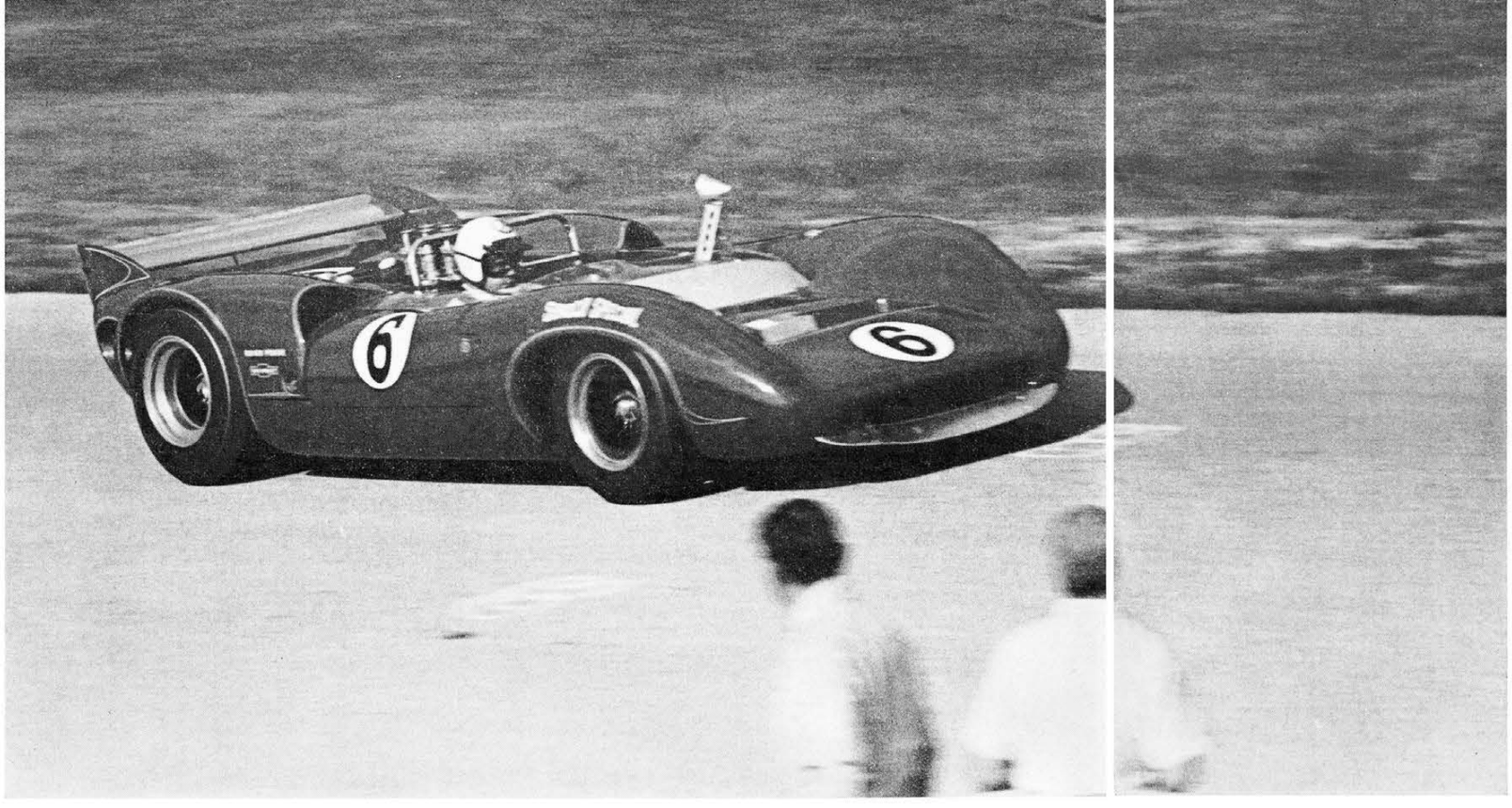


PENSKE LOLA TYPE 70 SPORTS/racing car

CAR LIFE COMPETITION SERIES 1 1968

Cover Car Uncovered

Technical Analysis

BY JON McKIBBEN/PHOTOS BY STANLEY ROSENTHALL, CAM WARREN AND WARREN FRY

THIS IS THE first in a monthly series that examines various types of competition vehicles. Each vehicle in the series will be an outstanding example of its particular type. The subject of this article certainly qualifies, as the Roger Penske Racing Enterprises Lola sports/racing car has compiled an enviable record of success.

Driver Mark Donohue won six of seven USRRC professional series road races in 1967. In so doing, Donohue convincingly won the points championship, a tribute not only to his consistently rapid driving, but also to superb preparation of the vehicle. Roger Penske has assembled as efficient and thorough a crew as has been organized anywhere. This crew maintains a level of workmanship that must be seen to be believed.

