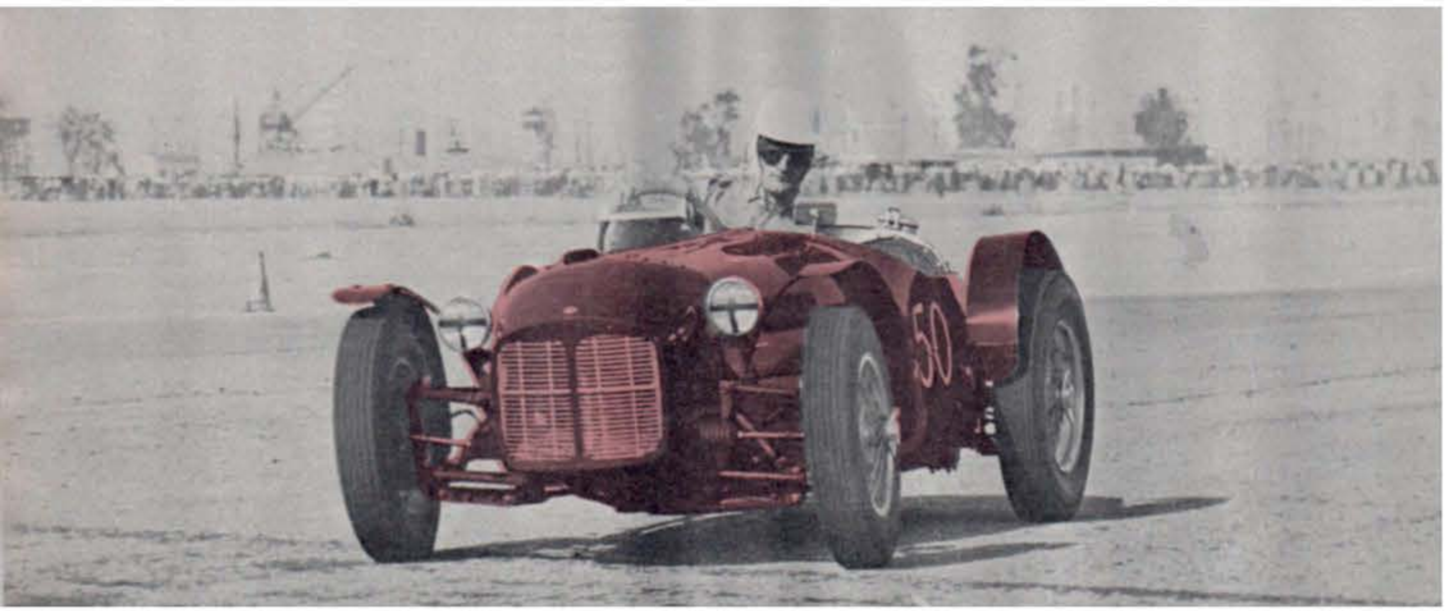
Designing and bolting together a sports car is not a casual undertaking but by taking stock of your assets and some careful thought a class winner can be made at home. Ken Miles tells how to . . .

BUILD IT RIGHT



PART I
By Ken Miles

Editor's Note: If anybody is qualified to tell our readers how to build a successful special that man is Ken Miles. Many readers will remember how Ken took up the challenge from the world's most successful under-1500 sports cars and whipped them hands down with a dual succession of MG based specials, becoming the nation's "Mr. MG" in the process. Since that time Ken has assisted in the building of two other cars, both successful. Here, he gives SCI's readers a thoughtful analysis of how this string of successes was accomplished and the pitfalls to be avoided by those who would strive to equal his record.

