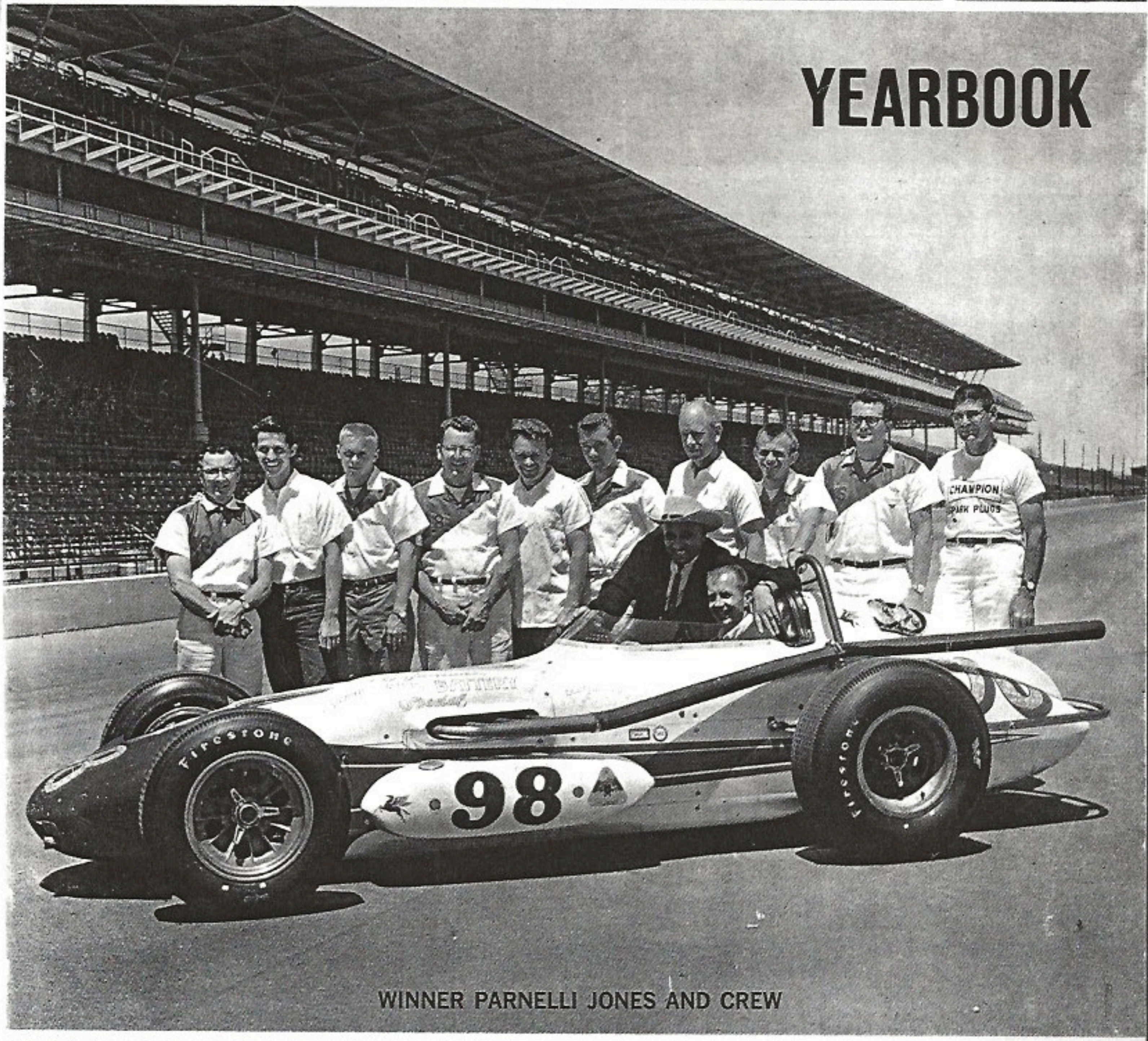
Floyd Clymer's 1963 INDIANAPOLIS

500 MILE RACE

USAC

YEARBOOK



WINNER PARNELLI JONES AND CREW

PUBLISHED BY
FLOYD CLYMER
LOS ANGELES

DETAILED ACCOUNTS OF THE RACE

TECHNICAL SECTION, PHOTOS, CHARTS & DRAWINGS

$4.00

ENTRIES IN FORTY-SEVENTH ANNUAL INTERNATIONAL SWEEPSTAKES

MAY 30, 1963

Distance—500 Miles

NON-STOCK SUPERCHARGED ENGINES, 170.856 CUBIC INCHES (2,800 cc.) PISTON DISPLACEMENT OR LESS AND NON-STOCK NON-SUPERCHARGED ENGINES 256.284 CUBIC INCHES (4,200 cc.) DIESEL ENGINES 335.57 CUBIC INCHES (5,500 cc.) OR LESS; AND TURBINE ENGINES, ENERGY OR FUEL CELL, HYDRAULIC ACCUMULATOR AND STEAM ENGINES OF UNLIMITED SIZE.

Car No.	Driver	Car Name	Entrant	No. Cyl.	Bore	Stroke	Piston Disp.
1	Rodger Ward	Kaiser Aluminum Special	Leader Cards, Inc.	4	4.28125	4.375	251.9
2	A. J. Foyt	Sheraton-Thompson Special	Ansted-Thompson Racing, Inc.	4	4.28125	4.375	251.9
3	Bob Mathouser	Schulz Fueling Equipment Special	C. O. 'Ollie' Prather	4	4.28125	4.375	251.9
4	Don Branson	Leader Card 500 Roadster	Leader Cards, Inc.	4	4.28125	4.375	251.9
5	Bobby Marshman	Econo-Car Rental Special	Lindsey Hopkins	4	4.28125	4.375	251.9
6		Hotel Tropicana Special	Novi, Inc.	8	3.187	3.600	166 *
7	Len Sutton	Leader Card Autolite Special	Leader Cards, Inc.	4	4.28125	4.375	251.9
8	Jimmy McElreath	Bill Forbes Racing Team Special	William P. Forbes	4	4.28125	4.375	251.9
9	Eddie Sachs	Bryant Heating & Cooling Special	D.V.S., Inc.	4	4.28125	4.375	251.9
10	Chuck Hulse	Dean Van Lines Special	Dean Van Lines: Racing Division	4	4.28125	4.375	251.9
12		Fiberglas Special	Smokey Yunick	4	4.28125	4.375	251.9
14	Roger McCluskey	Konstant Hot Special	Bruce Homeyer	4	4.28125	4.375	251.9
15	Ronnie Duman	Federal Engineering Special	Federal Automotive Associates	4	4.28125	4.375	251.9
16	Jim Rathmann		Lindsey Hopkins	4	4.28125	4.375	251.9
17	Troy Ruttman	J. Robbins Auto-Crat Seat Belt Spl.	Jim Robbins Company	4	4.28125	4.375	251.9
18	Bud Tingelstad		Charles M. Chenowth	8	3.640625	3.000	250
19		Dean Van Lines Special	Dean Van Lines: Racing Division	4	4.28125	4.375	251.9
21	Elmer George	Sarkes Tarzian Special	Mari George	4	4.28125	4.375	251.9
22	Dick Rathmann	Chapman Special	Harry Allen Chapman	4	4.28125	4.375	251.9
23	Johnny Boyd	Bowles Seal Fast Special	Salih-Paddock Corporation	4	4.3125	4.375	255
24	Junior Johnson	Chalik Am. Rubber & Plastics Spl.	John Chalik	4	4.28125	4.375	251.9
25	Al 'Cotton' Farmer	Wynn's Friction Proofing Special	Joe Hunt	4	4.28125	4.375	251.9

* Supercharged. † Rear Engined.

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MAY 30, 1963

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Car No.	Driver	Car Name	Entrant	Cyl. No.	Bore	Stroke	Piston Disp.
26	Bobby Grim		Gilbert E. Morcroft	4	4.28125	4.375	251.9
27	Johnny Rutherford	U. S. Equipment Special	George Walther Jr.	4	4.28125	4.375	251.9
28		Stearly's Motor Freight Special	United Rentals, Inc.	4	4.28125	4.375	251.9
29	Bruce Jacobi	Vita Fresh Orange Juice Special	Gordon Van Liew	4	4.28125	4.375	251.9
31	Bobby Unser	Chalik Am. Rubber & Plastics Spl.	John Chalik	4	4.28125	4.375	251.9
32		Sheraton-Thompson Special	Ansted-Thompson Racing, Inc.	4	4.28125	4.375	251.9
35	Allen Crowe	Gabriel Shocker Special	Pete Salemi & Nick S. Rini	4	4.28125	4.375	251.9
37	Ed Kostenuk	City Of Victoria Special	Ed Kostenuk	4	4.28125	4.375	251.9
38	Chuck Rodee	Konstant Hot Special	Bruce Homeyer	4	4.30125	4.375	253
41		Lysle Greenman Special	Lysle Greenman	4	4.28125	4.375	251.9
43	Gig Stephens	Hook Lobster Company Special	Edgar H. Stone	4	4.28125	4.375	251.9
44	Jack Turner	Precision Piston Ring Special	D.V.S., Inc.	4	4.28125	4.375	251.9
45	Chuck Stevenson	Bardahl Special	Fred Gerhardt	4	4.28125	4.375	251.9
46	Ebb Rose	Racing Associates Special	Racing Associates	4	4.28125	4.375	251.9
47			Ray Crawford	4	4.28125	4.375	251.9
48	Pedro Rodriguez	Cooper Special	Kjell H. Qvale	6	3.8583	3.6220	253.8†
52	Lloyd Ruby	John Zink Trackburner	John S. Zink	4	4.28125	4.375	251.9
53	Paul Russo		Walter Weir Jr.	4	4.28125	4.375	251.9
54	Bob Wente	Hoover Inc. Special	Tidewater Associates, Inc.	4	4.21875	4.375	251.9
55		Demler Special	Norm Demler, Inc.	4	4.28125	4.375	251.9
56	Jim Hurtubise	Hotel Tropicana Special	Novi, Inc.	8	3.187	3.600	166 *
61		Federal Engineering Special	Federal Automotive Associates	4	4.295	4.375	253

* Supercharged. † Rear Engined.

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MAY 30, 1963

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Car No.	Driver	Car Name	Entrant	No. Cyl.	Bore	Stroke	Piston Disp.
62	Joe Sostilio	White Spot Special	Myron E. Osborn	4	4.21875	4.500	251.9
63	Jimmy Davies	Kimberly Special	James H. Kimberly	8	3.625	3.100	256 †
64	Keith Rachwitz	Kimberly Special	James H. Kimberly	8	3.625	3.100	256 †
65		Travelon Trailer Special	Ernie Ruiz	4	4.28125	4.375	251.9
72	Cliff Griffith		Joe Lencki	6	3.750	3.8125	252.6
73		Chalik Am. Rubber & Plastics Spl.	John Chalik	4	4.28125	4.375	251.9
75	Art Malone	S.T.P. Special	Novi, Inc.	8	3.187	3.600	166 *
77	Chuck Engel	Dayton All Star Special	George Walther Jr.	4	4.28125	4.375	251.9
81		H. Thompson-H. Titanium Spl.	Mickey Thompson	8	3.750	2.880	255 †
82	Bill Krause	M. Thompson-Harvey Alum. Spl.	Mickey Thompson	8	3.750	2.880	255 †
83	Graham Hill	M. Thompson-Harvey Alum. Spl.	Mickey Thompson	8	3.750	2.880	255 †
84	Masten Gregory	M. Thompson-Harvey Alum. Spl.	Mickey Thompson	8	3.750	2.880	255 †
85	Bill Cheesebourg	Mickey Thompson Harcraft Spl.	Mickey Thompson	8	3.750	2.880	255 †
86		Racing Associates Special	Racing Associates	4	4.28125	4.375	251.9
88	Gene Hartley	Drewry's Special	M. & W. Racing Association	4	4.28125	4.375	251.9
89	Jack Conely	J. E. Engineering Special	Jack Conely	4	4.28125	4.375	251.9
91	Dan Gurney	Lotus Powered By Ford	Lotus Indianapolis Project	8	3.760	2.870	255.6†
92	Jim Clark	Lotus Powered By Ford	Lotus Indianapolis Project	8	3.760	2.870	255.6†
93		Lotus Powered By Ford	Lotus Indianapolis Project	8	3.760	2.870	255.6†
94		Agajanian Willard Battery Spl.	J. C. Agajanian	4	4.28125	4.375	251.9
98	Parnelli Jones	Agajanian Willard Battery Spl.	J. C. Agajanian	4	4.28125	4.375	251.9
99	Paul Goldsmith	Demler Special	Norm Demler, Inc.	4	4.28125	4.375	251.9