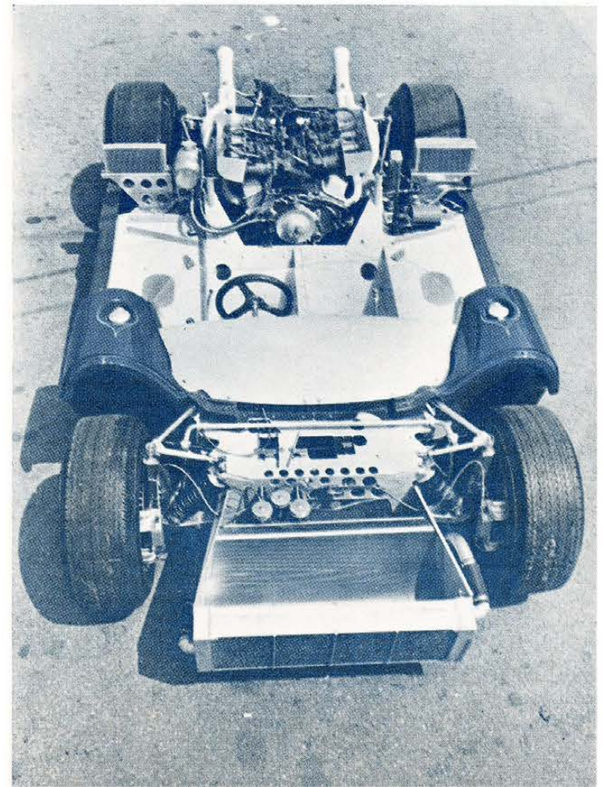
Although the Penske Lola is just that, a Lola Type 70, the car has been extensively reworked, not in basic chassis configuration, but in the myriad small details that enhance the reliability of any racing vehicle.

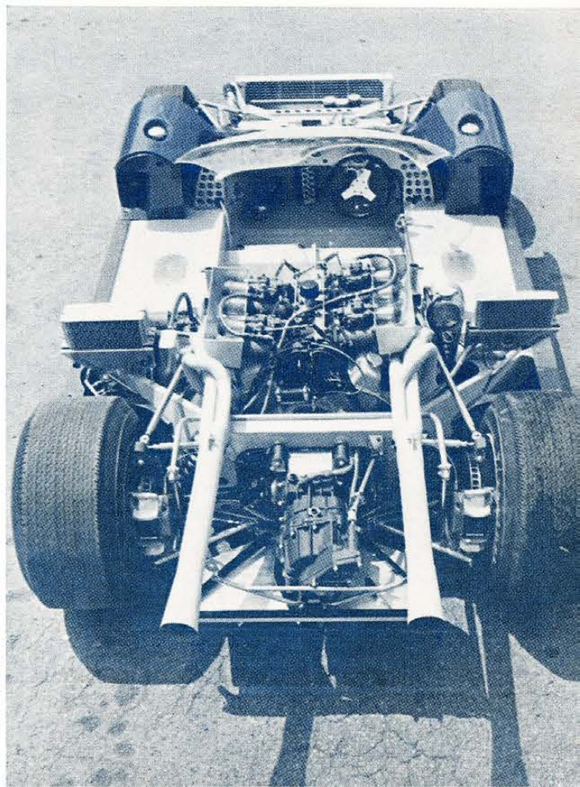
A description of the Lola Type 70 must begin with the chassis. The Lola is a monocoque-construction automobile. That is, the central chassis structure consists of a sheet aluminum assembly comprised of large hollow members housing fuel tanks, attached to a floor pan and closed at each end by a fabricated bulkhead. Front and rear bulkheads are built with box-section members extending fore and aft to accept suspension components. The chassis layout of the Lola Type 70 can best be understood by examining the cutaway drawing and photographs accompanying this article.

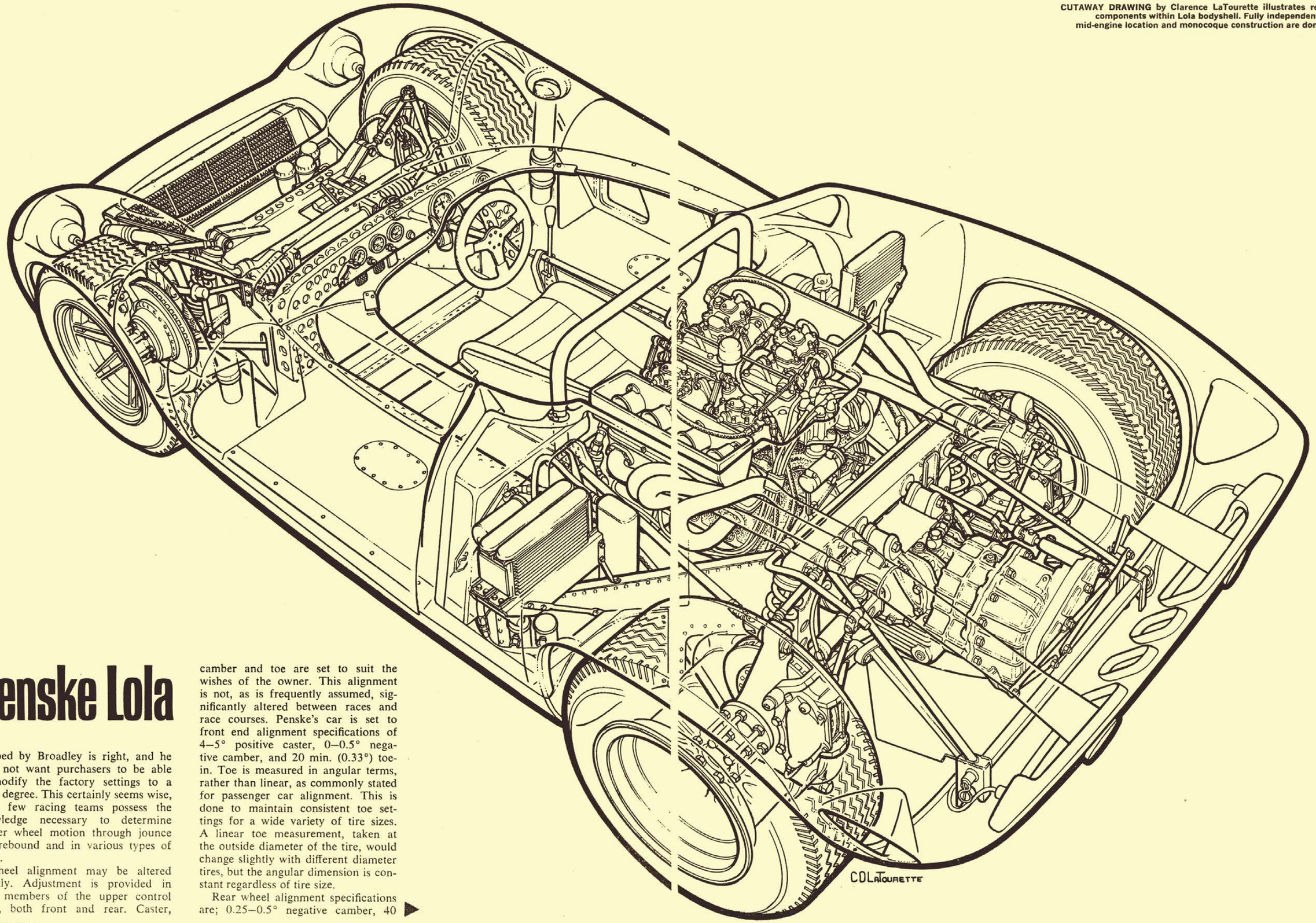
The Lola 70 is not the lightest Group 7 race car built today. However, the Lola is certainly among the lowest and most aerodynamic. In addition, the road holding of the Lola 70 is considered as good as, or better than, its competitors. An interesting sidelight to Lola handling characteristics came from Mark Donohue. Donohue stated that the Lola could be taken "off the boat," and raced with few difficulties. Some other currently produced Group 7 cars, according to Donohue, require an excessive amount of "sorting" before they can be considered raceworthy. Without this very careful setting up, these cars are ill-handling, and dangerous to drive competitively.

