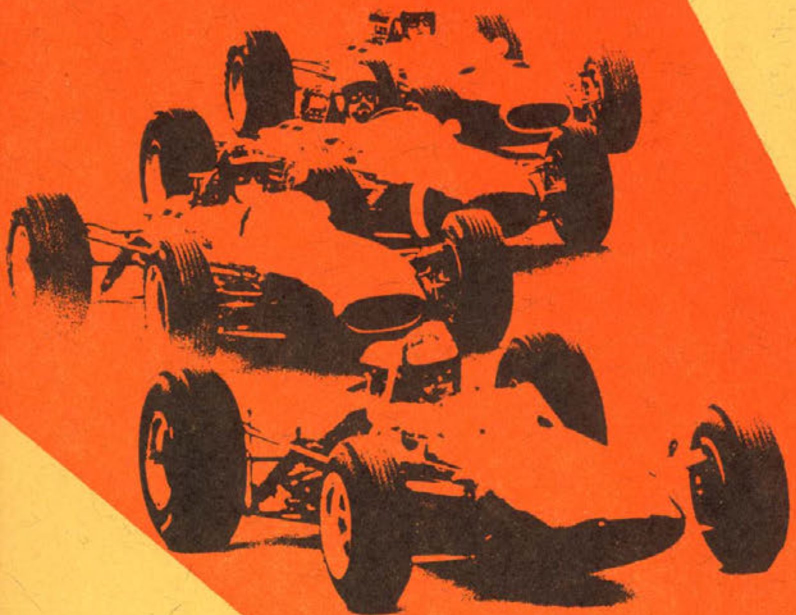
BY JOSEPH LOWREY

# ℞: Three Liters for Grand Prix Racing



***FIA Injects Stimulants for Chassis, Transfusions for Engines, Tranquilizers for Sponsors, and Restoratives for Spectators***

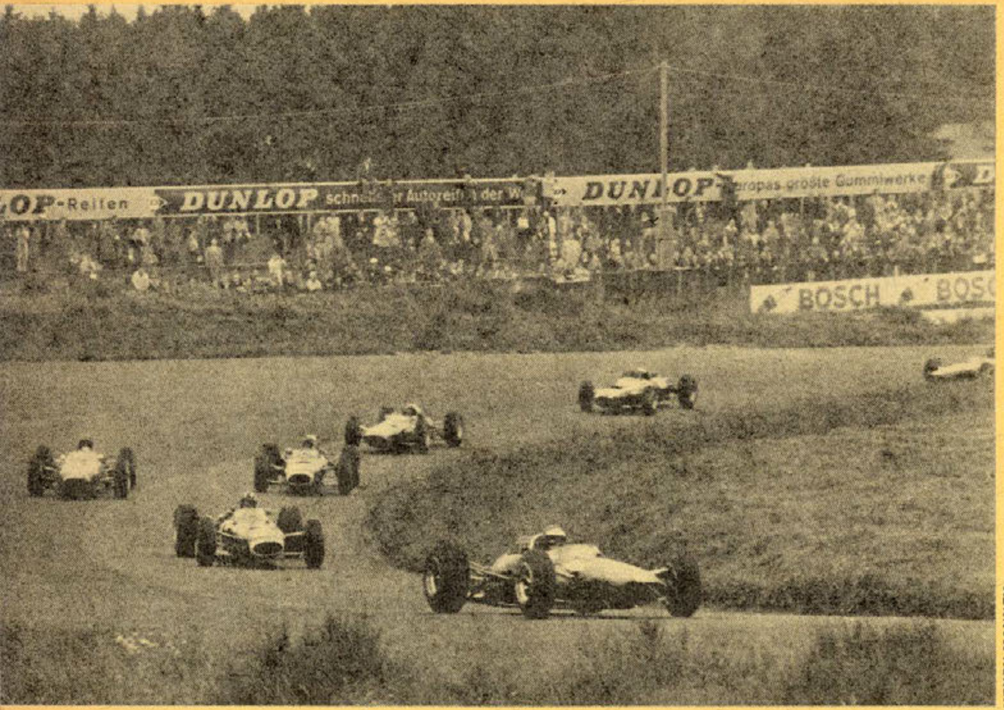
GRAND PRIX road racing undergoes a revolution every few years, when for technical or other reasons the rules concerning car eligibility are rewritten, and such a revolution is now in progress. Between 1954 and 1960 engines were unsupercharged and limited to 2.5 liters (152.5 cu. in.), alcohol fuel being allowed through 1957 and aviation gasoline (of 130 "Performance Number" anti-knock rating) compulsory from 1958 onward. For the period of 1961 through 1965, the maximum permitted engine size was cut back to 1.5 liters (91.5 cu. in.), without supercharging and burning commercial gasoline of 100 Research Method Octane rating. That drastic cut in engine size was a belated reaction to the death of many spectators in a racing sports car crash at Le Mans. Now, for 1966 and subsequent seasons, cars still are being required to race on pump gasoline, suppliers of which are major sponsors of Grand Prix racing teams. However, the allowed engine size has been doubled to 3 liters (183 cu. in.) displacement unsupercharged, or 1.5 liters (91.5 cu. in.) with supercharging.

Argument about the new Grand Prix racing formula is loudly public, while most of the actual preparation of engines and cars is being done as secretly as possible. There are arguments about whether the new formula should take effect at all, about the amounts of money needed from backers to finance the construction of new engines and cars, and about which sorts of cars will most likely win races under the new rules.

