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# Double-Wishbone Suspension for Honda Prelude

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ABSTRACT

This paper describes the double wishbone suspension used in the Honda Prelude. This system is designed to improve handling and anti-dive performance via the layout of the suspension arms and the springs and dampers. It also allows a low hood line over the transverse mounted engine for this sports-type vehicle.

FRONT ENGINE/FRONT WHEEL DRIVE (FF) VEHICLES have become the mainstream for compact cars. This same trend is now being noticed in sporty and specialty cars, such as the new Prelude, due to the increase in interior space and simplification of production procedures it allows.

Two important prerequisites for a well-designed and aerodynamically-efficient sports-type vehicle are that it have a low overall height and good visibility. Since the front suspension can become the limiting factor for hood height, these components are being made ever more compact. In spite of this, the performance demanded of the suspension system by sports-type vehicles continues to increase.

Taking the 1983 Honda Prelude as an example of modern FF sports-type vehicle suspension, this article deals with the methods employed to solve the various space-related problems (Fig. 1).

PERFORMANCE & PACKAGE REQUIREMENTS.

Described below are the requirements placed on the design of the 1983 Prelude front suspension system for performance and space saving.

SPACE GOALS - In order to meet styling and some other requirements, compactness as below was required.

(1) Make possible an approximately 80 mm reduction in hood height over comparable conventional automobiles.
(2) Make the system compatible with a FF transverse mounted engine.

To meet these styling and layout goals, the hood has to be lower than the earlier Preludes and Accords, for example (Fig. 2). Since the Prelude is intended to be a sports-type vehicle, the hood must be low enough to allow not only a low overall height of 1290 mm, it must also provide for good driver visibility and low wind resistance.

In addition, according to Japanese tax regulations, if the vehicle is wider than 1700 mm, it falls into a higher tax bracket. Thus the design must also take vehicle width into consideration, and the 1690 mm width of the Prelude is just under this limit.

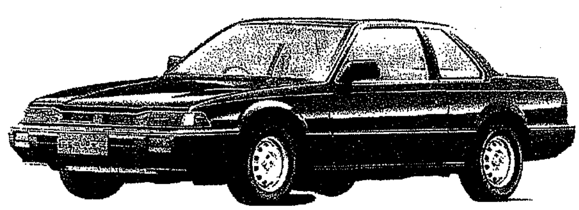

Fig. 1 '83 Prelude

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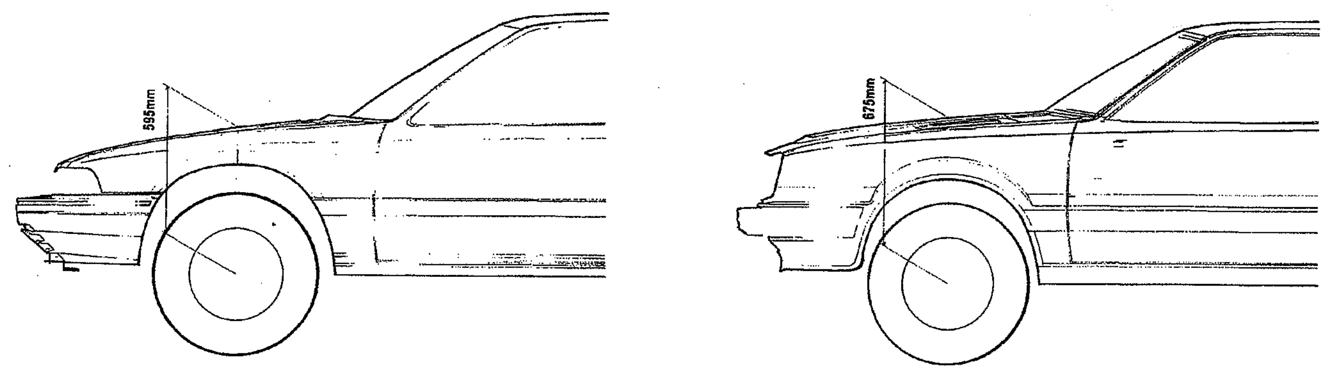



'83 Prelude

'80 Prelude

Fig. 2 Comparison of hood heights

PERFORMANCE GOALS - From a performance point of view, some of the major requirements are listed below.