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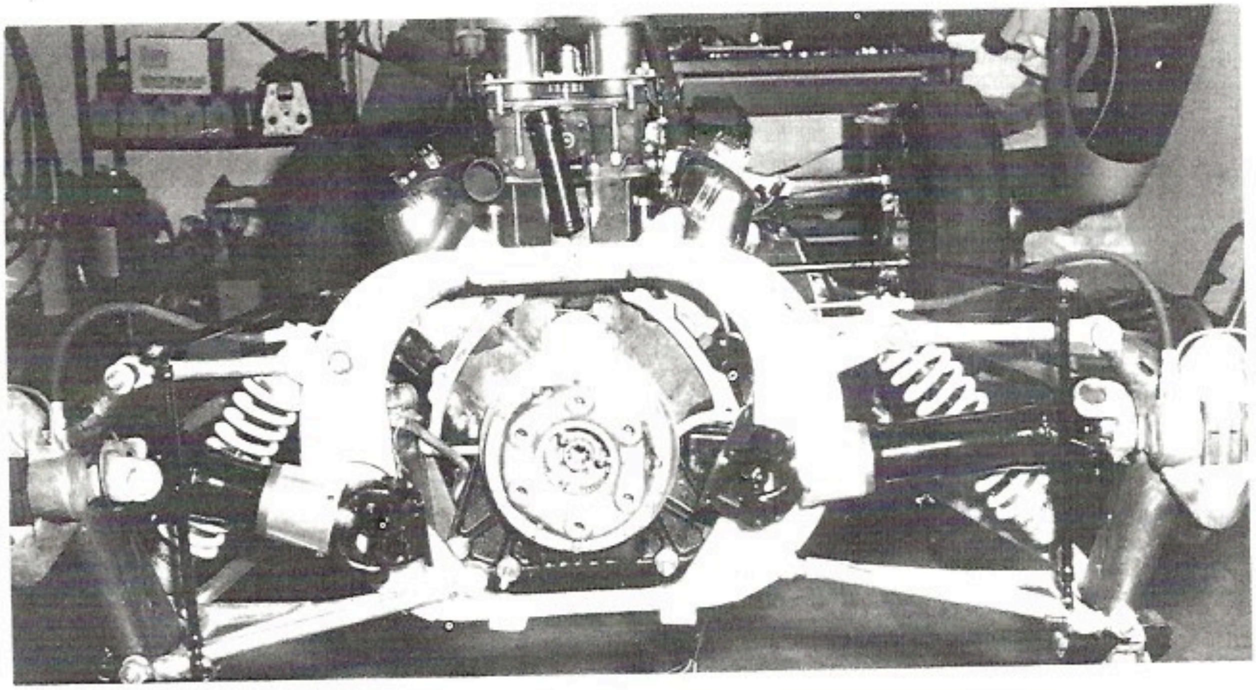
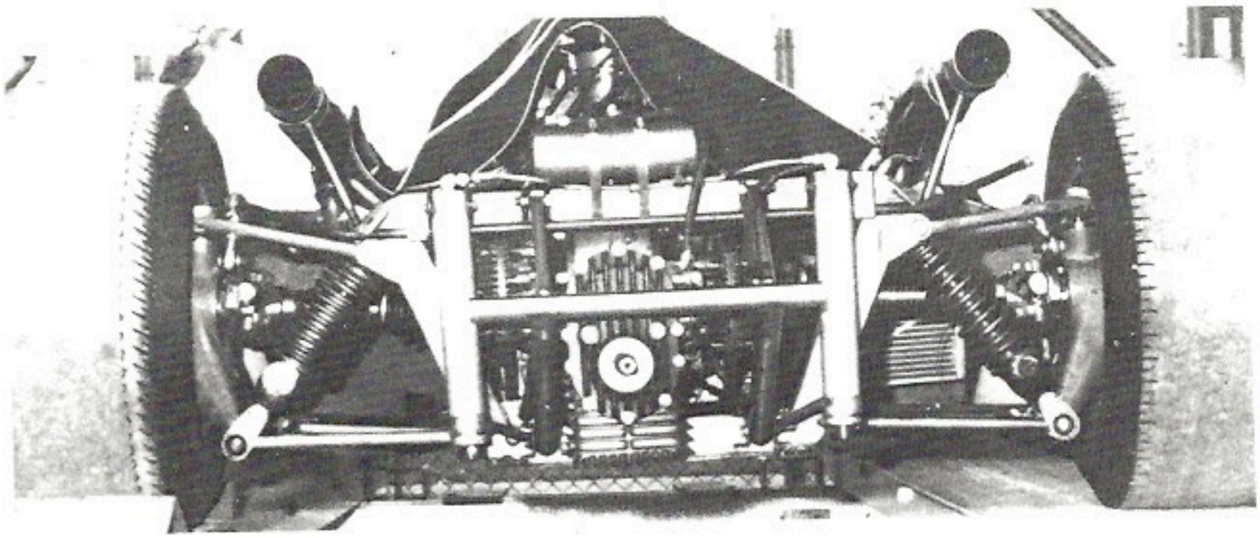
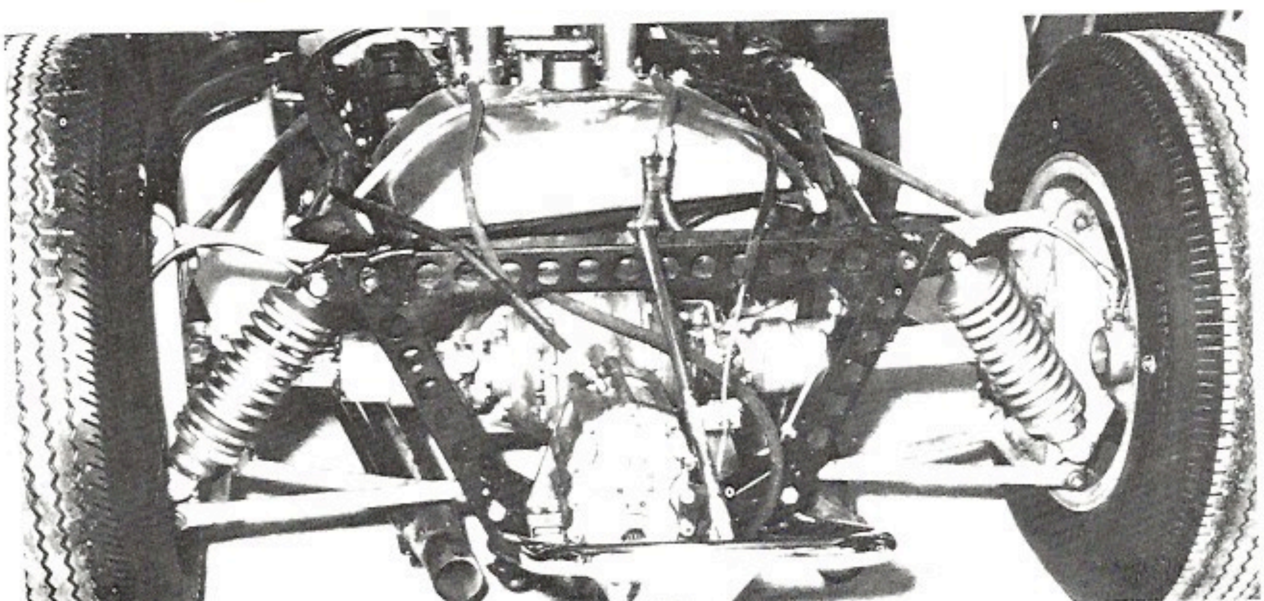
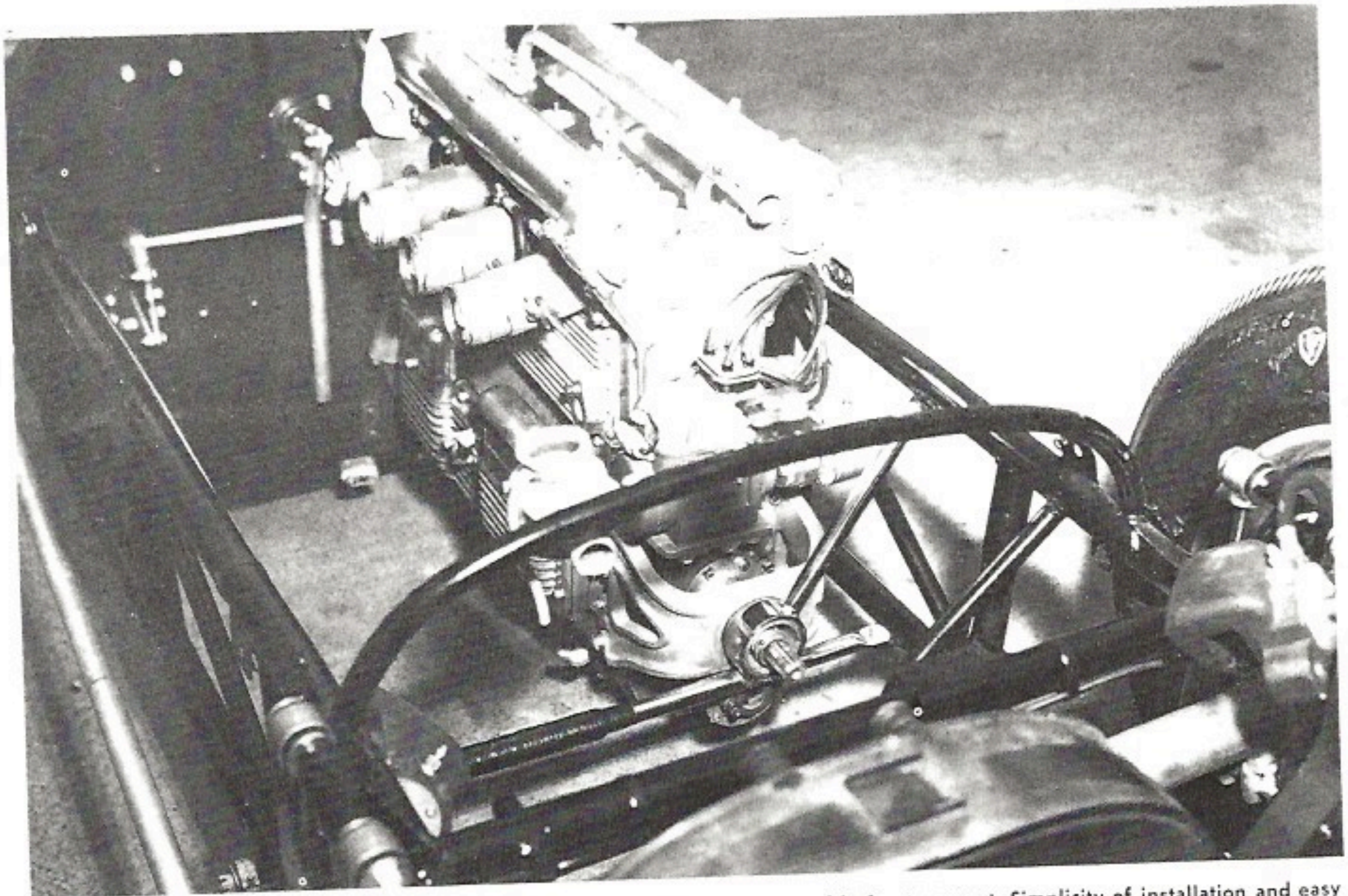


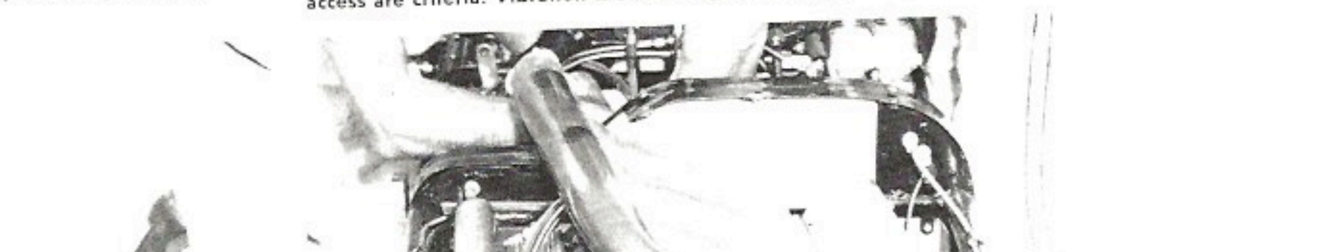




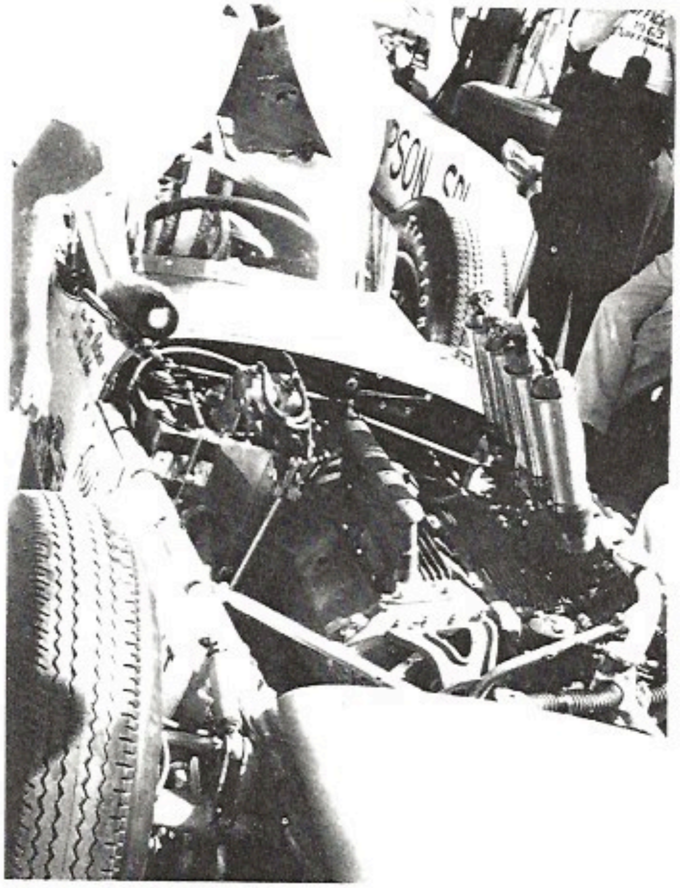
Independent rear axles all rear engined cars follow much the same pattern. Top: Lotus-Ford; center: Thompson-Harvey; bottom: Don Borth's Kimberly car No. 62.

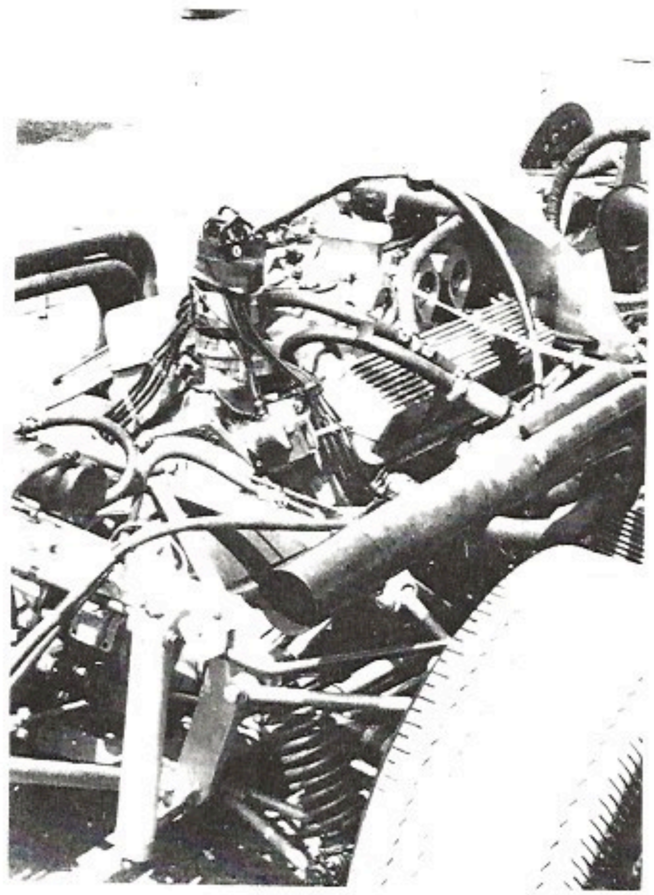


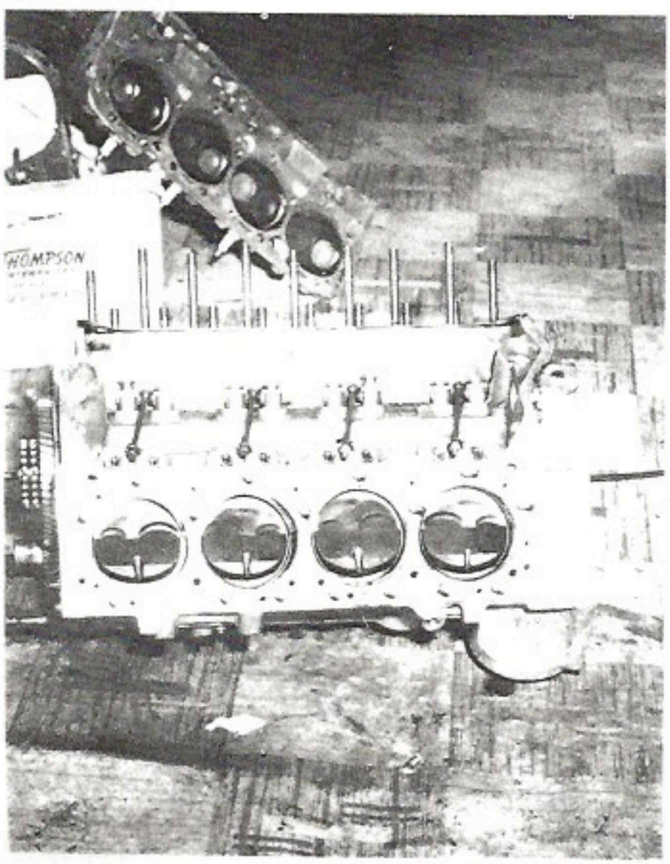
Offy is mounted rigidly in frame of conventional car at firewall and at removable front support. Simplicity of installation and easy access are criteria. Vibration is something builder has to live with.



Laydown position of engine is slightly more complex. Driver sits to right (inside) in this chassis and exhaust and intake are reversed.