The need for a new formula to save Grand Prix racing from total eclipse was very real indeed. Unsupercharged 91.5-cu. in. cars running on pump gas have achieved astonishing speeds, but with small engines and good road holding they have not been spectacular in action. Two-seat racing sports cars with basically stock American V-8 engines, built in accordance with modern Grand Prix ideas about chassis design, are now going faster than Grand Prix single-seaters and providing a far better spectacle for the paying onlookers. Either the Grand Prix rules had to be changed to let the cars go faster, or this class of road racing was going to be overshadowed by events for the faster 2-seat machinery.

There is very real worry about the possible dangers of racing under the new rules. This fear is not primarily for the drivers, because while it is being said that double-power cars will "sort out the men from the boys," the competitors know, and to a great extent control, the risks which motor racing involves. It is the risk to spectators which is causing concern. National government and local officialdom tend to become agitated when people who have gone to watch a dangerous event themselves get hurt. Many Grand Prix races still are run on the traditional circuits which are sections of otherwise public road temporarily closed to traffic. Other races are staged on private circuits designed so they more or less closely resemble public roads. Protection for spectators against an out-of-control car cannot be nearly as complete on public roads as at Indianapolis or Daytona, and more complex accidents can occur on the irregular turns and S-bends of a road circuit than are likely to happen on the one-direction turns of a simple oval.

In recent years, many road race organizers have tended to "improve" their ▶




HENRY MANNEY

**JIMMY CLARK glides easily to the 1965 World Championship, his second, at the German GP. The new formula may halt the Clark-Lotus win streak.**

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circuits by easing the corners, so that small-engined cars could reach higher speeds. Lotus designer Colin Chapman expects 3-liter Grand Prix cars to reach about 220 mph on the faster road racing circuits and this prospect alarms a lot of people. In the 1930s, when racing car speeds rose uncomfortably high for the chassis of that period, race organizers often limited the maximum speeds attainable on their circuits by putting a chicane, an artificial S-bend formed by hay bales, halfway along any long straight.

Such corners are not at all typical of real roads, but they seem quite likely to be re-introduced on some fast circuits as a means of limiting maximum speeds.

WHEN THE 2.5-liter formula was about to give way to the 1.5-liter formula five years ago, there were loud complaints that cars with smaller engines would cost more to build. Now the same people are saying that 3-liter cars will cost more than 1.5-liter cars! The real truth is, of course, that building entirely new engines and cars to the highest possible standards is inevitably more expensive than improving engines and cars which already exist. When a new formula is announced, every would-be competitor hollers as loudly as he can, hoping that his backers will put up enough money to let him build an ideal car, fearing that they will make him do his best on a restrictive budget. In the main, it is man-hours rather than materials in a racing car which cost a lot of money and for equal complexity, cars for different engine sizes are unlikely to differ much in cost of building and maintenance.

It is known that cars for the new Grand Prix formula are being built by BRM in England, by Ferrari in Italy and by Honda in Japan. Lotus of England, which won the 1965 Grand Prix world championship with a Coventry Climax engine and the Indianapolis 500 with power by Ford, will be racing cars with BRM engines during 1966. This use of bought-elsewhere power will be to keep Lotus team drivers and mechanics intact. Ford of Britain has provided sponsorship (probably to the tune of nearly $300,000 spread over the next three years) for construction of an engine to be used in 1967 Lotus GP cars.

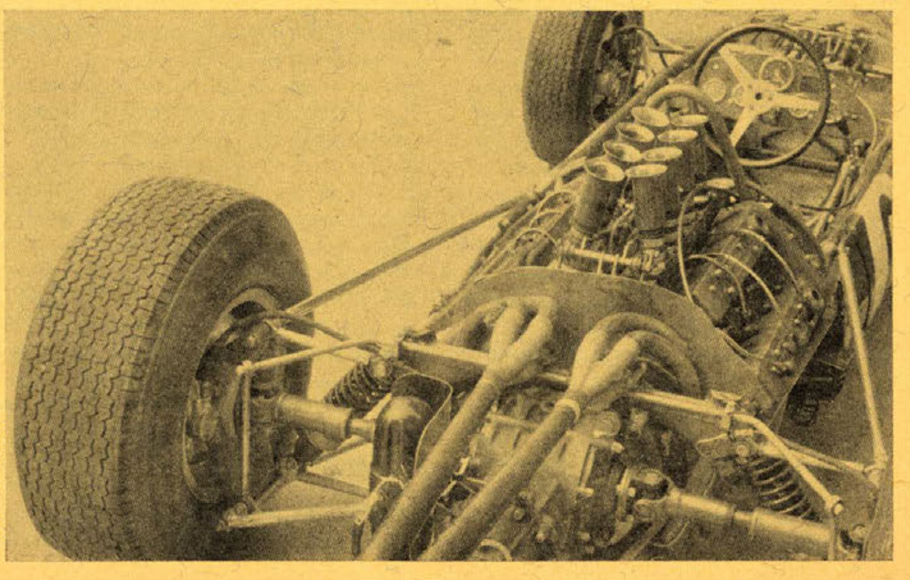
This Ford-backed Grand Prix engine for fitting exclusively in Lotus cars is to be designed and developed by Keith Duckworth and Mike Costin of Cosworth Engineering, hitherto known as highly successful builders of smaller and simpler Formula II engines. All possible secrecy is being maintained about details, but it is hoped to test out at least some features of the new design in Formula II racing during 1966.

It is an interesting thought that the Indianapolis Ford V-8 engine would only have needed its bore and stroke dimensions reduced by about 12% to make its displacement 3 instead of 4.2 liters. However, it might be difficult to derive more than 320 bhp from such a scaled-down engine. A greater number of cylinders probably would be necessary for attainment of the 400 bhp which is thought to be required for race-winning cars.