(1) Excellent cornering ability.
(2) Quick steering response.
(3) Excellent directional stability.
(4) Sufficient anti-dive performance.
(5) Use tyre size of 185/70SR13.

Using typical sedan tyres, the Prelude is intended to offer both good handling and excellent stability at highway speeds.

These performance requirements for this sports-type vehicle are met using a unique layout to improve the suspension's fundamental geometry.

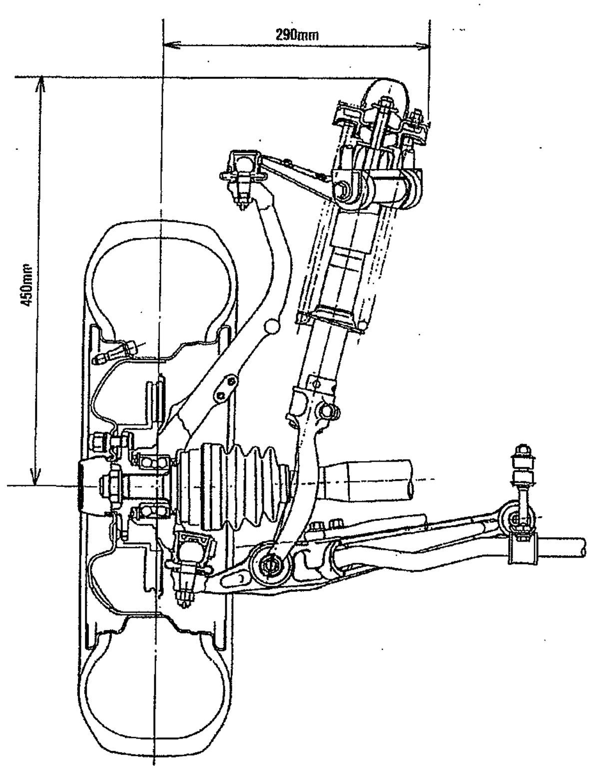



Fig. 3 '83 Prelude front suspension

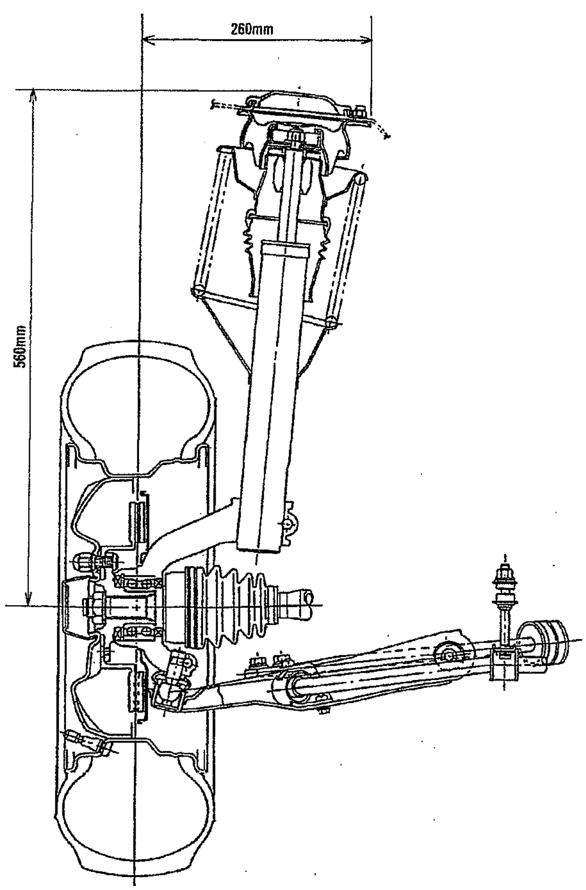



Fig. 4 Accord front suspension

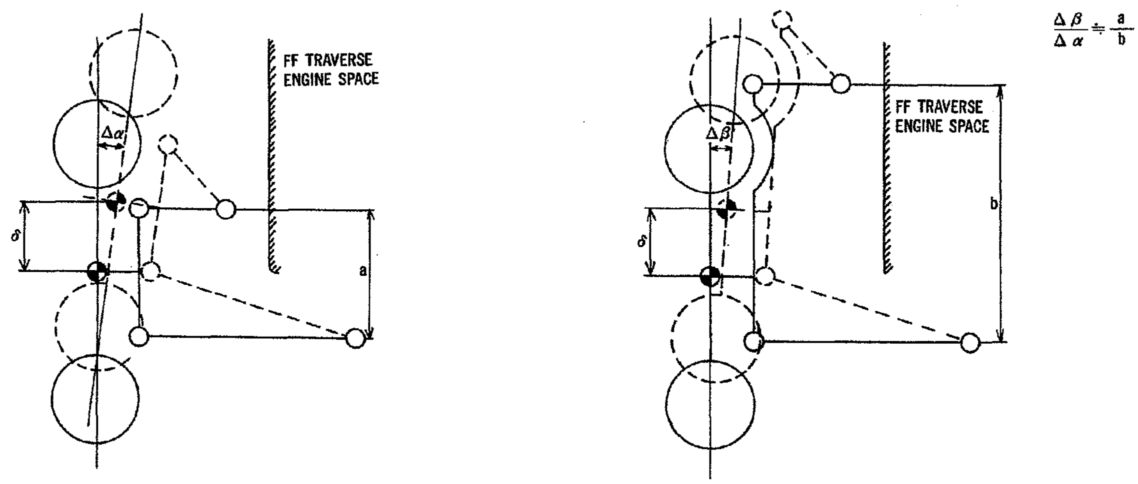



Fig. 5 Upper arm disposition and Camber change

SUSPENSION PROPERTIES - To achieve performance goals, the items below were considered to be essential.