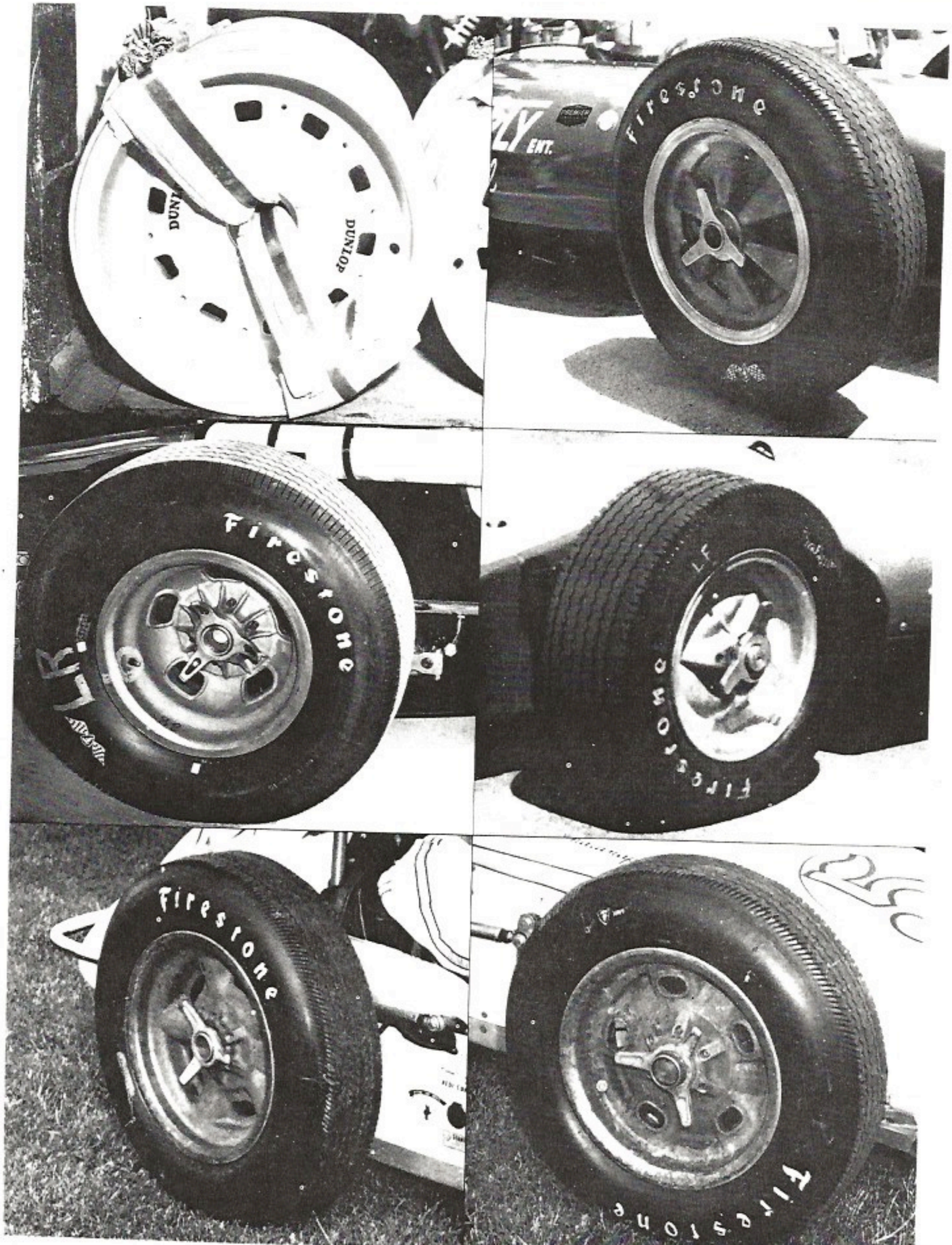






Top left: Another laydown arrangement has intake and exhaust in same relationship as vertical engine. This is Jim Robbins Special.

Rear engined V8's (top right) are most complex installation since chassis must be cross braced at the same point. Below: Chevrolet aluminum block used by Mickey Thompson has huge steel main bearing caps.

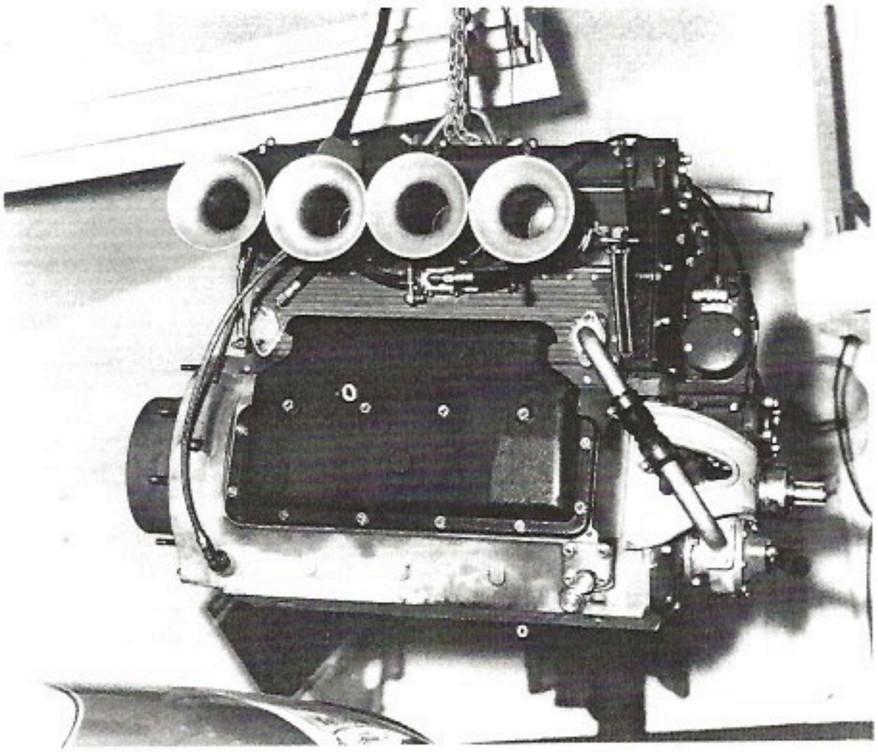


For the first time in history tires and wheels became a factor and came in many sizes and configurations. Top left to bottom right: Dunlop 15 inchers used by Lotus; Mickey Thompson's cast magnesium 15 inch; Ted Halibrand's 15 inch alloy; Thompsons 12 inch; Halibrand 18 inch rear; 16 inch front.

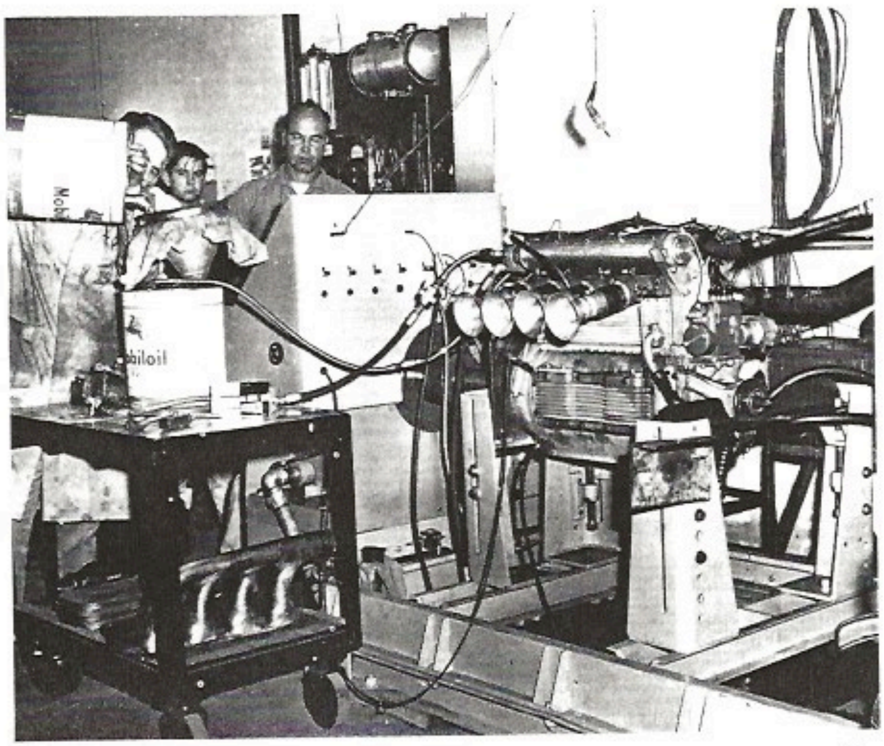
PREPARING AN ENGINE FOR THE 1963 INDIANAPOLIS 500-MILE RACE

By Dick Jones

Champion Spark Plug Co.



Four cylinder Meyer-Drake Offenhauser engine originated in 1931. 1963 version, like this one out of Eddie Sachs' Bryant Heating & Cooling Special is a steadily-improved but basically unchanged descendant.



Dynamometer testing is carried on by private individuals and accessory companies, such as Champion Spark Plug Co., as well as factory. Impressive horsepower gains are possible through experimentation.

This year, six different engines were represented among 80 cars, attempting to qualify for the race. The most popular and oldest design represented is the Meyer-Drake Offenhauser.

When Parnelli Jones took the checkered flag—it marked the 23rd win in 26 starts for the Offenhauser engine. That is an impressive record, any way you look at it. Prior to this year the Offie has dominated the Indianapolis race — and American racing for 29 years when — by all rules of the game — it should have been turned out to pasture years ago.

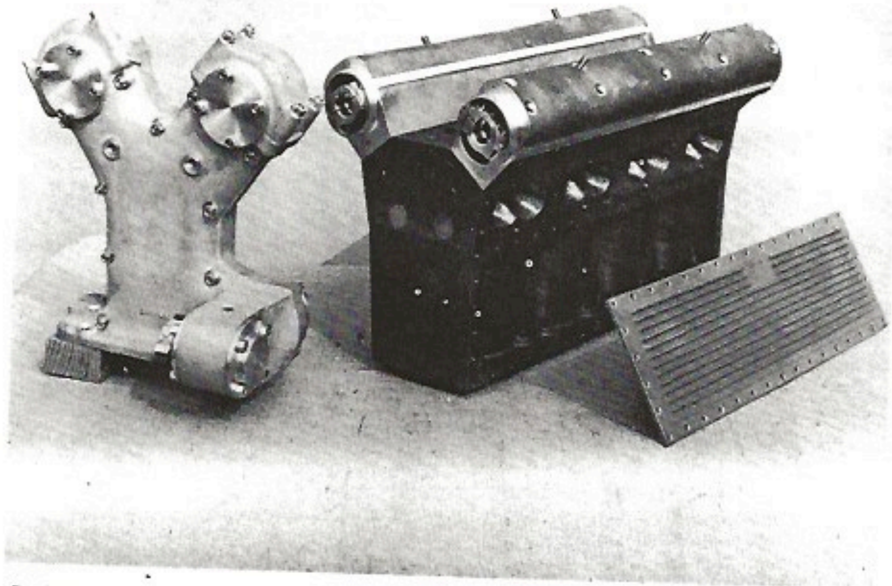
Offenhauser history dates to 1921. That year Harry Miller, Fred Offenhauser, and Leo Goosen, designed and built the first Miller straight eight — the original design concept of the now-famous Meyer and Drake Offenhauser.

Original drawings of the four-cylinder, 220- and 270- cubic inch engines were made for Harry Miller, in 1931. Two years of development followed. However, in 1933, Harry Miller went bankrupt. Fred Offenhauser then took over the business and continued building the four-cylinder version —

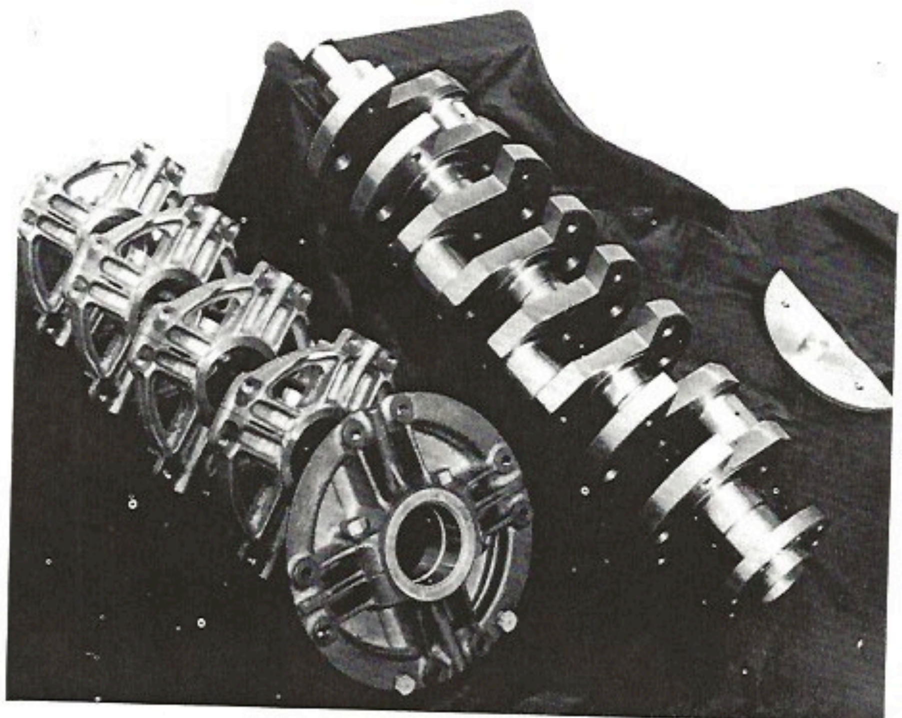
Until 1946 — when ill health forced him to retire — Offenhauser continued to operate the business. At that time, Louie Meyer — three-time Indianapolis winner — joined with an old-time racing friend, Dale Drake to buy the business — which they operate today.

Their principal product is a 252-cubic inch, four-cylinder-in-line, engine. It displaces 63 cubic inches per cylinder. It has an approximately square bore-stroke ratio — having a $4\frac{9}{32}$-inch bore, and a $4\frac{3}{8}$ inch stroke. The compression ratio is standard — $14\frac{1}{2}$, to 1.

Double overhead camshafts operate four valves per cylinder. The combustion chamber is one of the pent-roof design, it has a centrally-located, 18 millimeter cartridge fire spark plug boss, which utilizes a specially tailored Champion K-80R Racing spark plug.



Basis of engine is cast iron block with integral combustion chamber. Side plate for water jacket, gear tower cover and cam boxes are aluminum alloy.

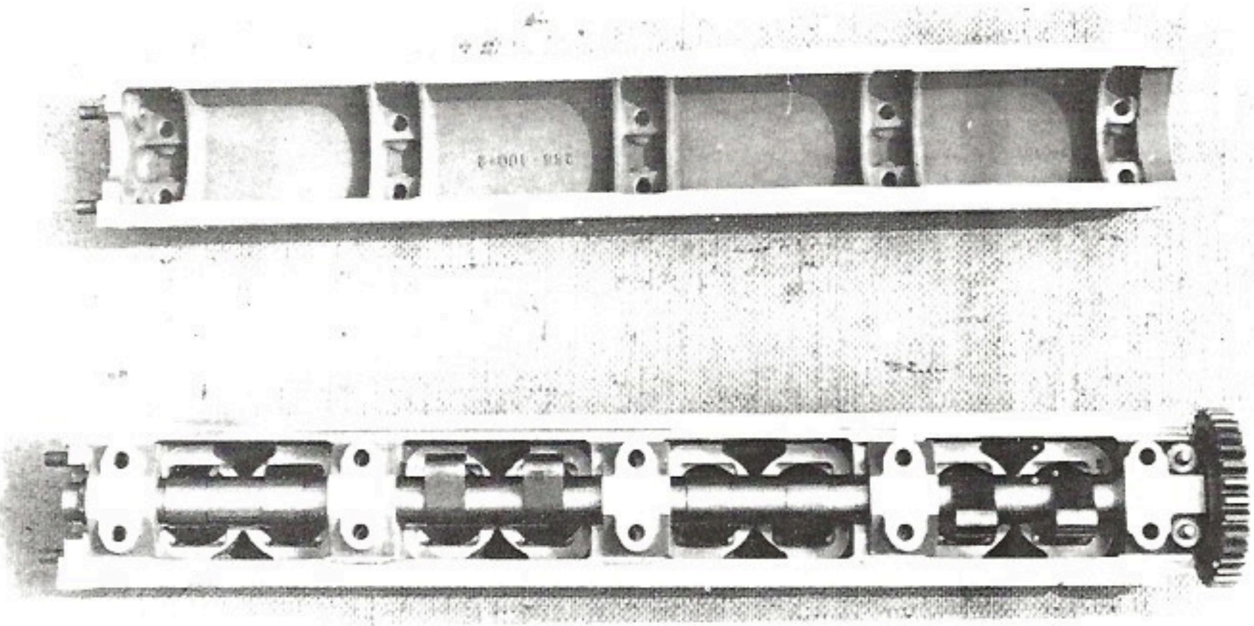


Five main bearing crank is machined from steel billet, has bolt-on bronze counterweights. Crank rides in diaphragm type bearing supports.