OTHER NEW cars are expected from smaller racing teams which will buy engines wherever they can. If the British Cooper team races it probably will use Maserati engines, built in Italy where 2.5-liter V-8 ATS engines also are being enlarged to meet the new formula.

Early in the new season, some cars with quite obsolete engines are likely to be raced by private entrants, at least to collect "starting money" by filling up the field at races for which newer cars

**JACK BRABHAM used a Coventry Climax V-8 in this rear-engined chassis for the 1964 season—a layout likely to remain in Formula I racing.**

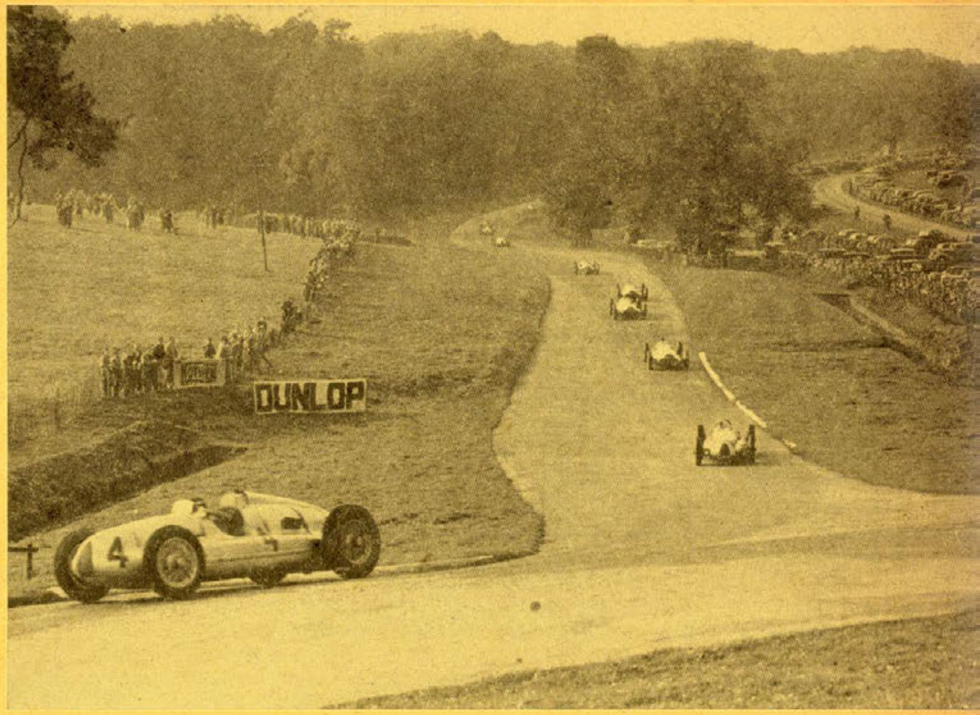


GÜNTHER MOLTER

are not yet ready, and perhaps even to win some prize money when potentially faster cars retire with new formula troubles. For example, Coventry Climax 4-cyl. engines which won races until late in the old 2.5 liter formula era can be stretched to 2.7 liters and though a power output of something over 250 bhp sounds modest, this engine is likely to re-appear during 1966 races.

Designing an engine for road racing is not solely a matter of producing maximum power at peak rpm; the factor which matters on a road circuit is the average power output over the range of engine rpm which a driver must use. Even with the best 5- or 6-speed transmissions, a fairly wide range of engine speeds is used on the GP circuits. Many racing engine designers deliberately limit port and valve sizes in order to improve torque at less-than-maximum rpm.

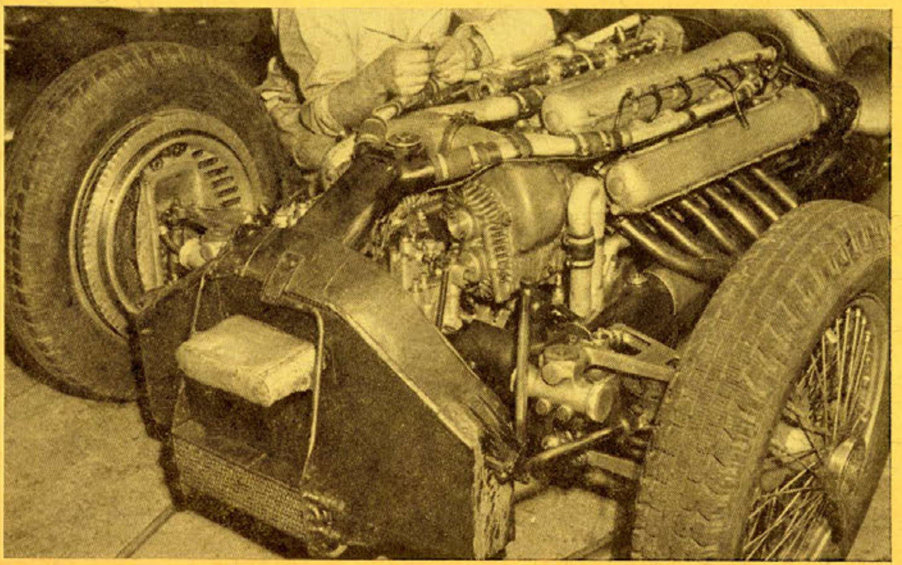
In comparison with cars which race only on oval tracks, Grand Prix road racers must be extremely versatile, so that with only a limited amount of tuning to suit a particular course the machines can face very varied conditions. At Monte Carlo, the Grand Prix is fought out around the streets and waterfront of a hillside town and the lap record for the 1.9-mile circuit is held by Graham Hill's BRM at only 76.72 mph. In contrast, the Belgian Grand Prix is held at Spa on an 8.76-mile circuit which curves gently through wooded hills, though cars must be geared to tackle one hairpin turn per lap. Dan Gurney's 1964 lap record with a Brabham-Climax stands at 137.33 mph. Road racing cars must be able to cope with extreme heat or with rain such as slowed the faster 1965 cars to a best lap speed of the Spa circuit of 12.5 mph below that recorded a year previously.