(1) During cornering, the tires should be kept as nearly vertical as possible. To enable this, three items were incorporated in design work.
    (A) Camber angle change during wheel travel was increased.
    (B) Kingpin inclination angle was decreased.
    (C) Camber angle rigidity was increased.
(2) Toe angle rigidity should be high.
(3) Toe angle change during wheel travel should be decreased.
(4) Anti-dive geometry should be incorporated.
(5) Sufficient fore/aft compliance for appropriate ride comfort should be achieved.

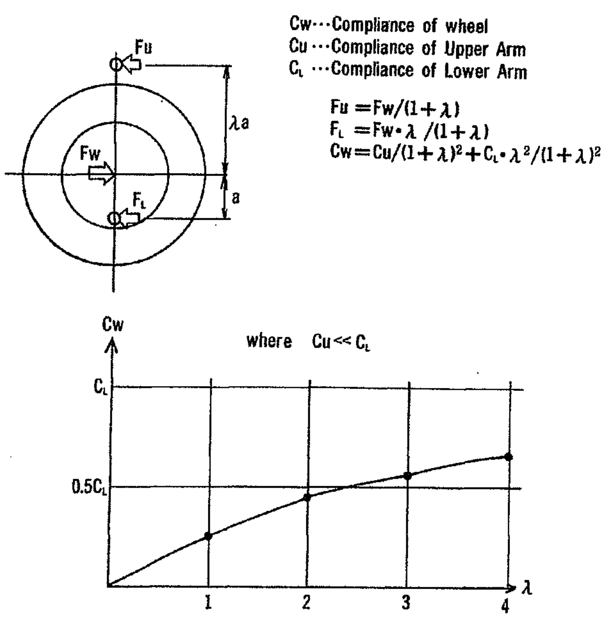



Fig. 6 Compliance of wheel

The initial suspension design used McPherson struts. However, because these package and performance goals could not be achieved satisfactorily, a double wishbone-type system was introduced.

