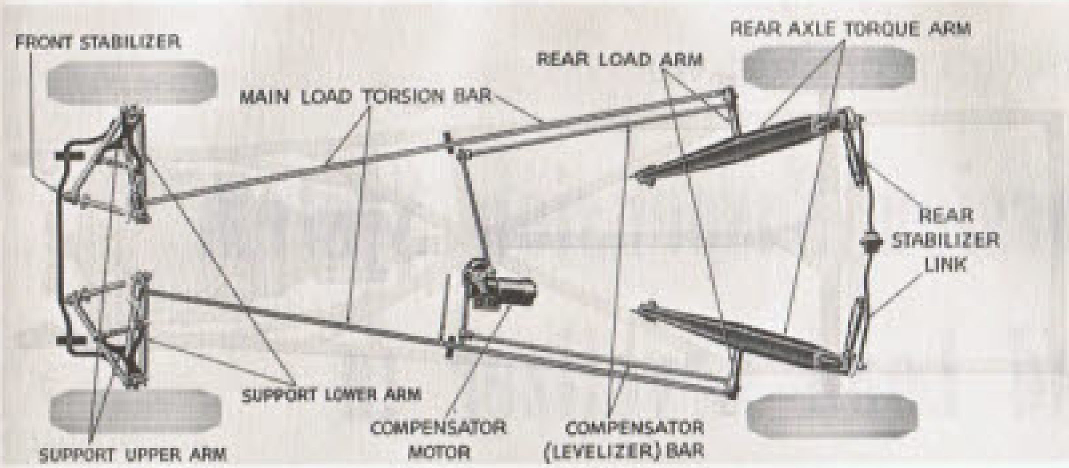
Descriptive Data on

Torsion Suspension System and Load Levelizer in American Automobiles

Information Bulletin from Engineering Department

Packard Division, Studebaker-Packard Corporation



THE TORSION SUSPENSION SYSTEM, LATEST RIDE DEVELOPMENT FOR AMERICAN CARS

One of the most dramatic engineering developments of 1955 is torsion bar suspension, which eliminates the front coil and rear leaf springs which have represented the auto industry's standard of suspension for years. One automobile manufacturer has incorporated a "load levelizer" into the torsion suspension system to achieve the first radical improvement in automobile riding comfort and safety since the introduction of so-called "knee-action" in 1934. Torsion bar springing is not a new idea as such, having been used on race cars and expensive European cars successfully for years. Until this year, however, there had never been a torsion system which used full length torsion bars and employed them in such fashion that both the front and rear wheels are connected to the same bar, thus receiving their loading from the same spring (note: main load torsion bar in illustration). A torsion bar serves the same purpose as a coil or leaf spring but is able to do a far more effective job of endowing increased comfort and handling stability in an automobile.

AUTOMOTIVE TORSION SUSPENSION

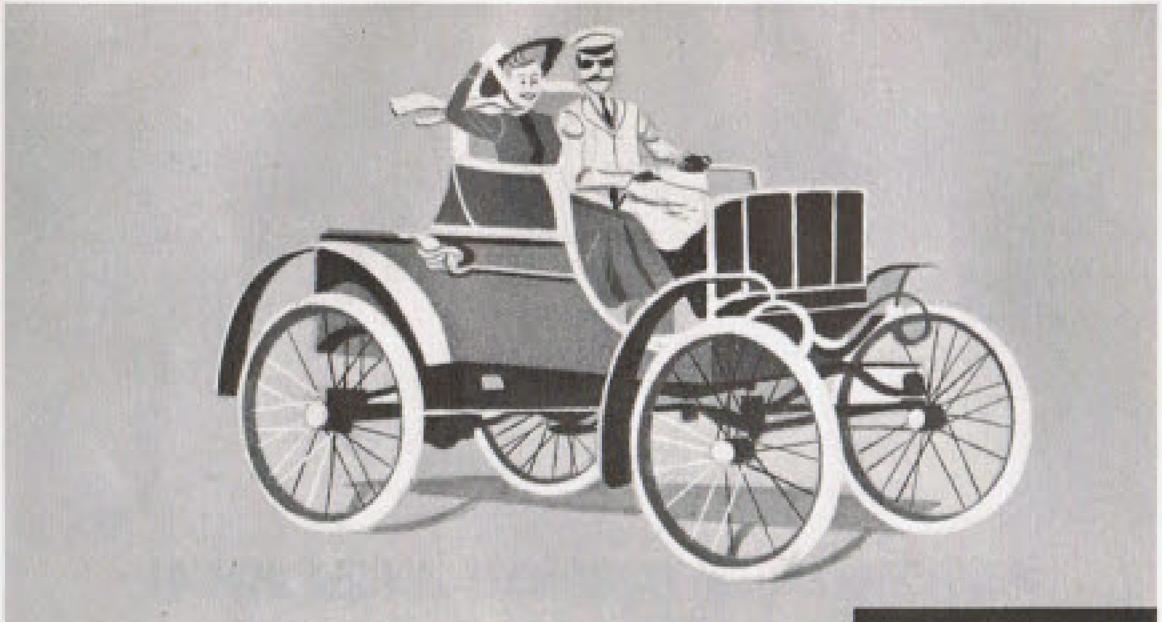
The year 1955 stands as one of the major milestones in the dramatic history of the development of the automobile in America.

