First installment of a Formula investigation-in-depth

HATCHING AN EAGLE

Part 1 by Pete Lyons

Are you a design doodler? Are you a person who likes to dream up new race cars, covering sheet upon sheet of paper with different component configurations, different frame layouts, different body shapes?

You're doing it right. That's exactly the way a professional designer works out a new race car. We have proof: a bundle of discarded idea sketches drawn up by Dan Gurney Racing's John Ward while he was conceiving the Eagle Formula Ford. They make a fascinating study of the many considerations, not all of them immediately apparent, that determine the ultimate shape of a competitive machine.

The differences in your approach and John Ward's may not be in kind, but there is a difference in degree. Having to turn the doodle into actuality, with all the attendant commitments in commercial resource, time, talent and to a very real extent human life, places a demand on the professional designer to come up with, not the best looking design, but the best.

Thus Ward, Dan Gurney, assistant designer Ron Hopkins and driver David Loring, all of whom had hands in the ultimate car, were not doodling. The Eagle FF had to be good; it had to be a potential winner. They simply could not afford a mistake.

For many weeks ideas were raised, cultivated, chewed, digested and — in many cases — eliminated. "We came up with lots of concepts, from mild to wild," recalls the designer, "before the best layout began to gell."

The drawings we reproduce here illustrate some of the steps in this evolution. Taken individually, some of these tentative designs appear to be everything a racer might drool over. Bullet noses, fully streamlined cockpits and afterbodies, tapered trailing edges, inset central radiators, inboard suspension at all four corners — all were drawn. But not, in most cases, finally built. Why?

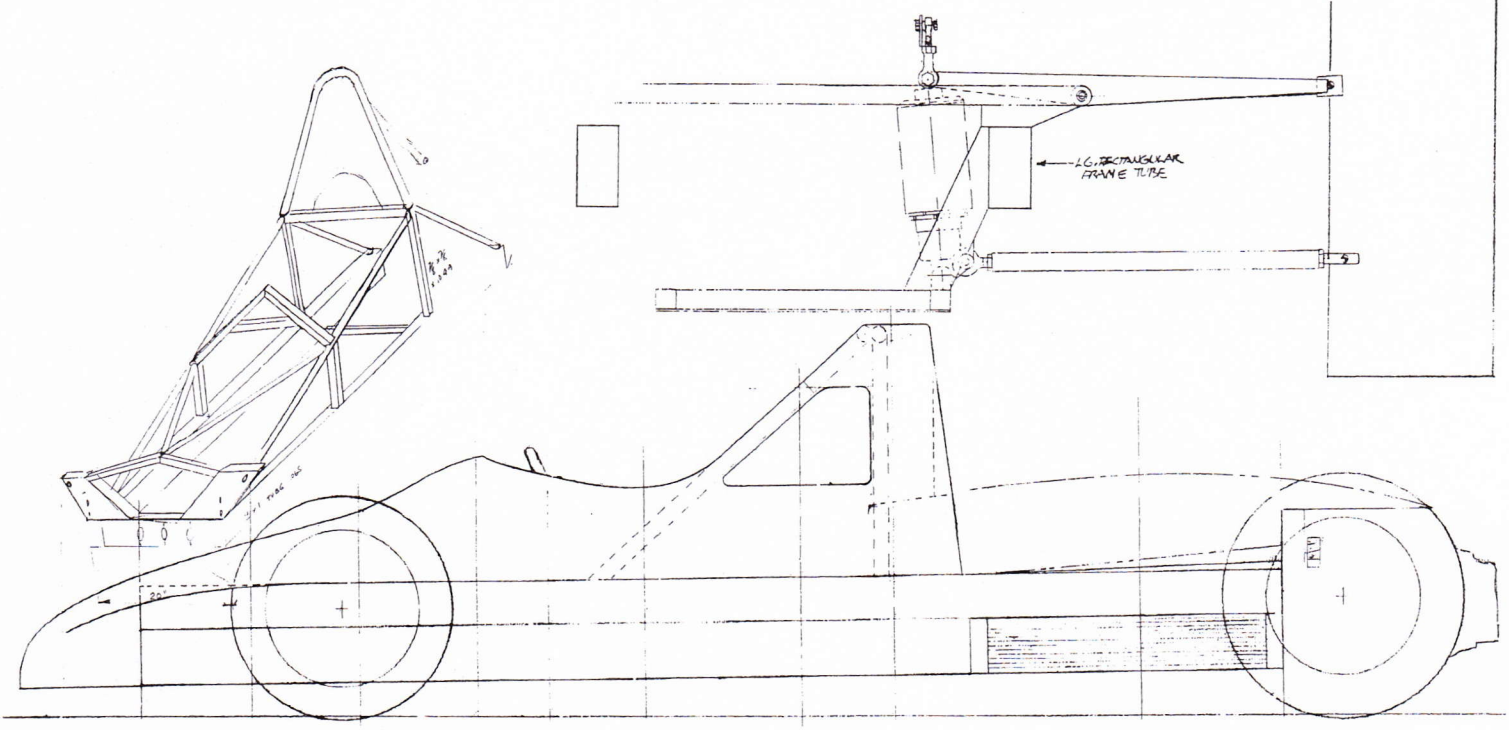
Because appearances with race cars, as with lovers, can deceive.

