

SUSPENDED IN TIME



Klaus Arning's Independent Rear Suspension for the 1964½ Mustang was almost too advanced for its time. Although patented for its unique design and tested by Shelby American, the IRS was dropped before ever appearing on a Mustang production car and then forgotten, although modified IRS versions appeared later on Ford GT-40s and 427 Cobras. In this *Mustang Monthly* interview, IRS designer Arning discusses the Mustang IRS, and why Ford ultimately cancelled the entire program.

by Jerry Heasley

For close to thirty years now, Klaus Arning has been an engineer for Ford Motor Company, specializing, during the 1960s, in advanced suspension, chassis, and new vehicle concepts.

It was Klaus Arning who developed the novel "four-link" independent rear suspension, which first appeared on the Mustang I show car. This new IRS was innovative to the point that Ford patented it (in Klaus Arning's name) in the United States, Germany, England, and Canada.

We felt it a great opportunity to discuss with Mr. Arning the various suspension systems which he helped develop for the Mustang. You've probably heard about the ill-fated "IRS"

Mustang, which was slated for production, then "died on the vine" when the Mustang became a runaway success. But did you know that the front suspension developed for this vehicle was carried over almost verbatim to the original GT-350? Or that the patented IRS of the Mustang I, in one of its various forms, was the basis for both the GT-40 and the famous 427 Cobra?

We spent an enjoyable hour and a half discussing suspension details with Mr. Arning, who incidentally, answers questions very articulately with his native German accent — which made the interview all the more interesting. Had Richard Burton been born in Berlin, he would sound like Mr. Arning.

Q: Would you begin by telling us a little about your background, including when you went to work for Ford, what jobs you held, and the college you attended?

A: I went to college in Bremen, Germany, and graduated in 1949 with a degree in mechanical engineering. However, I had joined the auto industry in 1939, as an apprentice, with the Borgward Automobile Company. During World War II, I served in the German Luftwaffe. I came to the United States for the first time in 1950, as a guest of the American government on a so-called professional people exchange program. This is how I got acquainted with Ford Motor Company. I spent almost one year there, working in many different departments; and then I returned to Borgward. In 1954, I immigrated to the States and found a job with Ford. As far as my professional career is concerned, up until about twelve years ago, most of my jobs were in advanced and research type



Klaus Arning

positions, as supervisor; and these groups mostly dealt with advanced suspension and chassis concepts, plus new vehicle ideas, which were the major reasons for my involvement in many of the competition car concepts. However, since 1971, I've been manager of a department engaged in safety and structures engineering, as well as special vehicle engineering assignments — such as designing and building a presidential limousine in 1971-1972.

Q: Let's start with your initial involvement with the Mustang program.

A: My first involvement was in connection with the Mustang 1 (see the Mustang 1 article on page 18 - Ed.), which was finished in September of 1962 and received very favorable reactions wherever it was shown. I was part of a small group that later went over to Germany to introduce the Mustang 1 at the Frankfurt Auto Show, as part of a promotion for the upcoming lineup of 1964 European Fords, especially the new Taurus M12 front wheel drive model. The powertrain for this model was originally designed in the U.S. for a "world-wide" car, the "Cardinal" project. The Mustang 1 powertrain was basically derived from this but put into mid-ship position driving the rear wheels.

Q: What did you design on the Mustang 1? What was your part?

A: My part was the suspension design, which incorporated, particularly on the rear suspension, some novel design features which were patented by Ford in my name in many different countries.