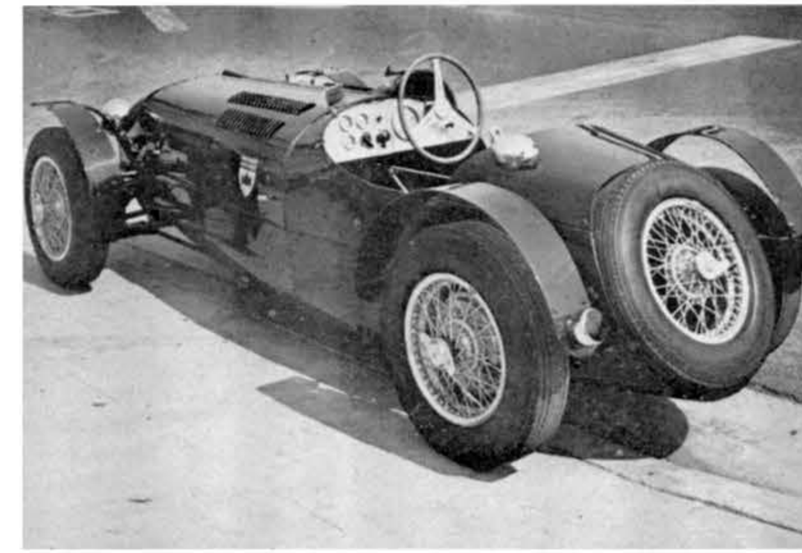
WHY do people build what are commonly known as "Specials"? Why, when there are cars of every conceivable shape, size, displacement class, price and prestige readily available for purchase to suit every possible need or fancy, for the hottest competition or the greatest luxury, would a man go out and sweat blood and tears, strain his imagination and his relations with his family, ruin his bank balance and his health to build a car to his own specifications, or, more usually, a specification thrust upon him by his friends, the magazines that he reads or the current trend of automotive fashion.

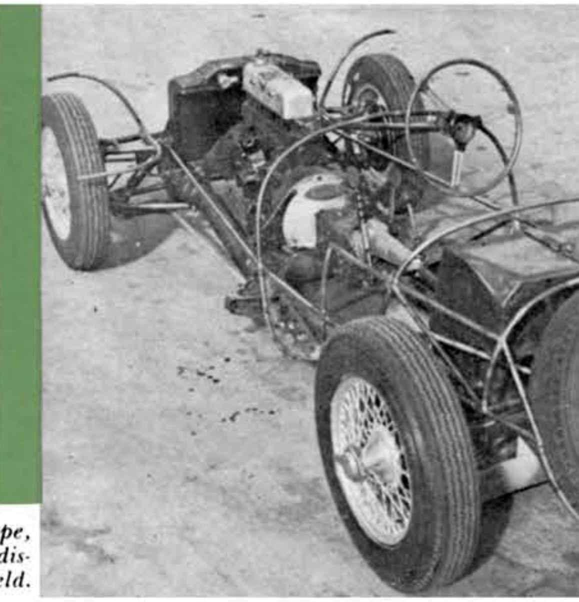
Certainly many of the "Specials" that I have seen have been a tragic and expensive mistake; for the cost, in money alone, disregarding the investment of time and energy, the builder could have bought himself a properly constructed car of superior performance, for unless you are endowed with an unusual degree of practical engineering skill, have an unlimited amount of spare time and excellent facilities for getting things done for free, it is illogical to assume that you can build a piece of machinery on a "one off" basis cheaper than a factory can produce the same thing in reasonable quantity. Furthermore, labor in this country, machine shop time, body panelling, and other work that the average special builder cannot do himself is the most expensive in the world.

It is absolutely and regrettably true that speed costs money, and the more money you are prepared to spend, the faster car you are liable to produce. Since high speed automobiles are essentially a limited production item incorporating an immense amount of hand labor, the best buy for your dollar is a car built by a firm specializing in this type of car located in a country where labor costs are a minimum.

All this must be perfectly obvious to anybody who is ambitious enough to contemplate the manufacture of a car of his own, yet still the specials appear, so there must be some other reason than mere economics. In some cases the reason is obviously political; you cannot very well earn your living selling M.G.s and race a Porsche; in others, the designer-constructor is anxious to try out his own solution to the many problems that confront him, but in by far the majority of cases the potential builder said to himself "I have lots of spare time, I have a nice little workshop, I love sports car racing, let's build a Special." If, at this stage, our budding race car manufacturer would sit down and think a little about the project before he starts cutting metal he would save himself a lot of time, money and anxiety.