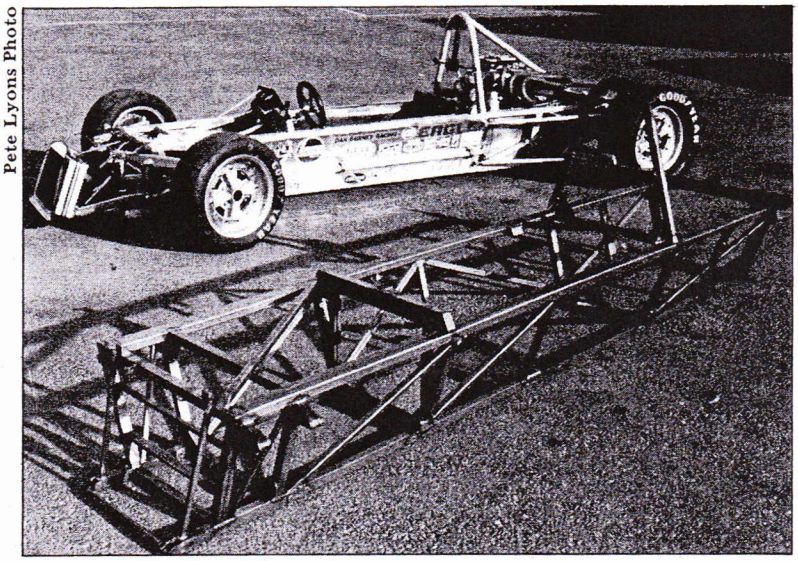
"The first thing we did, of course," recounts John Ward, "was to immerse ourselves in the rulebook. We had to find out exactly what great ideas we weren't allowed to come up with! Along with that, we started gathering input from everyone who had any experience about racing Fords. Starting in October, 1976, we started putting everything we knew and everything we wanted to achieve down on paper."

What the designer wanted to achieve primarily was straight line speed. Used to 800 hp Indy cars, Dan Gurney Racing was to an extent exploring new ground here; a good FF engine produces hardly more than an eighth of a USAC motor.

Dan himself explained to us what follows from that fact. "The Fords don't have a lot of horsepower and they do stick pretty well, so that translates into taking a lot of corners flat out. A lot of corners aren't going to really be corners. What I mean is, these cars are spending a larger proportion of their time at maximum speed than a lot of other kinds of car."

Downforce, that so-important virtue of ultra-powerful race cars, is not considered helpful by the Eagle men for this class. "In a car body you can figure that a ten pound increase in downforce is a ten pound increase in drag, near enough, and we just can't afford that," says Ward. In all our profiling of the body, and we tried out a lot of profiles, we weren't looking for downforce to any greater extent than just being sure we didn't have any lift."

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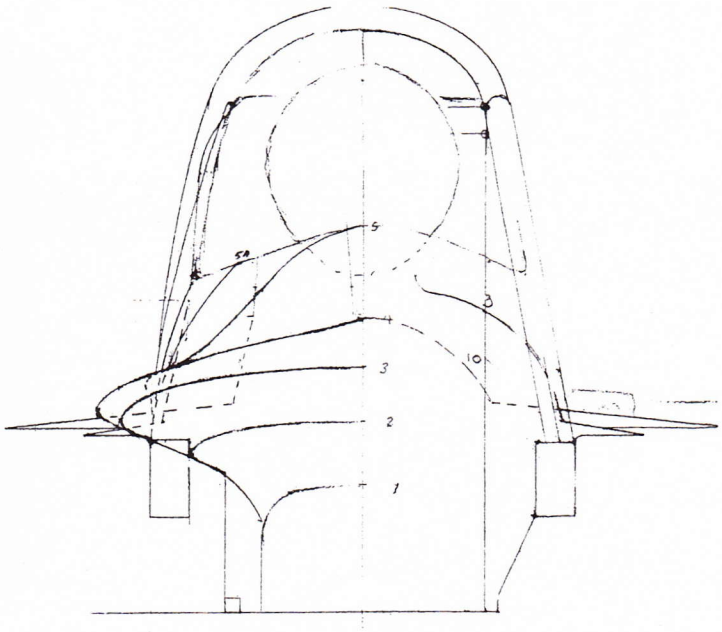