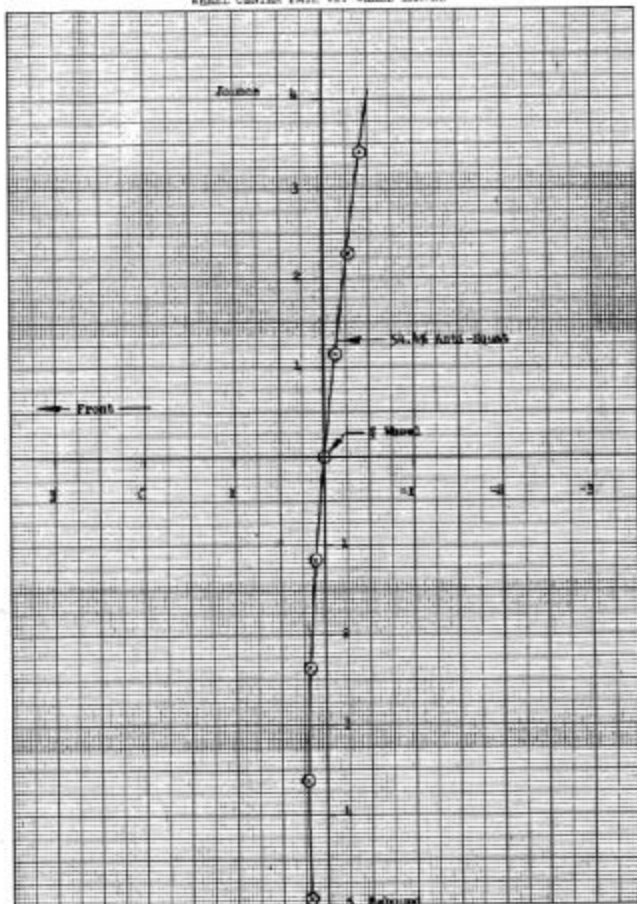
Q: What was this new principle that Ford patented? Tell us more about it.

A: First, it was, of course, an independent rear suspension, but it was unlike other IRS systems of the time in which understeer and anti-squat features were inherently incompatible. With the unique "four-link" IRS, we had a rear suspension that could be tailored to produce anti-squat characteristics. This is a feature to enhance accelerative capabilities and to minimize the effects of "throttle on-off" in turns. You could tailor steer characteristics for handling, which relates to toe-in and toe-out wheel movements. With the Mustang 1, the IRS was tailored to have a modest amount of understeer, yet it also had anti-squat characteristics under acceleration as well as anti-lift characteristics under braking.

Q: Since it was such an important new development, can you elaborate?

A: Weight shift front-to-rear under acceleration and vice-versa under braking is inherent; you cannot do a thing about it, except that the effects of weight shift can be manipulated. Now, if you have an IRS — where the differential is part of the chassis, rather than part of the axle — your wheel center, as it moves up and down, should describe a line that is not vertical. If it were vertical, you could push on this wheel center forward and aft, and there would be no reaction, because it is perfectly neutral to a force applied parallel to the ground. However, if this line were to move backwards and up, and forward and down (being inclined in the side view), you would produce an anti-squat effect. That is a force vector that wants to support the body as if you'd temporarily stiffened the spring between the suspension and body. Conversely, if the motion of the wheel were to go forward and upward, or down and backward, you would produce the opposite — enhancing the squatting of a body under acceleration. Now, if you take a swing-axle suspension, like in the original Volkswagen and early Corvairs, and you want to get anti-squat, your wheel would have to move backwards as it moves upwards. But at the same time, if you looked at the plan view, the wheel would toe-in. This movement is in the wrong direction — that is, in the oversteering direction from a

T-5 G.T. REAR SUSPENSION
WHEEL CENTER PATH vs. WHEEL TRAVEL



WHEEL CENTER PATH (Inches)

In Arning's Independent Rear Suspension system, the rear wheels actually moved forward and backward during up and down travel. That action improved the anti-squat characteristics during acceleration.

roll-steer viewpoint, since the wheel that moves up in cornering is the outside wheel in a turn, which dominates over the lighter loaded inside wheel due to lateral weight transfer.

Q: In other words, with most IRS systems, the desirable anti-squat characteristics also would have the undesirable effect on toe-out under roll which produces inherent roll oversteer?

A: Exactly! Of course, one answer to this problem of incompatibility is to take a complete front suspension and steering linkage and put it into the rear. Then you can manipulate your toe steer effect independently of what else happens to the wheel motion. But that means more pieces, weight, cost, and complexity.

Q: Continuing then, how did your novel four-link IRS solve this problem?

A: In the "four-link IRS," the steer action is built-in. Looking at it from the rear view, it was like any other "double wishbone" suspension. However, the lower pivot of the lower arm at the wheel hub is not parallel to the ground, but inclined forward/upward. And this very inclination of the "hinge axis" produces a steer effect which is more pronounced as you incline the axis further away from parallel. And in pictures that have been published of our Mustang 1, GT-40, and of the Cobra II (427 Cobra) rear suspensions, as well as of the experimental IRS for a potential production Mustang, you will find this lower pivot axis ("hinge axis") inclined forward/upward. It is not parallel to the ground, like

