frontend of your Vette racer, you might be able to just cut the existing springs to make them fit all your requirements.

Such good fortune might seem unlikely, but it happens on many occasions. The thing to remember is to use restraint when trimming springs. Cut off a little and then run the car to shake everything into place. The car will always settle somewhat, so don't cut off too much until you find out where it is going to end up. It's usually best to cut off one to 1 1/2 coils the first time and maybe a half coil at a time until the car height gets close to your goal. Final adjustments can be made by cutting off a quarter coil at a time.

This procedure might seem repetitive and wasteful, but it's one way to get there. If you can buy the exact spring you want from the manufacturer's parts list, by all means do it. You still might want to fine tune the spring length of a custom made spring; the technique is the same. Always trim a spring with a cutting torch, using as little heat as possible except where you're making the cut. Don't quench the hot spring in water—just let it air cool. As a hedge against a particularly bumpy track, or when going to Daytona, carry a set of round rubber spring shims in case you need to raise the car slightly for more ride travel.

These shims can be purchased from auto dealers who use them to fix cars that suffer from sagging springs. If, after the final trimming of your springs, the ride height is where you want it but the car still bottoms out, you need springs with a higher rate than your cut-down production ones. The two best sources of higher rate springs are:

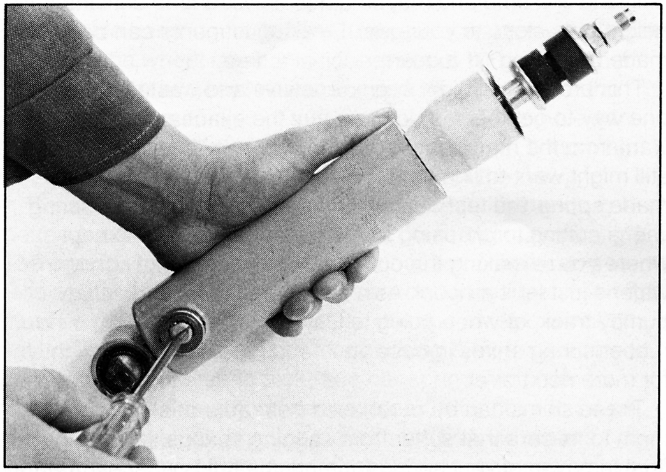
1. Your auto dealer's parts book. It will list optional springs for your car. Pick one from the list that has a higher rate and cut it to fit your length requirements.
2. Your local junkyard. Find a spring with the same overall diameter but with larger wire diameter and/or fewer coils for the same length. Such a spring will have a higher rate, and you can trim it to fit your application.

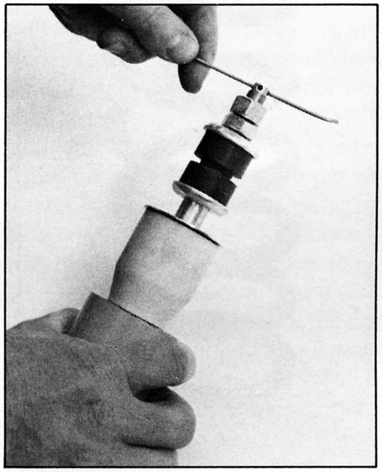
This procedure might not seem too scientific, but it does work and many racers have found it the only to arrive at the right spring combination. NASCAR stock cars are equipped with spring jacks to permit easy ride height and spring load adjustments. These devices can be installed in your Corvette if you feel that their advantages are worth the trouble to mount them.

SHOCK SELECTION

The philosophy behind selecting shock absorbers for a race car is similar to the principles used when choosing springs. Don't be misled into thinking that, because slightly firmer shocks are an improvement, then really firm shocks will be really better. Shock absorbers installed on production cars are quite soft. Because of the suspension's violent actions under racing conditions, heavy-duty shocks are required at the track. Ideally, you want just enough shock absorber control to keep the car from wallowing over swing bumps. If the shocks are too firm, the wheels and tires will not be able to move quickly enough to stay in contact with the road over the rough spots. The only way to know if the shock settings are right is to drive the car and feel it react.

Try a tighter shock setting, or a looser one, until you develop a feel for the critical dampening rate. Obviously, adjustable shocks are a real advantage in selecting the optimum settings. Koni makes special racing shocks that have seven rebound settings and seven separate jounce settings.





STEERING & ALIGNMENT

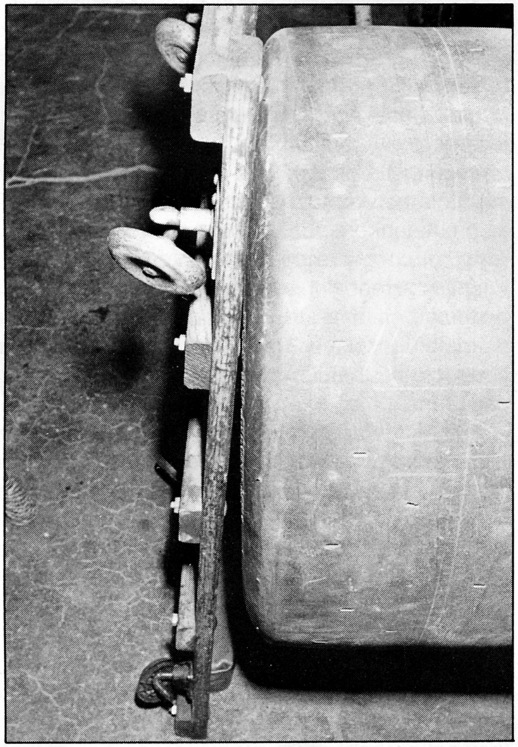
In order for the driver to maintain control of the car during the heat of racing, a steering ratio of about 16:1 is required. Fortunately, Corvettes with power steering have this approximate gear reduction.

Front suspension alignment must be set accurately after the car has been driven and everything else is done. You can only get an accurate wheel alignment after all the components have settled out and found their "natural" positions.

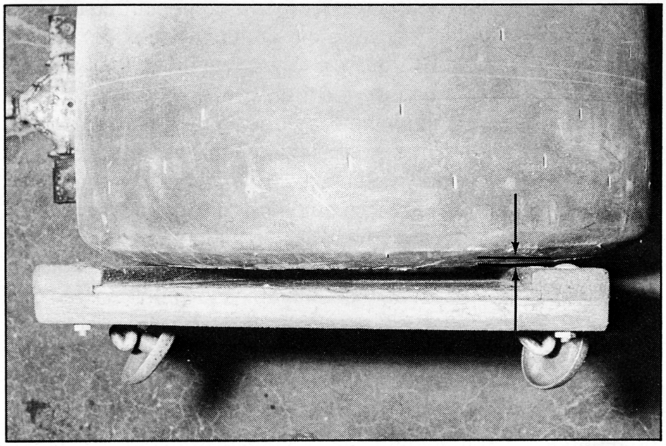
Front	
Caster	1 to 2 degrees positive
Camber	2 to 3 degrees negative
Toe-in	0 to 1/16-inch
Rear	
Camber	1 to 2 degrees negative
Toe-in	1/16 to 1/8-inch

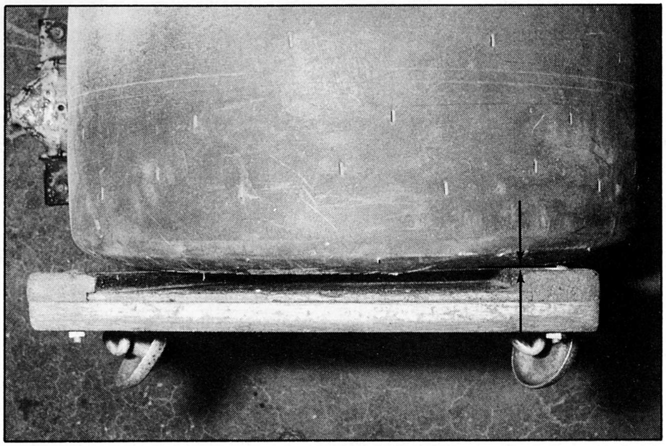
Experimentation on the skid pad and on the race track is required to optimize the settings, but in general, the final specs will probably be within one degree and 1/8-inch of the above.

BUMP STEER



Bump steer is the condition where the front wheels change their steering angle as the suspension moves through its travel. The factory designs in a certain amount of bump steer to make the car understeer; the engineers call it "roll steer." A slight amount of roll understeer is beneficial, and stock Corvettes have the right amount. Unless you change the control arms, their pivot locations, the front knuckle or the steering linkage, you don't have to worry about bump steer. The accompanying photos show how we can easily check bump steer with enough accuracy to make the car handle correctly. The basic idea in measuring bump steer is to determine how much change in the toe-in is produced as the suspension goes through its travel. The front springs must be removed so you can easily stroke the suspension. By using a fixed reference, such as a creeper leaned against the wheel, you can measure how much toe change occurs as the suspension is moved through its range. (Note: always check bump steer with the wheels pointed straight ahead.) If the wheel toes out as the suspension goes up, the result is roll understeer. As much as .030-inch of toe out is acceptable as the suspension moves from its normal ride height to the full jounce position. The amount of bump steer that occurs from ride height to full rebound is less important, because the wheels are not loaded as heavily under these conditions. If you need to change the amount of bump steer on your Vette, this is accomplished by moving the tie rod pivots.





