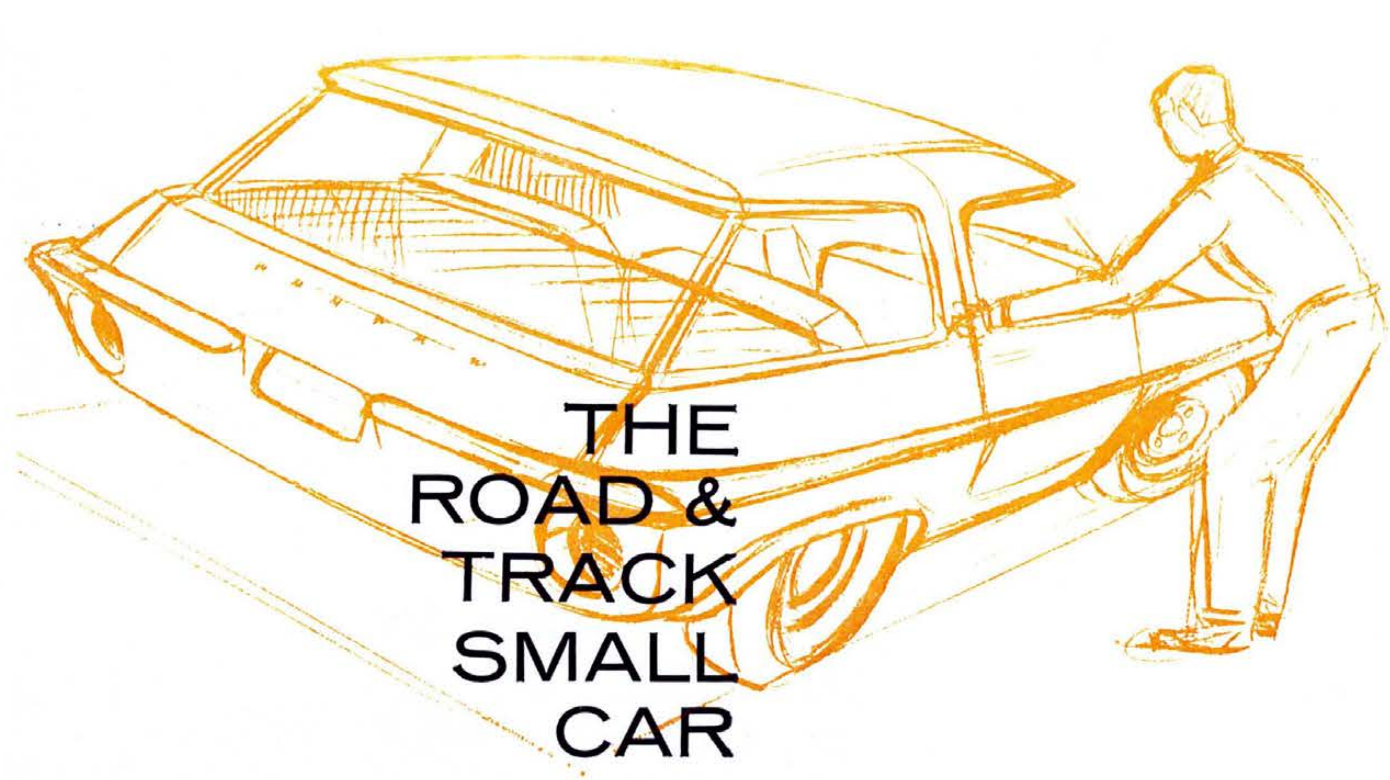


THE ROAD & TRACK SMALL CAR

Sports Car Design 50: A new kind of car for America

BY JOHN R. BOND AND GORDON JENNINGS

A SMALL economy-type car designed for family use is not usually catalogued as a sports car, but our staff did feel that it is qualified for the Sports Car Design series on two points. First, there is great current interest in similar projects; second, a small car, to be really successful in this country, should be a high-performance machine as far as possible or practical within the limits of reasonable operating cost. Admittedly, the definitions for such terms as small, economy, sports car, high performance, practical and reasonable can vary a great deal. For example, American manufacturers seem to feel that anything under a wheelbase of 110 inches is "small." We feel quite different and arbitrarily draw the line at 100 in. This is primarily because our lowest-priced cars were once very close to that dimension, and because the majority of makes of cars in the world are in fact smaller than that. If a car can only be defined as small when it has a wheelbase of 100 in. or less, then the European "mini-car," with wheelbase less than 80 or 85 in., can be logically placed in its proper perspective as smaller than small.

As mentioned last month, our staff finally agreed that our proposal for a universal car designed for worldwide appeal should have the following basic specifications:

1. Seating for four adults, with no thought of five or six in a pinch.
2. 100-in. wheelbase.
3. A tread of 54 in., primarily because anything narrower gives trouble on grease and wash racks.
4. Sufficient power to accelerate from 0-60 in under 20 seconds, with an honest maximum of 85/90 miles per hour.
5. One body of the wagon type, with two doors.
6. No options except an automatic transmission.

THE PACKAGE . . .