**AUTO UNION vs. Mercedes duels attracted thousands during the 3-liter era of the late 1930s. Rules changes could bring a return to the "good old days."**

Over the past decade, rival teams often have had access to identical engines, such as the Coventry Climax, and so have concentrated all their efforts on building cars to make the best possible use of available horsepower. It has been a matter of combining minimum weight and air resistance with maximum braking and cornering ability. The Lotus which won the Indianapolis 500 was rather larger in most dimensions than a 1965-season Grand Prix car and was fitted with asymmetrical suspension for left turns only, but its general design concept was extremely close indeed to modern European Grand Prix road racing practice.

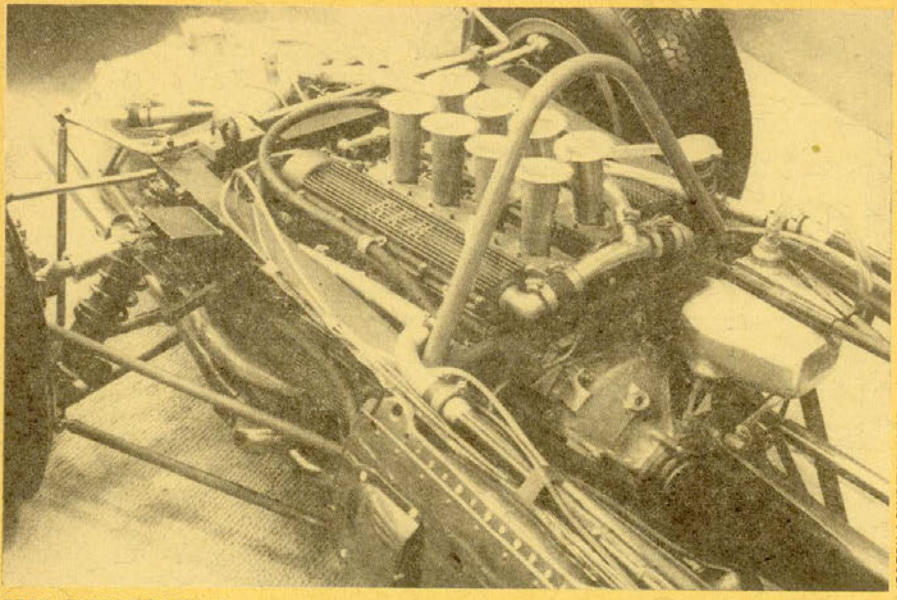
**BUILT TO the 3-liter formula, this blown Mercedes W-163 competed in 1947 and 1948 Indianapolis 500s, but was victim of engine failures.**



For a long while the invincible layout has been that which puts the engine just ahead of a rear transaxle, with the driver ahead of the engine. This layout provides a lighter car of lower frontal area than can be achieved with any known alternative. The driver nowadays lies almost flat on his back and the car's frontal area is determined almost solely by the size and shape of the engine behind him. Fully 55% of the car's weight rides on the rear wheels with this layout, ensuring good traction. Suspensions are set up for negative wheel camber and carry wider section rear than front tires to provide stability and phenomenally tenacious road-holding.

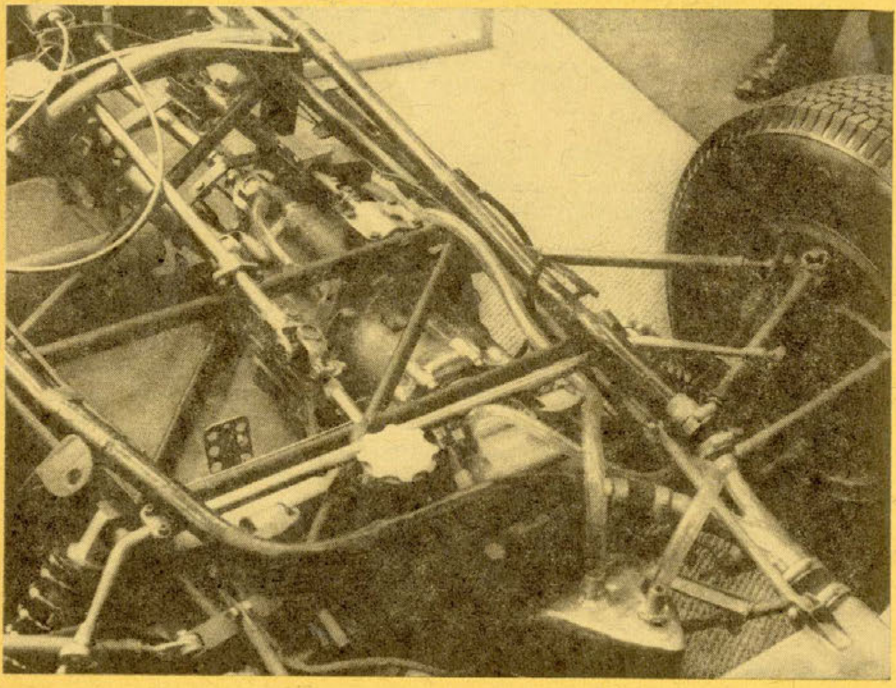
Not long ago the fashionable chassis was a multi-tubular space frame, a deep triangulated structure of small-diameter steel tubes welded to form a light and rigid foundation beneath aluminum body panels. Lately the fashion has swung toward what is inaccurately called monocoque construction, the car's body sides being formed into two box-sections linked by a stressed undershield. Successes by Brabham cars show that the easier-to-repair multi-tubular frame still is competitive, if well designed, though it may possibly give the driver less protection in a crash. One sees the skill of a frame designer in his ability to think in three dimensions rather than only in two, in avoidance of need for heavy brackets at power unit and suspension mounting points, and in the location of these mountings at points where they do not cause local bending of slender tubes or thin metal panels.

