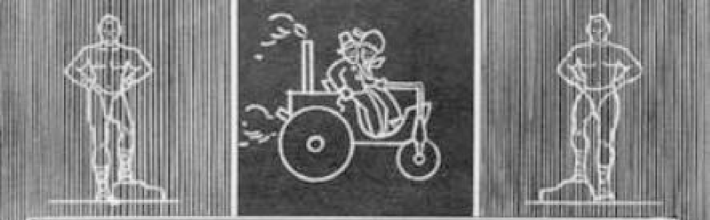
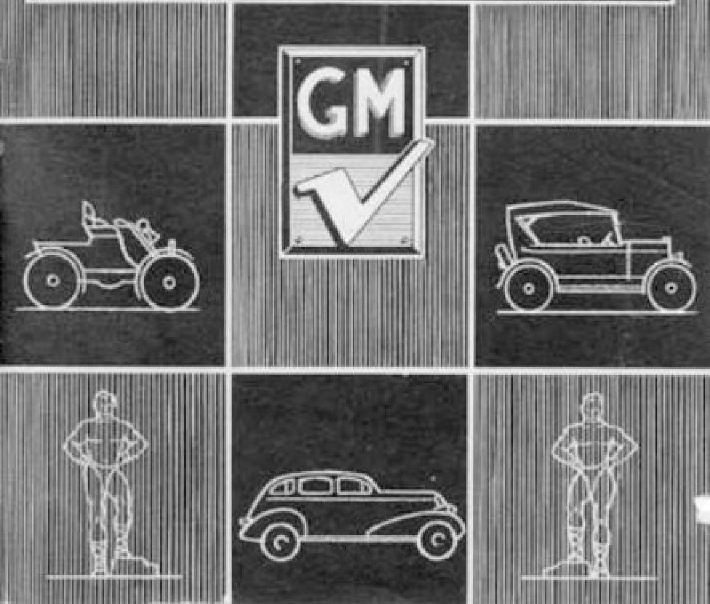


THE STORY OF KNEE ACTION

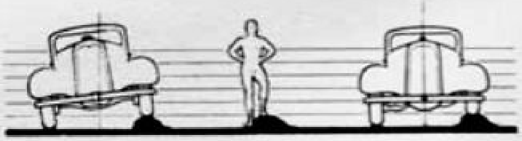


GM
CUSTOMER RESEARCH

"THE STORY OF KNEE-ACTION"

Its engineering aspects, its practical significance and its historical background.

This booklet has been prepared for people who want more information than is usually available in advertising literature.



"AN EYE TO THE FUTURE— AN EAR TO THE GROUND."

Through its Customer Research activity, General Motors has organized what amounts to a vast Public Advisory Committee consisting of hundreds of thousands of practical motorists—owners of all makes of cars who are cooperating with General Motors Customer Research Staff—pooling their practical experience with the technical skill of General Motors engineers and giving us the benefit of their views on new features of design.

Through continuous correspondence with this great body, we are better able to give you *what* you want *when* you want it—not only with reference to features of design and characteristics of performance—but as regards the *kind of information* that you feel you should have in order to choose your new car more intelligently.

This booklet is published because you have told us that you would like to have more detailed facts concerning "Knee-Action". It was prepared by General Motors Customer Research Staff in collaboration with General Motors engineers but *the motoring public has dictated the points that should be covered.*

We thank you for your interest and cooperation and we hope that this book—"tailored to your order," will prove helpful in enabling you to better appraise this new thing called "Knee-Action" when it comes to selecting your next car.

DEFINITION OF "KNEE-ACTION"

"Knee-Action" is the name of a highly developed type of independent front wheel mounting which is used on General Motors cars.

With "Knee-Action" the front wheels are fastened to the car in such a way that they are free to move up and down independently of each other in *fixed paths*.

In the construction commonly used up to 1934, stiff, short-travel leaf springs were employed and the front wheels *were not mounted independently*. They were rigidly connected by an axle supported underneath the springs. So when one wheel hit a bump the shock was transmitted to the other wheel.

With the "Knee-Action" design as worked out by General Motors, it is possible to use long-travel, soft-acting coil springs, with a resilience matched up to harmonize with the rear springs.

* * * *

This is only a small part of the story and before going further it seems appropriate to quote the *broad objectives as laid down by General Motors engineers when, some years ago, they began their basic studies of front wheel suspension:*

"1. BRAKING CONTROL—With increasing speeds and increasing braking power, it becomes increasingly essential to design a mechanism for holding the front wheels on to the car which will allow the car to be pulled up to a stop *without disturbing the steering and without disturbing the stability of the car in holding to its course.*"

"2. SOFT FRONT SPRINGS—In order to eliminate pitching and tossing in the rear seat, the design should allow the front spring rate to be *the same as the rate of the rear springs relative to the load carried at each end.*"

"3. RIGIDITY—In order to make the car stable and safe, the construction must be rigid enough to give the car *stability on the road when rounding curves at high speeds, or braking suddenly.*"

"4. TIRE WEAR—Should be reduced to a minimum."

"5. 'KNEE-ACTION'—The suspension should allow one wheel to pass over a bump *without affecting the opposite wheel*—this is not only necessary to protect the passengers from unpleasant jolting, but to facilitate steering and *protect vital parts of the chassis from twists and strains.*"

"6. WHEEL ALIGNMENT—It must assure that the wheels be held in *proper alignment at all times and under all conditions, so that steering will be easy and long tire life insured.*"

"7. STEERING—Road shocks should not be allowed to reach the steering wheel. Such erratic wheel movements as 'shimmy' and 'tramp' should be eliminated."

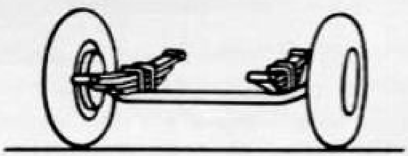
"8. SPRINGING DIVORCED FROM STEERING —The springs should *not have to act as structural members.* Their sole duty should be to spring the weight of the car."

"9. UNSPRUNG WEIGHT—Should be reduced to a minimum."

"10. RUGGEDNESS—The whole front-end suspension should be *strong, durable, dependable and SAFE.*"

Now then, with these requirements of a good front-end suspension in mind, let us next review some of the types of suspension that have been developed.

First, of course, there is the *CONVENTIONAL AXLE SUSPENSION* with two leaf springs running parallel with the frame. From the front it looks something like this:



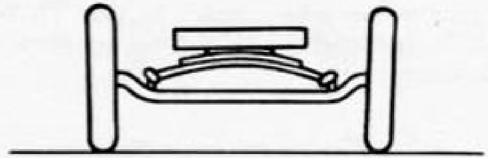
Elsewhere the limitations of this type will be dealt with pretty thoroughly, but let's just set them down here for clarity's sake.