First of all, let's consider the object of exercise. Are you going to try to build a car that will win overall against any opposition, or one that will win within its own class? Are we trying to build a car far superior to its competitors, or are we hoping to build a car that is just as good as the opposition, costs far less to build and will win by virtue of our superior driving skill . . .



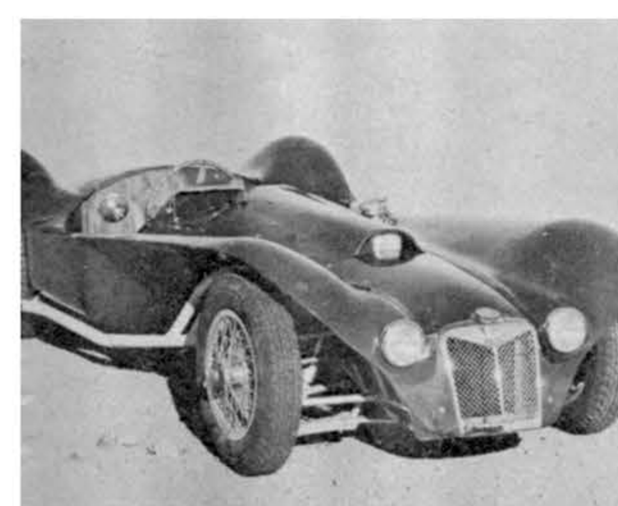


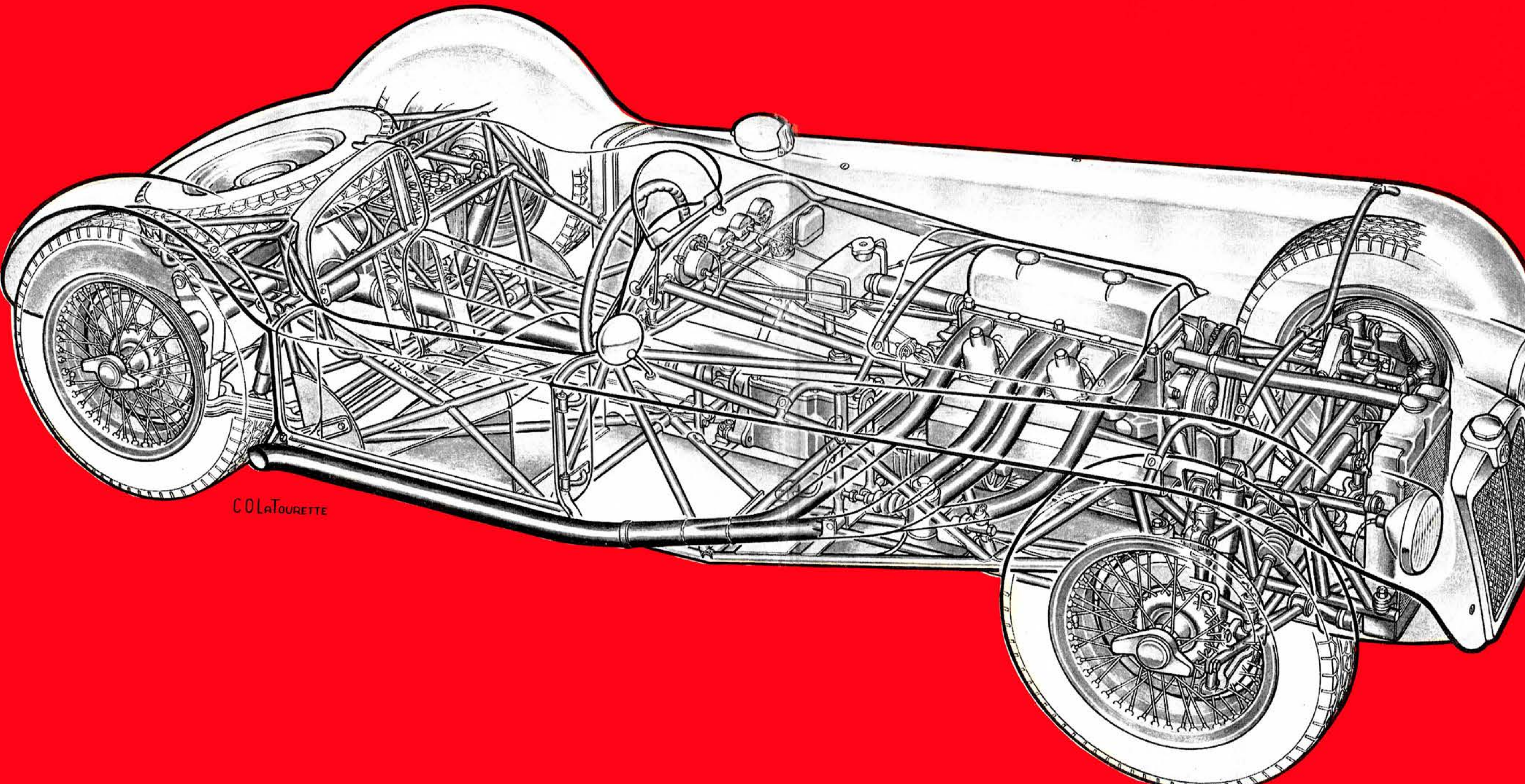
The first Miles special, the R-1, is a fine example of the use of the ladder-type, large diameter tube frame, with the attendant advantages (simplicity) and disadvantages (body framework requirements). Running gear was essentially Nuffield.