Ball-jointed s.l.a. front suspension has been highly refined by intense competi- ▶



JOSEPH LOWREY PHOTOS

BRM's EXPERIMENTAL Formula I car featured a V-8 engine coupled to the Ferguson 4-wheel-drive system. Below is the Ferguson forward gearbox.



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tion. Often one sees only two smoothly profiled arms breaking into the accelerated airflow through the space between a car's front wheel and the body. Vital steering connections and brake hydraulic pipes hide from the wind behind these upper and lower suspension links, while coil springs and telescopic dampers operate on inboard extensions of suspension arms so they can be completely enclosed by the car's bodywork.

Upper and lower transverse wishbones also are the normal form of independent rear wheel suspension linkage on Grand Prix cars. One wishbone on each side is arranged base-outward and this, in conjunction with a fore-and-aft radius rod, controls wheel alignment very precisely. Rubber-bushed joints never are used in Grand Prix suspension linkages, but a very large measure of adjustability is provided in most designs. Cars can be set up to suit a driver or a circuit by adjustment of wheel camber and toe-in, of the amount of swing-axle effect provided, and of the leverages at which the driver prefers his torsion bar stabilizers to operate.

WITH THE prospect of doubled horsepower in or soon after 1966, it had been thought that Grand Prix cars might require 4-wheel drive to show their full potential. Colin Chapman recently has been testing a modified Indianapolis-pattern Lotus on road racing circuits, its 4.2-liter Ford engine producing about the 400 bhp which 3-liter Grand Prix engines may soon develop. Results of these tests make him doubt whether 4-wheel drive could offer enough advantages to offset the extra weight, complication and frontal area which its use would involve. Modern tire compounds, applied to large-section tires on wide-rim wheels, provide so much traction that 2-wheel drive seems likely to remain adequate for most events.

However, the Ferguson system of 4-wheel drive already has been extensively track-tested, on both a front- and rear-engined racing single-seater, the latter car having been built by BRM. This patented Ferguson system has a central third differential gear between the drive-shafts to front and rear axles, controlled by extra gears to permit only about 10% speed difference before it solidifies and, as this control system works both ways, it helps to insure non-skid braking and extra traction on slippery surfaces.

Four-wheel drive can greatly alter the handling characteristics of a high-performance car by more or less completely eliminating the effects of power on oversteer or understeer. No longer can a driver help the tail around an acute turn by using excess power to spin the rear wheels, this being probably an advantage rather than a limitation once a car has been set up correctly and a driver has learned how to produce the best results. Undoubtedly 4-wheel drive advantages would be greatest on slow circuits such as that at Monte Carlo. If race organizers decide to limit maximum speeds by adding sharp artificial corners to their circuits, this may encourage development of 4-wheel-drive cars.

Light single-seaters with engines of only 1.5-liter size have been very kind to their wide-section tires, but double-size engines may shred the rubber much more quickly. If that happens, and wheel changes once again become necessary during races, center-lock wheels may return in place of the lighter bolt-on designs which have been in use recently.

All the talk now is that unsupercharged 3-liter engines represent the most promising of several alternatives which 1966 rules permit. Rotary piston engines such as the Wankel do not yet seem nearly ready to race against reciprocating engines. So far as gas turbines are concerned, the formula by which an "equivalent piston engine displacement" is calculated, on a basis of nozzle area and the attainable pressure ratios of various kinds of compressors, gives results which put the gas turbine at a disadvantage in comparison with positive-displacement engines.

It is tempting to deduce from past history that a supercharged 1.5-liter engine should be more powerful than any unsupercharged 3-liter. Certainly, during the 1947-53 period, supercharged 1.5-liter cars almost invariably defeated the unsupercharged 4.5-liter models which were then allowed to race against them. At that time, however, alcohol fuels rather than gasoline were being used in Grand Prix racing and the ability of alcohol to provide cooling inside the cylinders helps a supercharged engine far more than it does an unsupercharged unit.

To double an engine's specific power output per liter or per cubic inch of displacement by supercharging, it is necessary to raise the intake manifold pressure to considerably more than two atmospheres. This is for at least three reasons, one being that a supercharger heats air or fuel/air mixture while compressing it, so the gain in charge weight is not fully proportional to the increase in pressure. A second reason is that to prevent detonation, a highly supercharged engine needs a relatively low compression ratio, thus reducing the amount of work extracted from each pound of fuel/air mixture. Furthermore, the drive for a high-pressure supercharger takes a lot of horsepower from the crankshaft.

BECAUSE GOOD 1.5-liter racing engines already exist, it is natural that trials are being made with superchargers on them. Centrifugal superchargers, which work so efficiently on aircraft engines, do not provide enough boost at less than maximum rpm to be attractive on road racing cars. Hence it seems certain that only displacement superchargers will be tried. The rivalry will be between eccentric-vane designs such as the Shorrock, which can provide a large pressure rise in one stage, and the simpler Roots-pattern superchargers which probably will be used with two stages of compression in series.