The starting point was, of course, the seating package. No one wanted 13-in. wheels, and a tire size of 5.90-15 meant that the rear seat back had to be placed between the rear wheels to get adequate knee room. The front toe boards are right up against the front wheels, and a very slight wheel-house intrusion was considered acceptable. In general the actual seating package is almost identical to that of the four-passenger Thunderbird in profile.

Up to this point the arrangement and location of mechanical components received no consideration. But even a casual look at the package, loaded with four adults, shows that excess weight at the rear will be a problem. Accordingly the possibility of a rear engine location was immediately ruled out as impractical, even though it would be the cheapest to build. Front-wheel drive would have been quite feasible: with an approximate 55/45 weight distribution, the car would have had good directional stability. However, f.w.d. would have been by far the most costly solution and furthermore, since this is a four-passenger car, a modest central tunnel to house the drive line is not objectionable. As cars get lower, a tunnel of some sort appears to be desirable regardless of engine location. If the engine is in front, the tunnel is ideal for routing the exhaust pipe (for ground clearance); if the engine is at the rear, we need a tunnel for controls, wiring leads, heater ducts and the like.

THE DRIVE LINE . . .

The next important step was to rough-in a drive line that would require a modest tunnel. In our design we have in effect almost no tunnel at all, because the main floor pan has a 1.5-in. crown with foot wells. If we start with the floor pan at 7 in. above the ground (the Thunderbird's is 6.5 in.), the overall height of our car can be as low as 53 in. The tunnel itself is 3 in. thick, and as our transverse floor plan drawing shows, the actual tunnel used does not project above the crowned floor. A conventional tubular driveshaft is shown in one of the drawings. This employs the latest type small-diameter, high-torque universal joints and it measures just under 4 feet long. This central shaft is supported by two conventional steady bearings, one at each end. These bearings are, of course, sealed for life and rubber cushion mounted.