A careful examination of the suspension system used by designer and builder Eric Broadley shows that all essential suspension geometry location points are fixed. This is in contrast to usual race car designs which provide the chassis tuner with an infinite number of movable components for vehicle tailoring. Apparently the geometry de- ▶

COMPACT, COMPLEX chassis layout is evident in these shots of unskinned Lola Type 70. Huge tires are 9.20-15 front, 12.00-15 rear, mounted on 9-in. front and 12-in. rear wheels.







CUTAWAY DRAWING by Clarence LaTourette illustrates relationship of components within Lola bodyshell. Fully independent suspension, mid-engine location and monocoque construction are dominant specs.

Penske Lola

veloped by Broadley is right, and he does not want purchasers to be able to modify the factory settings to a great degree. This certainly seems wise, since few racing teams possess the knowledge necessary to determine proper wheel motion through jounce and rebound and in various types of turns.

Wheel alignment may be altered slightly. Adjustment is provided in both members of the upper control arms, both front and rear. Caster, camber and toe are set to suit the wishes of the owner. This alignment is not, as is frequently assumed, significantly altered between races and race courses. Penske's car is set to front end alignment specifications of 4–5° positive caster, 0–0.5° negative camber, and 20 min. (0.33°) toe-in. Toe is measured in angular terms, rather than linear, as commonly stated for passenger car alignment. This is done to maintain consistent toe settings for a wide variety of tire sizes. A linear toe measurement, taken at the outside diameter of the tire, would change slightly with different diameter tires, but the angular dimension is constant regardless of tire size.

Rear wheel alignment specifications are; 0.25–0.5° negative camber, 40 ▶

Penske Lola

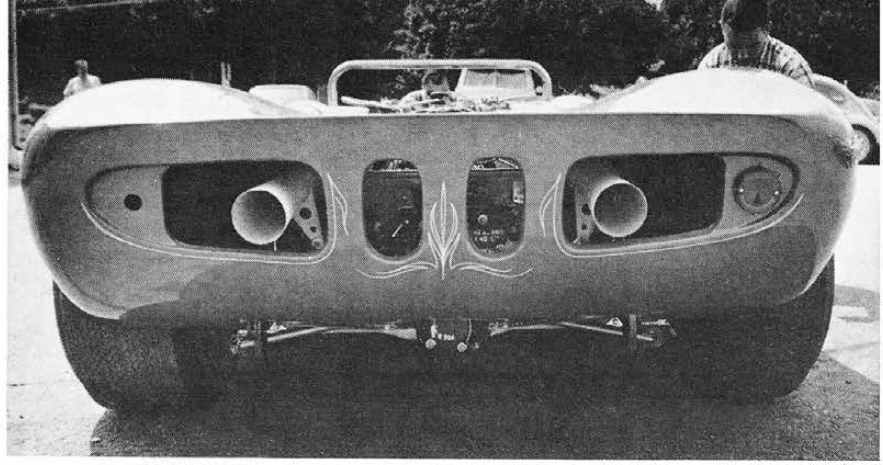
min. (0.67°) toe in. Again, these specifications are adhered to for nearly every race course or track condition. Special alignment jigs have been developed for the Lola by Penske's crew, and Mark Donohue personally supervises wheel alignment work to insure the settings he prefers.