we hope! Or are we building it primarily for the sake of exercising our own ingenuity and only incidentally hoping that it will prove better than the others in its class? This question can only be answered by the builder with reference to the facilities available. The quality of the finished product is going to be related directly to the amount of engineering skill, time, imagination and money that is lavished upon it. A shortage of any of these essentials can usually be counterbalanced to some degree by an unusual abundance of another: if you have lots of skill you can devise economical ways of making things; if you have lots of time you can do things yourself that would generally be considered the job of an expert; and if you have enough money you can buy skill, time and imagination.

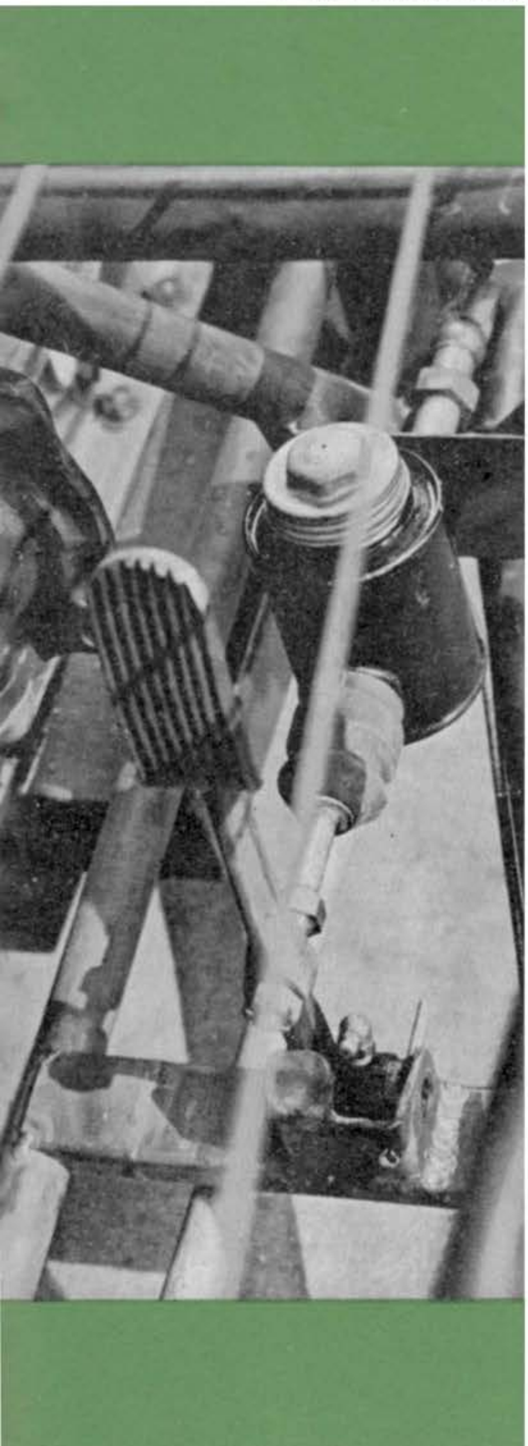
Most specials seem to be built on a relatively limited financial budget, ingenuity and time being in good supply and expected to substitute for money, so the very first thing to do is to examine the racing picture as it stands, see what cars are winning races, and why, and try to estimate where our proposed masterpiece will fit into the picture. If we are setting out to build ourselves a winning car we should ask ourselves, "What will our car have that the winning cars do not enjoy? Why should our car beat them?" Now there are only a limited number of reasons why a car will lap a circuit faster than the next one; either it has more power, by which we mean not necessarily a higher ultimate power output but a better overall power curve, less weight, better brakes, greater aerodynamic efficiency or superior roadholding. Sometimes a consistently successful car will have an overwhelming superiority in one particular or another but more usually they enjoy a slight advantage in almost all respects. No car is ideally suited to every possible type of course, and if your intention is to race chiefly on courses within the USA, then you can build a car that is suitable primarily for American courses and it will have a definite edge over cars built for general use. Most courses in this country are, relatively speaking, slow courses, inasmuch as they incorporate few turns that can be taken at speeds in excess of 100 mph and fairly short straights. Most of the turns will be taken at speeds in the region of 50 to 70 mph with a few as low as 30 mph, so that cornering ability in the 30 mph to 80 mph range will be much more important than good controllability in a 120 mph turn. A car set up to handle well in a 120 mph turn is