The engine comes equipped with a Hilborn continuous-flow, port-type fuel injector, which is calibrated to operate on methanol fuel. Ignition is by a converted Scintilla aircraft magneto. Total weight of the engine, ready to start — including flywheel and clutch — is 412 pounds. The cost is approximately 10,500 dollars.

The aluminum crankcase, is a barrel type cast separately from the cylinder block. The crankshaft is machined from a solid 4340 steel billet. It has **five** main bearings, full-pressure oiling and utilizes bolt-on type, manganese bronze counterbalance weights. Diaphragm-type, main bearing supports — which are produced from manganese bronze — are assembled on the crankshaft **prior** to its installation in the crankcase. The crankshaft and main bearing supports — assembled as a unit — may be lowered into position by turning them behind the lip of each support. Eight bolts through each main bearing support, hold the crankshaft in proper position in the crankcase.

The cylinder block has the pent roof combustion chamber cast integral as a single unit — thus eliminating the necessity of a separate head. The cylinder block bolts to the crankcase through the medium of 16 one-half inch studs. There are heavy bosses for cylinder block hold-down studs, also good uniformity, and cleanliness of casting through the water-jacket area. The cylinder block is a grey iron. The gear train case — which is commonly called the gear tower — bolts



Each camshaft operates 8 valves, two per cylinder, rides in plain bearing in cam box. Cup followers are used. Valve timing is accomplished through use of offset bolts on cam gear.

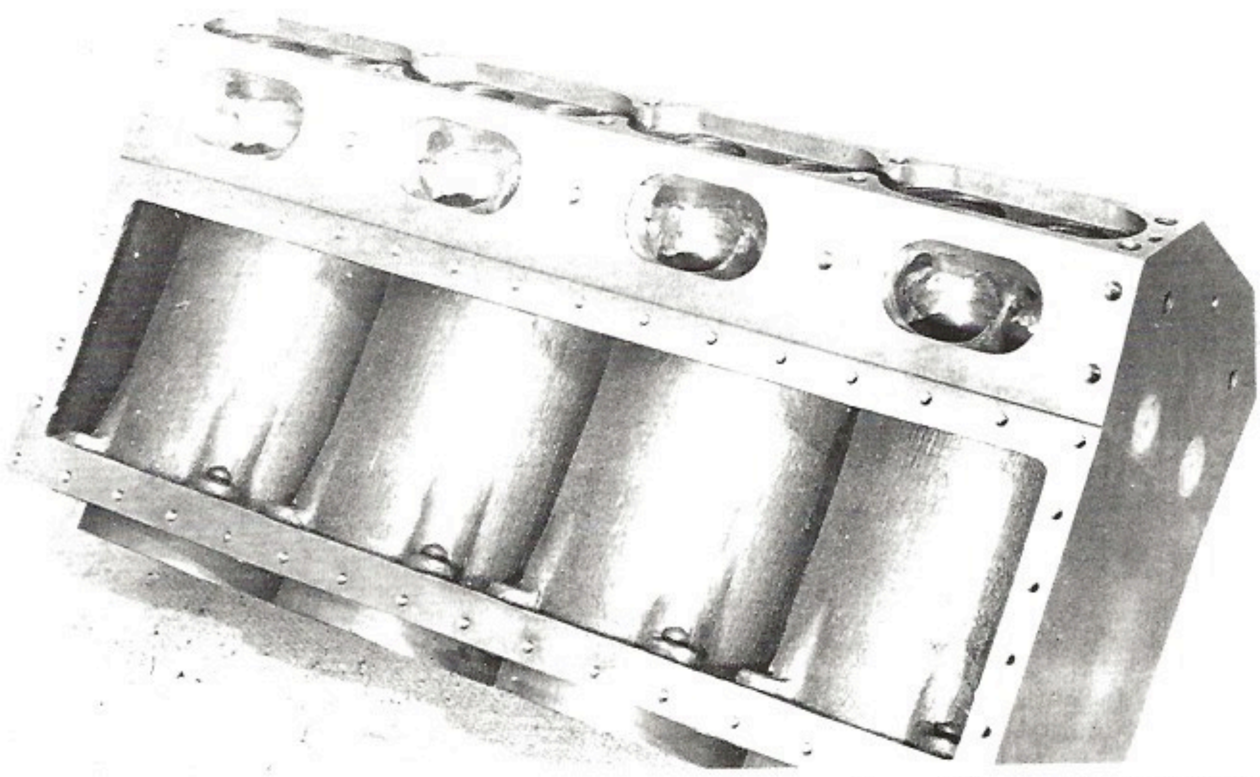
to both the block and the crankcase. A series of 12 gears drive the camshafts, magneto, oil pump — water pump and the power steering unit. The camshaft housings are installed, after final assembly of the valves, in the cylinder block.

The cam followers, or cups, are installed over the assembled valve springs. A key is riveted, and silver-soldered, vertically, to the side of the cup. This key must engage in a slot milled in the cam housing bore to maintain proper alignment, and stop rotation of the radiused cam-follower during the opening and closing of the valve.

Intake valves are manufactured from 4140. The exhaust valves are manufactured from 2112. Both are hard chrome-plated.

Valve springs are progressively wound — the inner and outer being wound in counter directions. Both springs are manufactured from 6145 aircraft quality, chrome vanadium wire.

The meehanite valve guides have shoulder registers for the inner and outer springs to position on. The



Exhaust ports in the block have been ground out as part of mechanic's preparation of factory-delivered engine. "Porting" according to experience and theory is in speed secret category.

4140 spring retainers also have position registers, for both the inner and outer springs.

The camshafts are hollow steel billets, have full pressure oiling and are held in position by five bearings. Valve timing is easily regulated, through the medium of an off-set bolt circle on the cam gear.

The piston is an impact extrusion, manufactured from 2018 ST, which is machined to exacting tolerances. The first and second compression rings are 1/16 inch in width. The oil control is 3/32 inch wide. The piston may be ordered in any compression ratio. The wrist pin—which is hard chromed—is 1 1/16 inch diameter, and is machined from 4340.

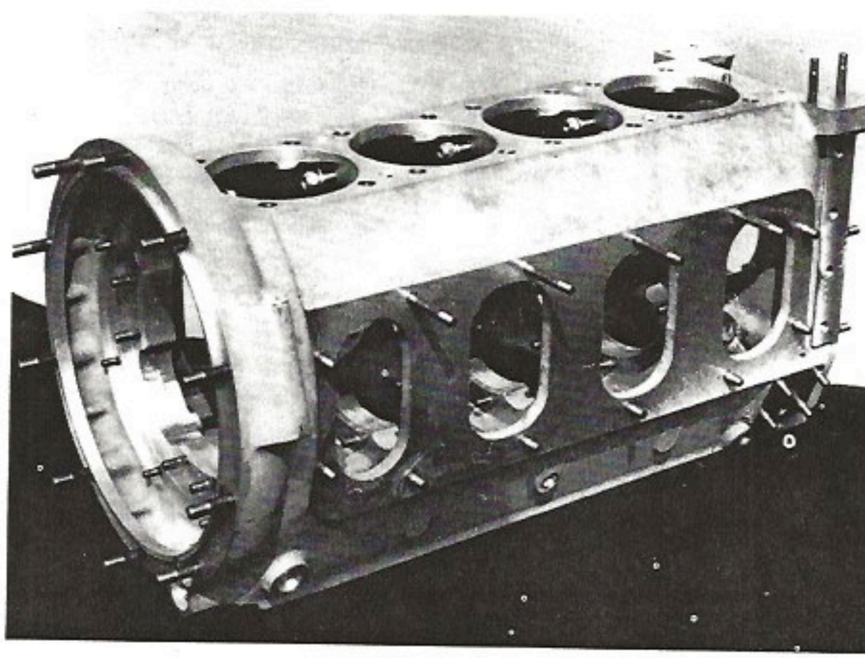
The connecting rod is a tubular-type, drop forging of 4340 steel. The connecting rod bolts are 1/2 inch in diameter. They are also machined from 4340, and utilize a Klincher-type nut. Both the connecting rods, and main bearings, utilize a tanglocked, insert-type bearing. It is interesting to note that this total assembly (piston, wrist pin and connecting rod) weighs a relatively heavy 5 1/4 pounds.

The Hilborn fuel injection unit is calibrated to operate on methanol fuel. It discharges a continuous flow of fuel directly into the intake port, through four, fixed, orifice nozzles.

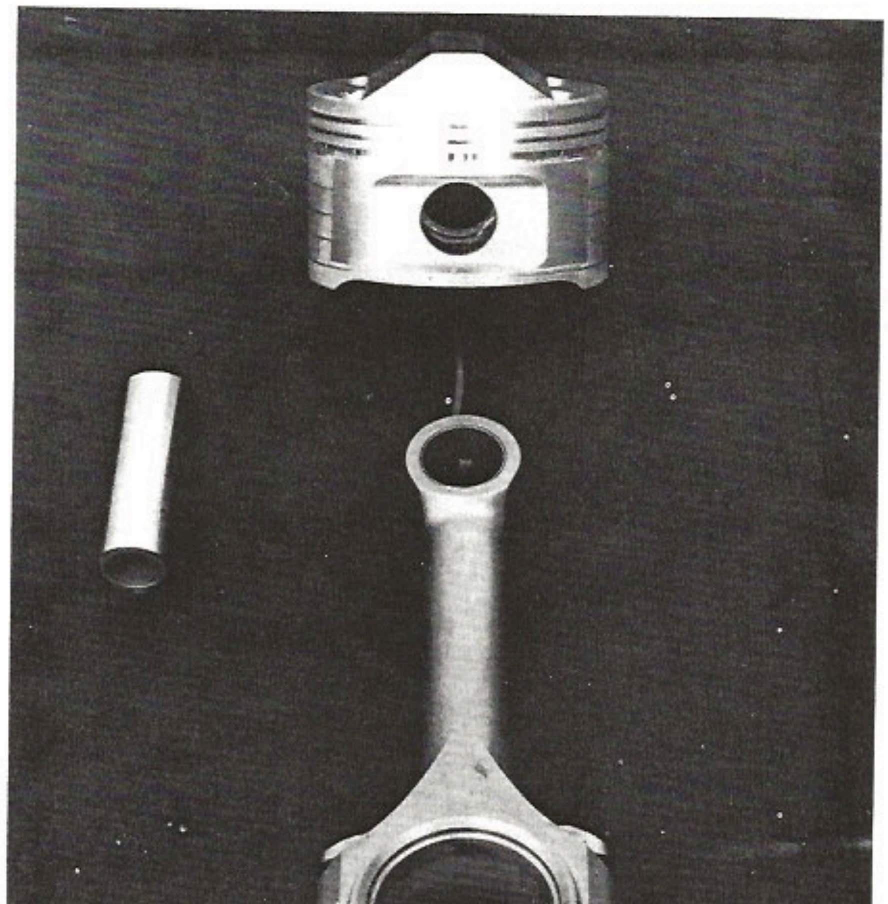
The magneto, has a timing adjustment coupling. The starter drive has a spring-loaded, dog clutch — which engages the crankshaft drive gear. A portable battery cart, and aircraft inertia starter, supplies the drive-power to start the engine in the race car. The centrifugal-type water pump is located just below the starter drive. The fly-wheel which accommodates a multiple, disc-type, clutch unit.

The standard Meyer and Drake Offenhauser is a potent piece of equipment as it comes from the factory. From its 252-cubic inches, it produces 340-pound feet of torque, at approximately 5200 rpm —developing 400 brake horsepower at 6500 rpm. (Graph I)

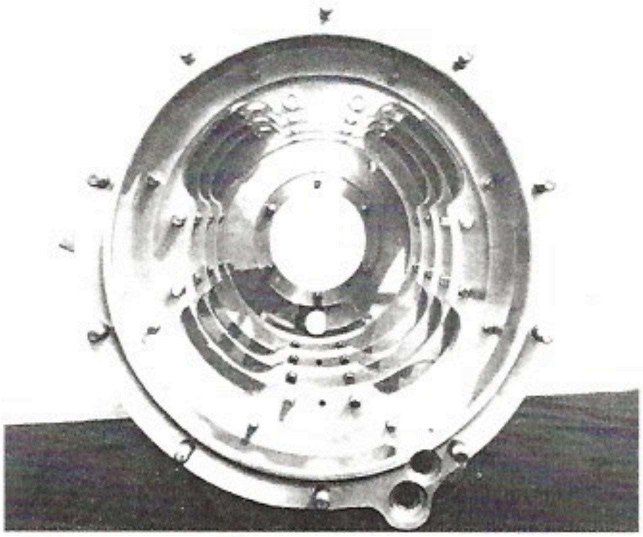
So what does the racing me-



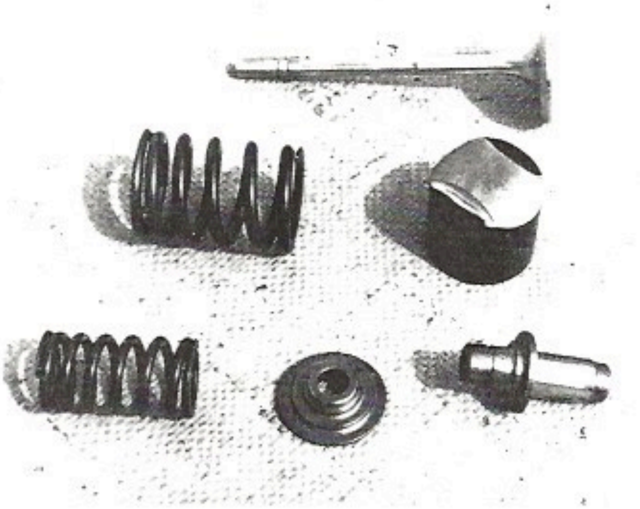
Barrel crank case is aluminum alloy casting. Attachment to block is via 16 half-inch studs. Bearing webs are held in place by 8 bolts each.



Heavy, drop-forged connecting rod has 1/2 inch cap bolts. Piston is impact extruded 2018 ST aluminum alloy. Pin diameter is sturdy 1-1/16 inches.



Precision boring and drilling is manufacturing requirement of Offy engine which inevitably raises cost, although Meyer-Drake plant has low spoilage record. Photo is end shot of crank case.



Valve assembly includes inner and outer springs, retainer, radiused cup follower, Meehanite valve guide and polished valve.

chanic do to improve the performance of this engine over that of his competition?