For one thing, it is scarcely practical, with this type construction, to make the rate of the front springs equal the rate of the rear springs (unless the rear springs are very stiff indeed)—and since they have to be made stiffer in the front the result is a pitching and bucking ride for rear seat passengers.

Then, too, any motion of one wheel is transmitted to the other wheel through the rigid axle. Thus, when the car goes over a bump, the body tips and jolts. It is hard to keep the road shocks from being transmitted to the steering wheel, making driving more tiring than it ought to be.

Lastly, the springs serve as structural members and hold the axle in place under the car, and this interferes with their ability to be good springs.

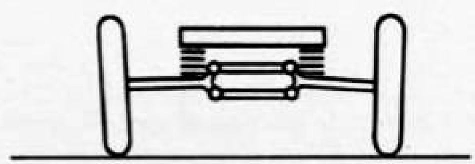
Another type, very much like the first one, is the conventional axle with a *TRANSVERSE LEAF SPRING*:



Since the rigid axle still connects the wheels together, it is clear that any force affecting one wheel will affect the other as well—hence this system does not give the advantages of independent suspension. It is subject to limitations similar to those mentioned above and, in addition, with only one spring it has to be made even stiffer to avoid breakage—and this makes it ride pretty hard. Furthermore the exposed position of the spring, with its entire length stretched across the car, allows mud and dirt to work in between the leaves, causing squeaks and irregular spring action.

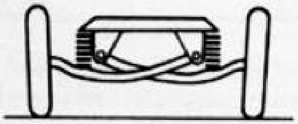
* * * *

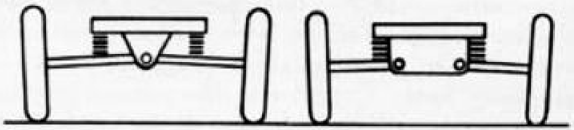
A *semi-independent* suspension is the *ARTICULATED AXLE TYPE*, which is really nothing but a conventional axle suspension, only with the center part of the axle cut out and the ends joined together by two parallel links, one above the other, hinged at the ends.



The old-fashioned leaf spring is used, in spite of its friction and its squeaking. Since the wheels in going over bumps in the road move in and out relative to the frame of the car, accurate steering is almost impossible.

This type is somewhat similar to the *"HINGED AXLE"* construction of which there are three main classifications.





While there is practically no change in caster* with these types, you do get a lot of variation in the camber† of the wheel and these designs introduce difficulties from the standpoint of steering control. About the only way to get away from this is to make the springs very stiff, and then, of course, you get a hard riding car.

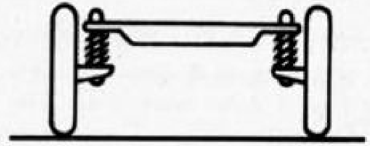
* * * *

Next we have the *"SLIDING SPINDLE"* or *"SLIDING KINGPIN"*. In this type, the axle, or anything closely resembling it, has disappeared. Clearly, the

*Caster: The angle that the kingpins are tilted backward.

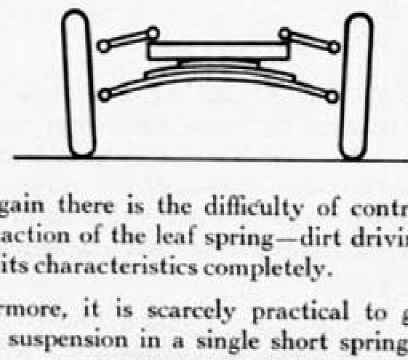
†Camber: The angle that the front wheels are tilted outward at the top.

wheels move independently of each other, for there is nothing to hook them together.



With this design, the vertical columns act as kingpins, spring guides and shock absorbers. Most of these types have a very poor steering geometry. Another big difficulty is that dirt gets into the slides, causing wear and friction, and the oil is difficult to retain in the column. Steering at slow speeds is very stiff due to the overhang of the wheel from the kingpin.

Another system that has been used frequently in Europe combines a transverse leaf spring at the bottom with parallel links on top. It looks something like this:



Here again there is the difficulty of controlling the flexing action of the leaf spring—dirt driving in may change its characteristics completely.

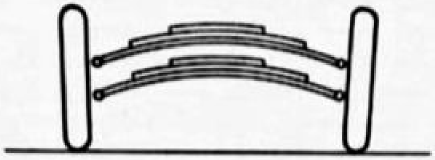
Furthermore, it is scarcely practical to get a soft enough suspension in a single short spring.

Another thing, the spring is called upon to act as a structural unit in holding the wheels in place, as well as taking up some of the driving and braking forces—

and all this takes away from its ability to do a good job of springing.

* * * *

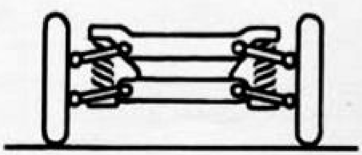
The *DOUBLE TRANSVERSE SPRING* type is one of the very earliest designs worked out over in Europe—in fact it dates back before the invention of the gasoline automobile. The spindles carrying the wheels are mounted at the very ends of flexible leaf springs, as shown in the sketch below:



The average American car weighs too much to use this type of suspension unless the springs are made so stiff that the automobile would ride like an old-time Army truck. Here again, the springs are acting as structural units—doing two jobs at once—which does not make for safety.

* * * *

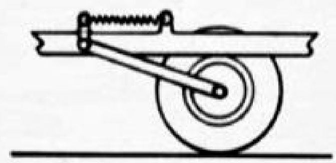
The *"EQUAL PARALLEL LINKS"* type uses a coil spring between the frame and one of the links, for example, the lower link, which gets away from all the disadvantages of the old leaf spring. This type is especially suited for heavy cars as it is possible to design a sturdy structure that is light in weight.



However, when the upper and lower arms are the *same length,* conditions are not quite at their best either for stability on corners, or for ease of steering.

In passing, it should be pointed out that this type, while it may closely resemble the "Wishbone" type used on the Oldsmobile, Buick, La Salle and Cadillac, is not really the same. General Motors perfected a variation of this link system in which the lower arm is considerably longer than the upper, resulting in the elimination of the disadvantages found when the arms are the same length.

The *"LONGITUDINAL LEVER"* method has found some supporters in Europe, but it really is not very satisfactory in terms of the standards to which the American motorist has become accustomed.



Application of the brakes will cause the car to "squat" suddenly or else nose up, depending on which way the arm is placed—ahead of or behind the wheel. The caster angle changes over a wide range, which makes for instability and improper steering. When the arm is lengthened to reduce the change in caster angle this system lacks rigidity against side thrusts.