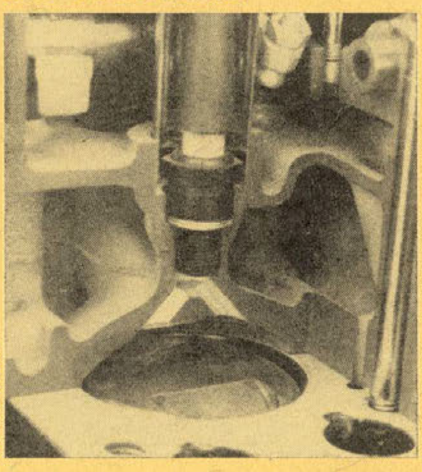
Whereas, on alcohol fuel, supercharged 1.5-liter engines developed power outputs well above 400 bhp some 15 years ago, it seems likely that destructive overheating of pistons and valves will occur at outputs around 300 bhp on pump gasoline. Aviation fuels can be blended and doped with chemicals for a high anti-knock value in the hot running conditions of supercharged engines. Today's pump fuels, as specified for Grand Prix racing, suffer a severe loss of anti-knock quality when exposed to heat, though they work excellently in the production engines for which they are blended. There is a possibility that carefully metered water injection may usefully improve the internal cooling of a gas-burning, supercharged 1.5-liter engine, allowing extra supercharge pressure to be used. While pure water could not be ruled illegal as being a fuel, its use would involve accommodating an extra weight and volume of liquid in additional tanks. Almost everyone seems to be coming to the conclusion that an unsupercharged 3-liter is the engine type most likely to succeed.

For an engine to develop the utmost power per liter, the important thing is to run it as fast as possible without sacrificing torque output or reliability. If unsupercharged 3-liter engines are to obtain the 400 bhp output which is expected of them, they will be required to run up to rather more than 10,000 rpm. That speed is unlikely to be achieved reliably with a piston stroke much in excess of 1.75 in. Use of this stroke dimension in a 3-liter V-8 engine requires a 4.08 in. bore diameter which represents an uncomfortably extreme oversquare ratio of bore to stroke. In a 12-cyl. engine of 1.75 in. piston stroke, the bore diameter could be 3.33 in. In a 16-cyl. 3-liter engine, a bore diameter of 2.88 in. with a 1.75 in. stroke would represent the acceptable bore/stroke ratio of about 0.61:1.

One engine configuration which seems certain to be tried under the new formula is the V-12 layout, which can be used with a 60° or a 120° angle between cylinder banks according to whether the designer is most anxious to reduce engine height or engine width. This number of cylinders seems unlikely to provide reliability and good torque above 10,000 rpm in a 3-liter size, but a factory such as Ferrari has so much know-how on V-12 engines as to make very attractive the prospects of quick success with such an engine.

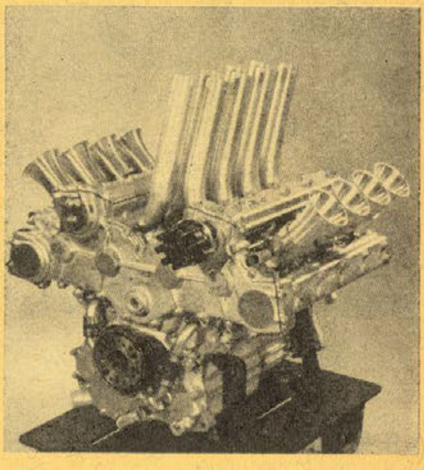
IT SEEMS equally certain that race-goers will see 16-cyl. engines in competition, though the 1.5-liter Coventry Climax flat-16, which was built for (but never raced during) the 1965 season, was not designed for enlargement to 3-liter form. The Coventry Climax factory has ceased manufacture of racing engines so that its engineers can work on new engines for Jaguar Cars. A very compact engine re- ►