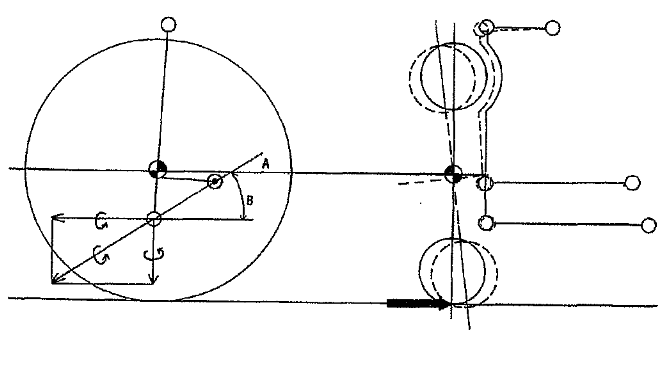
DESIGN FEATURES

Two distinctive features of the Prelude's double wishbone front suspension system (Fig. 3) are:

(1) The disposition of the upper arms and the lower arms.
(2) The damper and spring arrangement.

UPPER & LOWER ARMS DISPOSITION - Control arms of the Prelude suspension are distinguished by the followings.

(1) Upper arms are high.
(2) Upper arms are short.
(3) Upper arms are semi-leading type.
(4) Location of lower arms is raised using upside down ball joint.




*Since compliance of upper half of suspension allows rotation around axis "A" causing steer and camber change, small angle of "B" results in smaller effect on steer angle.*

Fig. 7 Lower arm disposition and toe rigidity

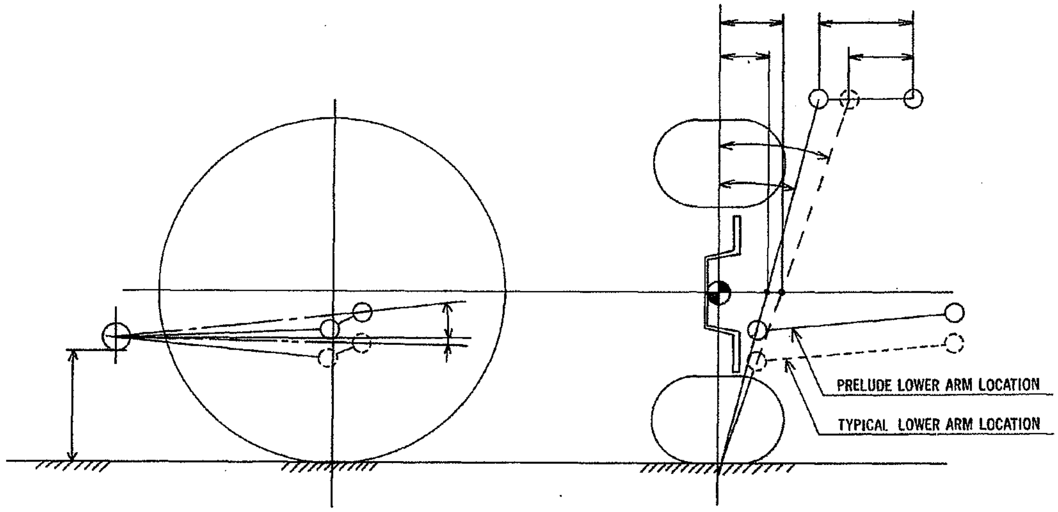



Fig. 8 Lower arm disposition and suspension geometry

A difficulty in using a double wishbone suspension system in a FF vehicle with a transverse engine is that the tight package requirement does not allow the upper arms to be as long as ordinary ones

In a conventional layout, if the upper arms are shortened, the camber and track changes during wheel travel are excessive.

However, if the upper arms are positioned above the tires, the spans of the upper and lower arms can be greatly increased, and the problems above can be eliminated (Fig. 5).