Many times through the first 50 years of its existence, the automobile has achieved stages of refinement at which many people have said "this must be the ultimate—here is a particular part of the automobile that has reached its fullest improvement."

But this industry's trail of progress has never ended. Out of the great laboratories of the pioneer auto producers at historic intervals have come startling mechanical innovations that have moved the American motor car onward and upward toward greater efficiency, durability, beauty and comfort.

The New Torsion Bar Suspension

The newest advancement is bringing a whole new concept in automobile comfort and efficiency, with the introduction this year of a revolutionary suspension system which eliminates the customary coil springs in front and the semi-elliptic leaf springs at the rear of the car. Development of this torsion bar suspension by one of the big-car producers marks the first radical improvement in riding quality and ride control since the general introduction of the so-called knee-action front coil spring suspension which swept the industry beginning in 1934.



THE FIRST HORSELESS CARRIAGES used stiffened buggy springs, but even at the low road speeds which were then considered top performance, the passengers were jounced and jostled about in a most rugged manner.

Fifty Years of Evolution

The automobile "ride" has evolved from the customer's desire for added comfort, better control, and safe transportation. The development of the "ride" has shown a willingness by the public to sacrifice control for comfort. Each year, as the softer ride developed, the engineers have been forced to make a compromise with stability and safety.

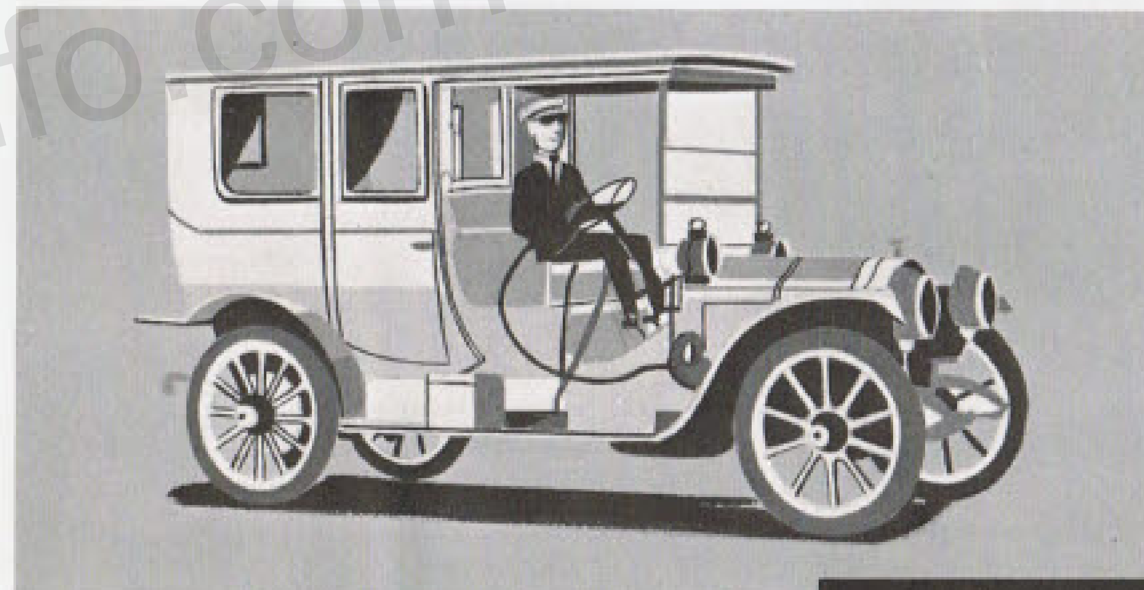
The first half-century of automobile progress was most concerned with improving the softness of car riding qualities. As springs grew softer and more flexible, it grew more difficult to control the stability of the car on rough roads and turns. Not until the 1930s did automobile builders make an industry effort to regain control of the ride. With each advance toward control, the industry came one step nearer its ultimate objective—safety for the passenger.