**THE GORDINI-Renault R8 beat the plug location problem with two masked passages.**

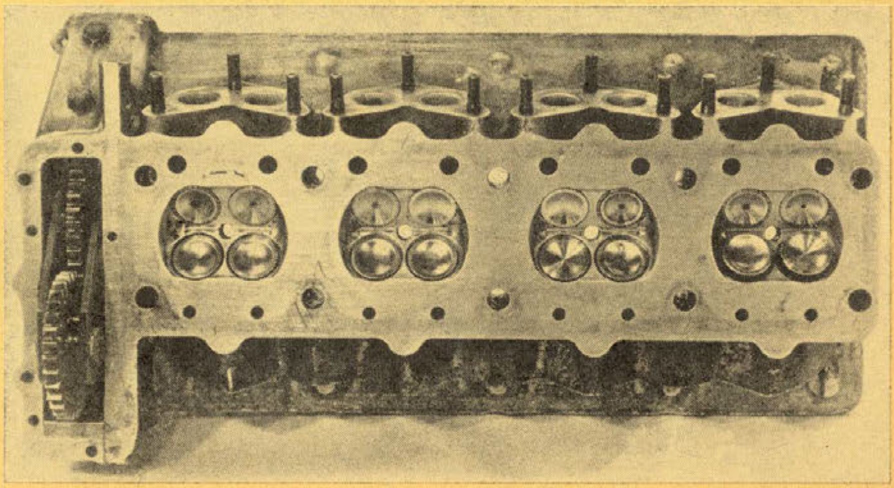


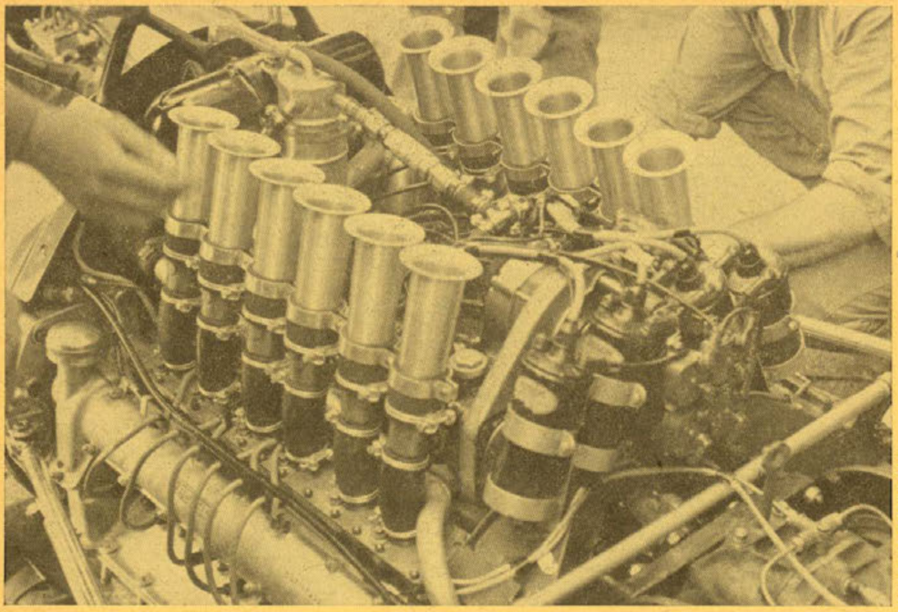
JOSEPH LOWREY

**THE INDIANAPOLIS Ford engine could be reduced to 3 liters, but bhp output would suffer.**



**FOUR VALVES per cylinder, as in this Coventry Climax V-8 head, could provide the horsepower boost necessary for successful 3-liter GP competition.**





GEOFFREY GODDARD

**ENGINES SIMILAR** to this Lucas-injected Ferrari flat 12-cyl. unit will appear on Europe's GP circuit as FIA rules allow doubled displacement.

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sulted from the flat-16 layout. The engine featured a shaft from power take-off and camshaft-driving gears in mid-crankshaft to the flywheel and clutch. However, a shaft between the engine and its flywheel introduced torsional vibration problems.

BRM has chosen to build a 16-cyl., 3-liter engine, which lets the know-how from its 1.5-liter V-8 engine be used directly. The layout which BRM has selected could be described as an on-its-side H-16. The H is formed by one horizontally-opposed 8-cyl. engine mounted on top of another, with a common output shaft driven by gears from two separate crankshafts.

THIS ARRANGEMENT was used during World War II, for a Napier Sabre 24-cyl. aircraft engine. Overall length of this 16-cyl. BRM engine should be conveniently small and the flywheel will be close to the two crankshafts driving it, while it may be possible to locate the output shaft at alternative levels to accommodate different transmission systems. Putting one horizontal cylinder block on top of another will leave each cylinder head with a blind side, lacking access for ports, but BRM has recently raced a V-8 with cylinder heads which have inlet ports between the two overhead camshafts. On a lazy H-16 engine, cylinder heads of this design would be ideal, providing two rows of four horizontal inlet ports at each side of the engine, plus vertical exhaust ports extending upward from the top bank and downwards from the lower bank of cylinders.

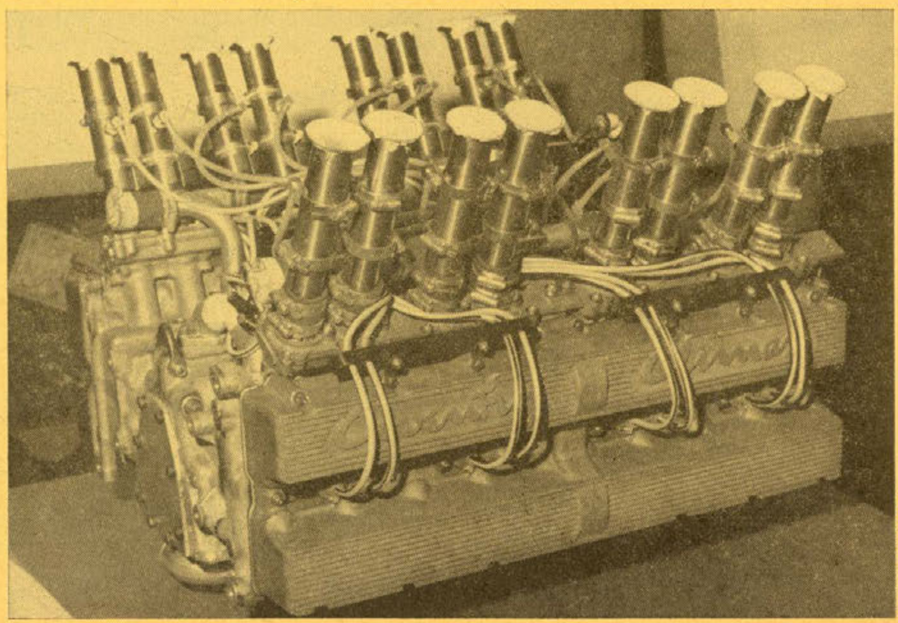
Lotus participation in Grand Prix races during 1966 will be with engines of this type, bought from BRM as stop-gaps until an exclusively Lotus engine can be completed. Frame design will be very different from what might suit a V-type engine, as the side porting would be incompatible with deep box-section frame members. A multi-tubular rear frame may be practicable, or it may be better to let the engine/transaxle unit serve as its own chassis in the manner of the old Fordson farm tractor!