SUSPENSION TUNING

Anti-roll bars, or stabilizer bars as they are often called, are the key to getting your car to handle well. The purpose of these bars is to control body roll and to stabilize the suspension systems. In addition to their primary functions, they can be used to control the amount of oversteer/understeer your car has.

Although there must be a limit, we have yet to see a production-based race car that had too much front roll resistance. There is, however, a practical limit to the diameter of the steel wire that can easily be formed into a stabilizer bar. Our experience has shown that a 1 1/4-inch diameter length 4340 or 4140 steel makes an ideal front stabilizer bar for '63-'82 racing Corvettes. Anything larger becomes prohibitively heavy and very difficult to form.

If you decide to form your own stabilizer bars, it isn't difficult if you use the production bar for a pattern. The bar can be bent when it is cherry-red and heated evenly over an area of about six inches in length. Heat it slowly with a heating tip or a big cutting tip so that the core of the bar gets hot at the same time as the surface. When it is hot all the way through, you can bend it by putting one end in a vise and pulling on the cold end. Let it cool slowly in the air to minimize stress. After the bar is made and checked for fit, it should be heat treated to about Rockwell C-38/40 at a heat treating plant.

A stabilizer bar is only as good as its mounts and linkages, so care should be taken to make them strong enough to handle the loads which the new stabilizer bar will impose. Wide angle spherical joints are available for fabricating bar-to-control arm linkages. You can use regular type spherical joints with straddle brackets if you like, but wide angle joints will probably be required to get adequate clearance for the parts during full suspension travel. Check the entire stabilizer bar linkage for clearance before final assembly; even the slightest binding or interference will break the joints. It is easy to check during full suspension travel if the spring and shock are removed and a jack is used to stroke the suspension.

Where the stabilizer bar mounts to the frame, you may build special aluminum block with nylon bearings to support the bar.

Rear stabilizer bars can be patterned off existing production rear stabilizer bar setups, or formula type rear bars can be fabricated. Links to connect a formula type rear bar to the axle can easily be made using spherical joints and a threaded sleeve. Arrange the bar so that at normal ride height it is parallel to the ground and the linkages are in the center of their travel. Stroke the rear suspension to the limits of its travel with the bar connected to be sure that nothing binds or rubs.

When you venture out to the track or skid pad, you will need to select the rear stabilizer bar diameter that gives the car neutral steer characteristics. Understeer is when the front of the car loses traction first; oversteer is when the rear loses traction first. Some drivers prefer a tendency towards understeer on the skid pad because this makes the car less likely to spin out during actual racing conditions. If you initially test with the recommended 1 1/4-inch front bar and all the spring heights correct, you will probably experience considerable understeer if no rear bar is installed. Bolting on the smallest diameter rear bar will reduce the understeer; you will notice more neutral handling characteristics and improved skid pad times.

Adding a rear stabilizer bar reduces understeer because it lets the rear wheels absorb more of the weight transfer forces. If a car with equal tire loadings and equal stiffness front and rear is run around a skid pad, it will generally exhibit neutral steering. But the stiff front anti-roll bar we have specified causes the outside front tire to absorb a large percentage of the forces trying to roll the body due to weight transfer from the inside to the outside of the turn. The car's springs can absorb some of these forces, but the thick front bar causes a higher percentage of this loading to be on the outside front tire.

Since the tires are already overloaded due to weight transfer, they are probably above the linear portion of their weight-traction curve. This means that as the front tires are loaded more heavily than the rears, the car will understeer; the front tires offer less traction in relation to the rear since they are operating at a point higher on the traction-weight curve. When a rear anti-roll bar is added, the rear tires share a percentage of the roll resisting forces, so they move up on the curve and the front tires move down. Substituting an even larger rear stabilizer bar takes even more of the roll-resisting force off the front tires and places it on the rear.

Eventually one of your larger bars will produce oversteer. Oversteer is not necessarily undesirable, so spend some time driving an oversteering car to get accustomed to how it feels. You can then select the rear bar diameter that you feel gives the best handling and the best skid pad times.

If you don't have access to a skid pad, do your evaluation on a curve of the test track that is smooth, constant in radius, and fairly long in duration. This type of curve allows the car to achieve steady state cornering long enough for you to get a reading on what it is doing. Entering and leaving a corner are transient conditions, and what the car does in these situations must be isolated from the steady state cornering conditions if you want to make exact determinations of the stabilizer bar choices.

Although it is not recommended, expressway off-ramps make excellent skid pads when no other facilities are available. A less risky site can be set up on a large, deserted parking lot. You can turn one into your private skid pad by painting a 200 foot diameter circle on a smooth area. If your stabilizer bar tests show that the car understeers in one direction and oversteers in the other direction, then the car has something in its total suspension that is not equal from side to side. In severe cases, you might have to shim one spring to get the car symmetrical. In most cases, though, you can adjust the length of the stabilizer bar links to take the "wedge" out of the car.

If the car understeers to the right and oversteers to the left, the right front or left rear link should be lengthened. Changing the link in 1/4-inch increments should produce noticeable results. This is a quick way to tune the suspension; even during race meets, you will find this is an easy way to get the car to handle as the driver wants it to.

After sufficient preparation and testing, you will want to actually go racing. And, if things hold true to form, your entire bag of tricks won't be able to answer the driver's complaints about handling. The most likely shortcoming, assuming that everything else is working correctly, is that the car understeers going into a corner and oversteers coming out. It's true; the car's understeer/oversteer characteristics will change due to the varying loads on the tires during braking and acceleration. Solving the understeer-braking/oversteer-acceleration problem is difficult, although there are some things that you can do to help.

Under braking, the front tires carry more load because of weight transfer forward. If this extra weight, added to the cornering loads, exceeds the point at which the outside front tire can maintain its linear weight-traction relationship, the car will understeer. Under these very high loads, one pound of weight no longer gives one pound of traction.

The second reason that a car can understeer under braking is that some of the tires' total traction capability is being used to slow the car. Since any of the total available traction used for braking reduces the amount of traction available for cornering, the outside front tire will have less traction in relation to the outside rear. The result? The car understeers. (It should be noted that in this type of handling analysis, only the outside wheels need to be considered. Under severe cornering loads, there is very little weight on the inside wheels.)

The best way to reduce understeer while braking is to get as much weight as possible off the front wheels. This will tend to equalize the wheel loads during braking. Throughout the car building process, removing weight from the front end has a strong impact on the car's ultimate handling capabilities.

Tire loadings and the resulting effects are not exactly the same under hard acceleration out of a corner, because in this instance the rear tires are pushing the car forward as well as helping it get around the turn. Most of us know that oversteer can be induced by applying power coming out of a corner. A tire has only a limited traction capability in any direction. If all the traction capability is being used for cornering, none is available for braking or accelerating. This pure cornering condition is essentially what we have on a skid pad at constant speed.

When you apply the throttle in a corner, you are asking the tires to employ some of their total traction capability to push the car forward; they automatically give less traction for cornering. Less traction in back means oversteer. It is easy to see cars on the track in this condition because they have the front wheels turned the opposite way as they power out of a corner. It looks terrific, but it isn't the fastest way to run a race car. If you can increase the static weight on the rear wheels, you will raise the total traction capability of the rear tires. Thus when some of their traction is spent on accelerating, there will be a reserve left for cornering.

Fore and aft weight transfer under acceleration is much less severe than it is during braking because a car can stop much faster than it can accelerate. For this reason, the outside rear tire is not loaded as drastically under acceleration as the front tire is during hard braking. Therefore it is still desirable to get as much weight on the rear wheels as possible, even though we might tend to raise the back tires' loading to the non-linear portion of the traction-weight curve. The net effect is that there will be more cornering power under acceleration if the weight distribution favors the rear.