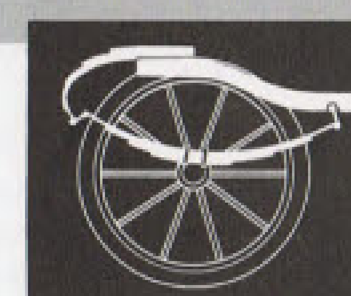
Automobile suspensions are the most important part of the car's system contributing to the ride of the car. The automotive suspension is made up of three functional ele-

ments: (1) structural design that positions the wheels front and rear. The structure attachments consisting of the radius rods, stabilizers, linkages, supports, brackets, bushings, etc., which contribute to stability, steering, and vehicle control; (2) the elastic part of the suspension that furnishes the softness of the ride, with the accompanying shackles, brackets, bushings, etc., to give cushioning; (3) the dampening of the elastic system to give proper control with shock absorbers, yokes, pins, etc. The proper combination of these three elements—structure, elasticity, and control provides the safest, most comfortable, efficient automobile that engineers so long have sought to design.

The First Springs

The infant automobile—the horseless carriage of the 1890s—used stiffened buggy springs to cushion the ride. The first motor vehicles were supported on their axles by leaf springs to cushion road shocks. A 1901 model introduced the first steering wheel and rigid steering column in place





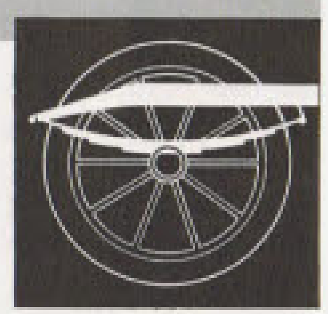
IN THE 1910 ERA the three-quarter and one-half elliptical type springs were favorites. These required a torque member to absorb thrusts from power and brake. They were an improvement, but body and frame were still subjected to wracking forces.

of the tiller or lever-steering—the first step toward control of the automobile and a safer ride. In 1903 the engine was moved under the hood at the front end of the car for better weight distribution, which improved both the ride ease and driving control.

Leaf Springs

Leaf springs were being used on horse carriages and railway cars as well as the automobile in the 1900s to cushion the ride. The three-quarter and one-half elliptical-type of leaf spring was popular. A 1906 model introduced semi-elliptical springs to replace the buggy platform type for ride improvements and one year later the wheelbase was increased to 123-1/2'' to provide more passenger room and improve the driving directional stabilty.

In the 1920s the longitudinal, semi-elliptical-type of leaf spring gained favor, which resulted in improved spring action with much less vertical travel, but the ride was still rough and rugged compared to today's. Semi-elliptical springs were still used on practically all cars in 1932. Only