The foregoing gives you some idea of the great variety of methods for springing the front wheels.

If we added the variations and combinations of these and other types described in the files of General Motors Research engineers the list would be prolonged indefinitely.

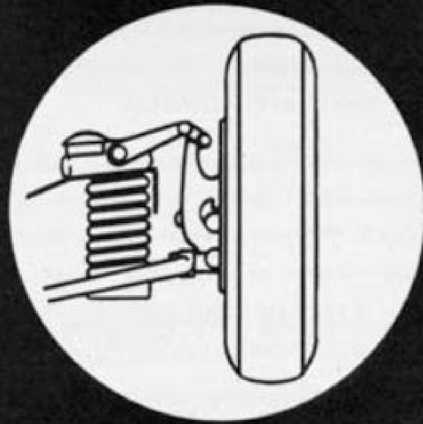
But it does not seem necessary to go any further in analyzing and appraising the various types of mountings that were studied by our engineers incident to the years of research that preceded the development of the types finally adopted on General Motors cars.

As a result of these studies and tests, General Motors engineers came to the conclusion that out of all the various methods that had been devised, there were at least two types that met ALL of the requirements equally well: The "Wishbone" type which is used on Cadillac, La Salle, Buick, and Oldsmobile*—
—and—the Dubonnet type which is used on Chevrolet and Pontiac.*

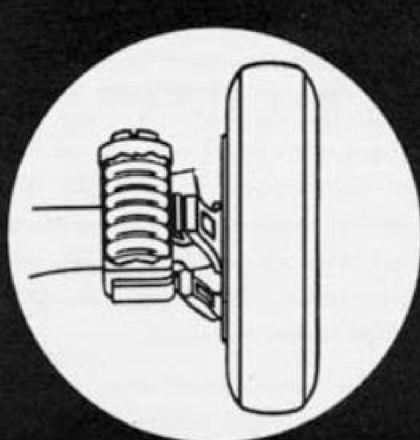
Since the design and operation of both these types are covered in great detail in literature issued by the Divisions of General Motors, such descriptive matter is omitted here except to say that both designs accomplish the engineering objectives outlined back on pages 2 and 3.

---

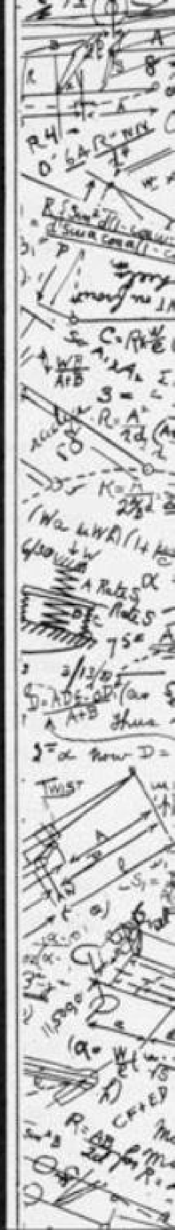
*Division Booklets showing the application of "Knee-Action" to any of these products will be mailed on request.



Wishbone Type



Dubonnet Type



"There is only one person qualified to say just what the motorist prefers and that person is

THE MOTORIST HIMSELF"

"Knee-Action" was first announced to the public late in 1933. Since that time, General Motors, through its Customer Research Staff, has invited more than a million motorists—drivers of all makes of cars—to give us the benefit of their reactions to this innovation in chassis design.

The results of this investigation—nation-wide in its scope—conducted among the owners of all makes of cars show that the majority of motorists accept this innovation without question; most of the remaining motorists are quite open-minded as to its advantages; while less than one-fifth retain any doubt as to the advantages of this new system of springing.

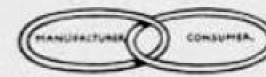
These doubts were usually expressed in the form of specific questions.

In the following pages are listed some of the more common queries—with answers based on the wide technical and practical experience of General Motors engineers—the very men who since 1930 have been working on "Knee-Action", improving and perfecting it for your greater safety and comfort.

Perhaps you have wondered about some of these points yourself. If so, you will be interested in the straight-forward, to-the-point replies given in the following pages.

100 YEARS AGO

Under the conditions of the one man shop, with the head of the business serving as designer, manufacturer, purchasing agent, salesman, and service expert, an intimate understanding of customer tastes and desires was automatically assured.



MODERN INDUSTRY

By the very nature of things, the bigger an institution grows, the wider becomes the gap between the customer and those responsible for directing the destiny of the institution.

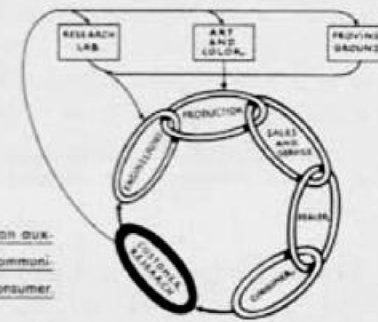
With producer and consumer so widely separated it becomes increasingly difficult to keep the business sensitively attuned to the requirements of the customer.

GENERAL MOTORS

There is a need for some kind of liaison which would serve as a substitute for the close personal contact which existed automatically back in the days of the small shop.

CUSTOMER RESEARCH

—fills this need by providing an auxiliary and more direct line of communication between producer and consumer.



"Why have two types?"