Suspension members are fabricated from round and square section tubing, with sheetmetal gussets added where necessary. Upper control arm adjustable sections incorporate aircraft-type Heim joints for accommodation of large angularities without binding. Ball joints are used, both top and bottom, at control arm-hub carrier junctions. Hub carriers, or uprights, are magnesium castings.

Steering linkage is simple, consisting of a rack-and-pinion gear mounted to the forward chassis bulkhead, and rack extension tubes extending to steering arms attached to front hub carriers. Heim joints are used at all junctions. A small-diameter padded steering wheel is located at arms' length in the semireclining cockpit. Steering is quite light, due to low vehicle weight, and very fast, with 2.3 turns lock-to-lock.

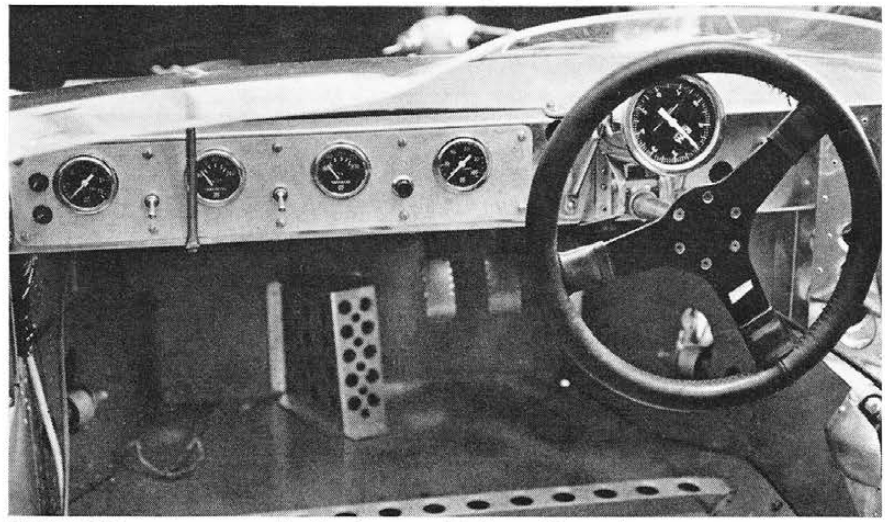
Suspension is provided by combined coil/shock units. These units are completely adjustable, both for damping and for spring load. Spring adjustment is performed by means of a threaded collar around the shock unit. This collar may be turned up or down, increasing or decreasing the effective length and load of the coil. Shock damping is altered by turning a knob at the base of the shock absorber. This changes internal shock valving, causing damping alteration.

As in most modern sports/racing cars, spring rates are relatively low. Soft suspension is essential for good wheel adhesion over irregular surfaces. Roll is limited both by roll center height location and by fitting antiroll bars front and rear. Understeer or oversteer is partially determined by size and adjustment of these antiroll bars. Both bars on the Penske car have a number of link mounting points, permitting roll stiffness adjustment by clamping antiroll bar links at different distances from bar pivots. Soft foam limit bumpers are fitted to the coil/shock units to limit jounce travel. Rebound travel is limited by internal shock absorber stops. Jounce travel is approximately 3 in., limited by ground clearance rather than suspension geometry.

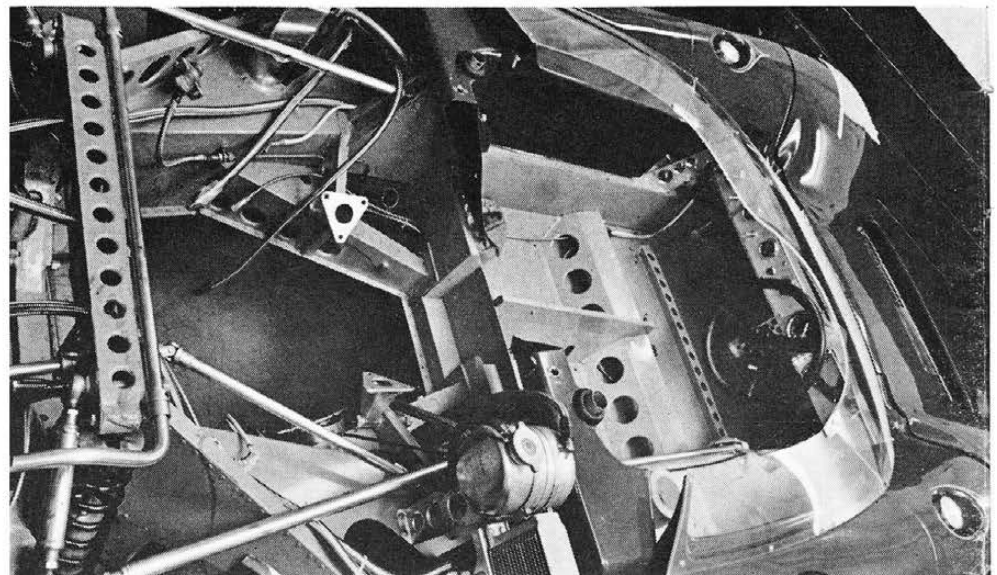


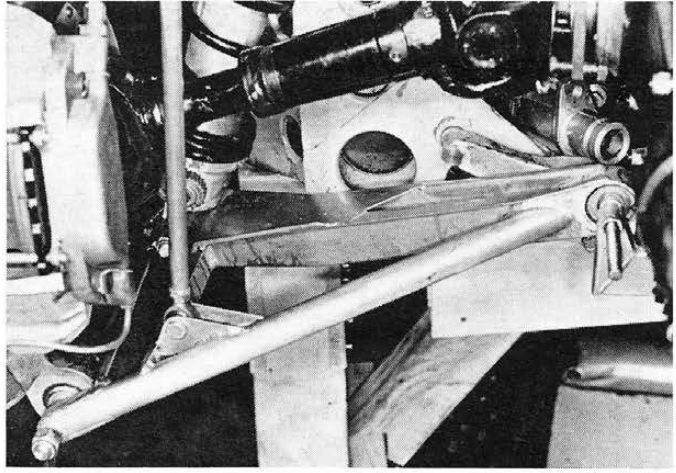
TAPERED EXHAUST outlets dominate rear view of ultralow sports/racer.