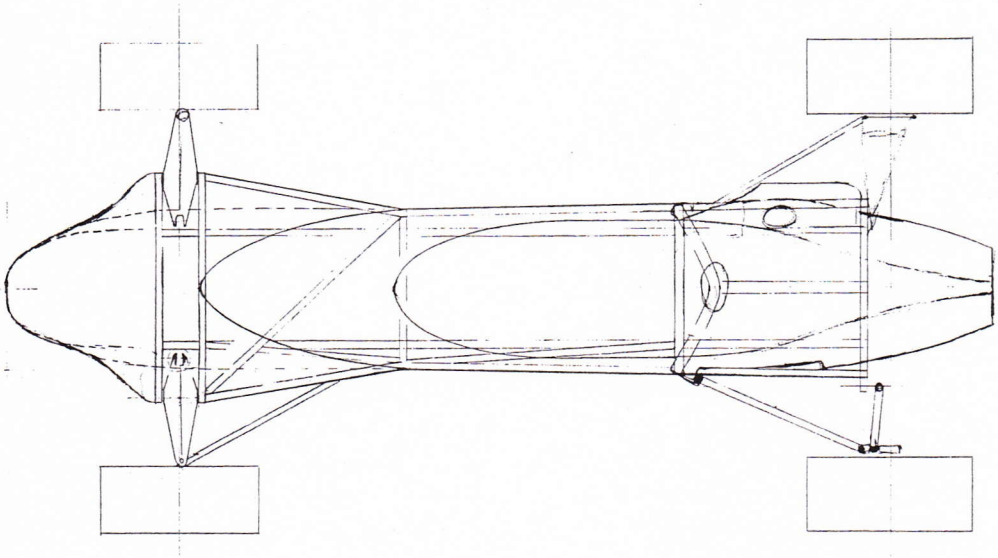

Thus there is no wedge shape in the final Eagle nose, no up-slant in the final body line at the rear. However, neither is there as much of the extremely sleek overall shape as some of the early drawings show.

"The basic realization here," says Ward, choosing his words, "is that the speeds we're working with are not really very high. Even an Indy car doesn't really operate at high air speeds, not compared with airplanes. For a Formula Ford we're talking about, as a number, 135 mph tops. That's more like Goodyear blimp speeds!

"What this means is that we don't have much dynamic pressure as the airstream meets the car. The pressure rise might be on the order of ⅓ psi from the normal atmospheric pressure of 14.7 psi, and it drops back to normal pretty rapidly back along the body. We've therefore got only a limited amount of time to act on the air to get it to do what we want, to get it spread around the car. The efficient leading edge for any low speed shape is quite blunt. Sort of the classic raindrop shape."

But he doesn't carry the "raindrop shape" back to the tail of the car. While it might look good to enclose the roll bar and carburetor and taper off the trailing edges of everything, Ward has real doubts that any of this is worthwhile. "There are differing opinions, but I personally believe that once the air has gotten back that far along the body the flow is so turbulent there's not a lot you can realistically do to smooth it out."

In a word the front of the car is more important than the back. Ward also believes that the actual shape of an open wheel car is not as important as the overall bulk of it — the size hole it punches in the atmosphere.

"We went to a lot of trouble to make the car as slim as possible, and I don't mean only the 'fusilage;' we went to a pretty narrow track, finally, too. I think you can consider the car as a box measured across the wheels and our tests indicate to our satisfaction that a narrow car is faster. It's almost, in fact, on a ratio of one less inch of track width being worth one more mile-per-hour. That's from back-to-back tests with our prototype."

He might consider even an open wheel car to be a "box" but Ward did pay

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We have a feeling at FORMULA that most of our readers who don't already race would like to start racing. Whenever they ask us how to go about it, we reply with our opinion that one of the best ways to take up the sport is to get into Formula Ford.

With this article, the first installment of a five-part series, we launch an in-depth investigation into one of today's most competitive Formula Ford designs. It is our contention that anyone taking up racing will profit by investing time in a thorough grounding in the basics, just as is true in any other profession.