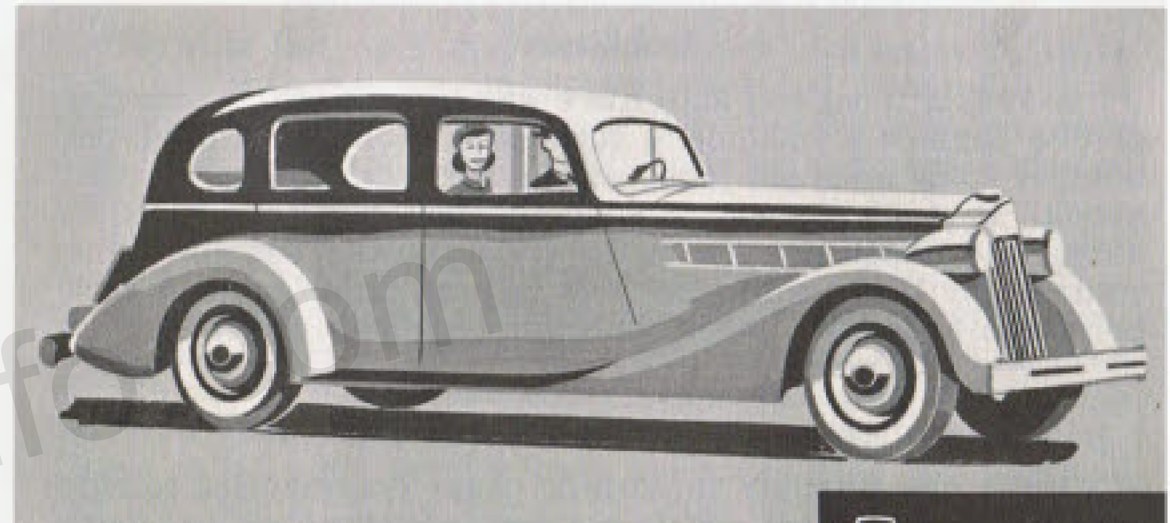


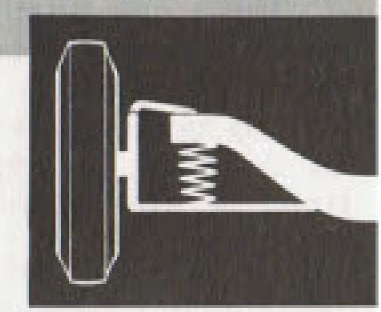
THE TWENTIES FOUND the longitudinal, semi-elliptical type of leaf spring gaining in favor. This resulted in improved spring action with much less vertical travel, but the ride was still far from smooth.

a very few models had introduced transverse springs at the front and double quarter-elliptical springs at the rear.

Coil Springs

Coil springs followed leaf springs relatively early in limited use. The 1908 Brush Runabout used the first American application of 4 coil springs working in tension. Coil springs working in compression were introduced when independent front springing was adopted and rigid front axles were eliminated during the early 1930s.





IN THE THIRTIES, "knee action" provided independent front wheel action. The first departure from the solid axle, it brought coil springing into extensive use for the first time . . . a better ride, but a long way from perfect.

Independent Springing and the Use of Rubber

The first independent suspension system was introduced in the industry in 1934. A "knee action" type springing provided independent front wheel action. This was the first departure from the solid axle. In 1935 independent suspension with rubber bearings in both lower and upper arms pioneered the use of rubber at this point in American cars. The superiority of this front end suspension and the ability of the system to use lower spring rates, as well as to prevent metal-to-metal contact by the use of rubber, was the basis of the improved automobile ride as it has generally been known.

Shock Absorbers

Shock absorbers became standard equipment in 1910. In the late 1920s a lever was put on the dash panel to adjust shock absorbers for smooth and rough roads. In 1939 a fifth shock absorber was added for control of lateral vibration and roll bars were used to prevent leaning on curves.

Stabilizers

In 1932 a front end stabilizer was introduced, consisting of two harmonic balancers located at each end of the front bumper to dampen out front end disturbances caused by road shock. In 1935 a rear ride stabilizer was introduced to assist the shock absorbers in giving better control of the vehicle. In 1937 came the first lateral stabilizer and 1939 brought a hydraulic shock absorber type stabilizer.

Tires

Tires are another important phase contributing to ride qualities. In 1932 balloon tires superseded the high-pressure tire while greatly improving the ride. Low pressure tires caused harder steering and other problems that necessitated an industry standard of increased air pressure. Balloon tires became standard equipment in 1925; the tubeless tire in 1954.