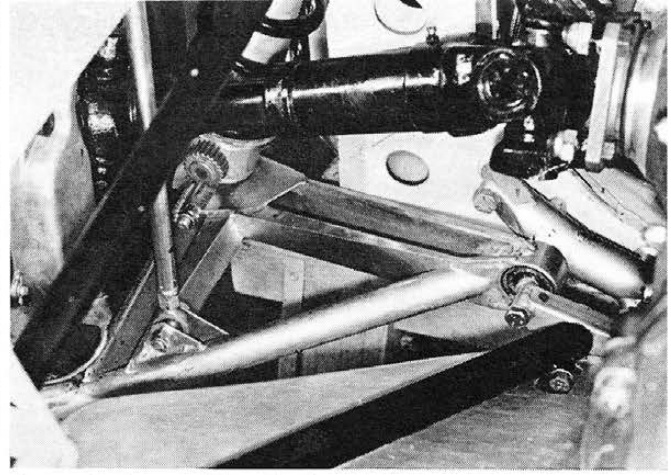
IMPECCABLE FINISH is characteristic of Penske racing machinery.



LIGHT, RIGID monocoque construction is apparent in these pictures of Lola structure. Plethora of lightening holes indicates zealous pursuit of minimum vehicle weight without structural-strength sacrifice.







LOWER CONTROL arms of Lola Mk. III (right) and IIIb (left) show geometry changes for increased tire adhesion.

Most road racing enthusiasts are under the impression that tire pressures are an extremely critical and widely used factor in tailoring a race car's handling to specific track conditions. This was proven a misconception by Donohue. Tire pressures in the Lola are set to 30 psi, cold, and are almost never changed at the race course. Tires themselves are changed, however, and most races are the scene of organized confusion as Goodyear and Firestone representatives try to supply the faster cars with the "latest and greatest" compounds, sizes, and other "black magic" to insure that the winning car will roll into Victory Lane shod with Brand G or Brand F.

Penske has contracted with Firestone and has strictly adhered to this brand throughout the current racing season. Normal tire sizes (if anything about a competitive racing vehicle can be considered normal) are 9.20–15 front, 12.00–15 rear. To better understand the enormous size of these tires, typical of Group 7 sports/racing equipment, it should be noted that actual road contact width is 7.5 in. front, 9.5 in. rear. Furthermore, these huge tires are supporting approximately 2000 lb. Obviously, maximum roadholding dictates extremely low tire loadings.

Wheel sizes are 15 x 8-in. front, and 15 x 12-in. rear. These already wide wheels are due for change in the near future, with 9-in. wide front wheels forthcoming. Other cars in Group 7 racing use rear wheels up to 15 in. wide, and the Penske Lola team may well go to larger sizes when convinced of their benefit.

Before leaving this discussion of car handling components, aerodynamics must be mentioned. Donohue states that he prefers a car that oversteers at low speed, on slow turns, but he definitely does not like oversteer on fast sweeping curves. This apparently disparate set of handling conditions is accomplished through aerodynamics, rather than by suspension system magic. The spoiler affixed to the rear body section of the Penske Lola is adjustable, and provides a large amount of aerodynamic loading to the rear of the car at high speeds. This loading is effective in providing the rear tire adhesion necessary to achieve high-speed understeer. Apparently this theory as practiced by the Penske crew is effective, since Donohue considers the Lola an easy car to drive. His competition record indicates that Donohue does not drive slowly, on any type of circuit, so the Lola must handle in an exemplary manner.

The attached specifications table lists major car dimensions, so no detailed description is needed here except to emphasize the basic weight distribution of the car. With 100 lb. of fuel, and Mark Donohue (180 lb.) in the driver's seat, the Lola weighs 2000 lb. Of this total weight, 800 lb. is carried by the front wheels, and 1200 by the rears. Readers who consider such cars as the Corvair to be unfit for high-speed driving should note that the Penske Lola carries 60% of its weight on the rear wheels. Obviously, suspension geometry and tires must be carefully selected to provide superb handling with any basic chassis layout, but it should be equally obvious that not all cars with strong rearward weight bias are inherently ill-handling or unstable.