CHAPTER SIX

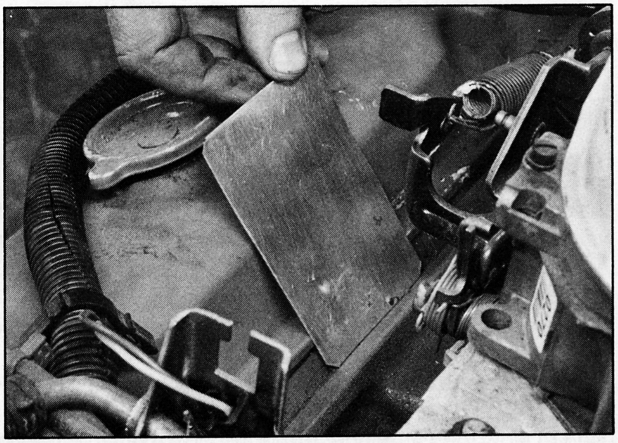
CORVETTE PERFORMANCE TIPS

TIRE PRESSURE

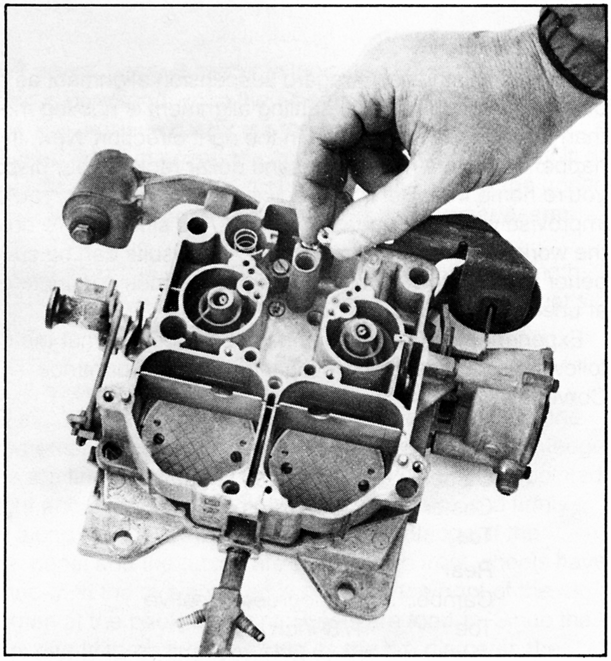
There's a persistent belief that handling characteristics can be altered by changing tire pressure, but our racing experience hasn't supported that notion. Since our race cars often use street tires (like the state-of-the-art Goodyear Eagle NCT's we ran at last year's 24-hour Daytona race), we've learned that a particular tire has an optimum inflation pressure which should be maintained within a fairly narrow range. We found that the Eagle NCT perform best for us at 30 psi. Other drivers may prefer inflation pressures as high as 35 psi, but that's not a significant change. When conducting your own tire pressure experiments, always make incremental change. That is, a tire inflated to 30 psi cold, may read 40 psi on a tire gauge after a quick run through a canyon road. Thus, to increase tire pressure by 5 psi, you should add enough air to bring the gauge reading to 45, even though that inflation may seem excessively high. When the tire has cooled, the reading will drop to a more moderate 35 psi.

HEAT RISER BLOCK

If you're willing to tolerate a slightly longer warm-up period in the morning, you can add some horsepower to your Corvette by blocking the exhaust cross-over under the carburetor. This increases the intake manifold's volumetric efficiency and permits tuned headers to operate independently (when the exhaust ports are not "siamesed"). You can block the exhaust heat risers without even removing the intake manifold. You'll need a small square of .020-inch thick stainless steel for each side of the manifold. Loosen the manifold bolts adjacent to the heat riser passages and slip the stainless steel between the manifold and cylinder head. Tighten the manifold bolts, and be sure to wire the heat riser valve in the open position; you'll now have cold, dense air filling your Corvette's cylinders. Don't use a slice of old beer can or tin cup in place of the stainless steel, since other metals will corrode quickly when exposed to hot exhaust gases.



CARBURETOR JETTING



The press of automotive emission regulations has forced the automakers to calibrate production carburetors as lean as possible. If you've made any performance or economy improvements on your Corvette such as adding cold air induction, headers, or an aftermarket camshaft, chances are that the fuel mixture is too lean for optimum performance. The most common carburetor on high-performance Corvettes is the Quadrajet, which responds well to slight enrichment of the primary circuit. Quadrajet carburetors have removable primary jets. In our experience, increasing jet size by three numbers is usually about right for best performance. You can obtain new jets from most GM dealers (or by mail from Herb Adams VSE). For example, if your Corvette is equipped with No. 70 jets from the factory, 73s will provide the correct mixture enrichment.

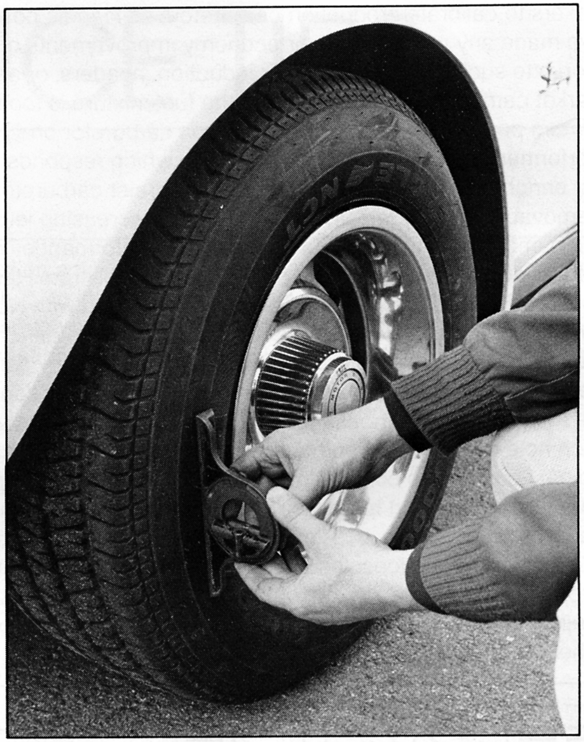
You can also make the necessary mixture adjustment by drilling your car's original jets. Quadrajet jet numbers closely correspond with the hole diameter in thousands of an inch; No. 70 jet has a .070-inch hole through it. If you have a set of number drills, measure the original hole size (to confirm the stamped number) and then redrill the jet with the next largest size drill. This will increase the jet size the necessary .002 to .003-inch. You'll probably find that the engine's fuel economy doesn't suffer, since you'll be driving with less throttle opening. And as an added bonus, warm-up driveablility is ususally improved and flat spots under moderate acceleration diminished.

HEEL & TOE

If you want to drive like a road racing champion, you've got to master the proper techniques. Going around corners quickly with a stickshift car sometimes seems to require three feet—one for the clutch, one for the brake, and one for the throttle. You can make do with only two, though, if you learn how to "heel and toe" by using your right foot to control both the brake and accelerator pedals.

Most production cars aren't built to accomodate this technique, including Corvettes. A Vette's accelerator linkage can be carefully modified to provide the correct pedal spacing, however. The pedal rod must be bent so that the gas pedal is approximately one inch away from the brake. Check that the carburetor still opens fully, and be careful of your foot positioning until you become accustomed to the new pedal location.

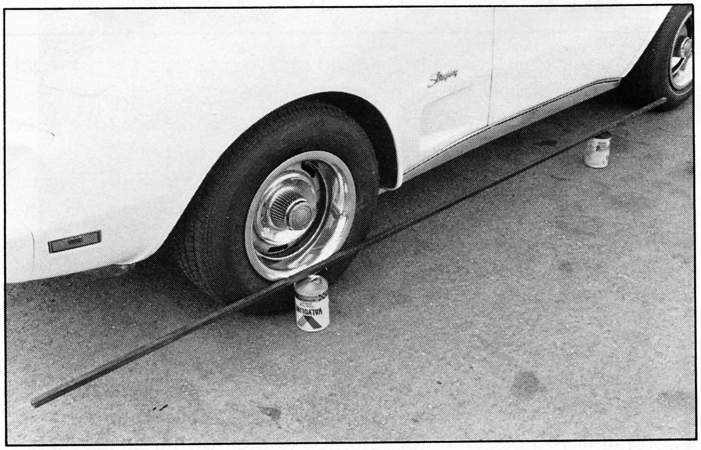
SUSPENSION ALIGNMENT



Many car enthusiasts regard suspension alignment as a black art. The truth is that settling alignment is nothing more than pointing the front wheel in the right direction. Now, if you happen to have a mega-thousand dollar rack at your disposal, you're home free. But if you're like most enthusiasts, you can improvise when the occasion arises. And since you're doing the work yourself, on your own car, the results can be superior to the flat-rate workmanship sometimes encountered at unenlightened alignment shops.

Experience on the highway has convinced us that the following specifications are ideal for high-performance Corvettes:

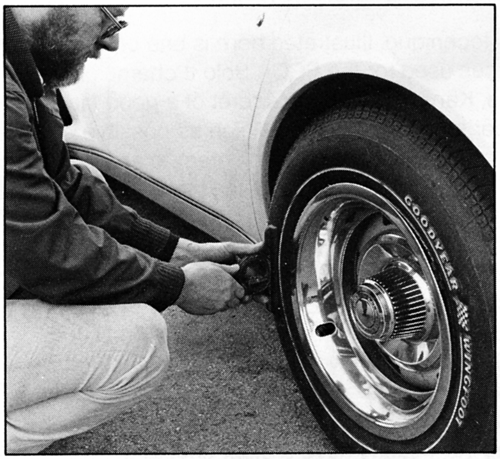
Front	
Camber	1.0 degrees negative
Caster	2.0 degrees positive
Toe	1/8-inch in
Rear	
Camber	1.0 degrees negative
Toe	1/8-inch in

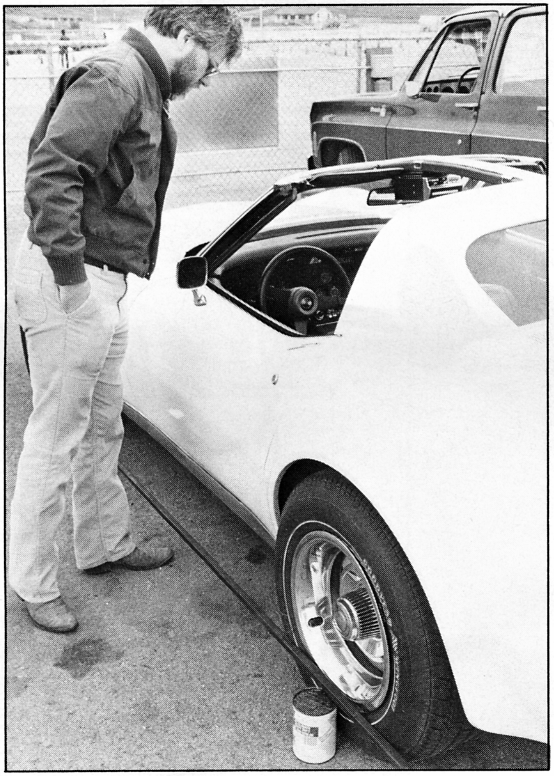


So how do you set your Vette to these specs when the alignment shop wants to use the factory settings? Simple. Do it yourself. Perfectly satisfactory results can be achieved with quite ordinary equipment.