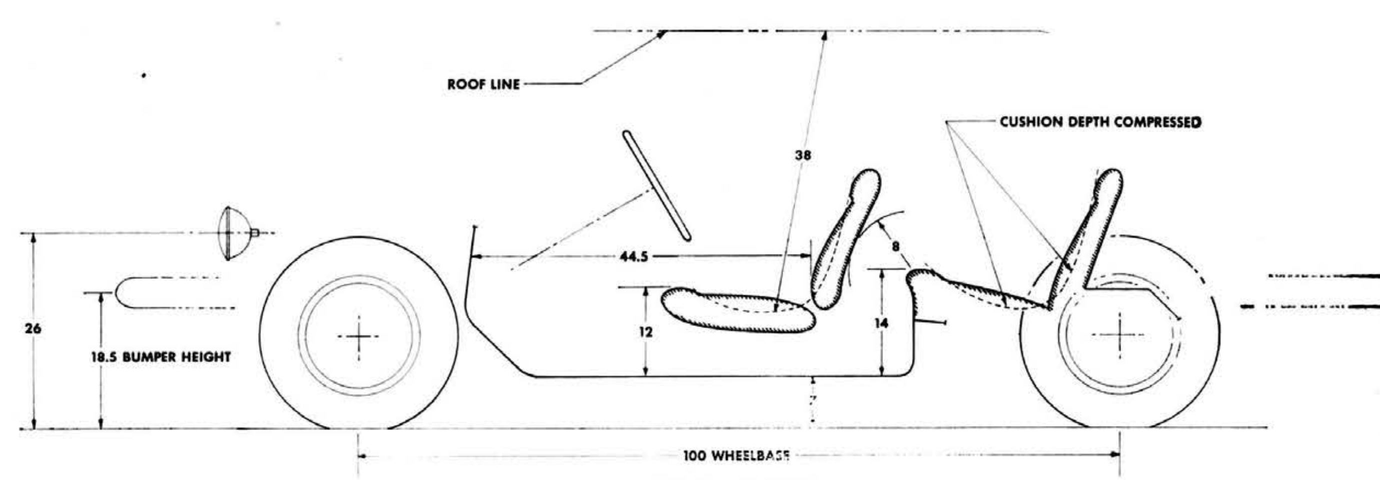
The complete drive line is a three-piece assembly. The shaft at each end is essentially a torsion bar with a crowned spline at one end to take care of misalignment up to 3°. The joints proper operate at a fixed angle of 6° at each end to give uniform velocity (most joints will absorb up to 12° or even 15° in operation).

THE TRANSMISSIONS . . .

Our original idea was to design a small multi-plate clutch to fit onto the rear of the engine in such a way that no toe board intrusion would be required. Then a more or less conventional 4-speed transmission assembly would be located amidships and inverted, with a neat, direct-action manual shift lever. When we began to plan the automatic transmission option it was immediately apparent that this unit would be nearly 8 in. in diameter and accordingly would not fit in the same space. It would also have to have a raised drive line and a higher tunnel. Furthermore, as specifications for the automatic developed, it became apparent that most of its parts could be utilized in a manually shifted box. We therefore decided on rear mounting for the standard transmission, as well as for the optional device. We also designed the automatic transmission first, knowing that a simplified version of it, with a manual selector, would be more compact and would pose no space problem.

The first basic requirement of the automatic unit, according to unanimous agreement by our staff, was that it should *not* have a torque converter, purely because their efficiency varies from 50% (at the worst point) to not over 88% at best. A fluid coupling as in the Hydramatic would have been acceptable, but its size (diameter) presented problems, and of course it is costly. With both these semi-cushioning devices eliminated, selection of the type of automatic revolves around the problem of securing adequately smooth upshifts (smooth downshifts are relatively easy to obtain). Our choice would be the relatively simple gear arrangement used in GM's Hydramatic, with two sets of epicyclic gears in tandem, each with a band brake and a multiple-disc clutch. This would give 4 forward speeds with the fewest possible parts. (A third epicyclic gear set is required for reverse.) At first we tried a conventional transaxle layout, with the transmission behind the differential. This could have worked out satisfactorily, but we ultimately mounted the transmission assembly transversely and ahead of the differential, thus avoiding an inconvenient trunk floor bulge and actually utilizing what was, prior to that, waste space behind the rear seat. In essence our final drive is a double-reduction type with a pair of spiral bevel (not hypoid) gears giving the first reduction—a ratio of 1.60:1. This puts a higher torque through the gearbox, but entails very little penalty because the epicyclic gear sizes were already larger than necessary in the concentric-shaft-overhung preliminary design. The slower speeds also mean easier shifting in the manual box, rather like typical motorcycle practice. The second reduction ratio (2.50:1) is by normal helical gears. This double-reduction design gives better balanced tooth loadings with larger pinions and smaller gears than a single reduction arrangement.