From a ride comfort point of view, the high upper arms in conjunction with fairly high lower arms position contribute to achieve sufficient fore & aft compliance without spoiling caster angle stiffness.

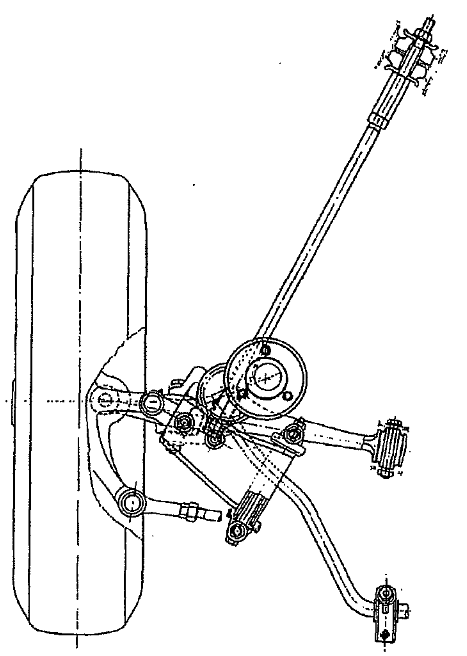


Fig. 9 '83 Prelude front suspension

To achieve both high caster angle rigidity and sufficient compliance, the items below are essential (Fig. 6).

(A) Larger ratio of the two distances to the upper & lower balls from wheel center.
(B) Long distance between upper & lower balls.

Additionaly, lower arms being disposed fairly high help improve anti-dive characteristics, because lower arm pivot center line can be inclined more, in side elevation, where ground clearance of radius rod pivot bush is restricted (Fig. 8).

Another advantage of high lower arms is small height difference between lower arm and steering rod. This contributes to achieve high toe angle rigidity and less side force under steer (Fig. 7).

High lower arms contribute also to reduce king pin offset at wheel spindle. And this helps reduce king pin angle. Small king pin angle is beneficial also to package longer upper arms when the inner end can not be lengthened because of space limitations (Fig. 8).

| | 84M PRELUDE | 80M PRELUDE |
|---|---|---|
| TRACK FRONT | 1470mm | 1400mm |
| KING PIN ANGLE | 6°50' | 12°48' |
| CAMBER ANGLE | 0° | 0° |
| CASTER ANGLE | 0° | 1°28' |
| CASTER TRAIL | 1.5mm | 3.7mm |
| KING PIN OFFSET AT GROUND | 13.5mm | −6.1mm |
| KING PIN OFFSET AT SPINDLE | 46.5mm | 55.2mm |

Table 1 Suspension geometry

DAMPER & SPRING ARRANGEMENT - Given the low hood, the position of the driveshaft and steering, and adequate clearance for the tires and tire chains, space for the springs and dampers is extremely limited.

This problem was solved by mounting the spring and damper on a fork-shaped adaptor which straddles the driveshaft and attaches to the lower arm (Fig. 3). To prevent interference between the spring/damper and the upper arm, a semi-leading type is used (Fig. 9).

This semi-leading type upper arm not only contributes to the suspension's anti-dive properties, but also allows the Prelude hood to be approximately 80 mm lower while only increasing width by 30 mm, even with 185/70SR13 tires.

In short, the double wishbone suspension allows this vehicle to be made substantially lower at the cost of only a small increase in width (Fig. 3 & 4).

SUSPENSION GEOMETRY

STATIC GEOMETRY - The suspension geometry of an unladen vehicle is shown in Table 1. The two primary aims in this area are:

(1) Reduce the kingpin angle in order to;
   (A) Avoid a detrimental influence on steer induced camber changes.
   (B) Achieve satisfactory steering effort in conjunction with appropriate Ackermann steering geometry.
(2) Reduce the offset at the spindle as much as possible to reduce FF torque steer characteristic.