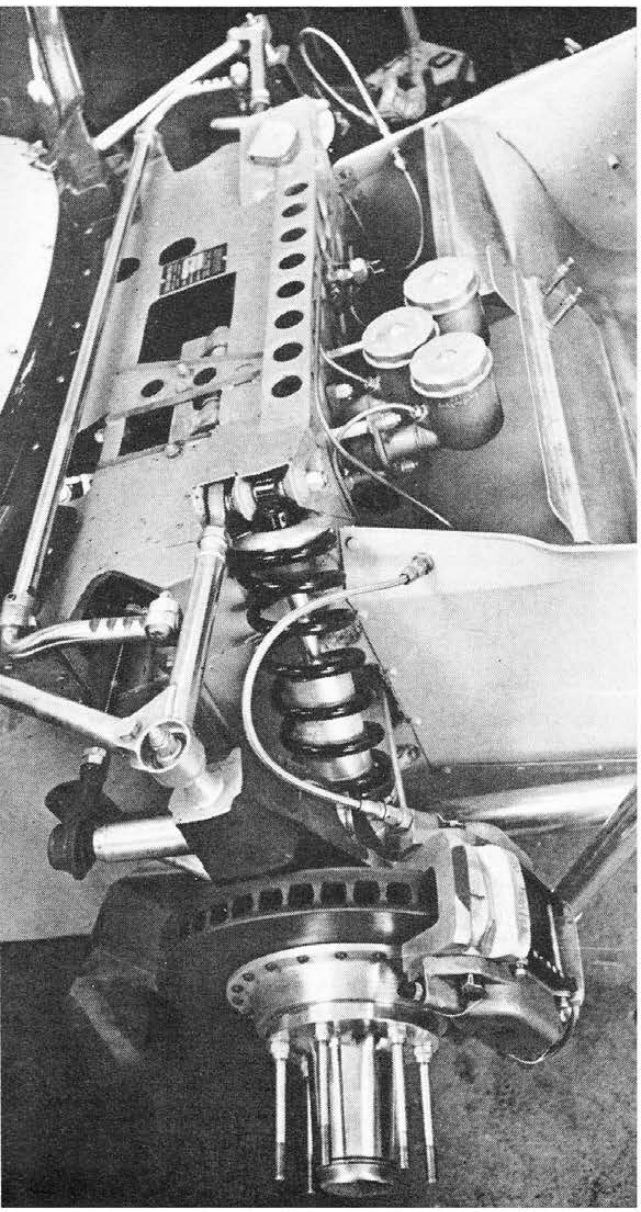
The brakes fitted to the Penske Lola are a relatively late development for sports/racing cars. These brakes are marketed by Lola, and consist of 1.25-in. thick, 12-in. diameter vented cast iron discs front and rear, with modified (for thicker discs) Girling calipers. A pair of master cylinders, mounted on the forward chassis bulkhead, is connected by an adjustable balancing device that permits variation of front-to-rear brake proportioning. These brakes have proven excellent for severe Group 7 racing application, and are used by most of the successful teams in U.S. competition. Donohue rates brake effort in the Lola as moderate, compared to other racing vehicles, and considers these brakes very controllable and consistent.

Penske uses a Traco-modified Chevrolet engine, as do many of the top teams in U.S. Group 7 racing. The Penske engine was originally built for the Mecom racing team for the 1966 racing season, and was purchased by Penske before the start of the 1967 season. This engine has been used for the large majority of wins in the current season, and is typical of Traco sports/racing powerplants.

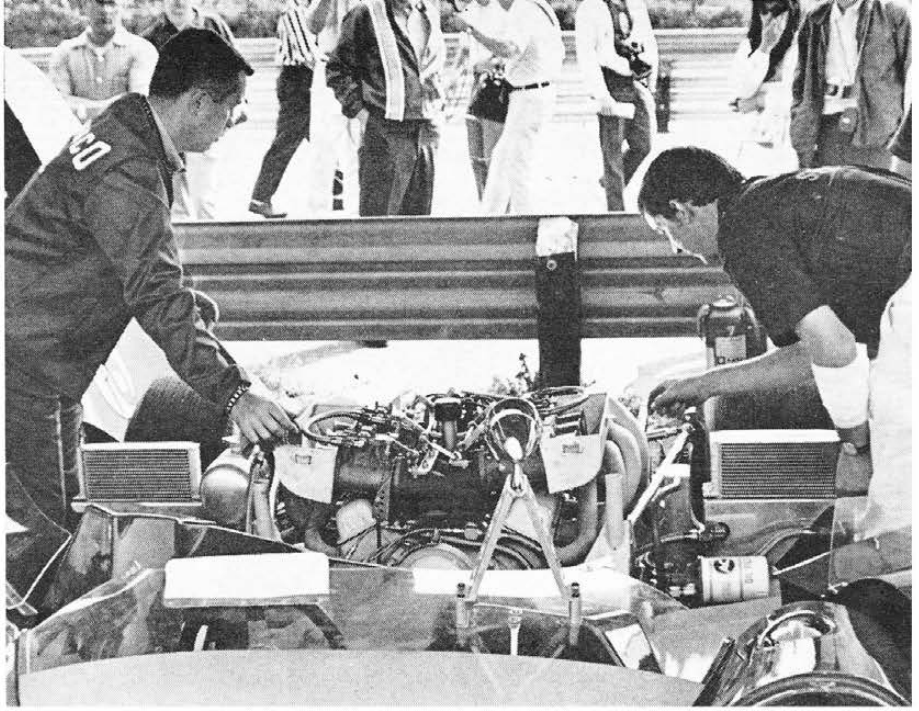
Traco Engineering of Culver City, Calif., is one of the top engine building firms in the U.S. Owned and operated by Frank Coon and Jim Travers, Traco has excellent facilities (though rapidly being outgrown) for building and developing racing engines, and has dynamometer equipment for both development work and customer engine tuning. The 359-cid Chevrolet engine used by Penske is capable of 495 bhp at 6500 rpm, with peak torque of 490 lb.-ft. at 4500 rpm. These figures are not extremely impressive in themselves, but the competitive record of Penske's Lola is proof of the adequate power, with outstanding reliability, characterizing Traco racing engines. It should be noted that the Penske engine is built to the same exacting specifications as engines Traco supplies to other customers. The fact that the Penske Lola has been more reliable, and more successful than others indicates that Penske's crew exercises more care in tuning, preparation and operation than other crews.