But, to revert to the GM Hydramatic type of transmission, it is necessary to use some kind of starting clutch to obtain smooth operation. Many Wilson applications used a conventional single-plate clutch, but later designs, such as the Armstrong-Siddeley (and earlier Talbots) use an automatic centrifugal clutch controlled solely by engine speed. We propose a small, external, multi-plate clutch similar to those used inside each epicyclic gear train, with control via the automatic's hydraulic system. *(continued)*



SEATING PACKAGE

The seating package shown above represents, in our opinion, the minimum acceptable amount of room in an automobile designed specifically for mass sales to the demanding American market. The 100-inch wheelbase may seem longer than necessary, but a shorter one would have forced an increase in the height of the car if the same leg room was held. The bumpers are located at the SAE-recommended height and also indicate the approximate overhang of the finished product; our stylist may disagree.

Automatic transmission controls have now become more complex than the old stick-shift jobs, with as many as six positions. For this car we propose a simple dash-mounted knob with two principal positions, Neutral and Drive. Two other positions will be necessary, down and to the left for Reverse and down to the right for Low. No illumination will be required because shifts can readily be made by feel alone.

The manual transmission would be similar to the automatic unit. We estimate demand at very close to a 50-50 division between the two types. Accordingly, to save on tooling, the manual unit uses gear trains very similar to those of the automatic. Two bands still give 1st, 2nd and 3rd (dependent on sequence) but the fancy hydraulic direct-drive clutch in each gear train of the automatic is deleted in favor of a simple dog clutch.

THE PERFORMANCE REQUIRED . . .

Up to now there has been no mention of the engine, except that it will be located forward. Before any choice was made, the Technical Editor made up a series of calculations based on a few elementary assumptions and requirements, as follows:

1. The loaded weight with two adults should be 2000 pounds.
2. Top speed, cruising speed and engine peaking speed should be equal, or nearly so.
3. Pounds/horsepower to be close to 30.
4. Performance factor to be 100 cubic feet per ton mile.
5. Wear factor to be close to 50.

Omitting the details, we arrived at the fact that a stroke of 3.25 in. and an axle ratio of 4.00:1 would do the job. The actual data then become:

1. 88 mph = 4610 revolutions per minute, and 60 mph = 3140 rpm.
2. Cruising speed = 88 mph at 4610 rpm and 2500 feet per minute.
3. Engine peak should be 4500 rpm.
4. Piston travel = 1700 feet per mile.
5. R&T wear index = 53.4.

From this point, similar calculations show that a 4-cylinder, 4-cycle engine would need a cylinder bore of 3.25 in. to give 98.2 cu ft/ton mile. This in turn gives a square engine with a piston displacement of 108 cubic inches, or 1770 cubic centimeters. An output of 70 bhp would require only 0.65 hp/cu in. and the lb/hp figure comes out at 28.6. (Note that our lb/hp is based on curb weight plus 300 lb, not on advertised shipping weight.)

At this point, we go back a little and ask the question, "Do we want a 4-cyl, 4-cycle engine?" The idea of specifying a 2-cycle engine was tempting, for this type offers very adequate power in a small package at extraordinarily low manufacturing cost. A 3-cyl McCulloch-Scott (outboard marine) engine develops 60 certified bhp from 1037 cc; an Evinrude-Johnson V-4 offers a 50-bhp output from 1159 cc. Either of these engines, enlarged to about 1500 cc, would weigh and cost about half as much as our conventional 1770-cc four. However there comes a point and a time in making decisions where discretion is the better part of valor. The 2-cycle would undoubtedly incur a great deal of sales resistance until it proved itself, and its development time would probably be longer. So we dropped the 2-cycle idea, but it could come along at a later date with a substantial price reduction (assuming no more inflation).