DYNAMIC GEOMETRY - The geometry changes of the suspension due to vertical travel are given in Figures 10 through 15. As shown in Figure 10, the steering angle change (toe change) in the normal use range is virtually zero.

The new sports-type Prelude has approximately double the amount of camber change when compared with usual McPherson struts (Fig. 11).

As seen in Figure 12, track change has increased slightly, but this is due to the compromises made necessary for camber change.

Anti-dive performance is indicated by "Bump & Rebound Locus of Contact Patch Center Point at Kerb, in Side View", which is shown on Figure 13 titled "Wheelbase Change". Anti-dive performance is one of the most important features of the new Prelude's suspension geometry. Since upper arms are semi-leading type, desirable progressive anti-dive characteristics are achieved.

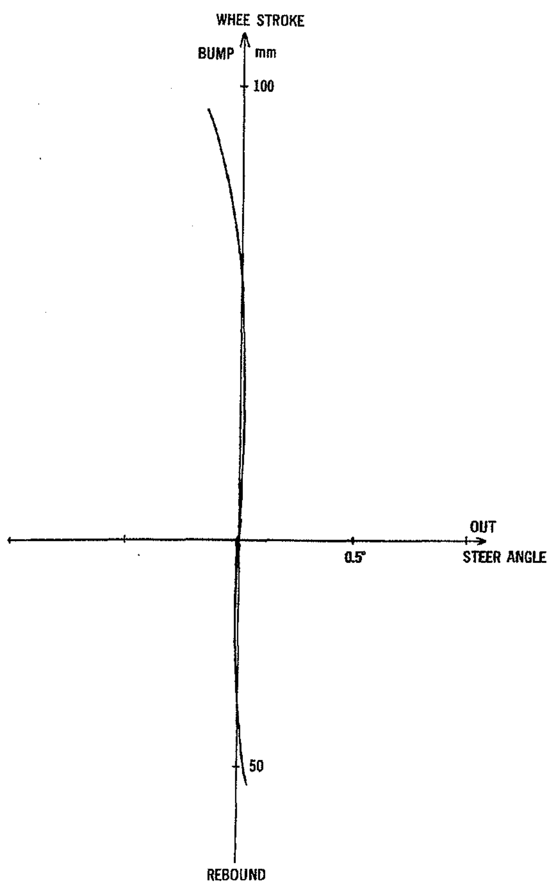



Fig. 10 Steering angle change (Toe change)