Ride Research

The introduction of coil springs for rear suspension in 1938 accelerated a research program aimed at the study of better riding qualities. Ride tests concluded: (1) "oscillations per minute" (frequency) are basically the controlling factor in riding comfort; (2) that actual oscillations per minute are closely proportional to the oscillation frequency calculated from static deflection on the car; (3) that roll tendency, bottoming, and general stability are governed by the springing; (4) that pitching could be reduced if oscillation frequencies were equal at front and rear; and (5) that without

a rear passenger load, the driving discomfort increased if oscillation of rear springs increased. The first approach to a better ride lay in designing a better type spring that would vary itself to the load.

A "boulevard ride" can be obtained in most cars on any modern boulevard, but the problem is to obtain the soft, easy "boulevard ride" out on a country road full of ruts and holes, or at high speeds around a long curve. This has not been possible with conventional suspensions.

First Use of Full Length Torsion Bars

Torsion bar springing is not a new idea as such. Up to now, however, torsion bars have replaced either the front springs or the rear springs. But in all instances, each wheel has been controlled individually by a separate torsion bar.

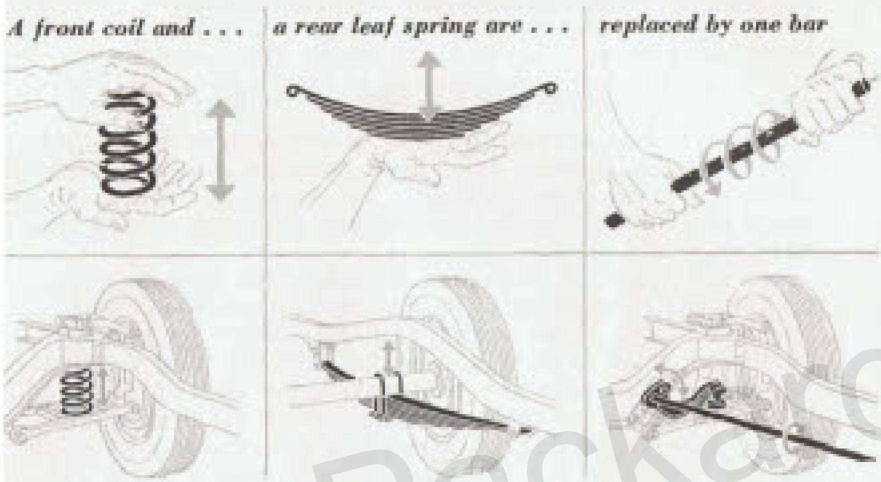
In the light of European practice, the new American torsion bar suspension system is revolutionary in that it is the first design in the world to use full-length torsion bars, employing them in such fashion that both the front and rear wheels on each side are connected to the ends of the same bar, thus receiving their "loading" from the same spring. These full-length torsion bars are about nine feet long and run the length of the car from front to rear on each side.

Similarities With Conventional Springing

Torsion bar springing doubtless is a strange device to most people. Simply stated, it is a method of using a long solid bar of steel as a spring. It serves the same purpose as the familiar coil spring or leaf spring but does the job far better and more effectively.

The term "torsion" means "twisting." The steel bar behaves like a spring when it is twisted at one end or the other and applied to the wheels and body of the car. As a spring, the bar twists a given amount depending upon the character of the road surface, then unwinds in a controlled manner and returns to its original position. In this respect, its behavior is similar to a coil or leaf spring which deflects or depresses on application of a load, then returns to its original position.

Made of special steel and given special treatment during the manufacturing process, this bar not only behaves like a spring but retains its softness and flexibility for life. In this respect it is superior to the conventional springs and can be designed to give a softer, more relaxed, and better controlled ride.



Key Differences From Conventional Springing

Conventional springing has changed but little during the postwar years, having reached a point of development which most engineers consider to be near "the end of the line." Springs have been made softer to give a smoother ride with increasingly heavier cars. But as springs are made softer and cars get heavier, the springs become overloaded; there is a tendency under heavier shocks for them to "bottom," meaning actually to bump against the rear axle. Also, the car rides too high when lightly loaded and drops too low when heavily loaded. In addition to discomfort on rough roads, these conditions make for poor handling and instability at higher speeds. There is often a feeling of insecurity when traveling at these higher speeds—just when one wants a feeling of greater security.

The management of one U.S. motor car company became convinced more than two years ago that the car of today must have the following:

1. A flat, level ride.
2. Adequate load-carrying capacity without danger of bottoming.
3. A minimum change in car height regardless of how the car is loaded.
4. An improved "boulevard" ride which, at the same time, gives greater stability at high speeds.