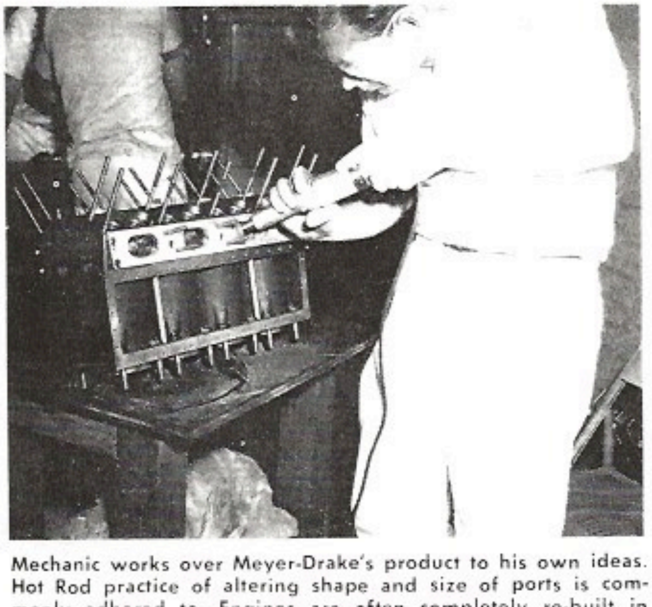
He begins with a complete engine dis-assembly. All component parts are inspected for flaws, or fractures, by x-ray, zyglo, or magnetic inspection. All parts are measured, to ascertain proper clearances and fits. All mating surfaces are checked for flatness. All bores are checked for roundness. Combustion chamber volume is measured. Desired mechanical compression ratio, and piston crown configurations are determined. Valve to piston clearance is checked. Camshaft lift-curves are evaluated. Special camshafts are ordered — for testing purposes. All valves, and valve seats, are precision ground, and hand-lapped.

Piston rings are hand-lapped in the cylinders. Bench tests are made of all accessories — including the injector, fuel pump, magneto, water pump, and oil pump.

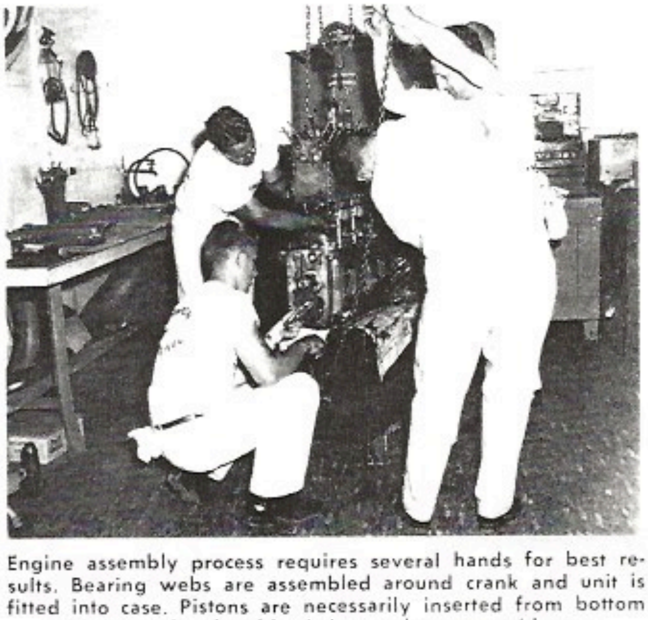
Then the engine is then re-assembled, and installed on the dynamometer. After a short run in period, a base-line-curve is established. The engine is now ready for further development, and evaluation testing

Many tests are conducted by the mechanic during the dynamometer program. The effects of many changes are evaluated, with one ultimate goal in mind. And that is to gain maximum power over the broadest, usable, speed range of operation; — which is mechanically acceptable to the engine, for the required distance, and time the engine must operate.

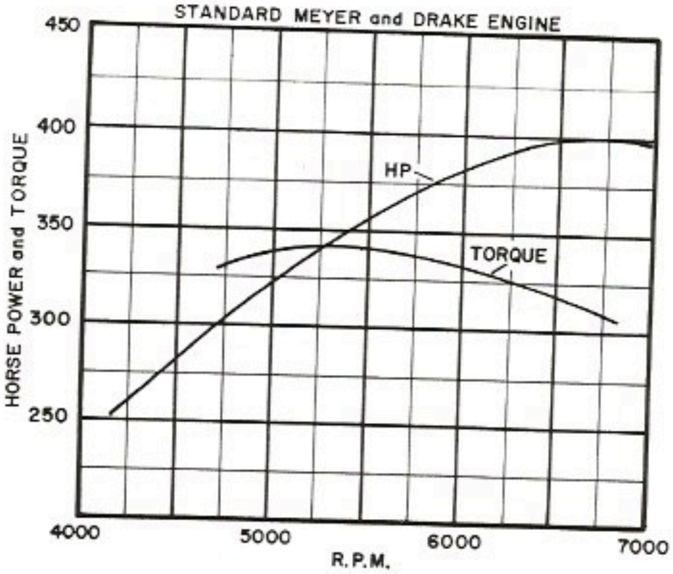
These include area and shape changes of the induction, and exhaust systems — piston crown, configurations — increased, or decreased compression ratio — combustion chamber shapes — various

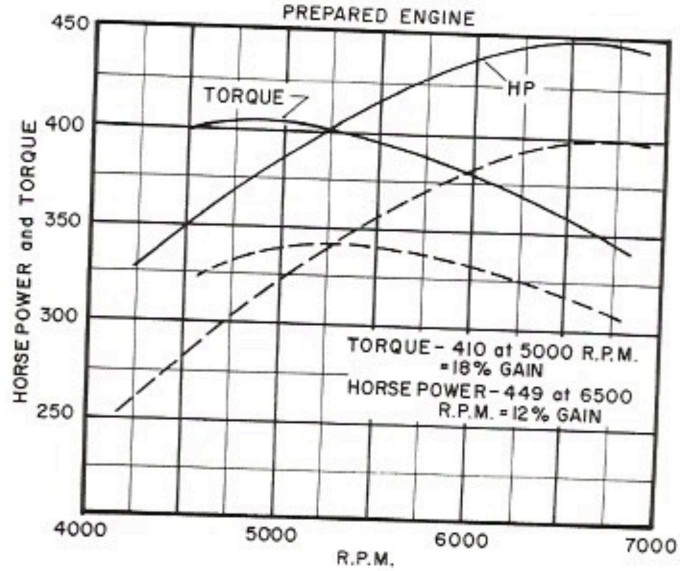


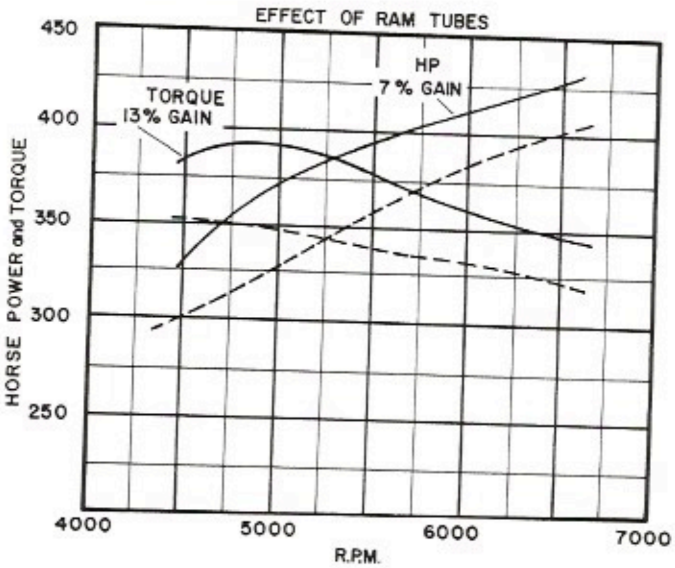
Mechanic works over Meyer-Drake's product to his own ideas. Hot Rod practice of altering shape and size of ports is commonly adhered to. Engines are often completely re-built in Speedway garages during race preparation.

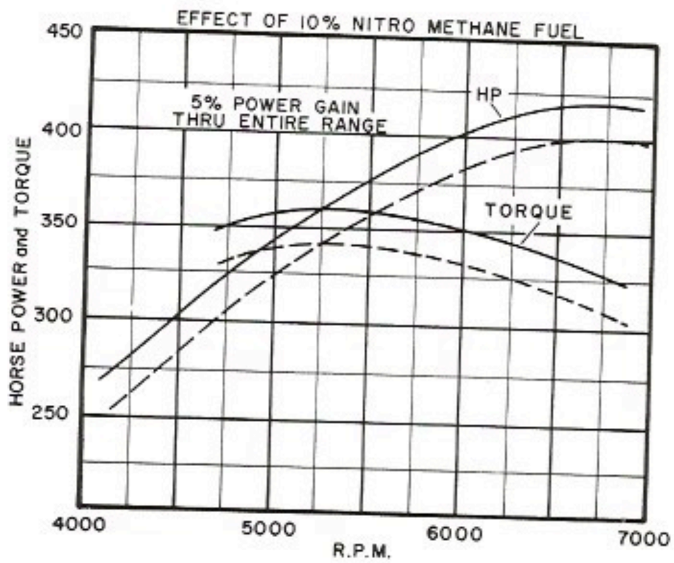


Engine assembly process requires several hands for best results. Bearing webs are assembled around crank and unit is fitted into case. Pistons are necessarily inserted from bottom of bores as head-en-bloc is lowered to mate with case.









spark plug positions and heat ranges—various valve areas—camshafts — carburetion — ignition — fuels — intake and exhaust tuning.

Through 30 years of constant development, and refinement, design efficiency has been extensively exploited.

This, naturally, makes it very difficult to obtain large gains in output through the medium of three relatively new techniques — or arts, if you will — impressive increases are being extracted.

These techniques are:

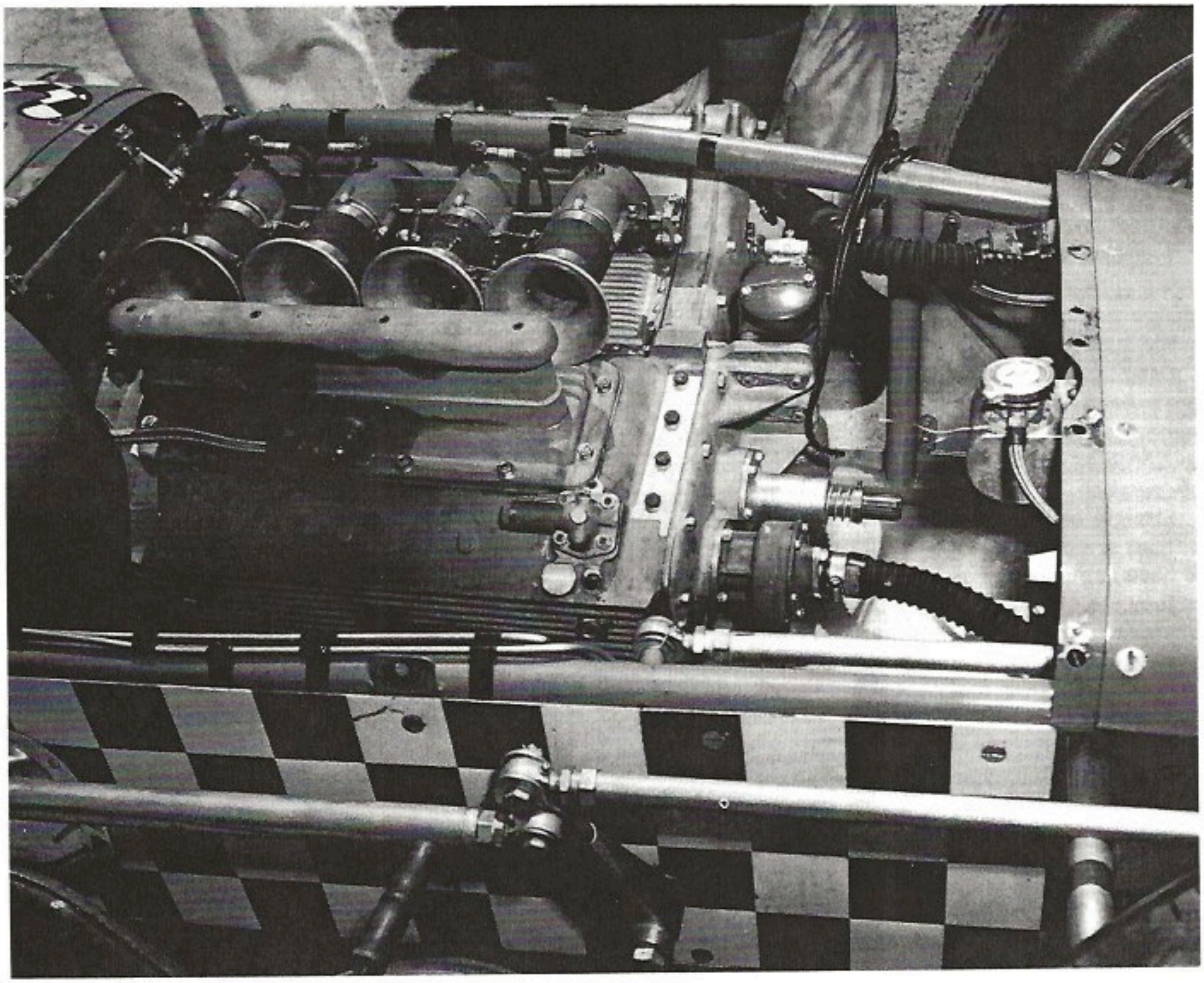
The use of oxygen-bearing fuels, induction and exhaust tuning. The accompanying graphs show the effects, and increases made possible, by the use of nitro methane, and induction tuning.

Large power gains may be obtained by the use of oxygen-bearing (or the so-called, exotic) fuels of the nitro-paraffin group. The most commonly used compounds are the chemicals containing nitrogen, which are notably un-stable. They come apart with ease. A good example of this ease is nitro glycerin.

The three nitro paraffins commonly used in racing engines are nitro methane, nitro ethane, and nitro propane.

Nitro-methane is the most extensively used of the three. This material is extremely sensitive, to both temperature and pressure. Controlled combustion must be maintained, or pre-ignition of the fuel charge — and possible engine destruction — will result.

With the use of proper compression ratio, fuel air ratio, spark advance and, in some cases, by in-



Bellmouth of entry on air inlet tubes to injectors has been found necessary when tuning for certain rpm ranges. Tall crankcase baffle came about when engine was tipped onto its side in chassis.

troducing internal coolants into the fuel charge normal flame propogation and engine operation is possible.

As graph No. 2 shows — there is an average resultant increase in power of 5 percent, for each 10 percent of nitro methane introduced into the fuel.

Due to the low heat-value per pound of this fuel, desirable fuel economy cannot be obtained if high percentages are used in the blends.

Fuel requirements vary with different engine combinations. Dynamometer tests indicate that a 6½ to 12 percent flow increase will be required to obtain a 5 percent power increase, when using a ninety/ten by volume, methanol-nitro methane blend.

Although induction tuning is not new to racing — and though it is available commercially at the present time — there is little specific information relative to its application on internal combustion engines. Yet, it is being used — and impressive, power increases are being obtained.

Various-shaped lengths of induction piping to each cylinder, attached before or after the fuel metering device, are commonly termed ram tubes, or ram manifolds. It has been fairly well established that dynamic charging of the cylinder, at some range of engine operation, may be accomplished by harmonic-resonant tuning of the intake pipe length — which, according to several empirical formulas, will tune in direct relations to the velocity of sound (plus or minus a small percentage for variables such as air stream).

Air entry shapes into the tube will increase, or dampen the resonance peaks. Experience shows that a short pipe will increase the speed value at which resonance will occur, and show the most peak power. Whereas, increasing the pipe length will show the most peak value for torque. Information obtained during induction-tuning development may change the thinking pattern necessary to its use. It now appears to have opened an entirely new concept in engine tuning.