The author's second effort was much more ambitious than his first. His R-2, with its small tube space frame and shortened-sump XPEG MG engine, carried an attractively unusual body, yet looked more like an MG.




C O LaTourette

Meticulous attention to even the tiniest of details is one factor of successful designs. For instance, the brake pedal's position must suit the driver's requirements. The problem is where to attach it to the frame. Ken used simple brackets and a very short pedal shaft.



usually pretty miserable in a slow turn and vice versa. But by a study of the consistent winners you should be able to assess the reason for their success, and their weaknesses, and if it is not possible to build a car with more of their advantages it might be possible to build one with fewer weaknesses.

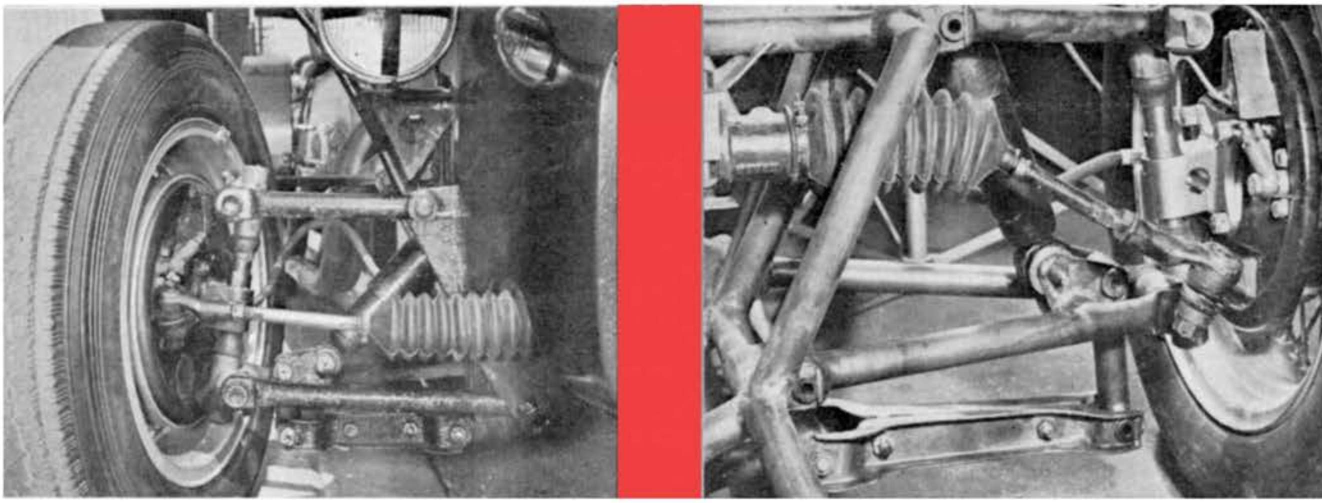
Remember that there is nothing that has not been tried before, at least once, and the reasons for ab ndoning the idea might not apply in your case. You can learn an awful lot about building a car by watching the mistakes that are made by others. This does not only apply to unsuccessful designs; some of the most successful cars are good in spite of quite serious design defects. You should not copy every feature of a car just because it happens to be a winning car; try to see what particular features of its design make it successful and copy only those. Where the products of the larger manufacturers are concerned, bear in mind that company policy often dictates what the designer may or may not use, and left to himself, the designer might have come up with an entirely different plan. Sales and production departments often insist that notable features of the production car be incorporated into the design of the racing car, to the extreme dismay of the racing department. From my own observation, I would say that most of the difficulties that the builders of specials have had with their cars could have been avoided if the designer had studied even an elementary book on automobile design and understood the basic engineering principles involved.