Since conventional suspension could not give these results, a radically new type of suspension was indicated. The answer was found in full length torsion bar springing.

How it Works

Let's consider the new system more in detail. Here we have a long steel bar on each side of the chassis frame, running from the extreme front end to the rear. Substantial forged steel arms are attached at both ends to transmit rotary motion of the arms into a twisting action of the steel bar. At the front end, the arm extends outward toward the front wheel; at the rear, the arm extends inwardly toward its point of attachment to the rear axle. Thus if the front wheel tends to move up, the resulting twist in the shaft causes the arm at the rear end to move in the opposite direction, causing the loading on the rear axle to be downward. This is one of the major advantages of the new system. By this means the twisting of the shaft or spring is confined within the bar and is not transmitted into the frame in the form of shock to the occupants of the car.

The rear axle is connected to the frame of the car through two driving torque arms; and is maintained in proper transverse location by means of two specially designed stabilizers, permitting true vertical movement of the body without transmitting lateral wheel shocks to the frame.

The mechanisms described here will assure a soft ride as well as stability on the road. However, the car would ride level for only one kind of load and would have problems caused by changes in the height of the body unless something were added to compensate for load variance.

The "Load Levelizer"

The answer is the "car levelizer" or "compensator" whose function it is to hold the car's body height on even keel regardless of passenger and luggage loads. This is an amazingly new feature, one that cannot be achieved by conventional methods of springing.

The compensator consists of two additional torsion bars, about half the length of the main bars, arranged at the rear. The rear ends of these bars are attached to the rear torsion arms, mentioned earlier, while the forward ends terminate in lever arms pointing downward. The outer ends of these arms then are connected by links to an actuator lever and gear box located in the center of the chassis. The gear box, in turn, is operated by a special two-way actuator electric motor which operates from a control mechanism to increase or decrease automatically the loading of the compensator bars, depending upon the changes in weight of the loading in the car.

The control mechanism consists of a switch located near the actuator motor, connected to a lever attached to the main torsion bar on the left side of the car. To prevent the switch from acting every time the car goes over a bump as well as to prevent it from acting when brakes are applied, it is provided with suitable "time tag" controls.

The Levelizer in Operation

Normally, when there is equal loading front and rear, the center portion of the long torsion spring shows little if any rotation and there is no action of the compensator. Suppose now that loading at the rear is increased. This causes the center section of the left spring to twist, thus rotating the lever connected to the control switch. At this instant the control switch makes contact, operates the actuator motor sufficiently to increase the loading on both compensator bars. This, in turn, raises the rear end of the car, making it level with the front end.

Suppose now that the rear end is lightened by passengers getting out. This time the center section of the main spring tends to twist in the opposite direction. Again the compensator switch is actuated, this time causing the actuator motor to run in reverse direction, reducing the loading on the

compensator torsion bars proportionately. This lowers the rear end level with the front.

Although it is necessary to itemize these steps graphically to provide an understanding of what happens, it must be appreciated that the mechanism senses them automatically and adjusts so smoothly as to be imperceptible to the occupants of the car.

Level Ride Has Many Benefits

The compensator action described above has been described as a means of keeping the car on level keel at all times. But that is an oversimplification of results. Since the car is held constantly level, the front suspension remains unaffected. Consequently, the position of the headlamps remains unchanged and the headlamp beam remains steady. Hence for the first time in history a motor car has achieved what had been considered virtually impossible—precision aiming of headlamps, with a steady beam on the road while driving at night. Besides giving best seeing conditions on the highway, it practically eliminates the blinding glare that results when headlamps weave up and down against oncoming cars.

Another advantage is that bottoming on the rear axle is automatically eliminated since the compensator bars take care of load changes as they occur. This is something that no conventional system can possibly provide.

In addition, there is better rear wheel traction—bite on the road—on acceleration, hence less slippage of tires on the getaway. This comes from the fact that the rear-end torque arms press heavier on the rear axle, "loading" the tires additionally. It is sometimes the practice of owners of conventional spring cars to load the trunk with cast iron or sand bags to get a somewhat similar effect.