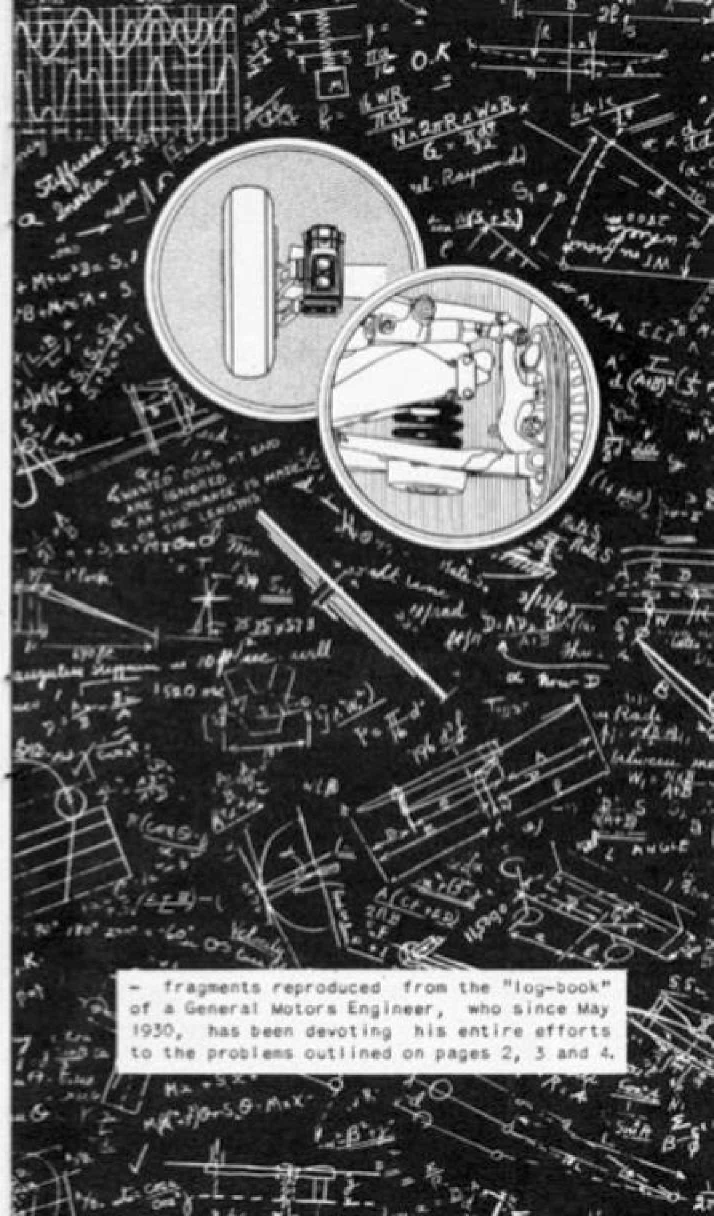
An eminent engineer once said—

> "In engineering, there is seldom just one way and only ONE way to accomplish a given result —nor is there just one BEST way. Generally speaking, I would say that there are about a thousand ways of designing any mechanical device. A dozen of them may be worth developing on the drawing board. A half dozen may be worth building experimentally—4 or 5 may work out satisfactorily in practical usage. And of this 4 or 5 there are likely to be 2 or 3 designs where it is a toss-up as to which is the best."

Automotive design confirms this broad statement. Take, for example, the many different types of automobile engines—sixes, straight eights, "V" eights, twelves and sixteens—or the various kinds of carburetors used. Rear axles have been part of the motor car for forty years, yet several different types are in common use today.

The same thing is true of the front suspension. As we have seen, there are a great many different ways in which the front springs can be arranged. You can use one spring or sixteen, you can use coil springs or leaf springs—you can have a whole axle, half an axle or no axle at all. And then you can combine these in a lot of different ways. Most of them will work—some will work better than others but *probably only two or three will be completely satisfactory from every standpoint.*

At one stage or another in the development of "Knee-Action" suspension, practically every known method of springing the front end was investigated and tested, as well as several that were not known up



— fragments reproduced from the "log-book" of a General Motors Engineer, who since May 1930, has been devoting his entire efforts to the problems outlined on pages 2, 3 and 4.

until that time. By careful study and comparisons of results, it was soon apparent that most of these different methods were unsatisfactory for one reason or another, and the developments finally centered around the two types mentioned above.

Although these types are different in appearance, THE RESULTS ARE THE SAME—the same gliding ride is found in whatever General Motors "Knee-Action" car you may drive.

"But since cars already rode better in the front seat than in the rear seat, wouldn't it have been more appropriate and timely to improve the rear springs instead of the front springs?"

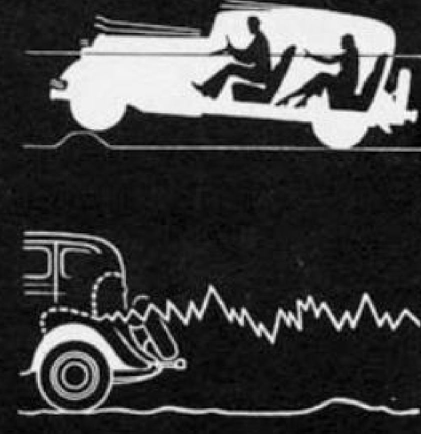
No, because surprising as it may seem, the pitching and jolting of the back seat passengers was not the fault of the rear springing system at all—it was due to the stiffness of the front springs. In other words, it had always been possible to make the rear springs soft enough but the full benefits of such softness could not be gained so long as the car had a stiff front-end.

To put it briefly, THE FRONT SPRINGS WERE OUT OF HARMONY WITH THE REAR SPRINGS.

"—But is 'Knee-Action' necessary with so many good roads?"

Although roads have been greatly improved, the cruising speed of cars has been greatly increased. Higher speeds of travel magnify the seams, waves and dips that are so characteristic of our improved highways.

America is criss-crossed in every direction by paved highways, highways that look just about as smooth as anyone could expect. But they really *are not smooth*



The Old Way

The New Way

at all—even the most modern are full of waves and dips, imperceptible to the eye, that cause the bobbing, pitching motion in the axle-type car.

As the speed of the vehicle increases, the long, slow waves which are typical of American highways, disturb the car more and more, and it is doubtful if this problem in road building will ever be solved, for it is caused by our climate and our wide temperature variations.

You see, above thirty miles an hour, a bump in the road that is *three inches high and thirty feet long* will disturb a car much more than a bump *three inches high and three feet long*, although the second is clearly visible as a "bump", whereas, the first is almost invisible. "Knee-Action" compensates for such irregularities and gives you much of the feeling of a boat in a following sea—a gliding, floating sensation.

And in addition to the foregoing, it opens up those inviting country roads—the traffic-free by-ways off the highways—that you have always wanted to explore.

A user of "Knee-Action" wrote:

> "What you have really done is to add about 50,000 miles to the American highways."

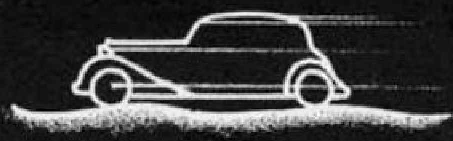
—an exaggerated statement but not without a point.

"Aside from riding comfort are there any other advantages in having 'Knee-Action'?"

Decidedly YES.

Smoother riding makes smoother, easier steering. Road shocks can no longer get through to the steering wheel—and a greatly improved steering linkage is made possible through the new construction. The

"Modern highways are full of waves and dips."



"At modern speeds a long wave becomes a bump."

"—by-ways off the highways."

danger of accidents from blow-outs is minimized. Your car is decidedly SAFER. A more scientific distribution of weight has been attained and unsprung weight has been reduced which, within itself, makes for smoother operation.

AND THIS NEW CONSTRUCTION IS DESTINED TO HAVE A TELLING EFFECT ON ECONOMY BY SLOWING DOWN THE RATE OF DEPRECIATION AND REDUCING REPAIR BILLS BECAUSE IT PROTECTS THE VITAL UNITS OF THE CHASSIS FROM UNDUE STRESS, STRAIN AND VIBRATION.