Dynamometer experience on the Meyer and Drake engine also indicates that total area and shape of the pipe are critical. A straight section of too-small a diameter, having the same resonant length as the proper-sized tube, will restrict engine-air demands. On the other hand, one of too-large an area, will not have sufficient column inertia force at inlet valve closing.

Longer length straight-section tubes appear to have the maximum charge potential but a very limited range of operation.

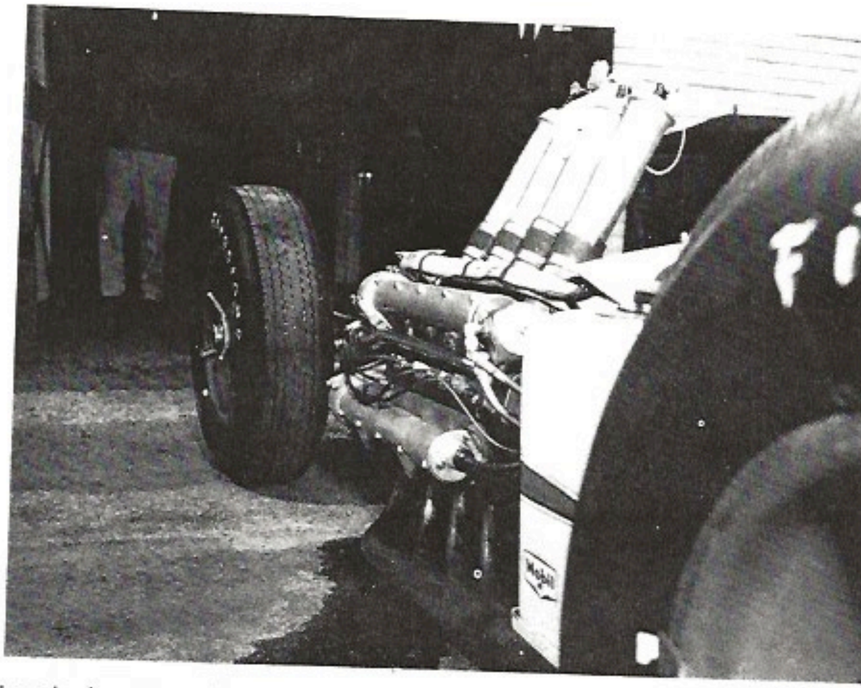
Long-tapered section tubes appear to have approximately the same charging ability as a straight-section tube — but a broader range of operation.

Straight or tapered section tubes without a stream-lined entry seem to have dampened charging, whether they are of long or short lengths, whereas stream-lined entries appear to have peak charging ability.

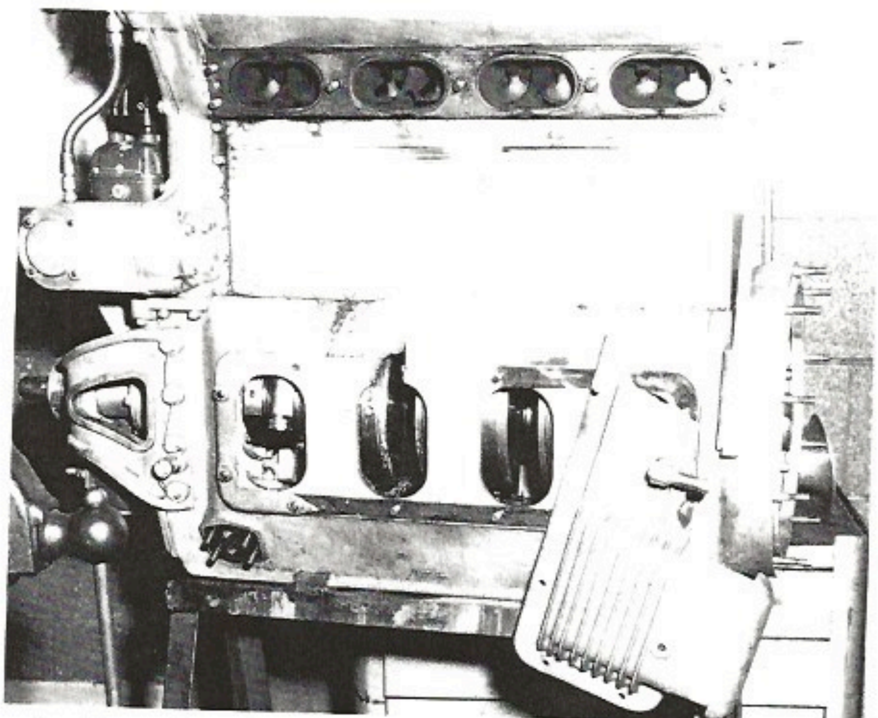
Graph 3 shows the power gain from a 16-inch, straight tube, with a 5-inch diameter, NACA entry bell versus the same engine with no ram tubes.

Note the hump in the torque curve at approximately 5000 rpm. It can be seen, from the shape of both the torque, and power curves, that the resonance increases to, and decreases from, a maximum value at approximately 5000 rpm. A 13 percent gain is noted at approximately 5000 rpm, decreasing to a 7 percent gain at 6500 rpm.

Camshaft timing plays an important role in induction tuning. Further power increases may be gained by closing the intake valve at the instant inertia ram reaches its highest value in the cylinder. To determine this timing point is extremely difficult without elaborate cylinder pressure instrumentation.



Length, diameter and shape of fuel injection ram tubes has been arrived at through practice as well as theory. Inlet and exhaust system tuning is critical in extracting maximum power.



Sturdy it may be, but the Offy is only human. Broken rod holed this crank case.

Manifold pressure fluctuations during engine operation with ram tubes make accurate measurement of peak-pressure in the induction system difficult. Consequently, most racing-engine ram tube combinations of shape, length and area are arrived at as a result of dynamometer testing.

Exhaust tuning also plays an important part. Through its use, the torque-peak may be moved up, or down. Engine output can be increased or decreased if shapes, areas and lengths of the exhaust system are compatible with the valve opening and closing diagram and with the tuned induction pipe. Then, not only can output gains be expected but, even more important, the over-all operational range of the engine will be significantly increased.

Graph No. 4 shows final results obtained through the mechanic's combined efforts compared to the standard, factory-delivered engine. The figures tell their own story: An increase of 70 foot pounds of torque at 5000 rpm; an increase of 49 brake horsepower, at 6500 rpm!

THE WHAT - HOW & WHY OF DISC BRAKES

by

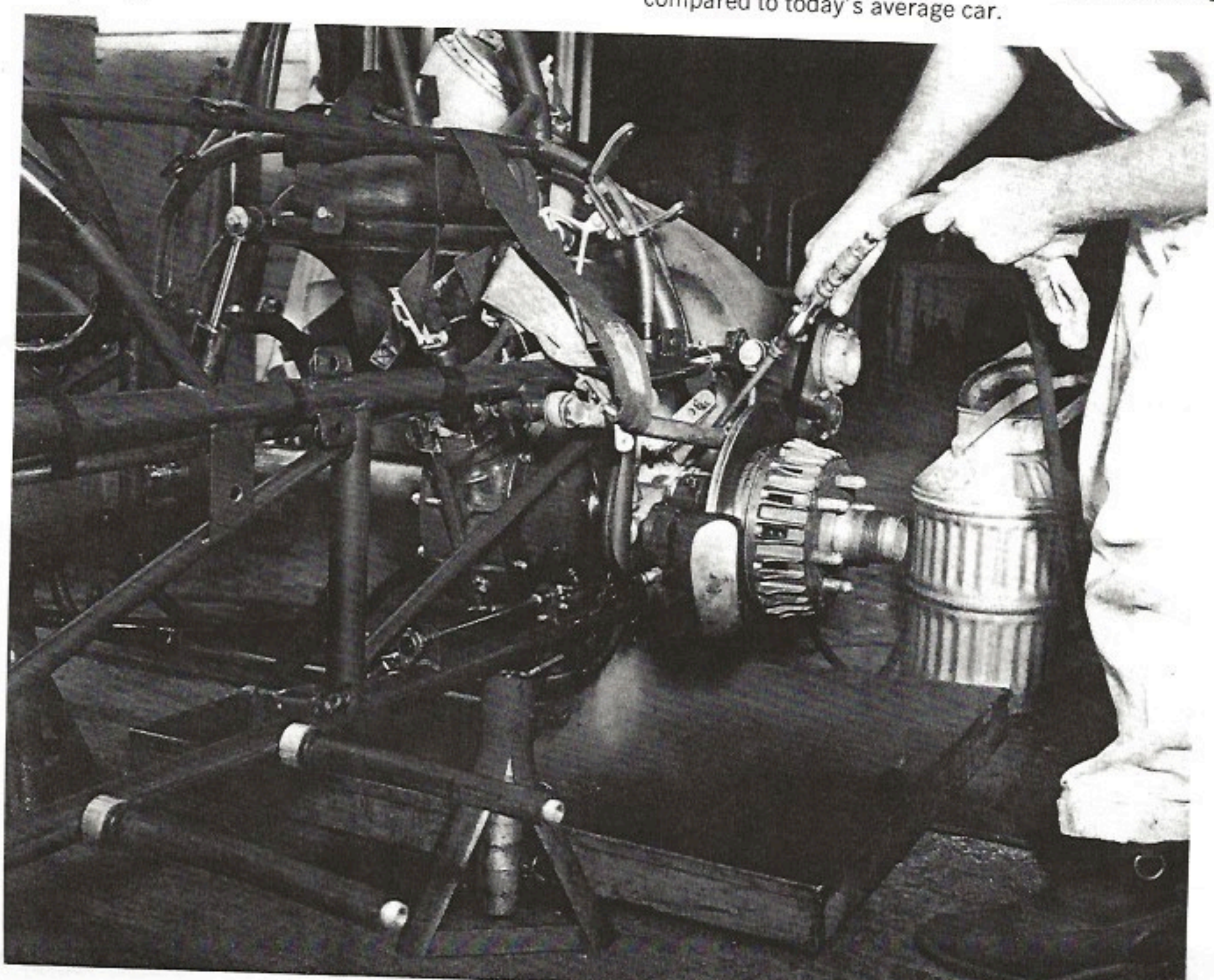
RONALD MOALLI
Chief Engineer
Brake Lining Development
Raybestos Division — Bridgeport, Connecticut

It is practically impossible to overlook the voluminous information recently published in the trade journals and associated publications concerning disc brakes. In addition to those concerned with racing, various articles coupled with advertisements and news of current planning in Detroit seem to indicate that the disc brake will be a greater factor in all our future automotive endeavors. There are several questions which can be answered to sum up the present state of the art.

1. What has been the recent history of disc brakes?
2. How and why do they work?
3. What is the possible future of the disc brake system?
4. What are the implications and ramifications of this program to automobile buyer and high performance enthusiast?

The history of U.S.-designed and U.S.-made automotive disc brakes is worthy of mention because it has been a history of notable failures leaving memorable scars in an objective analysis of the disc brake program.

For instance, Mr. Robert Walker of the Raybestos Road Test Department recalled a 1939 Ford in the fleet which was equipped with a Lambert disc brake. Even at that time the performance of this special braking system was rated as excellent with one serious drawback — extremely high pedal efforts were required to make a moderately severe stop. Yet, today's technology concerning power systems for power assisted brakes would have made that old Lambert an acceptable system. However, one must keep in mind that the 1939 Ford was a slow poke and a light weight compared to today's average car.



Mechanic cleans chassis with high pressure jet of solvent without affecting disc brakes. Unlike drum type, discs are relatively little affected by water, oil or detritus.

Between 1947 and 1949 Crosley introduced this type of brake. Again the system proved to be only moderately successful. The caliper head was subjected to weathering, road dust, ice and salt, and often the exterior sliding parts eroded into one solid, non-functioning part. As such, the disc brake no longer operated properly or, as in many instances, it did not operate at all. The corrosion problem proved too difficult to cope with so that Crosley ceased using the disc system — for that matter, the Crosley automobile ceased to exist some short time later.

Perhaps the most renowned of the automotive disc brakes of the past was the Ausco system by an American car manufacturer between 1951 and 1953. For those that were not exposed to this novel device let it suffice to describe it as a complicated full disc employing a "ball and ramp" arrangement to build self-energization into the brake. The idea behind this "built-in" servo action was to reduce the hydraulic line pressure to obtain a given output or stopping distance. The ball and ramp arrangement which abetted the efficiency also proved to be its downfall. As brake lining dust and road grit coated the ramps, the return mechanism failed to operate, thereby creating a dragging brake and increasing the frequency of brake relines. This was one of the reasons why the Ausco disc was discontinued.

"How do disc brakes work and why do they work?", are questions which, if answered completely, could represent a comprehensive study in dynamics, statics, thermo dynamics and hydraulics, beyond the scope of this discussion. However, the basic disc brake is a simple device for converting energy of motion into energy of heat.

This is accomplished by the pushing or clamping of friction material segments against a flat rotating plate. Please note the lack of self-energization of the disc which, conversely, is inherent in every drum brake manufactured in the United States today. This means that brute force must play an important part in the operation of the friction material against the rotor to provide a satisfactory stop.

A short outline of these characteristics will provide a better insight to the advantages and disadvantages of the disc brake.

DISC BRAKE
Non-Servo

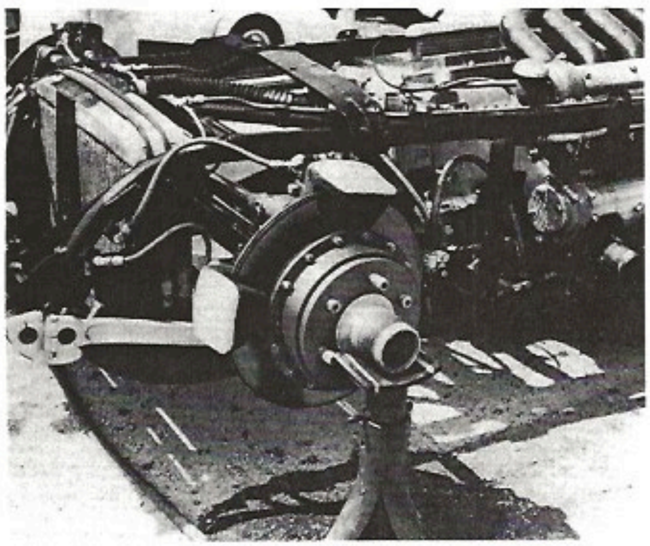
Con ← ↑ → **Pro**
High Pressures — Stability

Adding to the other side of the ledger one advantage — stability or freedom from pulling under all conditions. This is an outstanding feature of the discs as typified by our models. By listing this advantage it would be a folly to lull ourselves into a false sense of security by believing that these brakes are perfect in these respects — they are not! A disc brake will pull, but it is less prone to erratic action than the common drum brake of today. As described before, the disc brake does **not** have built-in servo action. If an unbalance occurs in the friction of the brake linings from side to side on a car, this effect is not multiplied through a wedging action or a primary to secondary servo action. Its effect is directly proportional to the change in friction and not by the friction multiplied by a factor of 4 to 5. The friction material properly selected for disc brake operation also often lends to their stability. These materials seem to have a stable friction at temperatures much higher than those normally encountered on drum brakes.