How the System is Mounted

The front arm of the system, attached to the long torsion spring, is pivoted on anti-friction bearings mounted on the frame front cross member and connected by an anti-friction link to the front suspension lower support. The rear end of the torsion spring similarly is pivoted on anti-friction bearings in a bracket on the frame side rail, and is connected by means of an anti-friction link to the rear axle torque arm.

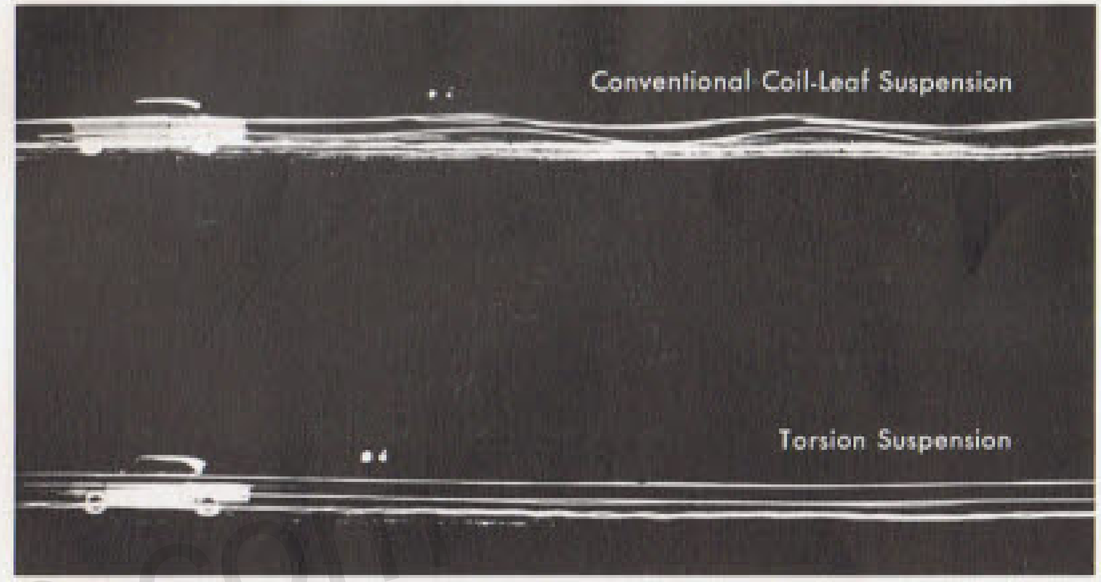
The two torque arms, mentioned earlier, are attached to the frame at the forward end by means of cored rubber bushings. They are additionally insulated by rubber at points of attachment to the rear axle housing to allow for free vertical movement of the housing without transmitting noise or shock into the frame. This design arrangement is noteworthy since it provides for better wheel traction during acceleration.

Finally, the entire suspension system is suitably balanced and given control by means of specially calibrated shock absorbers.

Ingenuity — Lifeblood of a Growing Economy

The thousands of persons who already have ridden in cars with torsion suspension, including professional engineers and experts of the automotive press as well as the general public, have been utterly amazed by the difference in riding. They are almost unable to believe the practically perfect smoothness of the ride as the car sails over rough terrain. They are fascinated when, after three persons enter the rear seat, they see the rear of the car return to its original elevation after the first impact has reached the levelizer. As they ride, the torsion springs are eliminating the effects of humps and bumps in the roads, and the all-important levelizer is keeping the car at a constant level regardless of changes in load.

Once again the ingenuity of American industrial management and engineering has solved a complex problem for the purpose of making a better, more appealing product, which in turn will increase sales and production volume and thus add new impetus to the growth of the American economy and the enrichment of the American way of life.



In a demonstration of torsion suspension on riding qualities of cars at the Packard proving ground, two cars went over the same W-shaped bump and dip pattern at 35 miles per hour. A bulb mounted on the wheel gives the lower light trace and a second bulb mounted on the fender shows the behavior of the body on each car. Upper car has a conventional coil and leaf spring system of suspension. The lower car is equipped with torsion suspension. Besides the smoother ride, one obvious advantage at night is precision aiming of the headlights on the road ahead since the car body remains level over the bumps.