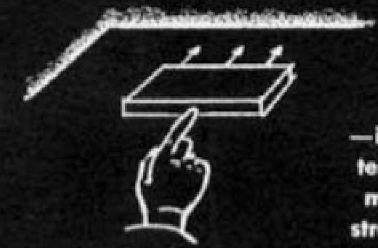
"Just what is meant by the 'More Scientific Distribution of Mass'?"

This question raises some involved engineering problems and frankly we, of the Customer Research Staff, have had difficulty in understanding the scientific explanations of it. Expressed in simple every-day language it seems that the riding qualities and stability of a car at higher speeds, as well as its stability in keeping its course, are dependent on the way the weight of the car is distributed over the length of the wheelbase (although the engineers use the word "*mass*" instead of "*weight*" and from a scientific standpoint, it seems that there is an important distinction).

One of our engineers, in attempting to explain it, used the example shown on the opposite page which we thought was worth passing along because it seems to convey the general idea without getting into a lot of mathematical theory.

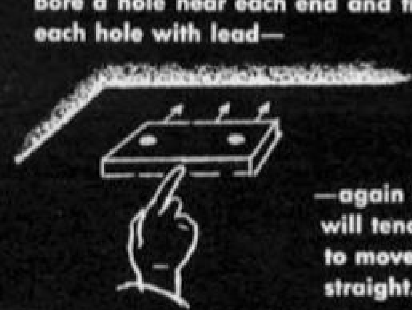
"Knee-Action" construction makes it possible to get a more scientific distribution of weight—or rather *mass*.

Take a block of wood and shove it across a perfectly smooth surface—



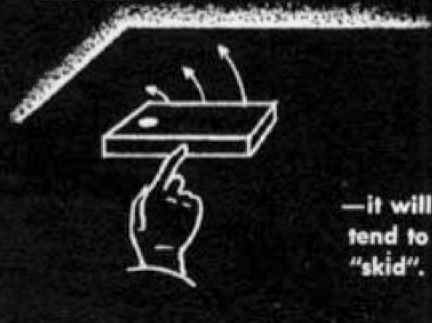
—it will tend to move straight.

Bore a hole near each end and fill each hole with lead—

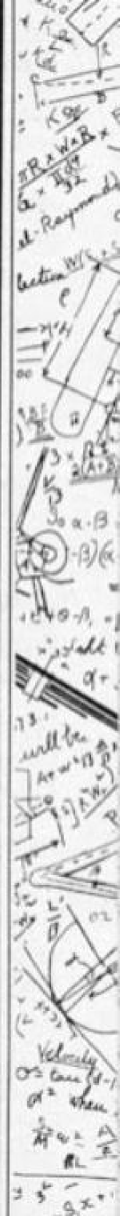


—again it will tend to move straight.

—but put the plug of lead in only one end—



—it will tend to "skid".

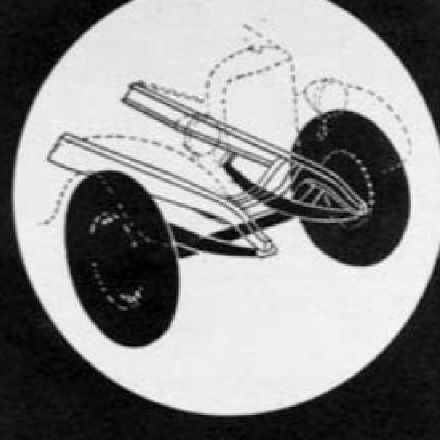


"Is it true that the front axle has been eliminated?"

Technically speaking "yes," which is to say the I-beam connecting the centers of the two front wheels is no longer present but just above the place where the axle used to be there has been added a strong and rigid cross-member at the front of the frame.

If we look upon the ordinary front axle as a brace supporting the springs and holding the wheels in position—then we might say that in General Motors "Knee-Action" construction this brace has been moved up and made a part of the frame with the springs mounted *underneath it* instead of *on it.*

This new approach to chassis construction has made it possible to reduce unsprung weight.



CONVENTIONAL CAR
With unsprung weight shown in black.

"Just what is meant by the unsprung weight?"

Engineers talk a lot about "*sprung weight*" and "*unsprung weight.*"

"*Sprung weight*" is the total weight of all the parts of a car which are supported by the chassis springs. For example, the body, the engine, the transmission are among the items that go to make up the "sprung weight" of a car.

The "*unsprung weight*" is the weight of all the items that are *not* supported by the springs. For example, axles and wheels are items that contribute to the "unsprung weight" of a car.

"*Unsprung weight*" takes the direct force of bumps in the highway without the cushioning effect of the chassis springs. You can take two cars, each weighing the same and the same in every other respect except that one of them has more of its weight

"KNEE-ACTION" CAR
With unsprung weight shown in black.

unsprung—THE ONE WITH THE GREATER UNSPRUNG WEIGHT WILL RIDE HARDER AND BE MUCH ROUGHER IN OPERATION THAN THE OTHER ONE WHICH HAS THE LESSER UNSPRUNG WEIGHT.

Now, in the old leaf spring suspension, there was a rather heavy axle along with the wheels, tires, brakes and so forth—all of which went to make up what is called "unsprung weight," that is—weight which is not supported by the springs. The unsprung weight is something that must be kept down to a minimum if a good ride is to be obtained.

"Isn't 'Knee-Action' construction weaker than the leaf spring and axle type?"

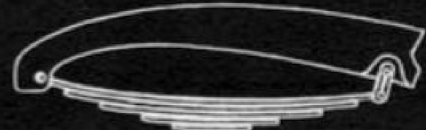
No, it is considerably stronger.

With the axle type suspension, all that held the front wheels in place under the frame were two thin strips of highly stressed spring steel bent up into loops at the ends and wrapped around shackle pins. With independent suspension, heavy arms and links, of thick section take the place of the old spring leaf.

The fixed cross member to which the steering knuckles and wheels are attached is considerably stronger than the I-beam axle. The steering knuckles have also been made stronger. This assembly provides an exceptionally strong, rugged and durable type of construction, proof against all ordinary road hazards. The coil springs are of the greatest strength and they will last as long as the car itself.

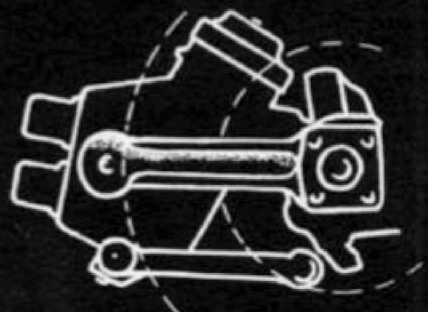
"Why isn't it possible to make a soft acting front spring of the leaf type?"