The most well known advantage of the disc brake is its ability to resist heat fade —

DISC BRAKE
Non-Servo

Con ← ↑ → **Pro**
High Pressure — Stability, Fade Proof



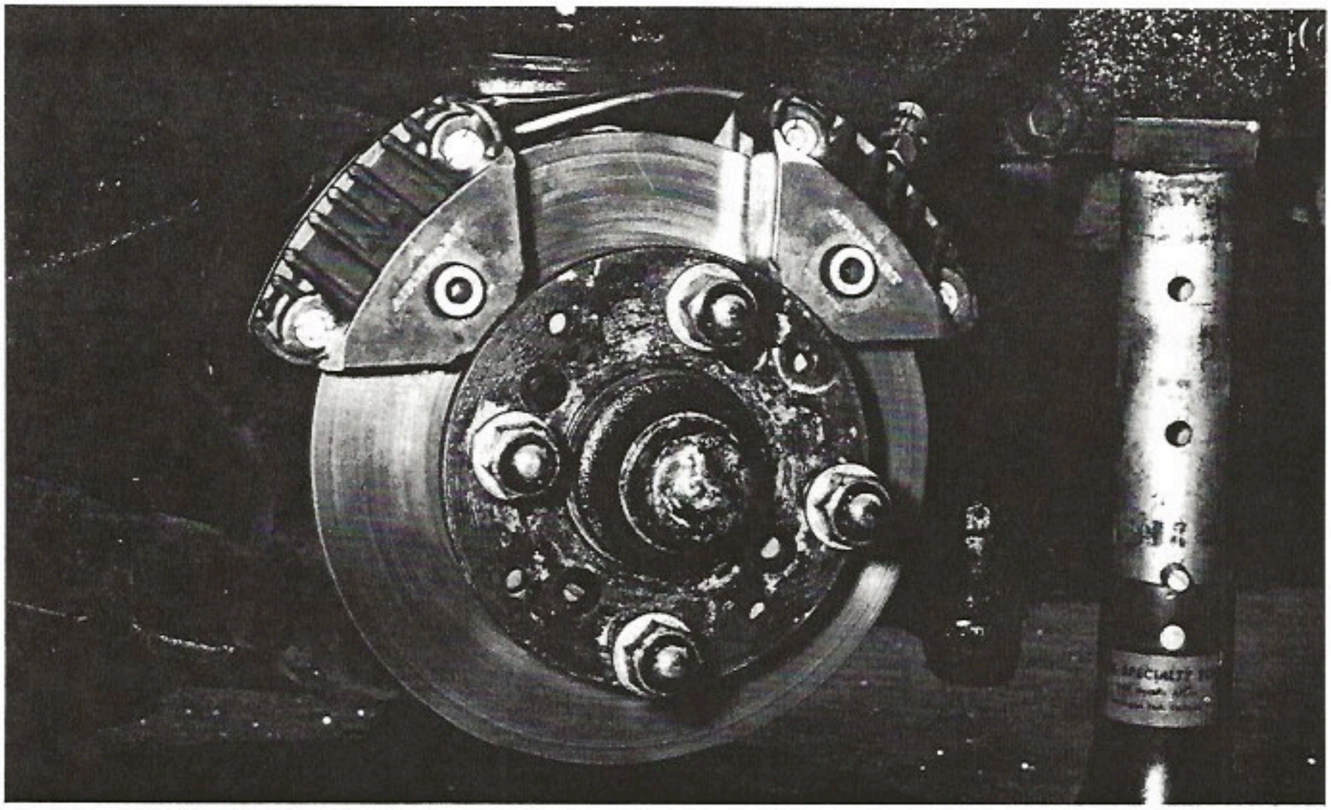
Two-caliper unit is used on front wheels of Championship car because of greater weight bias forward. Discs were used by all 33 qualifiers this year.

Risking the danger of over-simplication I shall point out the major characteristics which influence fade.

1. As the temperature increases in a drum brake the drum grows radially. The diameter measurably increases and this growth may be sufficient to cause the brake linings to contact the drum in a **line** pattern. But because brake shoes spring open under pressure the line contact theory is a fallacy — however the true area in contact most certainly does shrink. The disc brake will also expand radially at elevated temperatures, but this expansion is of no consequence since the linings remain in full contact at all times during a brake application.
2. During a brake application approximately 2/3 of the drum rubbing surface is in contact or near contact with the brake linings at all times.

The heat path from the friction created at the interface of these two surfaces is, for the most part, through the cast iron to the outer surface of the drum. However, in a disc brake something less than 1/6 of the rubbing surface is in contact with the friction pads at one time during a brake application. This leaves about 5/6 or better exposed for the dissipation of heat to the surrounding air.

3. The last major characteristic which enhances the disc brakes' ability to withstand fade conditions is one in which an apparent wrong makes a right. The rotor of many disc brakes weighs only one-half the weight of a conventional drum. By forcing a definite amount of heat created by a



Double-caliper installation on passenger car using aircraft-derived units. Airheart Co. is first manufacturer to build conversion kits for changeover from drum brakes.

stop into the lighter rotor the temperature would quickly reach high values. This is corroborated by the common knowledge that disc brakes do run hotter, but in doing so they are also capable of dissipating more heat. Under very severe conditions the disc will reach equilibrium conditions, i.e., the disc will eventually dissipate the heat as rapidly as it is being put in. This is not true with a drum brake. It will just continually drive to higher and higher temperatures until the drum is burnt or the lining will fade out completely, leaving absolutely no stopping ability.

The conditions of high temperature and high pressure result in undue stress on the friction pads of a disc brake. The wear rate of the linings, in terms of thickness loss per 1000 miles, is considerably higher than the wear rate of shoe brakes. This would add to the list of disadvantages —

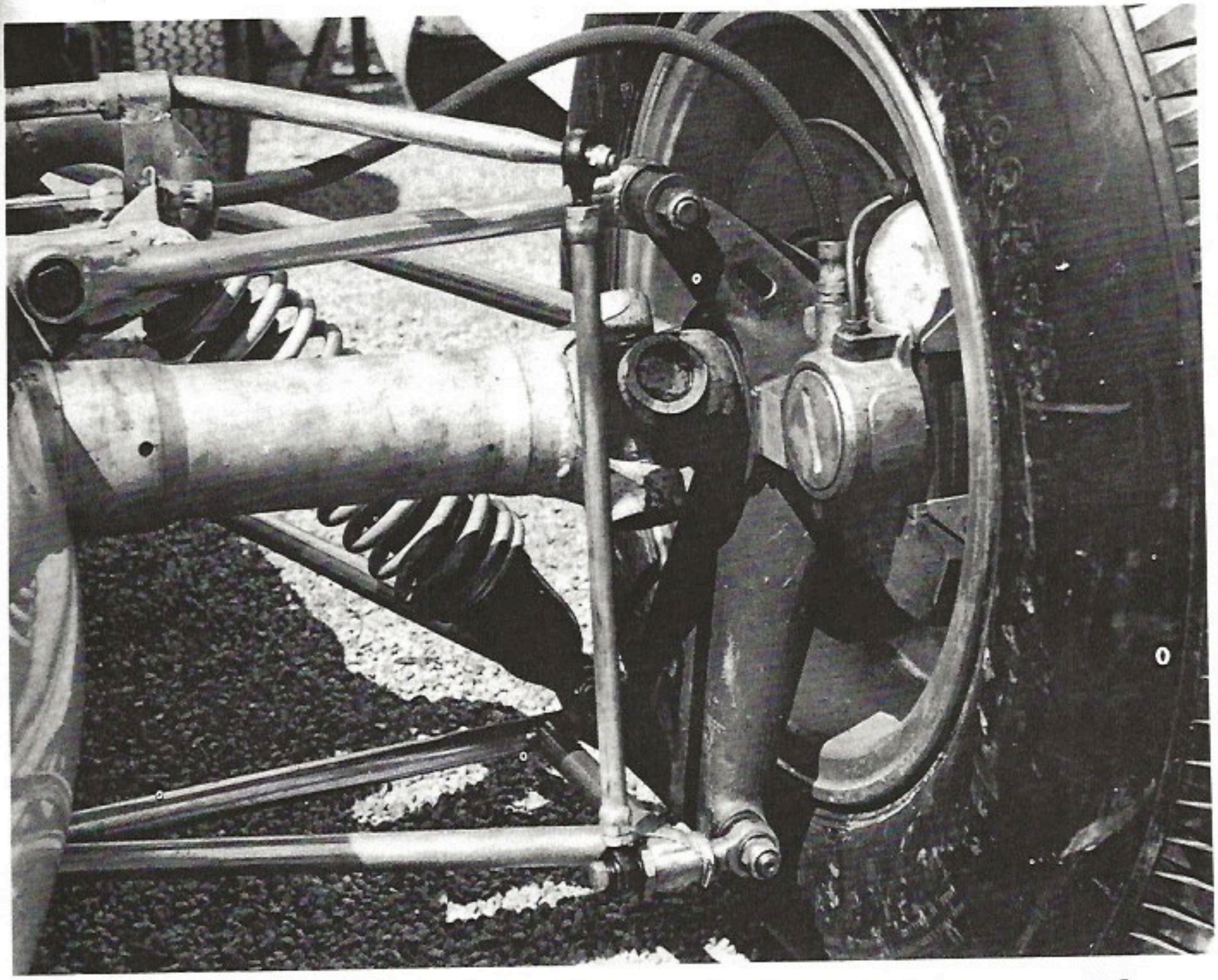
DISC BRAKE
Non-Servo

Con	**Pro**
High Pressure	Stability
High Wear	Fade Proof

In addition disc brakes are also costly to manufacture. Bringing the outline along —

DISC BRAKES
Non-Servo

Con	**Counter Con**	**Pro**
High Pressure	Boosters	Stability
High Wear	Thick fric. Mat'l	Fade Proof
High Cost	High Qual. Mat'l	Var. in Design
	Improved Cooling	



Dunlop discs, such as this Lotus installation, have been used for several years on both racing and passenger cars in Europe.

If these disadvantages as listed on our chart were to remain problems, the disc brake would never be used on the heavier U.S. built passenger cars. To counter these factors of high pressure supply, high wear rate and high initial cost, modern technology provides the following solutions.

1. Since a large number of automobiles produced today are equipped with power-assisted brakes, a source of high pressure is now available for disc brake operation. This would require a modification of the booster system.
2. There are obvious ways to improve wear life of the friction material. The first, is to provide more brake pad to wear out — simplicity in itself, yet quite effective. The second method is to provide a material which will not wear out rapidly. The difference between poor and high quality friction material formulations will manifest itself more quickly on a disc brake than on a conventional drum brake. The last item for the improvement of wear life is better cooling. The effect of cool braking surfaces has been obvious for years to everyone concerned with friction applications.

Two more items should make our chart complete. The disc brake could have sales appeal to the American consumer. This should be added to the advantage side of our outline. Only time will tell if this has been a justifiable assumption. The last item unaccounted for is what could be done with the high initial cost of a disc brake. Over an extended period of time it will be a good up-to-date American mass production know how which will solve the problem of high unit cost. — Our simple outline is now complete.

DISC BRAKE
Non-Servo

Con	**Counter Con**	**Pro**
High Pressure →	Boosters	Stability
High Wear	Thick fric. Mat'l	Fade Proof
High Cost	High Qual. Mat'l	Var. in Design
	Improved Cooling	Novelty
	AMERICAN PRODUCTION	

Several facts indicate that discs have a good future on passenger cars as well as wider use on competition cars.

Fact #1 is the inception of the Studebaker Avanti as, perhaps, the first U.S. car in some time to offer a disc brake as standard equipment. The same disc is also offered on other Studebaker models as optional equipment.

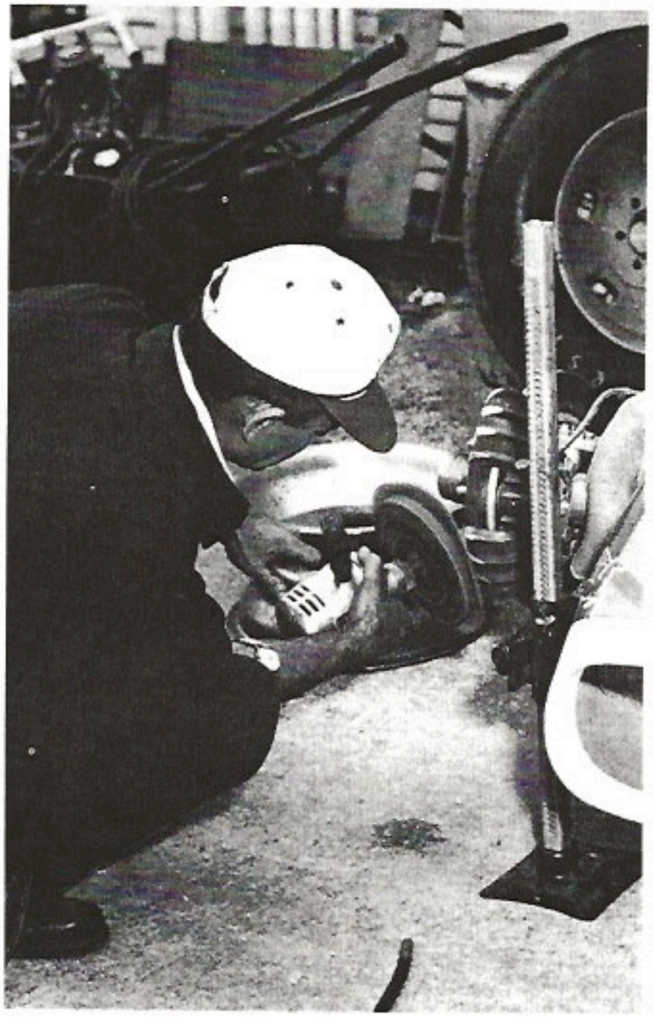
Fact #2 refers to the large number of articles recently printed in hot rodding, racing and trade magazines featuring the advantages and repair techniques of foreign disc brakes.

Fact #3, pertains to the Ford Falcons entered in the Monaco Rally. These may represent the first attempts by a U.S. manufacturer to enter durability competition against European built cars. The Falcons were equipped with a Bendix disc brake and the performance of these brakes was carefully followed by both representatives of Ford and Bendix.

Fact #4 became well known during a recent SAE meeting and display in Detroit. Kelsey-Hayes and the Budd Company displayed newly-designed disc brakes. The models from both companies were equipped with rotors patterned after a Sirocco blower and adequately designed to suit passenger vehicles in the 5,000 lb. class. This Bendix brake was also on display as, perhaps, a brake well-suited to cars lighter in weight.

These four points lead quickly to future planning. From bits of gossip and some associated facts some pertinent conclusions have been reached. Close contact by Raybestos representatives with the automotive companies and the foundation brake builders has revealed the preparation for testing of hundreds of prototype disc brakes. The Raybestos Division is currently supplying substantial quantities of large disc brake friction pads for these prototypes. Raybestos will be road testing the most advanced and most desirable of these prototypes on a heavy semi-sport car type of vehicle since we believe that the disc brake could be released in quantity production by mid-1964.

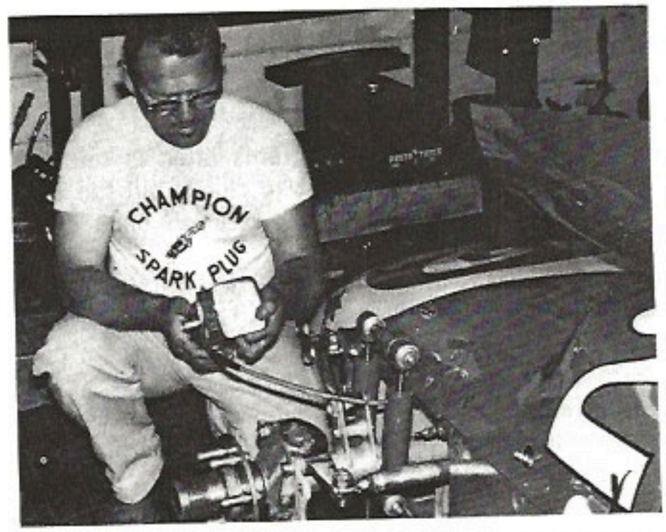
1. Let us assume that there is a transition to disc brakes in the United States, the transition should be gradual. It would also be safe to assume that disc brakes will only be used on front axles due to the difficulty of adapting a satisfactory hand brake or emergency brake to disc brakes if proposed for rear axle use. However, there are several foreign cars that use disc brakes on both front and rear.
2. The life expectancy for friction pads will be equal to or shorter than the average life expectancy for lined brake shoes, but as technology improves, the miles between relines could become greater. There is a general tendency for the general public to abuse disc brakes because of their seemingly indestructable characteristics but these are factors which are currently unknown and only experience on foreign car disc brakes lead to these initial assumptions.