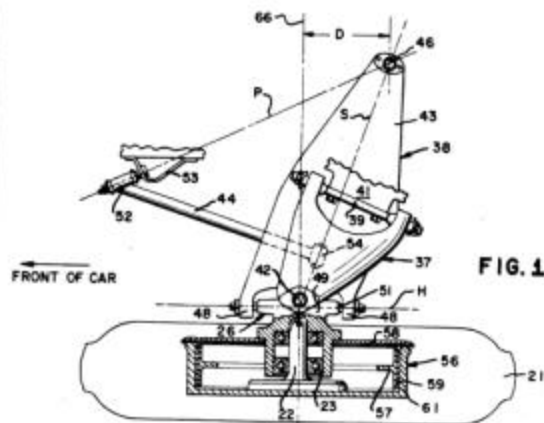


FIG. 1

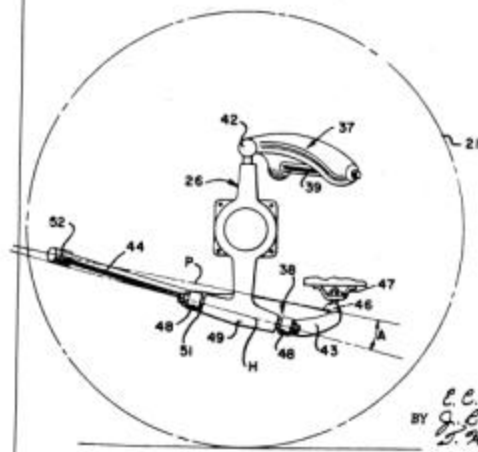


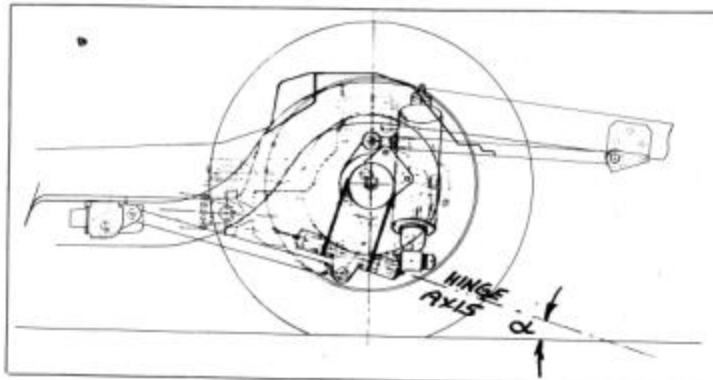
FIG. 2

K. H. ARNING
INVENTOR.
BY *E. C. Melroe*
J. C. Faulkner
S. H. Carter
ATTORNEYS

the then current practice in Grand Prix-type rear suspensions. And this inclination produces, by the very nature of the geometry, a steer effect, which counters the inherent "wrong" steer effects associated with anti-squat features. So, for once we were able to have two features that were usually incompatible with one another. This is the principle on which the patent was granted. Physically, the suspension could take many shapes. As a matter of fact, one version shows almost a Watts linkage, where one of the fore and aft locating rods is forward, the other arm is aft; and that's the system we utilized in the early Mustang exercise to make an IRS production rear drive Mustang. So it's sort of like having your cake and eating it too. We added no extra linkage, but still had a built-in steer effect. And this built-in steer effect (tailored for slight understeer coupled with anti-squat characteristics) was one ingredient that was particularly important with large displacement, high-torque-type engines. They usually produce an instantaneous response in acceleration, but also, due to deceleration, the famous "throttle-off" in a turn effect. In other words, the four-link IRS reduces suspension travel resulting from throttle-on as well as throttle-off applications by more than 50% which enhances the handling characteristics of the car.