It is quite possible to make a leaf spring just as soft as a coil spring but in the conventional front wheel



Cross section of master leaf of conventional spring

Cross section of "Knee-Action" wheel support arm (Dubonnet Type)



suspension the springs have to be made stiff enough to hold the front of the car in alignment. In other words, they serve as braces or structural members in addition to springing the car.

"What are the advantages of coil springs?"

They occupy small space. The stress is more equally distributed within the metal of the spring. A coil spring is stressed IN SHEAR, and a leaf spring IN TENSION. Since steel is more elastic in shear than in tension a coil spring will absorb more work per pound of metal than a leaf spring.

Furthermore, a coil spring has no friction within itself and therefore requires no lubrication.

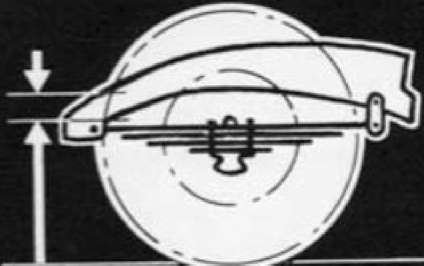
"What happens if a spring breaks?"

Nothing serious. Inasmuch as the springs in "Knee-Action" design merely support the weight of the car at the front-end and have no function at all in holding the "Knee-Action" parts together, no loss of control can possibly be experienced. In fact, if one or both coil springs in General Motors "Knee-Action" cars break, the car could still be driven to a service station without any greater inconvenience than a bumpy ride.

"How does individual springing affect wheel alignment?"

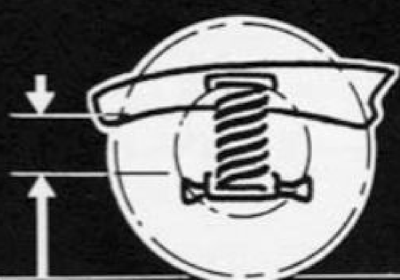
The front wheels of a motor car are held in better alignment by "Knee-Action" construction than they ever were before, which accounts for the greatly improved roadability of "Knee-Action" cars as well as their extremely safe characteristics under heavy braking from high speeds.

HARD STIFF SPRING



SHORT TRAVEL
QUICK STIFF REACTION

SOFT SPRING

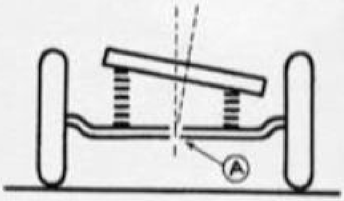


LONG TRAVEL
SOFT REACTION

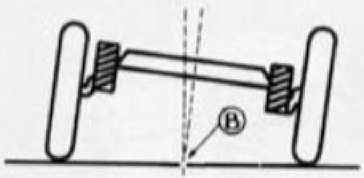
"What about the wheels leaning when the car goes around a curve?"

When cars equipped with a front axle go around a curve the body rolls or tilts somewhat, due to the centrifugal force, but the front wheels remain more or less at right angles to the ground.

You will notice the center of rotation (A) is located somewhere above the axle.

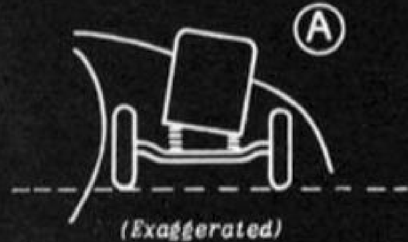


With the "Knee-Action" construction, however, a natural function of the design is that the front wheels tilt slightly with the body.

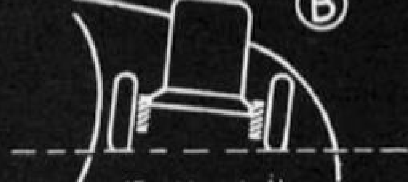


In this illustration note the center of rotation (B) is at or near the ground. When properly designed this wheel lean is extremely valuable to the safe handling of cars at speed. This tends to steady the car on the curve whether the road surface is icy, wet, or dry—preventing it going into a "flat spin" (skid).

This is the way the axle-type car looks when rounding a curve at high speed. The body tilts but the wheels remain in an upright position.



(Exaggerated)



(Exaggerated)

The Knee-Action car looks like this—the front wheels tilting with the body. This makes the car steadier and there is less danger of skidding.

"Does 'Knee-Action' permit higher speeds on curves?"

No, but "Knee-Action" permits better and safer handling on curves at the same speeds.

"How will a front tire blowout affect a 'Knee-Action' car?"

A front tire blowout on a "Knee-Action" car will cause a lot less disturbance in the control of the car than it does on a conventional axle type car.

In tire bursting tests on "Knee-Action" cars it has been found that to correct the force of the burst, the steering wheel need be turned only about half as far with about half the effort as compared with a conventional axle type car.

"How will muddy roads and freezing affect 'Knee-Action'?"

With the General Motors designs, neither dust, dirt, water nor ice will have any detrimental effect on the operation or the durability.

"What effect will heat and cold have on the operation of 'Knee-Action'?"

No discernible effect whatever.*

---

*Since this question occurred mostly in connection with the enclosed type, it is interesting to note that the fluid used in the unit is exactly the same as that which has been used in shock absorbers for years past. This lubricant will retain its fluid characteristics as low as 40° below zero.

"How about squeaks?"

In case of neglect squeaking is, of course, possible with "Knee-Action" construction. But in actual fact, it is very rare because there are no spring-leaves which rub against one another and which are so difficult to lubricate.

"How about road clearance?"

"Knee-Action" cars have standard road clearance.

"What about jacking up the wheels?"

Jacks of adequate "lift" are provided with every car, and are used in the same way as with the axle type suspension.

"Isn't it complicated by too many parts?"

Any unfamiliar structure looks complicated when first seen and until you understand how it works. As a matter of fact, "Knee-Action" construction has just exactly the same number of working parts as the axle type of construction.

"How about lubrication?"

With moving parts, there must always be lubrication. With the axle type there were from 17 to 19 different points to be lubricated, depending on the particular car. With "Knee-Action" construction there are from 14 to 18 lubrication points depending again on the type of design.

"What is the difference between the steering on a 'Knee-Action' car and that on a conventional car?"

Through General Motors construction, steering has been entirely divorced from the problem of spring suspension.

If you'll get down and peep under the front-end of an old-style car you'll find that the springs are depended upon to hold the front axle in place. A bump under one wheel will raise the axle and tilt the other wheel—and perhaps you know from your own experience (or from the experience of others) that if you BREAK a front spring, the whole steering mechanism is thrown out of commission.