A flat-4 was discarded on the basis of its higher cost as well as its relatively poor accessibility. So, by elimination, we arrived at a conventional in-line 4.

THE ENGINE . . .

Fairly complete details of this engine will be published next month. Most unusual external feature is a forward-mounted, marine-style flywheel. This was incorporated to get a low drive line. The crankshaft must be exceptionally rigid in torsion, so it will have four main bearings in the style of the current Opel (these were also once used in a 4-cyl Packard truck!). Since it is generally known that no automotive manufacturer is planning any of his future engines around sand castings, this one is designed to be cast in metal molds. The material is of course aluminum alloy. Internally, the engine's most unusual feature is a single overhead camshaft that will make the engine cheaper to produce than a rocker-arm overhead-valve type.

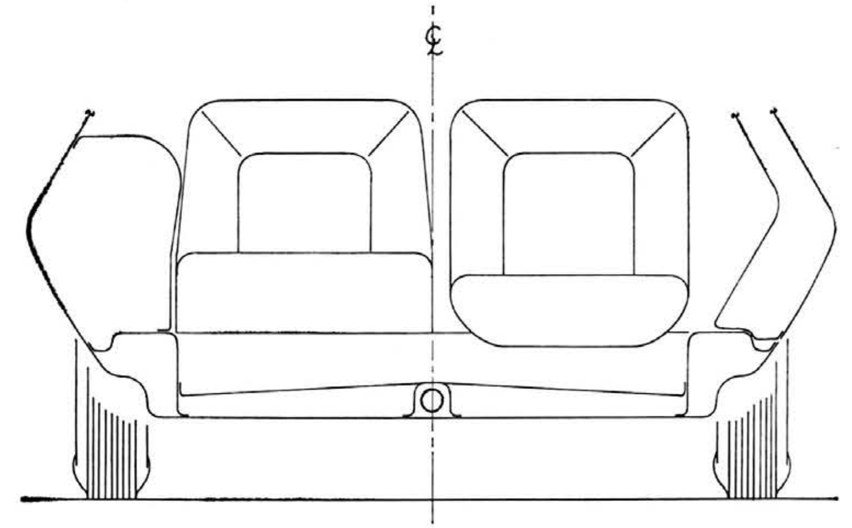
THE BODY AND STYLING . . .

To secure a curb weight of 1700 lb on a 100-in. wheelbase, unit construction is certainly a must. Since no annual models are contemplated, this presents no real problems and the use of only two doors, along with a well supported roof, makes for easily obtained structural rigidity.

Again by unanimous decision, we ruled out a wrap-around windshield. We compromised on a curved piece of glass, provided that it has one constant radius.

Our technical department is at present engaged in a great struggle with our favorite styling consultant, Strother MacMinn; the gap that separates us is the classic argument of styling concept as opposed to manufacturing convenience. This is the same argument that we find going on in Detroit, with one important difference: styling will not be allowed to influence engineering to any great extent here.

Actually, we are exaggerating things a bit; Strother MacMinn has a marvelous knowledge of manufacturing procedure and seldom comes up with anything impractical. Next month we will present the drawing that result from our meetings with MacMinn; we do not yet know exactly what the car will look like, but we can promise you something new and different.



At left: this section drawing reveals, to the right, the front seat and the shape of the door, while the left side shows the back seat and rear wheel well. Also shown are the two boxed-in side members that provide much of the chassis strength and the low, narrow floor tunnel enclosing the driveshaft. Below: the three basic possibilities in arranging the mechanical components. First, the rear-engine layout; this is workable in very small cars where engine weight can be compensated for, but the lack of proper balance forced us to abandon this appealing design. Second, the front wheel–drive chassis, which looks rather promising at first glance but entails too many complexities and compromises for our tastes. Third, our final choice: the conventional front engine with rear-wheel drive, unusual only in that the clutch, gearbox and final drive are rear mounted.