In laying down the specification for your car a compromise has to be drawn between what you would like to do and what is possible with the resources in money, time and skill available. Generally speaking, it is much better to execute a simple design well than a complicated one badly; the more complicated the design and the greater its promise of success the higher degree of skill required to execute it. There used to be a well known formula for success in specials which went "Simplificate, and add Lightness". Though somewhat of a contradiction in terms, for reasons that we will discuss later, it none the less expresses an idea – a machine as light and uncomplicated as possible.

Simplicity is in itself a primary goal, since the more complicated the design the greater the cost, but simplicity must sometimes be subordinated to efficiency, efficiency to weight and weight to cost, so that all design is essentially a compromise. A case in point is the rear axle. Almost everybody will agree that the most efficient type of rear end is one where the wheels are suspended independently, but most independent rear end systems entail a weight penalty and a vast increase in complication. In some cases it is better for the special builder to use the simple and reliable live axle rather than embarking on the complication and dubious advantages of the independent system.

Durability has to be considered. The ideal racing car is one which is just strong enough to cross the finish line in one piece, having won the race, disintegrating immediately thereafter, but maintaining a car of this type becomes rather a problem. On the other hand, the total mileage that a racing car will cover during the season is relatively small, so there is no need for it to be built like a truck. The ease with which the car can be maintained is often a very important factor in its continuing success; there is an obvious reluctance to embark on maintenance projects that are inordinately difficult, and many a race has been lost because "We can check that over next time." And next time was too late. You should bear in mind when you lay out the design of your car that there is no part of it that never requires attention. For the same reason it is impossible to emphasize too strongly the advantages that accrue from the use wherever possible of stock component parts that can be purchased "off the shelf", even if they have to be incorporated into highly non-stock assemblies. Your production components are, on the whole, stressed for far higher loads and more brutal treatment by an ignorant and heavy handed public than they will ever experience in a racing car. They have been subjected to an enormous amount of testing and development to guarantee their reliability, which explains the popularity amongst such manufacturers as Lotus and Cooper of wheel spindles and running gear off one of the smallest and cheapest production sedans in the World. Specially manufactured components are always a potential source of trouble. Not only is there the risk of failure of a totally untried design, but the difficulty of replacing these parts when they fail far from home can easily cost you the race that you could have won with a less esoteric design.

Now, to get down to a more particularized examination of the pros and cons of various design features, it has been my experience that most people who set out to build a special will have a particular engine in mind, around which they propose to build their car, and it is at this point that they make their first mistake. There are very few power units that are worth building a car around; no chassis, however brilliantly executed, is able to compensate for a serious lack of horsepower or reliability. Too often the engine itself is an "ifit". . . "if we do this and if we alter that the engine is sure to give unprecedented quantities of power with complete reliability", and so much time and



R-1 (left) and R-2 (right) both used Minor torsion bars. Wishbones are tubular copies of TD. R-2's steering is disconnected.