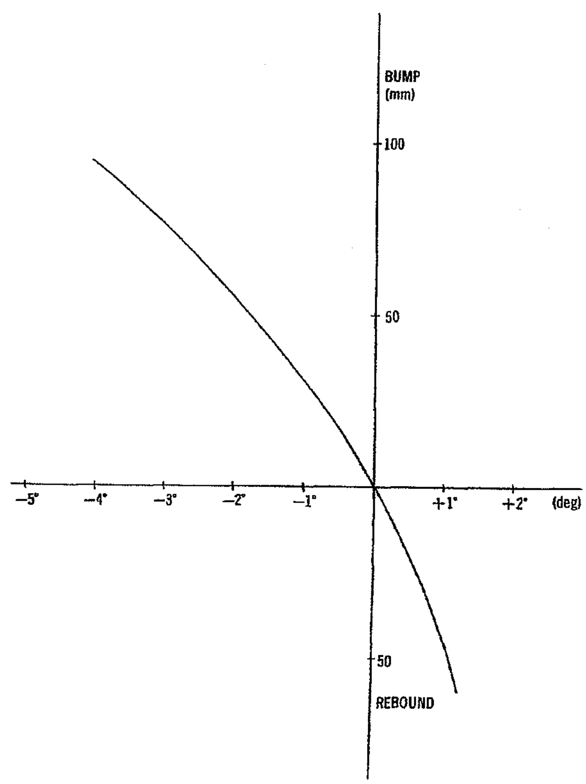



Fig. 11 Camber angle change

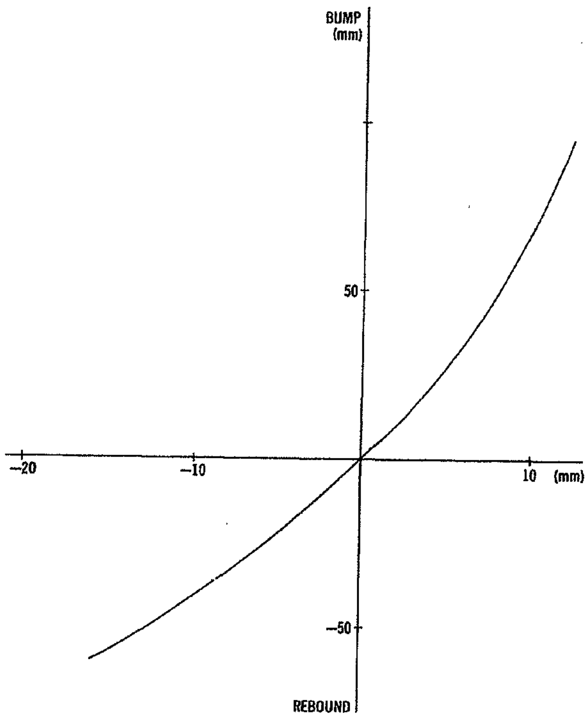



Fig. 12 Track change

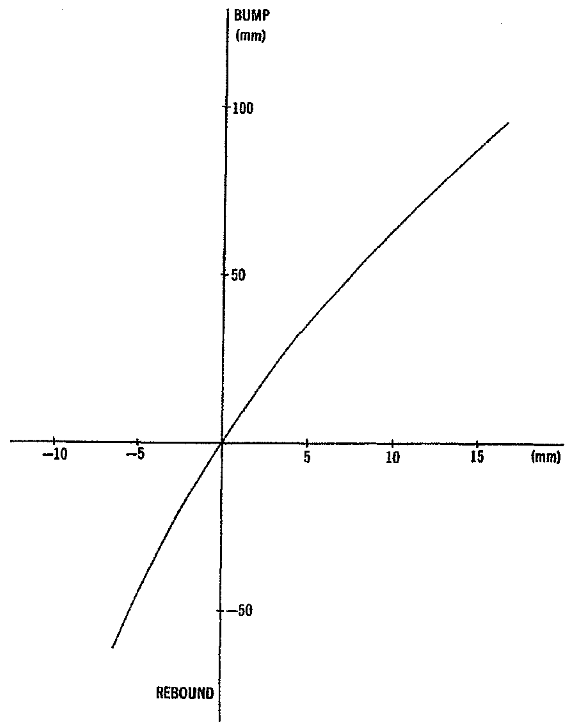



Fig. 13 Wheel base change

Another advantage of semi leading upper arms is that body structure for upper arm fixing can be made more rigid because of its location near toe board. It also enabled brake servo to be packaged without offset to brake pedal.

Because of anti-dive geometry, caster angle and caster trail changes considerably during wheel bump (Fig. 14 & 15). Prelude front suspension made use of this characteristics in order to improve agile handling by adopting small initial caster trail.

The understeer characteristics relative to 0 g cornering were 1.34 at 0.5 g for the earlier Prelude, and this figure is only 1.25 for the new Prelude (Fig. 16). The lower understeer rate illustrates the new Prelude's sporting handling behavior, compared to the more "Personal" character of the earlier Prelude.

The amount of roll at 0.5 G lateral acceleration has also been reduced: 3.2° for the old Prelude, and 2.3° for the new (Fig. 17).