Engine modifications performed by Traco include enlarging cylinder head ports, fitting larger valves (2.03-in. intake, 1.625-in. exhaust), installation of 11:1 compression-ratio Forgedtrue pistons, and minor modification of a stock Delco ignition system. For improved reliability, Warren Machine Co. connecting rods are used.

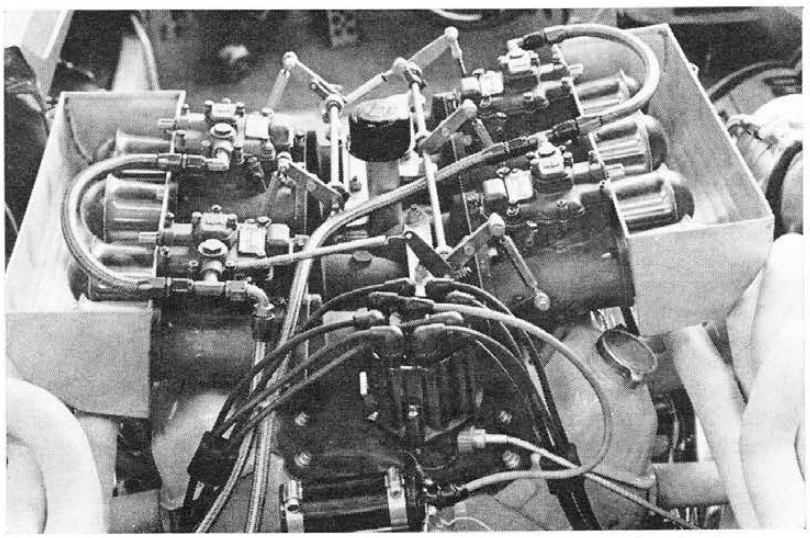
These rods are machined from steel billets, and have proven completely reliable under racing conditions. The ▶



FRONT suspension incorporates adjustable upper control arms and antiroll bar.



ROGER PENSKE (left) takes active part in preparation of his race cars, lending experience gained as successful competitor in international road racing.



CROSS-RAM type intake manifold mounts four Weber 58 DCO3 sidedraft carburetors for maximum power throughout speed range encountered in racing.

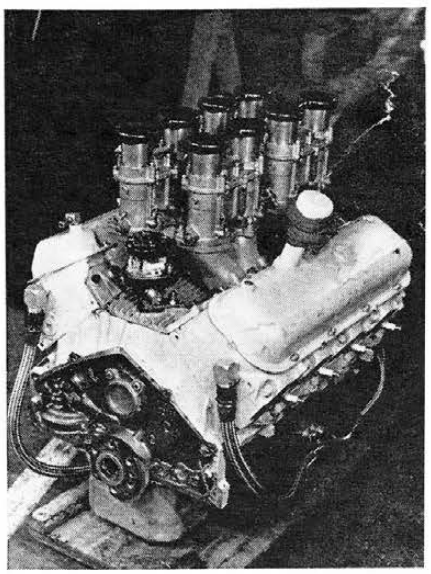
Penske Lola

stock Chevrolet crankshaft is improved either by shot-peening or by using the Tufftride process. Both methods increase fatigue strength, and are considered equally successful by Traco.

Before building up a racing engine, Traco checks all critical components by magnafluxing, and examines all castings, including the cylinder block, with the Zyglo process. Auxiliary equipment includes a Traco-developed cross-ram intake manifold mounting four Weber 58 DCO3 sidedraft carburetors, Engle camshaft, Traco valves, Mickey Thompson rocker arms, and Champion J86Y spark plugs.

The exhaust system developed by Traco, and used by most of its customers, consists of four equal-length exhaust pipes from each bank blended into a collector. Primary pipe length, ahead of the collector section is 27 in. The transition section increases from 3- to 4-in. diameter in a 7-in. long taper, and joins the 21-in. tailpipes. This system has proven to be very effective in boosting power throughout the range normally used in road racing.

As with any major racing team, Penske obviously has more than one engine. For the sake of clarity, only one has been discussed in this article. Backup engines are similar, but not necessarily identical. Detail differences may exist in valve train accessory equipment, and even slight displacement variations. The preceding example, is, however, representative of the engines used by the Penske crew, and



LARGE-block 427-cid Chevrolet engine has been disappointing in initial testing.

is essentially accurate as a description of the team's most successful powerplants.

Power from the Traco Chevrolet is transmitted through a 5-speed Hewland transaxle. The Hewland unit is manufactured in England, and widely used in Group 7 competition. The unit in the Penske Lola is the latest and largest transaxle built by Hewland, and is designated LG 600. This transaxle assembly has five forward speeds plus reverse, and incorporates a conventional clutch-type limited-slip differential arrangement.

Following common sports/racing car practice, the gearbox is all nonsynchromesh. Because of the extremely close ratios, gear shifting is relatively easy. Actually, Donohue downshifts regularly without using the clutch. George Follmer, newly appointed driver of a second Penske team entry for the Canadian American Cup Series, makes clutchless upshifts, but uses the clutch for downshifts. Obviously, a skilled driver is not handicapped by the Hewland's lack of synchromesh. Further, the gearbox can be stronger, for a given package size, by eliminating synchromesh mechanisms.