To measure camber, a caliper level (available at any Sears store) works well. With the car parked on level ground and wheels straight ahead, place the level against the tire sidewall, avoiding raised lettering and other irregularities. Centering the level's air bubble will indicate the camber angle. Ideally, both front tires should tilt in one degree toward the center of the car. To change a Corvette's front camber angle, add or subtract shims from both upper A-arm mounts.

Caster is the inclination of the front spindle. Positive caster —the rearward tilt of the spindle—is essential for high-speed stability. A fairly accurate measurement of caster can be made by taking two camber readings. First record the camber when the wheels are turned full right, then repeat the measurement with the wheels turned full left. The difference between the two readings closely approximates the caster angle. (For





the left wheel, positive caster is indicated when more negative camber is produced when the wheels are turned right. For the right wheel, positive caster is produced when the wheels are turned left. It may sound confusing, but that's the way it works.) To increase caster, add shims to the rear of the upper A-arm mount, or remove shims from the front upper A-arm mount.

Measuring toe-in is a snap. Two oil cans, an 8-foot length of rectangular steel tubing, and a tape measure are all that's required. In a pinch, you can even substitute a straight two-by-four for the tubing. Set the tubing on top of the oil cans as shown, with the tubing just touching the front tire sidewalls. (Again, avoid raised letters which may disrupt the measurement. The oil cans are there to raise the straightedge above the tire bulge.) Make sure the steering wheel is pointed straight ahead and be certain that the door is closed firmly. Sight along the rocker panel and the straightedge. If the rocker panel and the tubing are parallel, the front wheels have zero toe-in. If the straightedge is closer at the front of the door than at the back, the front wheels are toed-in. Since the door is nearly three times as long as the tire diameter, the offset should be three times as great as the recommended toe-in specifications. Thus if the front wheel has the desired 1/16 toe-in, there should be 3/16-inch difference between your measurements from the straightedge to the front and rear of the door. Toe-in is adjusted by turning the thread sleeves which connect the inner and outer tie rod ends.

Since a Corvette has independent rear suspension, it can be aligned just like the front suspension. For most highway use, you want about 1 degree of negative camber, and about 1/8-inch of toe-in at the rear. The camber angle can be changed by turning the cam bolts where the lower rear strut bars attach to the differential. The rear toe-in can be changed by adding and removing shims on either side of the rear swing arm, where it attaches to the frame. More shims outboard the arm will give more toe-in.

It is best to have the rear alignment done by a competent alignment shop, but you can check your alignment using the same tools and techniques that are outlined in the front suspension section.

AUTOCROSS COMPETITION

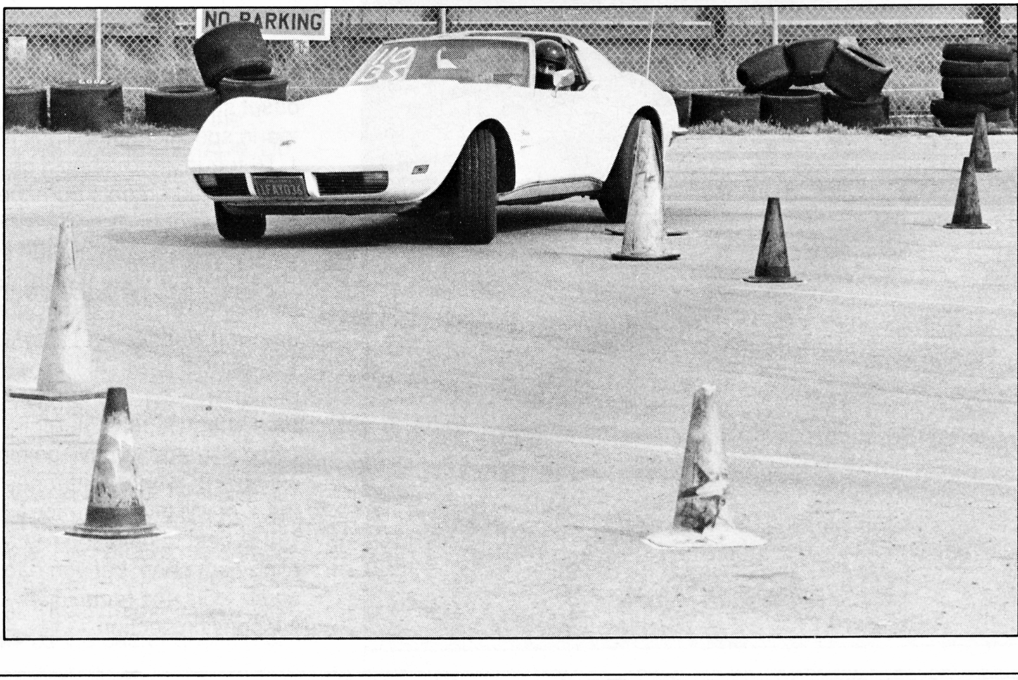
Running an autocross course is very similar to driving a lap on a track. The same techniques used to cut a good lap time on a road racing circuit can be used to lower lap times on a Solo II course set up in a shopping center parking lot. A good lap time on any course requires that the car be in top condition, that the driver be capable, and that the driver fully understands that course layout. It's this last element that many novice drivers neglect because they are concentrating on the other aspects. Car preparation and driver conditioning are certainly important, but an improvement of over a full second in lap times is easily realized if you master the course.

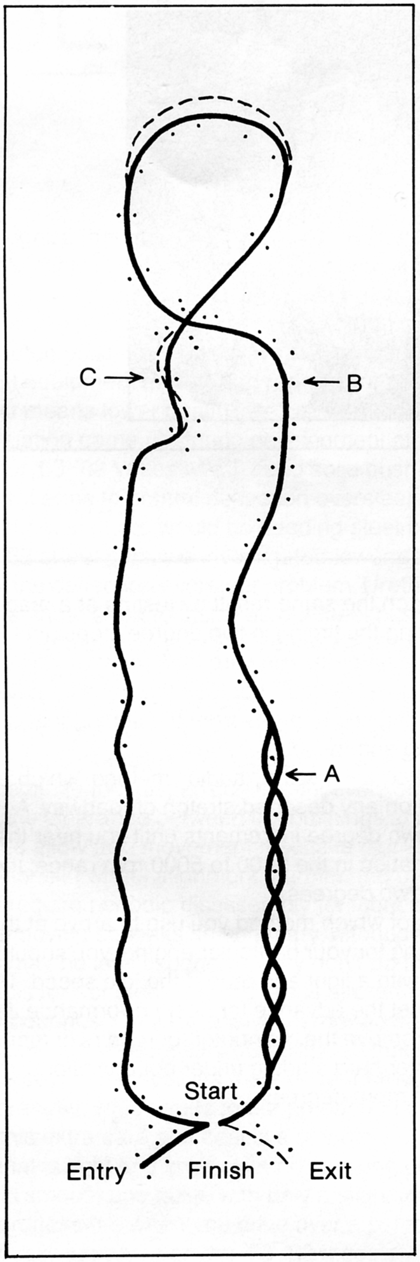
There is a popular belief that in order to produce better lap times you have to scare yourself more. This is a false notion. The best lap times come when the driver is in complete control. It is very important to know precisely where the car should be in every portion of the track. The job of driving should focus on placing the car in the correct position as smoothly and as quickly as possible.

An example of how to study and understand a given course will explain this technique. Illustrated here is one of the autocross courses used for the SCCA Solo II championship runoffs in Salina, Kansas. Since the secret of a good lap time is to keep the car's average speed as high as possible throughout the course, we can use a diagram to analyze the fastest way around each portion of the circuit.