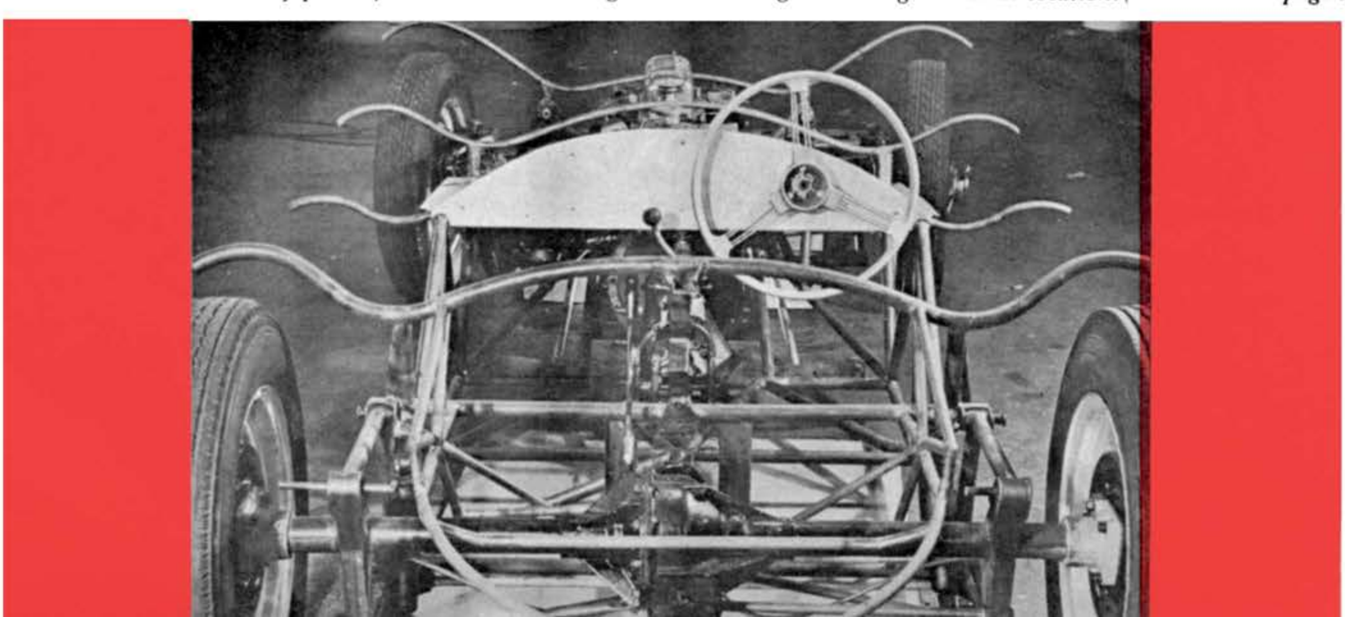
money is spent on trying to get power out of some cast iron clunk that there is none left to spend on the car. The only sound basis for your calculations is how much power you *know* the engine will give, and under what circumstances, without drastic, expensive and unpredictable modification.

What good power units are available? In the 750 cc class the field is fairly open. The miraculous little Crosley competes with the D B and the Renault, with the modified 750 cc version of the Fiat as a possible contender. First and foremost in the 1100 cc class is the Climax engine, nothing else approaching it in terms of power output per unit weight. Once you get amongst the 1500 cc cars nothing seems to run with the Porsche Spyder engine except the equally unobtainable 1500 cc Climax. In every class above that, Ferrari has achieved almost complete dominance, and not until you get into the really heavy metal do you find a domestic engine worthy of mention. I hasten to add that I have not overlooked the OSCA or Maserati power plants, but had discarded them both on the score of unreliability, whilst the engine with the greatest potential of them all is the little 1300 cc Alfa Romeo unit. I cannot think of why this engine has not yet formed the basis of a really fast 1500 cc car, unless possibly they are as unobtainable as the Porsche engine.

Having acquired an engine, a bottomless well of enthusiasm, and a little money (it won't be enough, it never is!), the next consideration is going to be the general layout of the body-cum-chassis. The type, style, material and proportions of the body will profoundly influence the type of chassis that is feasible, as will the design of the front and rear suspension and the type of final drive employed. I am assuming for the sake of discussion that we are considering a more or less conventional disposition of the major assemblies, with the engine at the front and the rear wheels driven. While there are undoubtedly points in favor of a rear engine location I believe that the average driver will be happier with the engine in front of him, and, generally speaking, the design problems are fewer. Perhaps it would be as well to examine the respective advantages of the three main types of chassis construction.