In other words, under the old-style construction the front springs HAD TO DO TWO JOBS—*they not only had to serve as SPRINGS but they had to keep the front-end of the running gear in proper alignment.*

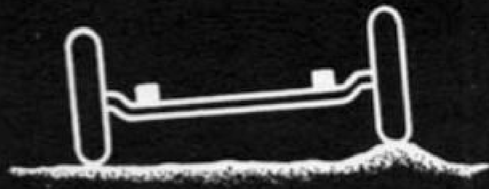
With General Motors "Knee-Action" construction, a broken spring will *not throw the steering mechanism out of commission.*

Steering is much easier and more efficient. "Knee-Action" construction holds the wheels rigidly in place so that they move in one direction only—up and down. They are not deflected by obstacles. Road shocks do not get through to the steering wheel.

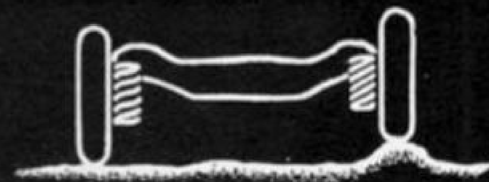
The control of the car is greatly improved—not only in normal driving but in case of accidents—*thus, "Knee-Action" makes a distinct contribution to safety.*

"How many miles has 'Knee-Action' been tested?"

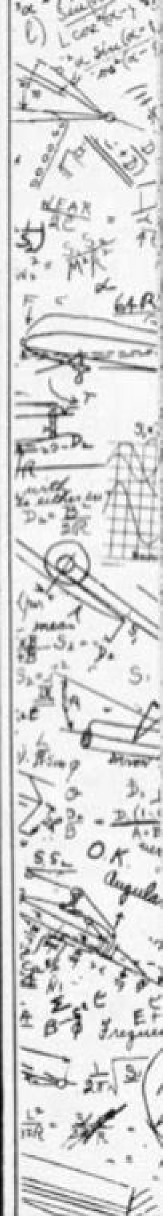
Through the facilities of General Motors Proving Ground, "Knee-Action" cars were run 1,433,000 miles under the most careful observation before the designs were put into production.



In the conventional construction the springs serve as structural members, and are therefore an essential element in the steering mechanism. Since the springs are flexible the road shocks affect steering, and if a spring breaks the steering mechanism is thrown out of commission.



Since in "Knee-Action" construction the springs do not serve as structural members, the steering is undisturbed by spring action. Even if a spring should break the steering mechanism continues to function.



In addition to these exhaustive and gruelling tests, it is interesting to note that at the time this book goes to press, over 700,000 General Motors "Knee-Action" cars are in every-day use in the hands of practical motorists throughout the world.*

"But after all isn't 'Knee-Action' still in the experimental state of development?"

This is a question that always arises in connection with any basic improvement. The same question was raised when Mr. Kettering's electric self-starter was first introduced—the first Fisher Closed Body was challenged on the ground that it would make the car top-heavy and unsafe—Balloon Tires and Four-Wheel Brakes also came in for the usual amount of questioning. Then too, the flame of skepticism is always fanned by salesmen representing competitive products until such time as the innovation has become generally adopted.

So it is only natural that this is one of the most frequent questions that has been raised in connection with "Knee-Action."

The answer is positively "NO"—in fact it could be said that "Knee-Action" is one of the few—if not the ONLY basic improvement in automotive design ever introduced in America that can in no sense be termed an experimental venture.

But this is a strong statement and you could hardly be expected to accept it at its face value, without the facts upon which it is based.

---

*Our Customer Research surveys indicate that the Average Motorist drives his car 11,500 miles a year. The average "Knee-Action" car has been in service at least 6 months—so assuming that they have run 5,000 miles apiece, we might say that "Knee-Action" has been proved through 3,500,000,000 miles of practical usage. (700,000 multiplied by 5,000.)

The Horseless Carriage

The Self-Starter

The Closed Body

Four Wheel Brakes

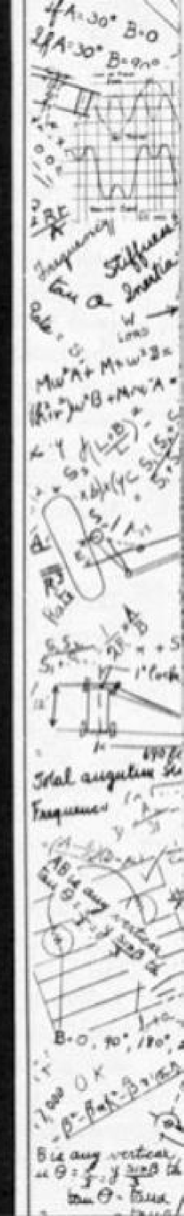
And in order to present these facts, it is necessary to go back to the very beginning of the industry—in fact, it is necessary to go back to the year 1878 which was at least 10 years before the gasoline car was born and a full quarter of a century before General Motors was even organized.

Since this is an extremely interesting story, maybe it's worth including here—because it is the only way to present the real background of "Knee-Action" and should prove especially interesting to those who appreciate the drama and romance of automotive developments.

Ever since the time when man invented the wheel and began to roll himself and his belongings around, efforts have been exerted toward cushioning the shocks of the road and this explains why independent wheel suspension was attracting the attention of ingenious inventors even before the birth of the gasoline vehicle.

Back as early as 1880 and 1890 independent suspension was receiving a lot of study, mostly by French and English engineers. Naturally, their first attempts were pretty crude—things were cluttered up with a lot of extra levers and cranks and arms—but they had an idea, and as time went on they continued to experiment and test and improve, until finally they got something that was pretty satisfactory for the kind of operating conditions they had to face.

Now, American engineers have certainly been the chief contributors to the perfection of the motor car—they have pioneered a great many major improvements. But in the work of independent suspension the Europeans were far more active up until a few years ago.