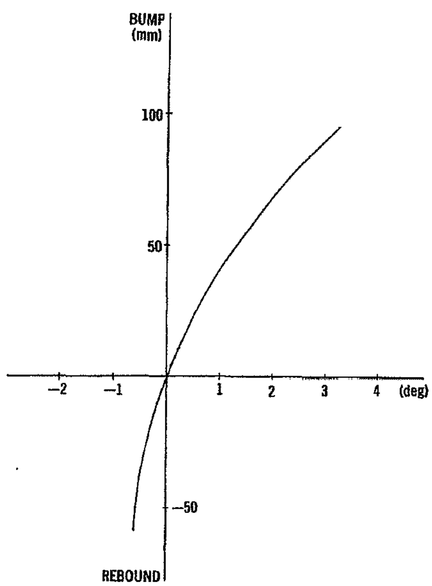



Fig. 14 Caster angle change

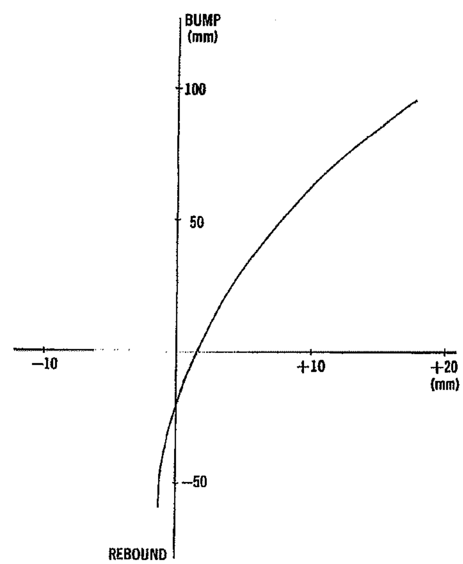



Fig. 15 Caster trail change

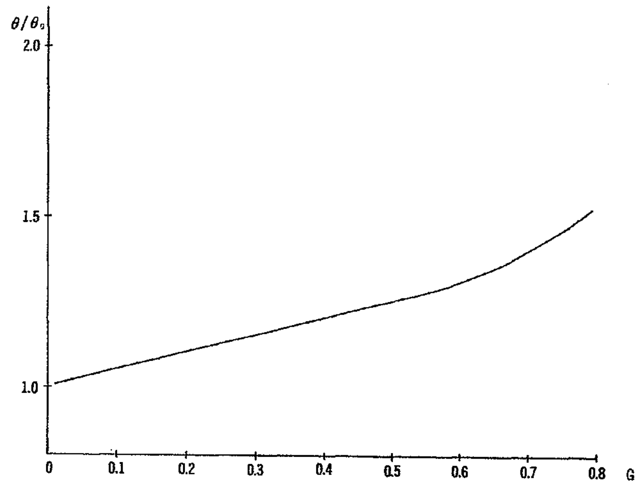



Fig. 16 Under Steer Characteristic (R=30m)
2 Passengers

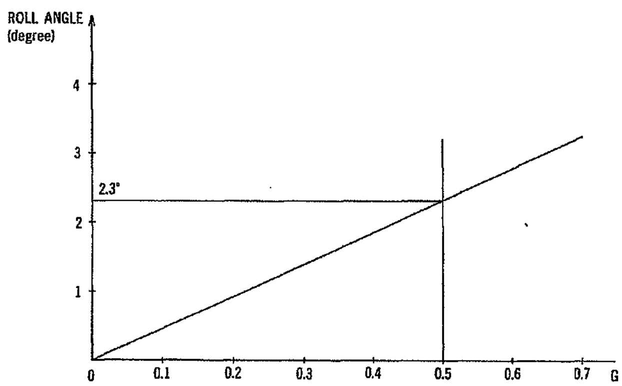



Fig. 17 Roll Response 2 Passengers
(R=15m)

CONCLUSION

In terms of space saving, this type of suspension is useful for automobiles with a low hood line and wide track. In terms of performance, because it has camber change characteristics unmatched by McPherson-type suspension the desired understeer qualities are maintained even under high lateral acceleration.

Since the double wishbone system is heavier and more costly than the McPherson-type suspension, it cannot be considered to be an all-purpose suspension. It is, however, a good design for sports-type FF cars where styling, superior aerodynamics, and performance are important.