We chose the Gurney Eagle for a number of reasons. It gave us a chance to follow the entire design and development period from scratch, as carried out by one of the greatest race car construction organizations in America. Yet Dan Gurney Racing had never built a Formula Ford, so the problems that had to be solved would be fresh in the minds of everyone we talked with. Dan himself and designer John Ward were very cooperative, too, and opened to us files that offered an enthralling insight into the group mind of a first rank team. Happily, the new Eagle proved to be a real flyer as well; David Loring won one during the first season, 1977, and was a strong contender in many others.

Our series starts out this month with a background look into the problems presented by the formula and how the preliminary Eagle design was painstakingly developed into its final configuration. The second part, in our February issue, will describe the actual construction process. In succeeding articles we will detail the development testing of the prototype car, and follow that up with stories about setting up a customer car for specific race tracks and actually running a race weekend.

EAGLET

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attention to airflow down between the sides of the car and the wheels. At the front suspension the springs are mounted inboard, operated by rockers. He originally intended to mount the rear springs the same way, but "we began to see where it was going to be heavy and expensive and not really give us much advantage." The rear uprights, however, are tucked away inside the dish of the rear wheels, out of the airflow.

As for the early schemes showing radiators sunk into the sides of the car, even behind the driver's seat in one case, the ultimate location in the nose was a case of other considerations than aerodynamics coming into play. "With the tires you run in Ford there isn't any point in carrying a lot of your weight on the back wheels. In high powered cars, yes, you might have two thirds on the rear and you've got tires developed for that condition, but for the Ford we decided to aim at a static distribution of about 57 or 58 percent on the rear wheels.

"Once we'd put the driver into the place we wanted him for safety, back from the extreme front of the car, the position of the radiator in the nose was pretty well mandatory. That means the radiator is protecting his feet in a crash to some extent, and so are the suspension and the whole front of the chassis".

The tires available determined the Eagle's suspension geometry, too. "Well, you actually work backwards from what the tires want. Set up your camber changes and roll centers and so on according to the characteristics of the tires. Over the years we've evolved the idea that we want our roll centers to be above the ground level at both ends, with the rear a little higher than the front. A forward slope to the roll axis helps promote stability.

"Roll center is directly related to track change. The lower the roll center the less track change you get with bump deflection and therefore the less tire scrub. If you have a geometry that moves the treads a little bit sideways on every little ripple you're going to get them breaking away a little more easily and the driver is going to feel the car sort of worming around under him. It's unsettling.

"Then we dial in the magic camber change curve, whatever we think the tires need. This is a process open to trial and error. No, I'm not going to let you publish any figures, it's a big secret around here what our car has in this department. We're very happy with it. We're cornering faster than any of the other cars — this was visible at Atlanta — despite having a narrow track. We're using the tires just about to their optimum, we think."

Deliberately, Ward has not given the prospective Eagle owner much scope for adjustment of suspension geometries. "First of all, a lot of adjustability would drive up the cost and the weight. Secondly, we decided not to encourage our owners to play around with geometry. It's going to

work out best for them if they don't, in terms of the simplicity of the car, its weight, its durability. On some of the other cars you've got super adjustability, lots of holes to put things into for changing geometry for wet conditions and so on, or so they claim. But all we do with our car for the rain is soften it up and it seems to be all that's required. David has been quickest in the rain, too."

Consideration of the owner emerges as one of the major design goals. "Simplicity is a pretty big virtue, you know," confirms Ward. "Simplicity is what's going to be helping our customers when they're out there in Iowa at 3AM, if you know what I mean!

"That's one reason we selected mild steel for most of the chassis structure instead of some of the exotic stuff we considered at first. Well, the roll bar is 4130, it's worth it there, but our rectangular and square section mild steel tubing is easier for us to fabricate and it's going to be easier for our customers to repair in the field."

He goes on to point out that the square material is stronger in a bending sense than equivalent round tubing, which enhances driver safety. "We have given a lot of attention to crash survivability. You see in some of the drawings how we played around with various layouts incorporating large-section side rails. Our idea was not only to make a simple frame layout but to give the driver a kind of impact barrier too.

"What the drawings showed us, though, were a lot of disadvantages in other areas. Problems like getting the rack and pinion through, or picking up the suspension loads, or, say, getting at the starter motor to change it. The starter motor on Formula Ford engines seems to need a lot of changing, according to what David told us. The twin-tube idea looked neat at first but it just gave us various and sundry problems that just didn't make sense when you're trying to put an actual race car together.

The space frame we finally settled on gives us a simple car to build and a simple car to straighten out, if need be. It's plenty strong — we've unfortunately tested its crash strength a couple of times! — and we can change the starter motor pretty easily too!"

(We continue next month with Part II, Construction Analysis.)