It is obvious that you want to make as fast a start as possible. The first obstacles encountered are six pylons arranged in a row like a slalom run. The course officials' diagram shows that these can be taken to either the left or right side at the driver's option. The entrance to the slalom would be slightly faster if you went to the right of the first pylon, so this is the "normal" course to take. But if you study the course layout it's clear that this line will be slower on the exit because the car doesn't have a clear shot at the first straightaway after the slalom segment. It is crucial to exit from a turn quickly, so the best line would be to take the first pylon on the left.

The exit from the slalom portion presents a good opportunity





to cut the overall lap time. By starting on the left at the first pylon, it is possible to begin accelerating for the straight by the time you reach point A. In fact, the car will be traveling faster on the entire straightaway up to point B. Since shifting gears takes time and may break your turning concentration, it may be advantageous to upshift before reaching the slalom, selecting the gear required for maximum acceleration at point A. Little power is needed to run through the slalom, so it is pointless to over-rev the engine during this maneuver.

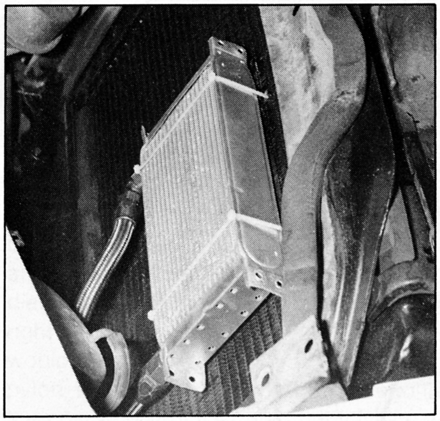
At point B, the driver must slow down to negotiate the corner. The most common cause of slow lap time is excessive braking. Every mile-per-hour lost in braking has to be earned back, and the lap time climbs while this is happening. The turn at point B is probably the most important section of this course, because it separates two very fast segments of the circuit. Getting through the turn at B quickly will raise the average speed all the way from point A to point C. This amounts to nearly half of the total course, so it's clear how much this turn contributes to the total lap time.

The loop at the end of the course is actually much faster than it appears to be, since there are no pylons marking the outside of the turn. We all know that the shortest distance between two points is a straight line, but when going around a course such as this, the fastest line is a wide curve. Many novice drivers would negotiate this loop with a series of quick turns around each pylon. This is not a smooth technique; since it upsets the balance of the car, maximum cornering power is not maintained. The fastest way around the loop allowed the car to accelerate as well as corner. This technique will produce the maximum speed in the straight section approaching point C. It would be possible to start accelerating for the loop just after B, and then take the line shown with dashes on the diagram.

At C, the driver must slow for the S-turn. In general, the fastest way through an S-turn is to sacrifice speed in the first part of the turn in order to take the second part as fast as possible. The dotted line on the diagram shows the best route through this particular turn. It provides an opportunity to start accelerating for the final straight sooner, so the average speed will increase and the lap times improve. Reducing speed for the first part of the S-turn is more than offset by the faster speed this method will produce down the straight.

OIL COOLER

An oil cooler is a vital addition to any high-performance Vette. Even though the speeds are not great during autocross competition, the constant acceleration and deceleration can raise oil temperatures to dangerous levels. VSE coolers feature braided steel lines for durability, and add a full-flow oil filter to the lubrication system. The cooler should be positioned parallel to the radiator as shown, taking care to provide clearance for the bumper supports and hood hinges. When plumbing an oil cooler into the lubrication system, use teflon tape on all pipe fittings to prevent leaks and make disassembly easier.



POWER TIMING

Setting your Corvette's ignition timing correctly is one of those marvelous exercises that can improve both performance and fuel economy. And, since optimizing spark advance costs absolutely nothing with our method, it has to be one of the best automotive bargains anywhere. The correct ignition timing for your particular application depends on countless variables—engine condition, compression ratio, gasoline quality, timing chain wear, distributor end play and dozens of other factors. That's why distributor "recurve kits" don't always produce the desired performance gains. The best way to adjust ignition timing is to let the engine itself tell you how much advance it wants. That's what "power timing" is all about.

The range of engine speed where ignition timing is critical is between 2500 and 5000 rpm. If you have access to a chassis dyno, the right advance setting for your engine can be found by running the car at wide open throttle at 4000 rpm. The distributor is turned in two degree increments until the maximum power level is found. (Note that all of the methods outlined here retain the factory advance curve.)

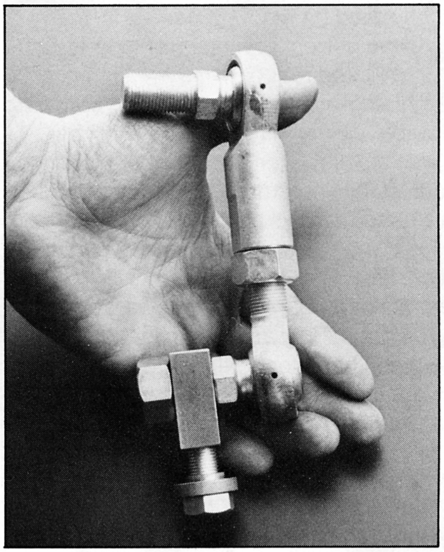
You can reach the same result by testing at a drag strip. Keep advancing the timing in two degree steps until the speed reading reaches a peak. (Beware of detonation on your test runs. If the engine "rattles," back off the throttle immediately.) Retard the timing two degrees from the setting that produced the best speed and the job is done.

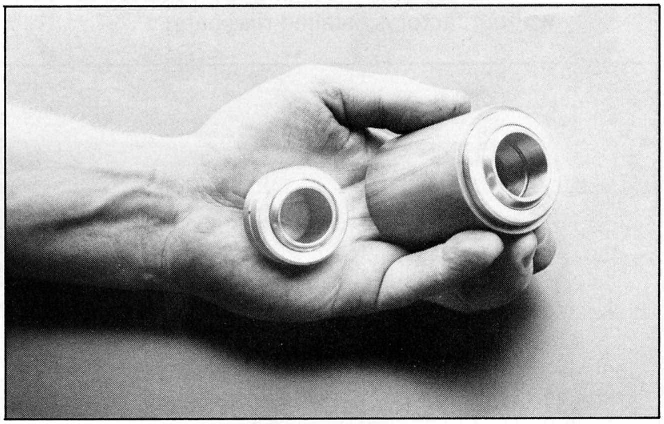
The third alternative is the "audio" method, which can be performed on any deserted stretch of roadway. Advance the timing in two degree increments until you hear the first signs of detonation in the 2500 to 5000 rpm range; then back off the timing two degrees.

Regardless of which method you use to arrive at the best advance setting for your particular engine, you should note the timing at idle with a light and record the idle speed. This data will let you reset the advance for best performance if you ever need to remove the distributor for repairs or maintenance. If you encounter hard starting under hot conditions, retard the timing two more degrees.

CHAPTER SEVEN

VSE COMPONENTS





We recognize that the cost of building and maintaining a high-performance car is always a consideration. At VSE, we constantly look for ways to reduce our prices so that more enthusiasts can afford the pleasures of driving a spirited, responsive automobile. There's always the temptation to offer lower cost equipment as a way to reduce our prices. But when lower cost means lower quality, we just won't make the switch.

This situation came up during development of our suspension kits for '63-'82 Vettes which need solid bushing kits on the front control arms to control deflection oversteer. Since many of our customers would be needing steel bushing for their '63-'82 street cars, we investigated lower cost ways to control the deflection oversteer problem. Urethane bushings require the same effort to install as our steel bushings, but offered a potential savings of $175 because of the difference in the cost of materials.

We were greatly disappointed by the performance of the urethane bushings our test car. The joints cause too much friction so the suspension cannot move freely. The ride is choppy because the suspension is effectively bound up. Increasing the clearance between the bushings and their mounting sleeves allow free movement results in clunking noises and variations in wheel alignment. Further, the urethane bushings require periodic disassembly for lubrication to prevent annoying squeaks. In summary, although urethane bushings may be less expensive, they don't do the job.

The basis for our steel bushing kits is aircraft quality spherical bearings. Only expensive, hardened steel bearings and races have the necessary durability, so that's what we use. The sleeves and spacers must be machined to extremely close tolerances, which adds to our production costs. The result of this extra care and cost is a smoothly operating suspension that is tight and snug, with no clunking or squeaking. The ride is smooth and quiet, with only a slight increase in impact hardness (as when you drive over a pothole). Handling is dramatically improved on the '63-'82 models.

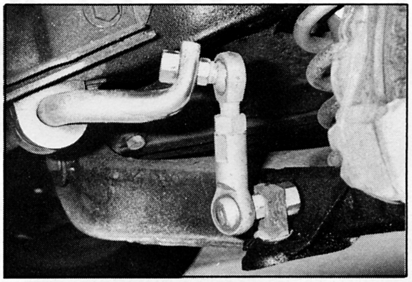
The final result is a very precise suspension that cost a considerable amount of money. We don't have a low-cost alternative that works, so we only offer what we know will perform—even though the cost may be higher. That's why quality is one VSE difference.