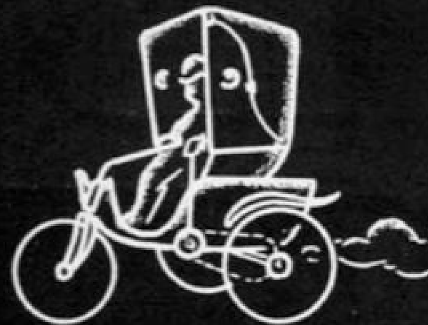


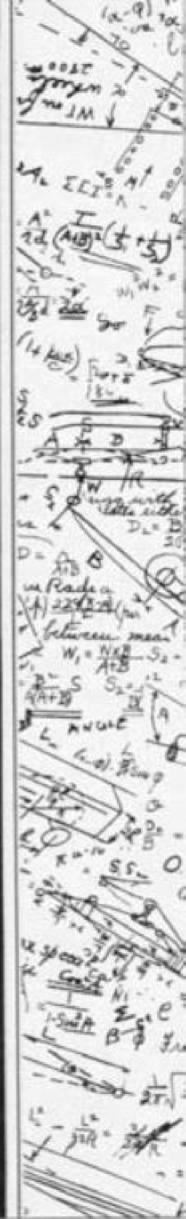
This was due to such things as habit, past experience and training, and it came about in this way:

Many of the very early European automobile makers had been in the *bicycle business* before they started making cars—just as the motor car industry in the United States grew out of the *carriage business.* So it was only natural for the Europeans to think along lines of bicycle design because the automobile was, to them, simply a substitute for the bicycle and an improvement on it. In some instances they called their automobiles "Cycle cars" and made them as much like a bicycle as possible. Of course, it was necessary to add another wheel or two, but they stuck to such things as light frames and light wire wheels, keeping the weight and size of the car down to bicycle standards.

Now, coil springs and sliding forks were familiar devices to bicycle makers, and when they came to work out the suspension systems for their motor cars they simply adapted what they already knew to the new set of conditions.

European roads also had a lot to do with it, for they were pretty rough and narrow, with lots of sharp curves, and so roadability was a most important thing. The highways of the Continent were planned and built long before the birth of the motor car—whereas, American road building was almost negligible until the automobile came into general use, and then the two sort of grew up together. As automobiles were improved and their speed increased, our highways were being widened, straightened and paved. So in this country our problem in roadability was quite different from that which confronted the engineers of Europe.





Over there it was quite a problem to design a car that would cling to their roads at all times, and take rough cobblestone pavements without losing control.

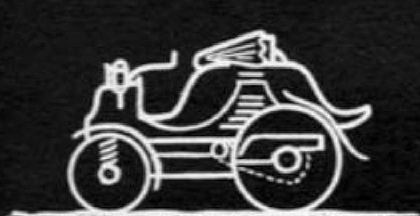
And so it is really not so strange after all that most of the early work on independent suspension was contributed by men like Bollée, Decauville and Sizaire, of France; and Wolseley, Parnacott, Egan and Garson of England. Bollée was one of the earliest of the inventors in this field, obtaining a patent on a crude system of independent suspension for steam vehicles back in the year 1881.*

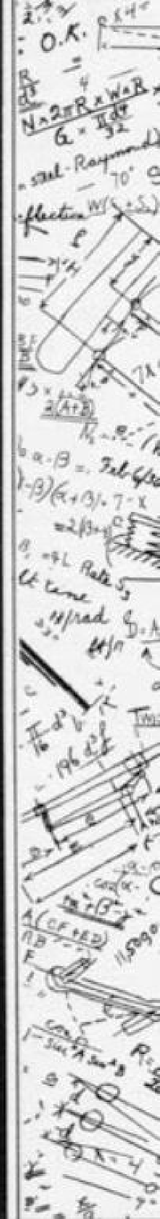
It was Decauville who worked out the sliding kingpin type about fifteen years later, which Sizaire modified and used on his cars as early as 1906. Wolseley patented, in England, no fewer than five general types of independent suspension, along in 1911. The automotive journals of the Continent are full of references to the work of these and other engineers for a great many years back. The ones mentioned here are only a few of the more outstanding.

In the meantime the American engineers were devoting their energies to the improvement of the body, the frame and the engine, and adapting their designs to large scale production.

As mentioned before, American manufacturers had been raised and trained in the era of the horse and buggy, and they thought in those terms. The automobile was, in their eyes, just what they called it—A "HORSELESS CARRIAGE".

*Amédée Bollée, Sr., it appears, was not only an inventive genius but he was also a builder of steam carriages. One of the attractions at the 1934 Paris Salon was a steam vehicle built by Bollée in the year 1878 and which was equipped with independent front wheel mounting.





When they started making cars they made the bodies look like carriages—frames were designed like carriage frames—in fact, the real early models were rebuilt out of horse drawn vehicles—substituting an engine for the horse and hooking it up to the wheels with a loop of chain and a few gears. SOMETIMES THEY DIDN'T EVEN BOTHER TO REMOVE THE WHIP SOCKET!

They knew how to make that type of vehicle, and they kept right on making just about the same thing, even after they changed the motive power.

The long leaf spring had been used in carriages for a good many years—so naturally that went into the automobile too, along with other things like patent leather dash boards and doors at the rear. Of course, from time to time springs were improved, but they always remained carriage springs, and were not very well suited for travelling at modern speeds over the dips and waves and around the curves of the modern highway.

For a number of years, car owners responding to General Motors Customer Surveys had stressed the need for better riding rear seats—not that the rear seat ride was any worse than it had been right along—but because here was a thing that had not been improved in the same measure as other features of design and the approach to perfection in other directions emphasized the shortcomings of the bouncing rear seat in comparison with the improved performance of the car as a whole.

General Motors, through its European engineers, had for years been studying the experiences of European manufacturers with independent suspension and early in the year 1930 a group of development engineers

were assigned the job of making a very intensive study of this and other problems relating to riding comfort.

All the data existent in the General Motors Research Laboratories and the Proving Ground were brought to bear on the subject. The scientists from the tire factories and the spring steel manufacturers were called into consultation and certain phases of the problem were delegated to them for special study, analysis and experimentation.

The evolution of European practice was carefully studied not only in Europe but through exhaustive tests of European cars imported for that purpose and tested at the General Motors Proving Ground under driving conditions duplicating those encountered by the practical motorist here in America.

Thus General Motors in adapting and improving the principle to suit American operating conditions had the benefit of over 25 years of European experience.

So "Knee-Action" is not an experiment but the culmination of a long series of experiments and practical usage.

* * * *

In the light of the foregoing facts, we feel warranted in saying that no innovation in the entire history of the American automotive industry has ever been so thoroughly tested and proved as has "Knee-Action" construction.

Motor Enthusiasts

If you have found this little book interesting perhaps you would like to have copies of the following publications, provided you have not already received them:

"The Proving Ground of Public Opinion"

—a profusely illustrated questionnaire which gives you the opportunity to "cast your vote" on 65 features of design.

"The Automobile Buyer's Guide"

—an 84-page book based on our extensive customer surveys and containing interesting chapters on advances in automotive design during the past five years.

"The Third Link in General Motors Fact Finding"

—outlining the philosophy back of General Motors Customer Research and reviewing the past history of this work.

Copies will be mailed free on request—and we'll also be glad to mail copies to any of your friends who may have a special interest in motoring, if you will send us their names.

CUSTOMER RESEARCH STAFF
GENERAL MOTORS, DETROIT


GM
CUSTOMER
RESEARCH