No gear ratios are shown in the accompanying data panel, simply because there are no "standard" ratios. Both intermediate gear and final drive ratios are changed for individual race courses, providing the driver with exactly the right gear for every corner and for maximum use of available straightaways. Penske's chief mechanic, Karl Kainhofer, keeps a log of race courses and gear ratios, and pre-selects ratios based upon previous experience at each course.

For the sports car enthusiasts, it was noted that pedal positioning in the Lola is perfect for heel-toe downshifting. The accelerator pedal is the same height as the brake pedal and closely adjacent. Thus, the driver can apply the brakes with the left portion of his right foot, and rock the right edge of this foot onto the accelerator for double-clutching.

The bodyshell of the Lola 70 is just that, an auxiliary shell. No attempt is made to utilize the body as a structural member. Nose section, doors and tail section are quickly detachable by pulling out a number of mounting pins. The only portions of the bodyshell which are integral parts of the chassis are the lower side panels, immediately below the doors. These sections are parts of the monocoque chassis which enclose the rubber fuel cells.

Lola body configuration is dictated primarily by aerodynamic considerations. With a top speed capability in the 200-mph range, lift is a critical problem. Nose contours are intended to produce aerodynamic pressure downward on the front of the automobile at high speeds. Penske's crew has provided a small aluminum spoiler across the lower edge of the nose section for additional antilift protection. Sharp-eyed race observers are aware of the subtle body modifications performed by various Lola race crews to improve stability, reduce drag and minimize weight. Donohue's car, number 6, has a reworked tail section which is much lower than standard, and incorporates flared wheel openings to eliminate interference problems caused by fitting larger tires. The Number 16 car, currently being driven by George Follmer, has a tail section that is essentially standard Lola.

Driver accommodations in the Lola are adequate, but certainly not luxurious. Driver comfort is aided by an excellent, semireclining driving position, and all controls are perfectly located for maximum efficiency. Seat contours are formed to fit the body, and the aluminum seat is covered by a snap-in cushion of approximately 1-in. thickness.

This, then, is a brief analysis of the winningest Lola Type 70 Mk. III in the U.S. The crew of Roger Penske Racing Enterprises is to be congratulated. The Penske Lola is one of the most superbly prepared racing vehicles that this writer has ever examined.

Mark Donohue has proven that he has the ability to race in the fastest of company, and is a perfect match for this consistently fast automobile. The Sunoco Specials of Roger Penske will be worth watching in the future, for they are certain to be among the front-runners in any sports/racing competition. In racing, as elsewhere, the old adage holds true; class will tell, and Penske's crew is pure class. ■

1 1968 DATA PANEL

PENSKE LOLA TYPE 70 MK. III

DIMENSIONS, GENERAL

Wheelbase, in. 95
Track, f/r, in. 58.3/60.0
Overall length, in. 157
width 74
height, body. 33.5
height, roll bar. 36.0
Ground clearance, in. 3.9
Weight with driver
and 100 lb. fuel. . . . . 2000 lb.
distribution, f/r. 40%/60%

CHASSIS/SUSPENSION

Frame type: Monocoque.
Front suspension: Independent by s.l.a., coil springs, telescopic shock absorbers, antiroll bar.
Steering system: Rack-and-pinion gear, tubular rack extensions, ball-jointed uprights, right-side driving position.
Steering ratio, overall. 20.0:1
Turns, lock to lock. 2.3

BRAKES

Type: Two-line hydraulic system with separate master cylinders, vented cast iron discs front and rear, no power assist.
Front rotor, dia. x width. . 12.0 x 2.0
Rear rotor, dia., x width. . 12.0 x 2.0
Total swept area, in.^{2}. 501.6

WHEELS/TIRES

Wheel rim size, f/r. . . . 15x8-9/15x12
Tires: Firestone Indy.
size, f/r. 9.20-15/12.00-15
normal inflation press.,
psi f/r. 30/30

ENGINE

Type: Traco Chevrolet 90° V-8, ohv
Bore x stroke, in. . . . . 4.04 x 3.50
Displacement, cu. in. 358.977
Compression ratio. 11.0:1
Fuel required: Premium gasoline.
Rated bhp @ rpm. . . . . 495 @ 6500
Rated torque @ rpm. . . . 490 @4500
Carburetion: 4x2, Weber 58 DCO3.
throttle bore, pri./sec. . . 2.28/2.28
Valve train: Engle mechanical lifters and pushrods, M/T rocker arms, Traco valve springs and retainers.
Camshaft: Engle 252.
timing, deg. int./exh. . 90-46/46-90
duration, int./exh. 316/316
lift, int./exh. in. 0.5/0.5
Exhaust system: Individual tuned pipes into single collector per cylinder bank.
pipe dia., exh./tail. 1.625/4.0

DRIVE TRAIN

Clutch: Schiefer, 2-disc type.
Transmission: Hewland LG 600 transaxle.
Gear ratios: All variable, depending upon course length and types of curves.
Differential: Spicer limited-slip ratio, specified for particular course.
Shift lever location: Extreme right side of cockpit.

CALCULATED DATA

Lb./bhp (with fuel and driver). . 4.05
Lb./in.^{2} brake swept area. 3.99
Frontal area, ft.^{2}. 13.9