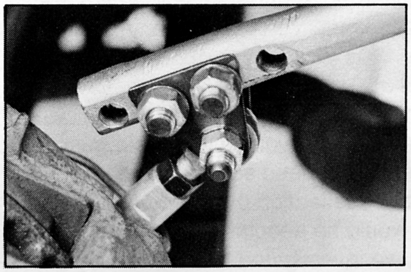
STABILIZER BARS

VSE stabilizer bars are the foundation of any Corvette owner's suspension improvement program. They are designed to control excessive body roll, which reduces cornering speeds by overloading the car's tires. VSE front and rear stabilizer bars are precision formed on jigs for a perfect fit, then carefully heat treated to the correct hardness for long-lasting performance. Both our front and rear bars feature spherical rod ends to produce lightning-quick response during cornering maneuvers. These durable, heavy duty rod ends eliminate the "time lag" found with stock rubber stabilizer bar bushings. The rear bar is fully adjustable to permit precise changes in chassis tuning. This feature allows a Corvette owner to tailor his car's handling to his own style of driving and his particular car's weight distribution, tires, and powertrain.

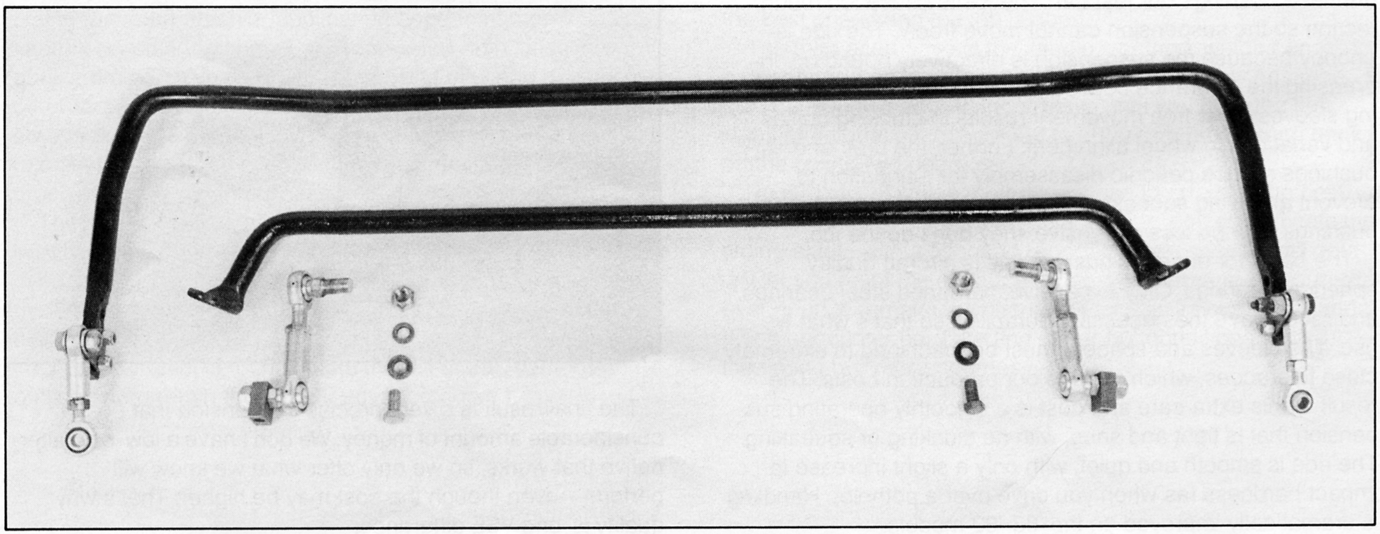
These front and rear stabilizer bars work together to produce perfect handling balance. They are designed for easy bolt-on installation with common hand tools; all hardware and complete instructions are included. VSE stabilizer bars are the best investment a Corvette owner can make to improve his car's handling.

92000 '63–'82 Corvette Front Stabilizer Bar Kit
92300 '63–'82 Corvette Rear Stabilizer Bar Kit
92301 Rear Stabilizer Bar Mounting Kit (required for cars without factory-installed rear bars)





For more information on stabilizer bars, see pages 7–9. Chassis tuning with stabilizer bars is explained on pages 46–48.



SOLID BUSHINGS

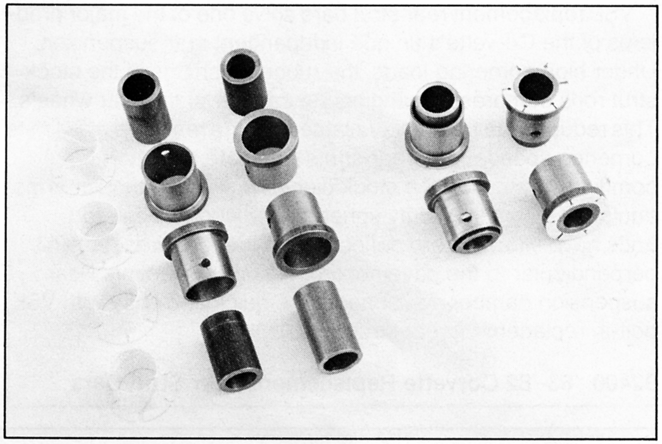
Solid suspension bushings eliminate the major cause of poor handling in '63-'82 Corvettes. Under hard cornering, the stock rubber bushings in the A-arms and rear struts compress. This natural tendency of the rubber to "give" under cornering loads causes the geometry of the front and rear suspensions to change dramatically. This causes the "twitchy" feeling that many Corvette drivers experience when driving hard. In addition, because of the location of the '63-'82 Corvette steering linkage, the driver must make constant steering corrections during fast cornering.

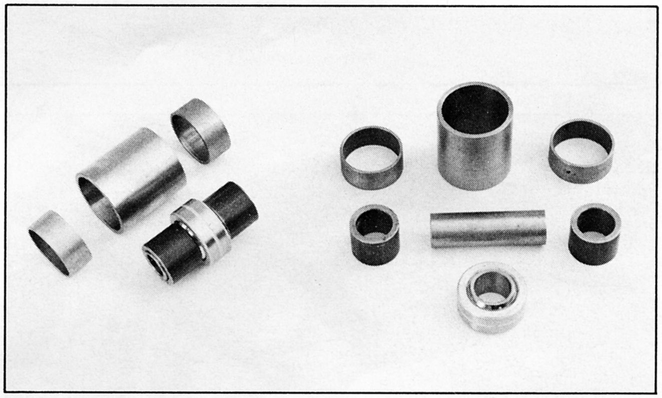
Our precision solid suspension bushings replace the stock rubber with aircraft quality spherical bearings and nylon bushings. These changes virtually eliminate the deflection found in factory-installed bushings. Camber, caster, and toe-in adjustments remain close to the optimum settings, giving the driver more confidence in his Corvette's handling.

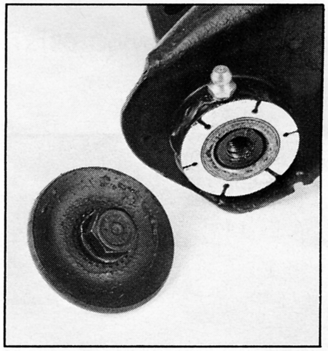
VSE steel bushings are machined to extremely close tolerances to prevent annoying squeaks. Disassembly of the front and rear suspension is required to install these kits, and some welding is necessary.

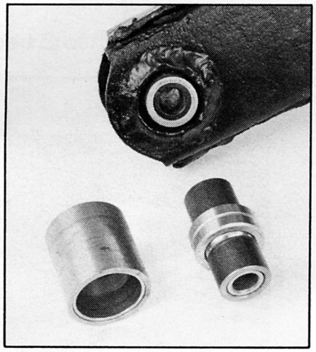
92600 '63–'82 Corvette Solid Front A-arm Bushings
92500 '63–'82 Corvette Solid Rear Arm Bushings

To learn more about solid bushings for Corvettes, see pages 16–22.









Since many of our customers do not have welding equipment, VSE offers steel bushing installation service. You can remove the control arms from your car, clean them and send them to us for bushing installation. Damaged parts will be returned with no work done. If you fail to clean the parts before shipping, we will clean them and add the labor to the charge for installing the bushings.

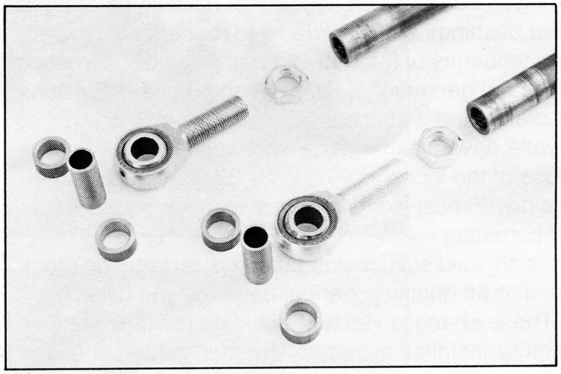
Normal turn around time is about 1 week. It usually takes about 8 hours work to install a set of front bushings (4 arms) and about 4 hours to install a set of rear bushings (2 arms).