The chassis for the modern sports car should be designed to accomodate extremely supple suspension, with wheel movements in the order of four inches on both bump and rebound, for a total of eight inches overall, in line with current thinking. If the car is to handle well with so much wheel movement the suspension geometry must be extremely accurate, which requires as a basis an extremely rigid chassis, both as a beam and in torsion. Beam rigidity, the ability of the chassis to prevent itself from sagging in the middle, is easy to come by; torsional rigidity, the strength to resist "racking" when one wheel is under extreme load, is not at all easy to achieve with low weight. Probably the most efficient type of chassis frame that could be devised would be none at all, instead a body so designed that all the suspension, driving and braking loads were absorbed directly by the body skin without the aid of a separate chassis frame. If we consider the body as a large diameter tube, able to resist both twisting and bending loads, we can see that it is quite feasible to design a car in such a manner, especially if the car is a sedan or coupe. With our sports

Live rear axle is located by pairs of radius rods; lower right one is triangulated to give lateral location. *(Continued on page 46)*



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car we have a rather different problem, since we are concentrating on keeping the size and weight as low as possible, since the cutout required for the cockpit and the engine represent such a large percentage of the total area of the tube. There is very little left to carry the load. The "D" type Jaguar is a perfect example of this type of chassis, and you will see from a study of this car that it was found necessary to provide a subframe to carry the suspension and engine loads. A further difficulty with this type of construction is that of avoiding local load concentrations around the suspension attachment points. I would feel safe in recommending this particular type of chassis only to those enthusiasts who work in the stress department of an aircraft factory.

Easiest of all to design, in that it is practically impossible to go far wrong, is the simple ladder-type frame, consisting of a couple of hefty tubular side members joined together with a small number of cross members of similar proportions. Not only is this type of structure inherently simple to lay out on the design table, but stress concentrations, due to the heavy wall thickness of the tube, are of little importance. It is easier for the home craftsman to construct, since he is dealing with a heavier gauge of metal that is easier for the amateur welder to work on and more adaptable to commercial arc welding.

By far the greatest majority of specials and of professionally-constructed racing cars of recent years, have been of this type construction. Even the latest products of Modena use basically simple ladder type frames stiffened up with a little elementary lattice work. What, then, are its disadvantages? Chief amongst them is such a frame is relatively heavy for a given torsional rigidity, but running a good second is the difficulty of fastening anything to a large diameter tube. All your suspension mounts, engine mounts, and body attachment points have to be bracketed off the main frame structure. The final chassis frame is far from the simple structure you originally envisaged, and far heavier.

The third type which is rapidly gaining favor, being used by such experts at the game as Mercedes Benz, Aston Martin, Porsche and Cooper, and represented in its highest and purest form by the Lotus is the "space frame", characteristically a frame made up of a multitude of small diameter thin-wall tubes either in tension or compression. The chief merit of such a structure is its light weight, the steel being used to its greatest advantage, but other points are the ease with which load concentrations can be spread over the entire frame structure and the ready availability of the frame structure for body mounting points. Indeed, given reasonable care in the design stage, internal body panels can be used as an integral part of the frame, thereby gaining some of the advantages of the stressed-skin type of construction.

The disadvantages of the "space frame" are not numerous but are formidable, namely the extreme care required at all stages of construction to ensure sound welds on the very thin wall tubing without distorting the whole structure, and the difficulty in achieving sufficient torsional rigidity through the cockpit area without extreme complication. A study of the Chevrolet S.S. Corvette will show you what I mean. On the whole, it would seem that the advantages lie with the "space frame", and I would certainly use this type of construction in any future car of my own.

So far we have discussed only the general aspects of the automobile, i.e., chassis form, basic frame, engine etc. From this point we can diverge in almost any direction in the matter of what we want to hang on this structure. Next month we will go further into these factors with suggestions as to specific items.

—Ken Miles