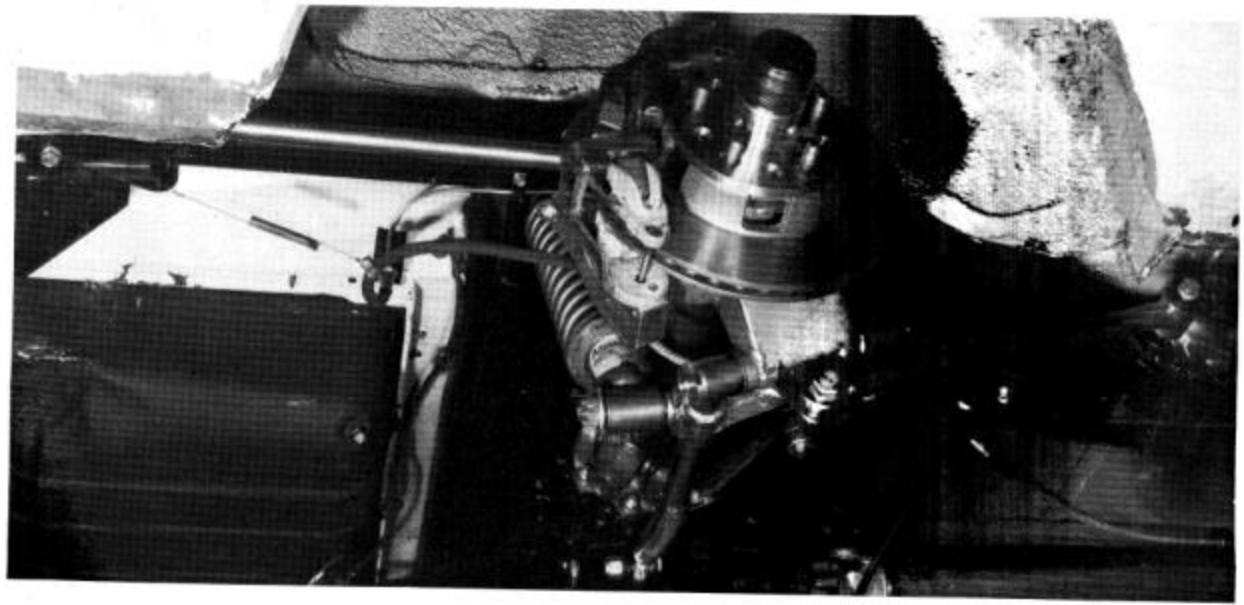
Q: What about the front suspension of the Mustang?

A: It was conventional, except the construction was along the lines of a Grand Prix race car — tubular, and lightweight. By geometry, there was nothing unique.



On March 29, 1961, a patent was filed by Ford for Arning's Independent Rear Suspension. The patent was later granted.

The Mustang IRS utilized fore and aft locating rods. The forward rod was inclined, which produced a steering effect for the rear suspension.



Q: After the Mustang I, what came next?

A: Parallel to the production Mustang development with its solid axle/leaf spring rear suspension, we also developed a package for the Mustang that could be converted to an IRS, as a special model offering. Also, we revised the front suspension geometry for crisper steering and handling response, and compatibility with the new IRS. Of course, we had "fun of driving" and competition in mind.

Q: This package was developed prior to the GT-350?

A: Yes. Shelby-American, however, was engaged in part of the development of this IRS Mustang, which we tried out first using the Falcon body to camouflage the car, because the Mustang was not even introduced officially at the time. And the assessment of its potential for competitive introduction in sports car class racing took place in Los Angeles, and on Riverside Raceway, with the Shelby-American people.

Q: Why did you engage the help of Shelby-American at this point?

A: Because we not only wanted to develop the chassis and the suspension for competition, but also a "hot" engine set-up to go with it, which Shelby was involved in. Already, a V8 was to be tweaked-up, and so on. So we wanted to have sports car track-type driving evaluated, and the late Ken Miles was involved. Richie Ginther was the major development driver on this project, which was code-named "T5 Falcon."

Q: So you took the Falcon to Riverside?

A: Yes, but let me back-track a bit. Already, we had developed at Ford the suspension and the whole handling package to a point where we said this could lead to a production version of an IRS Mustang, just right for the guy on the street. The development at Riverside was for the next step — the competition version of this same package.

Q: Could you describe the suspension of this vehicle in more detail?

A: What is significant is that the front suspension modifications were later carried over to the GT-350 Shelby Mustang. The front suspension was virtually stock on this car, except for relocating two important pivots, which was all we did. Drilling new holes into a cross-member lowered the upper arm inner pivot about 7/8 of an inch. And we moved the lower pivot of the lower arm outboard by a small amount. There were really few new hardware pieces required; it was

just a very slick change of geometry on the front suspension which raised the roll center, reducing toe-steer and roll camber. Also, a shorter steering arm quickened the steering ratio.

Q: Continuing, what about the rear suspension of this special production version IRS Mustang?