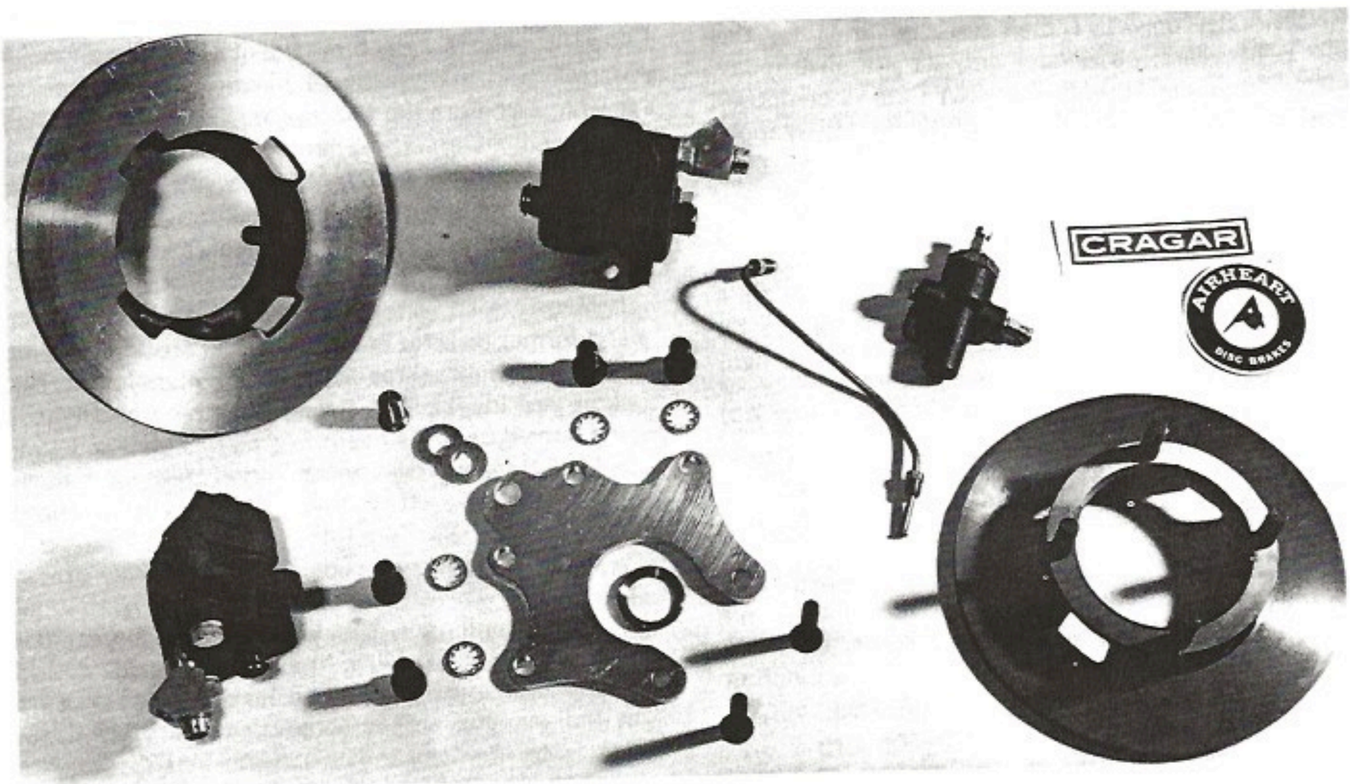
Alloy caliper bodies are finned for strength and heat dissipation. Grinding of casting was made necessary by reduction in wheel size from 16 to 15 inches this year.

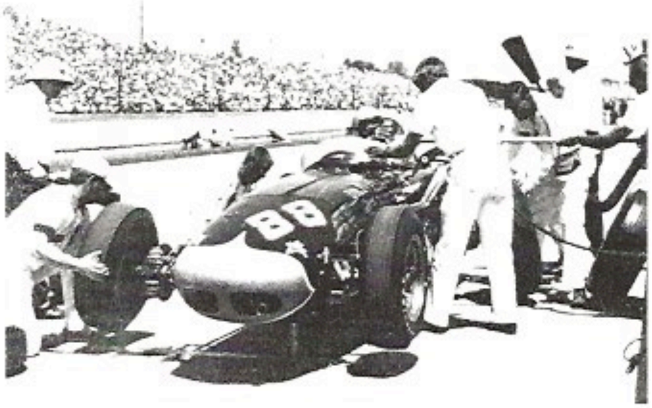
3. After a short period of time, there will be a large variety of sizes and configurations of disc brake pads.
4. All friction pads are and will be bonded to a steel shoe or reaction plate. In most instances the torque produced by the disc brake is taken on this reaction member. Flatness and parallelism of the shoe and lining assembly are extremely important for the proper function of the brake. Reclaiming of the steel shoe may not be economical since these parts do warp when subjected to high temperature and the cost of fabricating a new shoe is relatively low.
5. It will not be necessary to rework or replace a disc brake rotor as frequently as the current brake drum. These rotors, discounting future modifications, are not subject to eccentricity, heat spotting or bell mouth problems. They are still subject to scoring and wear.
6. Some relines may be performed within minutes while others, especially discs designed for heavier cars, may require complete disassembly for a brake reline. The hydraulic system may present some initial problems to the garage man.

7. The hydraulic wheel cylinders of a disc brake are highly unconventional. Flat seals, lip seals and "O" rings are frequently used. It will also be necessary to use a non-metallic heat insulating type piston on those designs proposed for future U.S. Production to prevent hydraulic fluid boiling problems. Most future designs incorporate 4 cylinders per wheel.
8. We at Raybestos feel so strongly about the disc brake program that we are now producing those friction pad and shoe assemblies necessary for every significant foreign made vehicle in this country and the new Studebaker disc brake. These parts have been proving-ground tested. Ever since Raybestos supplied nearly all World War II disc brake equipped aircraft with friction material, it was apparent to us that these formulations were necessarily different. This is also true today. Deviations from these premium linings will not function properly.

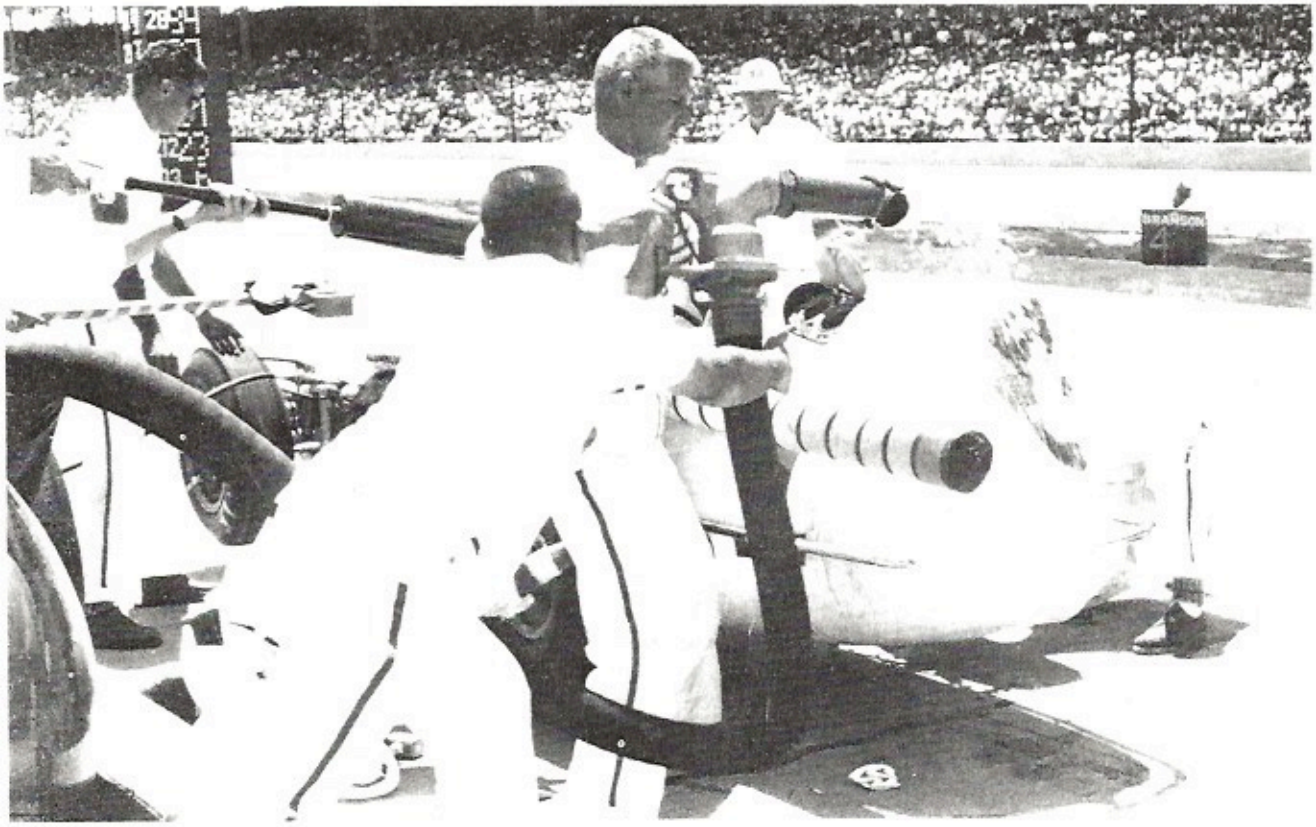


Although simple in appearance disc units are made to exacting tolerances. Movement of pad which produces stopping action is measured in thousandths of an inch.

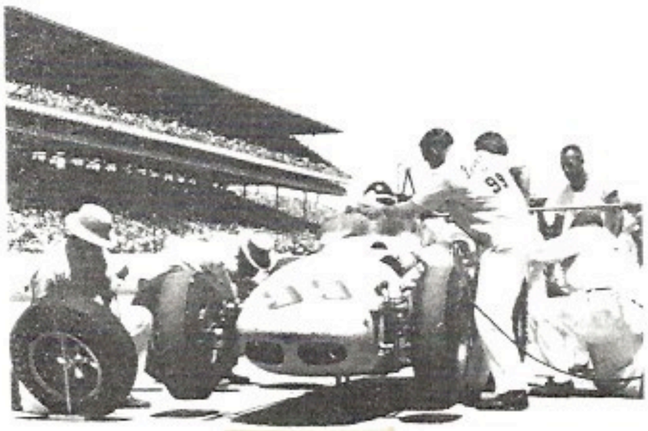


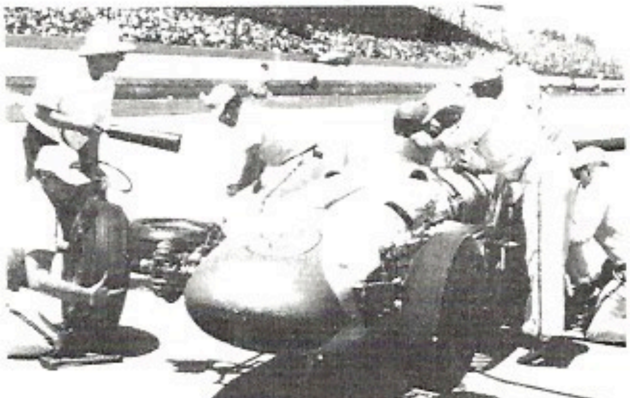


The first round of pit stops gives pit crews a chance to apply what they have practiced. Left: Eddie Johnson gets the works. Right: Bobby Marshman signals for a stop.



The hose valve fails to shut off completely and highly inflammable fuel is spilled in Rodger Ward's pit; luckily no fire resulted.





Studies in fast motion: Pit crews change tires on the cars of Paul Goldsmith (left) and Eddie Sachs.

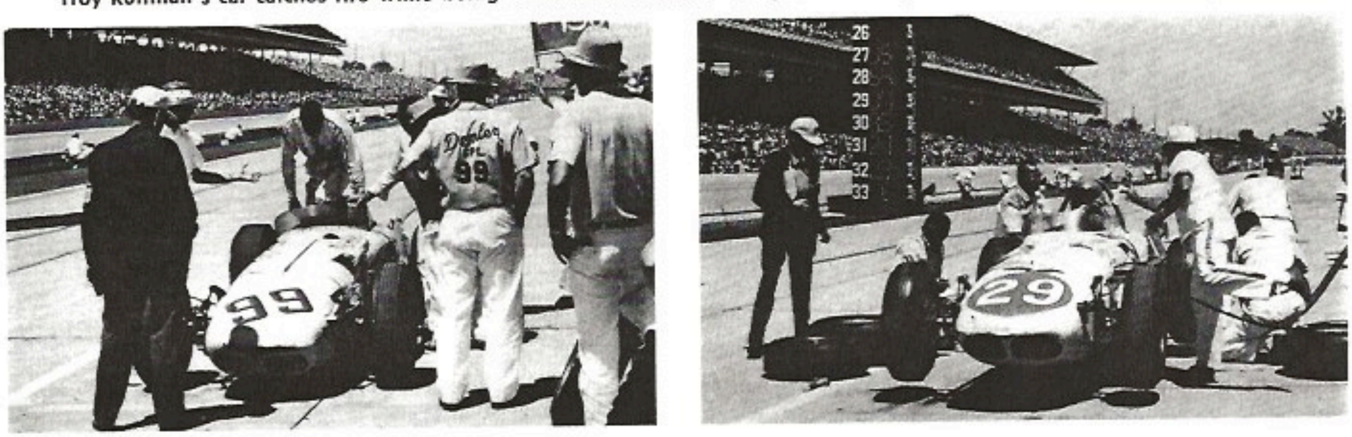
NO 83

STANDINGS OF THE LEADERS AT THE END OF 150 LAPS OR 375 MILES:

98- JONES
92- CLARK
2- FOYT
93- GURNEY
14 MCCLUSKEY
9- SACHS
1- WARD
8- MCELREATH
4- BRANSON
5- MARSHMAN

THE TIME WAS TWO HRS 37 MINS 0.15 SECS. THE SPEED WAS 143.310, A NEW TRACK RECORD. THE OLD MARK OF 139.834 WAS SET BY RODGER WARD IN 1962.

Troy Ruttman's car catches fire while being refueled. Driver sits calmly in the cockpit while flames are doused by CO_2.



Paul Goldsmith crawls wearily out of his Demler Special (99) as it is retired. More fortunate Dempsey Wilson is about ready to pull out after pit stop.

NO 88

CAR NO. 99, PAUL GOLDSMITH WAS OUT OF THE RACE ON THE 153RD LAP. THE CAUSE WAS UNDETERMINED AT THE REPOXXXAT THIS REPORT.

CAR NO. 16, JIM RATHMANN, WAS OUT OF THE RACE ON LAP 109 WHEN THE CAR STALLED ON THE NORTH TURN BECAUSE OF FUEL TROUBLE.

NO 89

CAR NO. 29, DEMPSEY WILSON, PITTED ON LAP 156 FOR FUEL, RIGHT FRONT, RIGHT REAR AND LEFT REAR TIRES. HE WAS IN THE PITS 29.8 SECS.