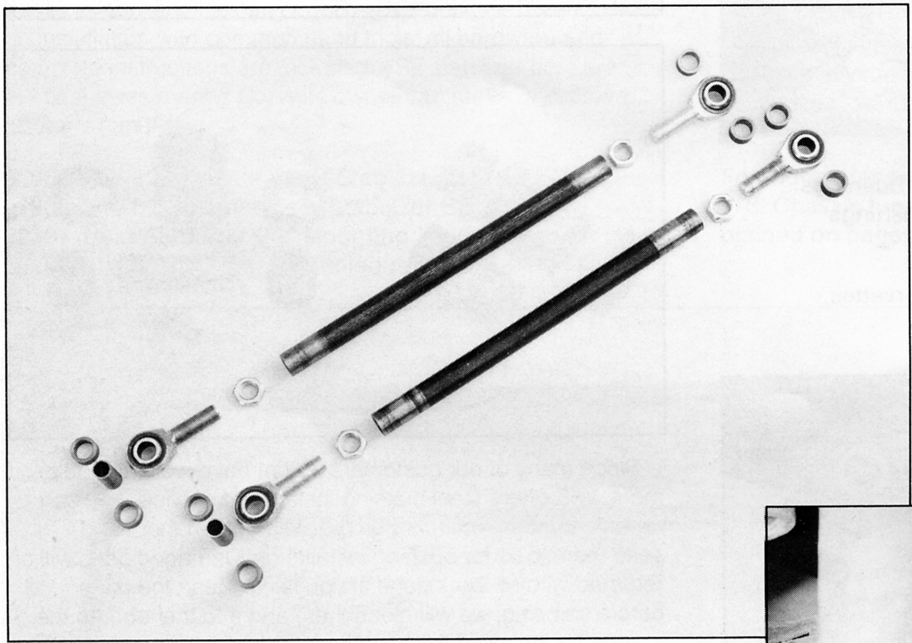
The normal VSE sales policy is used to cover customer requested labor. VSE's current labor rate is $40 per hour.

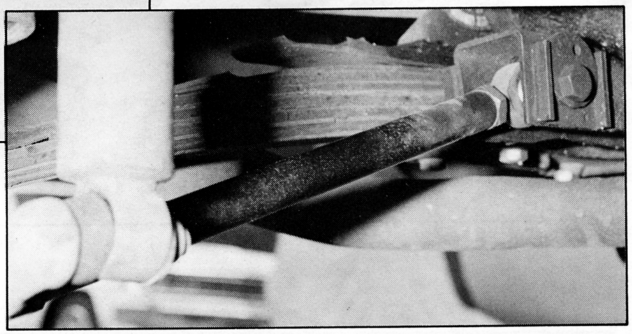
REAR STRUT BARS

VSE replacement rear strut bars solve one of the major problems of the Corvette's unique independent rear suspension. Under high cornering loads, the rubber bushings in the stock strut rods compress, changing the camber of the rear wheels. This reduces the traction available from the rear tires, and limits cornering speeds. VSE rear struts eliminate this shortcoming by replacing the stock pieces with tough tubular arms equipped with heavy-duty spherical rod ends. These rod ends have virtually zero deflection, so the rear tires remain perpendicular to the pavement for maximum traction. Rear suspension camber adjustments are quick and easy with VSE bolt-in replacement rear strut bars.

92400 '63–'82 Corvette Replacement Rear Strut Bars



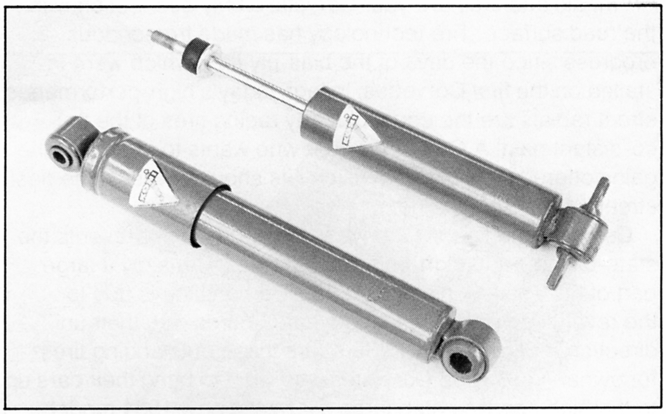




See pages 18–19 to learn why Corvettes need VSE replacement strut bars for optimum handling.

SHOCK ABSORBERS

For many years, Koni shock absorbers have been recognized as the highest quality suspension dampers on the market. They are quickly and easily adjustable through a wide range of settings; a simple twist of the shock body is all that's needed to change from soft to extra-firm, or any point in between. This feature allows a Corvette owner to select the exact degree of suspension control that suits his car and driving style. These will be the last shock absorbers you'll ever need to buy: even after thousands of miles of use, a quick adjustment will restore like-new performance.

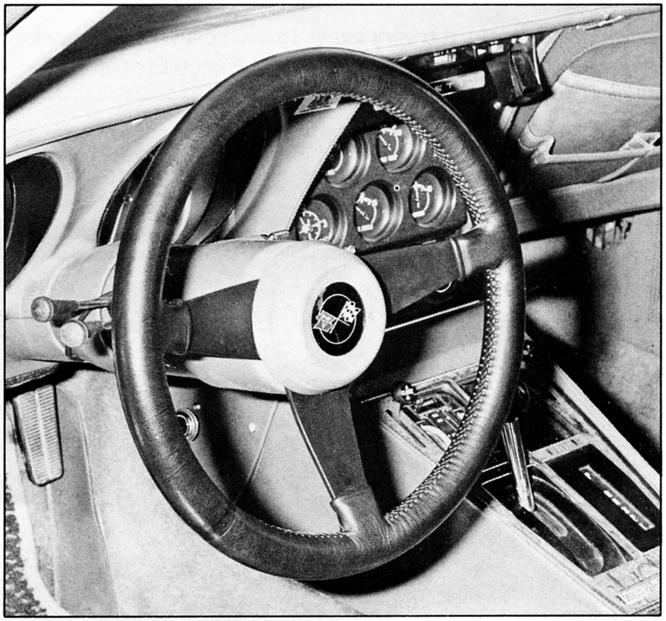


92001 '63–'82 Corvette Front Koni Shock Absorber
92302 '63-'82 Corvette Rear Koni Shock Absorber

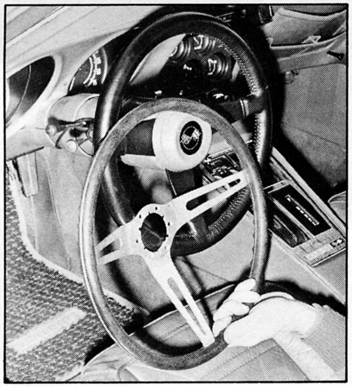
Want to know more about shock selection? See page 46.

STEERING WHEEL

Replace your Corvette's skinny steering wheel with this luxurious leather-wrapped wheel. Its thick, padded rim lets you get a firm grip on your car's steering when you are racing or touring. Black anodized spokes and hand-stitching make this French import the finishing touch for any Corvette interior. Its 14 1/2-inch diameter will slightly increase steering effort for a more positive feel, while it also adds leg room and makes getting into your Corvette easier.



12120 Corvette Leather Wrapped Steering Wheel



TIRES & WHEELS

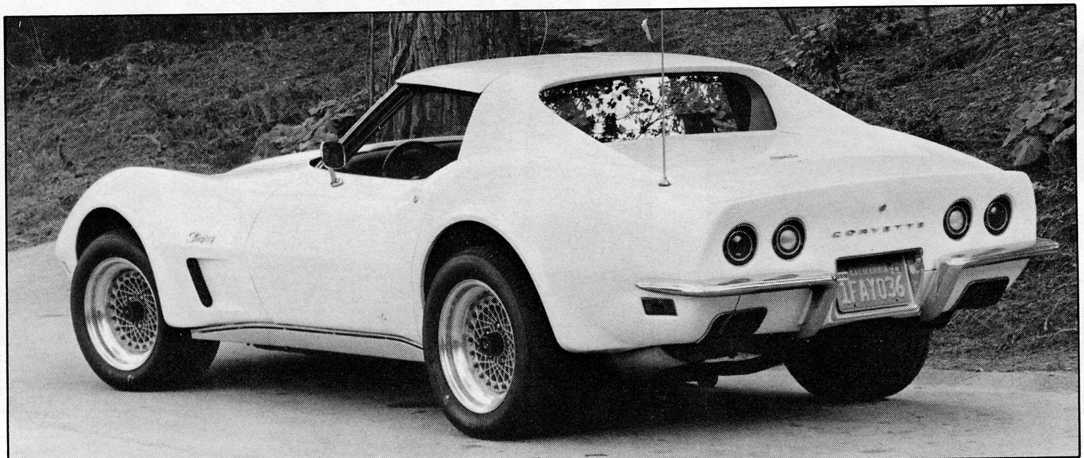
Wheels and tires are your Corvette's only connection with the road surface. Tire technology has made tremendous progress since the days of the bias-ply tires which were installed on the first Corvettes. In fact, today's high-performance street radials are the equal of many racing tires of the not-so-distant past! A Corvette owner who wants to realize all the gains offered by VSE suspension kits should invest in the best street rubber he can find.