A: It was an independent rear suspension of the four-link type, which had disc brakes and aluminum wheels developed by Kelsey-Hayes. A very modern combination in terms of 1963. Very beautiful looking. The rear suspension was designed so that the fore and aft linkage were virtually fitting right into the same pivot points that the leaf springs normally would occupy. Of course, a new cross-member had to be added near the wheel center to accommodate the fixed differential. The axle halfshafts were of fixed length and functioned also as the upper suspension arms. And again, the suspension had the built-in anti-squat and anti-lift characteristics, and yet the steer characteristics were nearly neutral with slight understeer. The anti-roll bar could be easily changed in size for the most compatible roll stiffness distribution. This special version of the IRS was constructed very much like a Grand Prix suspension, in tubular fashion, with solid spherical bearings, rather than rubber bushings for precise wheel guidance.



Competition Shelby Mustangs, like SFM5R001 here, benefited from the Mustang IRS testing.

Continued On Page 47



Lowered upper control arms from the IRS Mustang's front suspension were incorporated into the 1965 Shelby street cars.



Although Aring's Independent Rear Suspension was never productionalized in a Mustang, it became an important part of the 427 Cobra suspension in 1966.

MUSTANG IRS

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Q: And you were using the Mustang body at this time?

A: Yes! No longer the Falcon. We put this version — the one with all the fancy aluminum or magnesium wheels and all — into regular Mustang bodies for evaluation. Three such vehicles were built. Only the first one was built under the Falcon disguise, and that was the one we tooled around with in Riverside. So nobody knew the real intent. But then at Ford in Dearborn, we had these three vehicles built with the same suspension, but with production fastback Mustang bodies.

Q: How did it drive?

A: Very good ride and handling! There was, of course, less unsprung weight, so it could be tuned for a very comfortable ride. And that suspension design was to be productionalized, which means that instead of expensive tubing, you design stampings, and rubber bushings to replace spherical bearings etcetera.

Q: But this car was not productionalized. Why?

A: That effort was eventually halted, simply because the Mustang sold so well that it was thought that we really did not need this special option which would have required a very high investment for tooling.

Q: At this point then, you still lacked a competition Mustang. Looks like the time was ripe for a Carroll Shelby to enter the picture?

A: It was about that time frame, the middle of 1964, that the question was raised, "How do we get a competitive Mustang and enter it into racing, and also make a special street version? From that, the GT-350 was born. I do not recollect who started it, whether it was at Shelby, or a combination of Shelby and the people at Ford Planning.

Q: What part did you have in the design of the GT-350 suspension?

A: The front suspension that we had developed for the IRS Mustang was made part of the GT-350 Shelby Mustang package.

Q: It was simply carried-over from the IRS Mustang?

A: Yes, the front suspension was virtually carry-over componentry, taken more or less verbatim from the IRS car.

Q: What were the main changes made, compared to a stock Mustang production car?

A: One was to raise the roll center, from near ground level to about four inches. And secondly, to increase the camber change. If you increase the camber change, you decrease the camber change effects of the car under roll conditions. So we



Testing at Riverside, from left to right: Ford's J. McQuaid, Shelby American drivers Richie Ginther and Ken Miles, and Klaus Arning.

wanted to favor the cornering capabilities. And a quicker steering ratio.

Q: Why didn't Ford go ahead with the IRS in the GT-350?

A: It would have been a very expensive investment and piece-cost proposition.

Q: We read that Carroll Shelby said the IRS was not worth it, for the GT-350, to make it competitive.

A: Yes, I have his book in front of me. It says "...fanciful hopes of enthusiastic automotive writers said there would be an IRS," and then he says, "the swing axle IRS was strictly a developmental program..." Well, first off, our IRS was not a swing-axle design (laugh). "Swing-axle" is a dirty word — that design was used in the original Corvair rear suspension, and also the early Volkswagens. Although the least expensive form of IRS, its inherent limitations (i.e. very large camber change, very high roll center) gave the "swing axle" a bad reputation. Our four-link IRS was far more sophisticated. Carroll certainly agreed to that later when he used our IRS design in the famous Cobra II chassis with Ford's 427 engine, and he gives full credit to this fact in his book *The Cobra Story*. Nonetheless, it is true that the IRS Mustang never got into production, but it was not because of deficiencies of design. It was strictly an economical decision, due to cost. No doubt about it. And of course, solid axles on race tracks can do pretty well. Take a look at our stock car racing. Right? And remember that the IRS was not developed solely for competition on the Mustang, but it was primarily thought to be truly an option that everybody could buy. And then it could be further developed for a competition type of car. Efforts did continue to try to productionalize it, but it was finally cancelled because it was clear that there would be a pretty high investment for the number of cars sold. Maybe we under-estimated its appeal, but nonetheless, it was a good design.