Currently the line of Goodyear street radials represents the state-of-the-art in high-performance tires. Certainly a large part of the 1984 Corvette's impressive handling is due to the revolutionary 16-inch Goodyear GT tires with their unidirectional tread pattern. VSE offers these outstanding tires for owners of '63–'82 Corvettes who want to bring their cars up to the high handling standards set by the new 1984 model.

We recommend installing these new tires on 9-inch wide, 16-inch diameter Epsilon modular wheels. These three-piece wheels feature gold centers, polished rims, and high-strength fasteners. In addition, VSE has developed the correct wheel offset to successfully mount 16-inch wheels and tires on '63–'82 Corvettes.

VSE also stocks the very latest 15-inch diameter Goodyear high-performance tires, as well as 15 x 8-inch Epsilon modular wheels.

Please call or write for current specifications, prices and part numbers on Goodyear tires and Epsilon wheels.



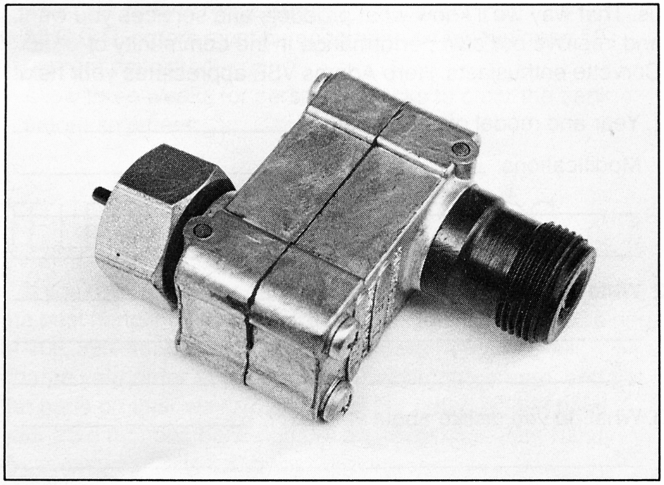
SPEEDO CONVERSION

Federal regulations required Chevrolet to install 85 mph speedometers in Corvettes, even though these cars could attain much higher speeds. If your Corvette is equipped with an 85 mph speedometer, you can convert it to a 170 mph speedometer with our kit. This 2 to 1 gearbox is easily installed between the transmission and speedometer cable. It drives the speedometer at half speed, so an actual road speed of 60 mph will indicate 30 mph on the speedometer face. You can quickly compute your true speed by doubling the reading on the speedometer.

Since the speedometer is running at half speed, the odometer will also indicate one-half of the actual miles traveled.

VSE also offers a 62% speedometer conversion. This allows you to read out your Corvette's speed directly in **miles per hour** on the speedometer's **kilometer** scale.

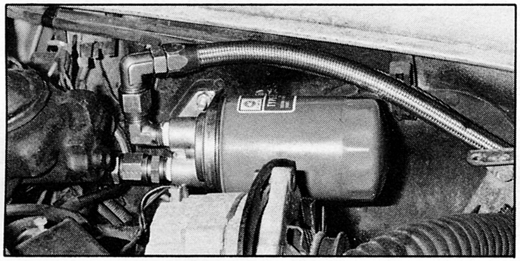
82001 **50% Speedometer Reducer**
82002 **62% Speedometer Reducer**

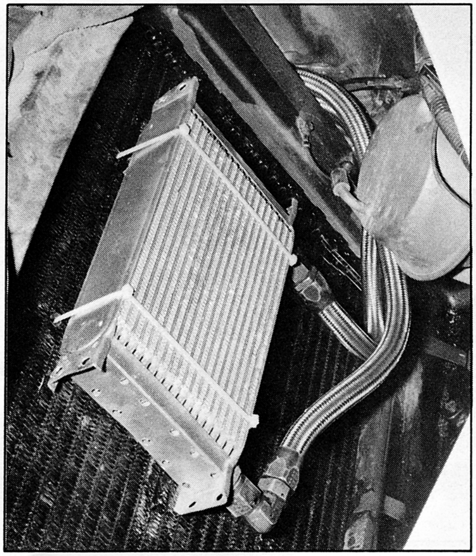


OIL COOLER

Any Corvette that is driven hard or entered in autocross competition needs a VSE oil cooler kit to protect its engine. Oil starts to break down at approximately 300 degrees F, but a VSE oil cooler kit will keep your Corvette's engine lubricant safely below the danger zone. Our kit is a complete engineered package that includes a high-quality cooler, a remote filter mount, braided steel hoses, and anodized aluminum fittings. Help your Corvette engine keep its cool with this VSE kit.

83100 **Corvette Oil Cooler Kit**





BUSINESS POLICY

100 CALLE DEL OAKS
DEL REY OAKS, CA 93940 408-899-4859

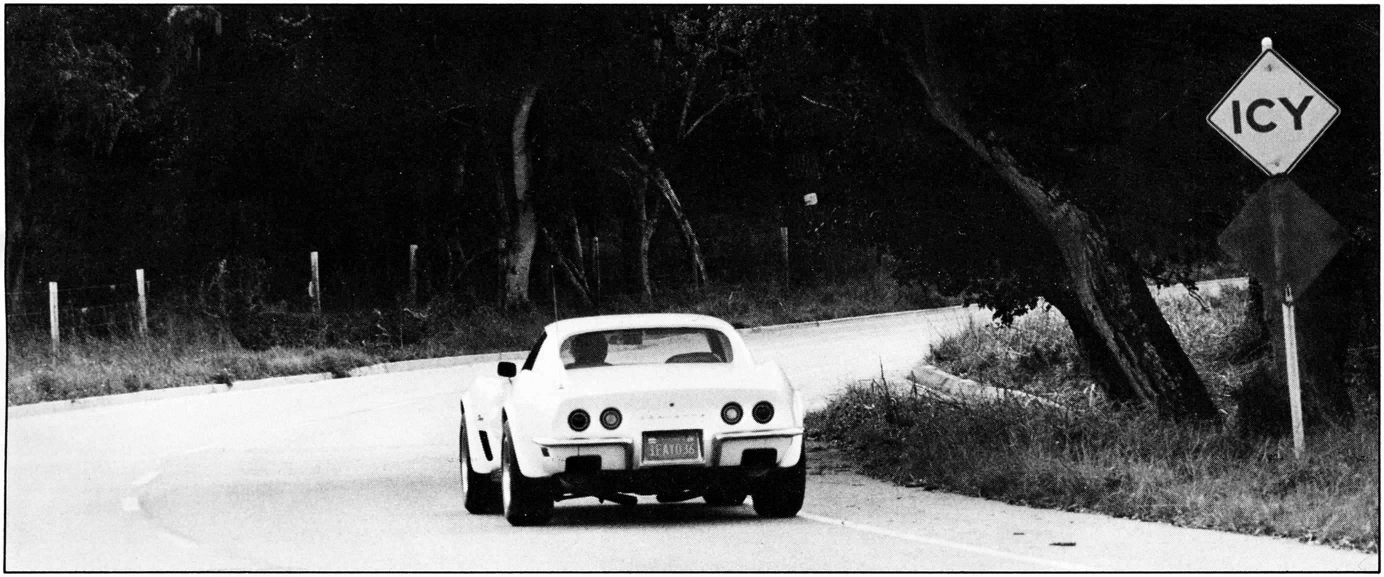
- All prices are subject to change without prior notice. You will be notified of any price increase on an order prior to shipment.
- There will be a 20 percent handling charge for all merchandise returned and found not to be defective. All returned merchandise must be accompanied by a return number. No merchandise can be returned after 90 days.
- California residents must include 6 percent sales tax.
- All shipping charges will be C.O.D., cash or money order. We ship via UPS whenever possible, but will ship by whatever means requested.
- All C.O.D. orders must be accompanied by minimum 50 percent deposit.
- Allow three weeks for personal checks to clear the bank before shipment.

WARRANTY

All products offered for sale are sold on an "as is" basis, and no warranties of any kind, whether written or oral, are made by Herb Adams VSE, its agents or employees. All implied warranties, including the implied warranties of merchantability and fitness, are expressly excluded, and the buyer bears the entire risk as to quality, performance and use of these products. Should any product prove defective following its purchase, the buyer, and not Herb Adams VSE, the manufacturer or the distributor, assumes the entire cost of all necessary servicing or repair. Herb Adams VSE reserves the right to change specifications or discontinue parts without prior notice.

TELEPHONE ORDERS

If you're in a hurry to get to work on making your Corvette the best handling car on the road, give Herb Adams VSE a ring at 408-899-4859 during normal business hours. We will charge your order to your Visa or Mastercharge card, and get the parts on their way. To speed up the order, please have your card number, bank number and expiration date handy. We're only a phone call away!



VSE by Herb Adams

VERY SPECIAL EQUIPMENT

MONTEREY, CA.

100 CALLE DEL OAKS, DEL REY OAKS, CA 93940