It is just possible that somebody may venture to try the lightest kind of piston engine, the radial with 5, 7, or 9 cylinders grouped around one crankshaft throw. One of the major problems of this layout, mixture distribution, ceases to exist when fuel injection is used. Two rows of 7 cylinders might produce a convenient 14-cyl. radial engine of 3-liter size. Mounted with its crankshaft in a vertical position, such an engine could be linked by bevel gears to shafts running to the front and rear axles of a 4-wheel-drive car. However, the chances of such an adventure proceeding appear slender. Many novel development problems obviously would crop up. Getting a radial engine big-end bearing to work reliably at speeds far above aero-engine practice would be just one of the problems.

FUEL INJECTION is used on every modern Grand Prix engine because it eliminates the carburetor venturi as an obstruction to airflow and can cope with the pressure pulses in tuned-length inlet pipes. Ferrari has used Bosch injection directly into the cylinders. BRM and Coventry Climax have employed the Lucas system which delivers timed fuel jets at a lower pressure into the inlet ports. Honda also uses a low-pressure injection system. There seems to be every likelihood that each engine builder will persist with the system about which he knows the most, there being little to choose between port and cylinder injection on unsupercharged engines.

Ideas about ignition have been rather varied recently. Italian engine builders remain loyal to traditional systems, with multiple coils and contact breakers to

**COVENTRY CLIMAX** built this 1.5-liter engine, hoping it would sweep Formula I. Unsuccessful, the engine could be a model for builders.



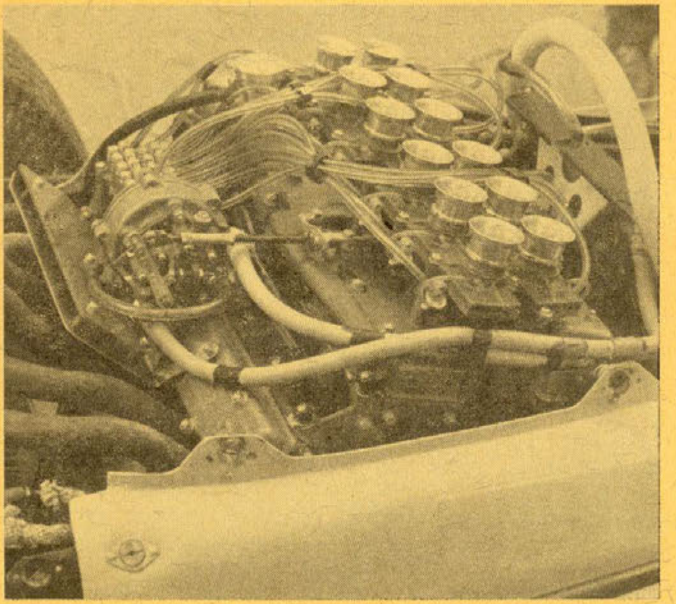
JOSEPH LOWREY

cope with a 12-cyl. engine's need for a 1000 timed sparks per sec. at 12,000 rpm! British engines have incorporated an effective, but not always 100% reliable, Lucas transistor ignition system, the contact breaker replaced by triggering pulses from magnets on the engine's flywheel.

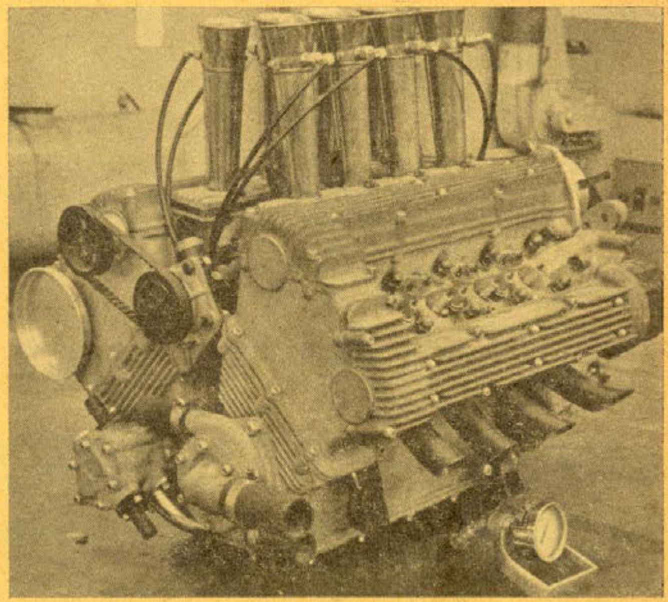
A CHANGE from two to four valves per cylinder, made on several V-8 engines during the 1.5-liter formula, produced disappointingly little extra gas flow or horsepower. The main advantage was, with smaller and lighter valves, that safe limits on engine rpm could be raised and a car could race with a higher numerical top gear ratio, thus accelerating better and yet not putting valves through its pistons. With two valves per cylinder, there is not room for a spark plug at the center of the combustion chamber, and rather than accept one off-center point of ignition, many designers resort to dual ignition. A thought is, if supercharging should prove competitive, a 3-per-cyl. valve layout could prove attractive. Two small exhaust valves are easier to cool than one large one and there is a place in such a layout for an almost-central spark plug.

As always, at the start of a new Grand Prix formula, the near future is one large question mark. Enough is going on for it to seem certain that spectacular and technically interesting races lie ahead. ■

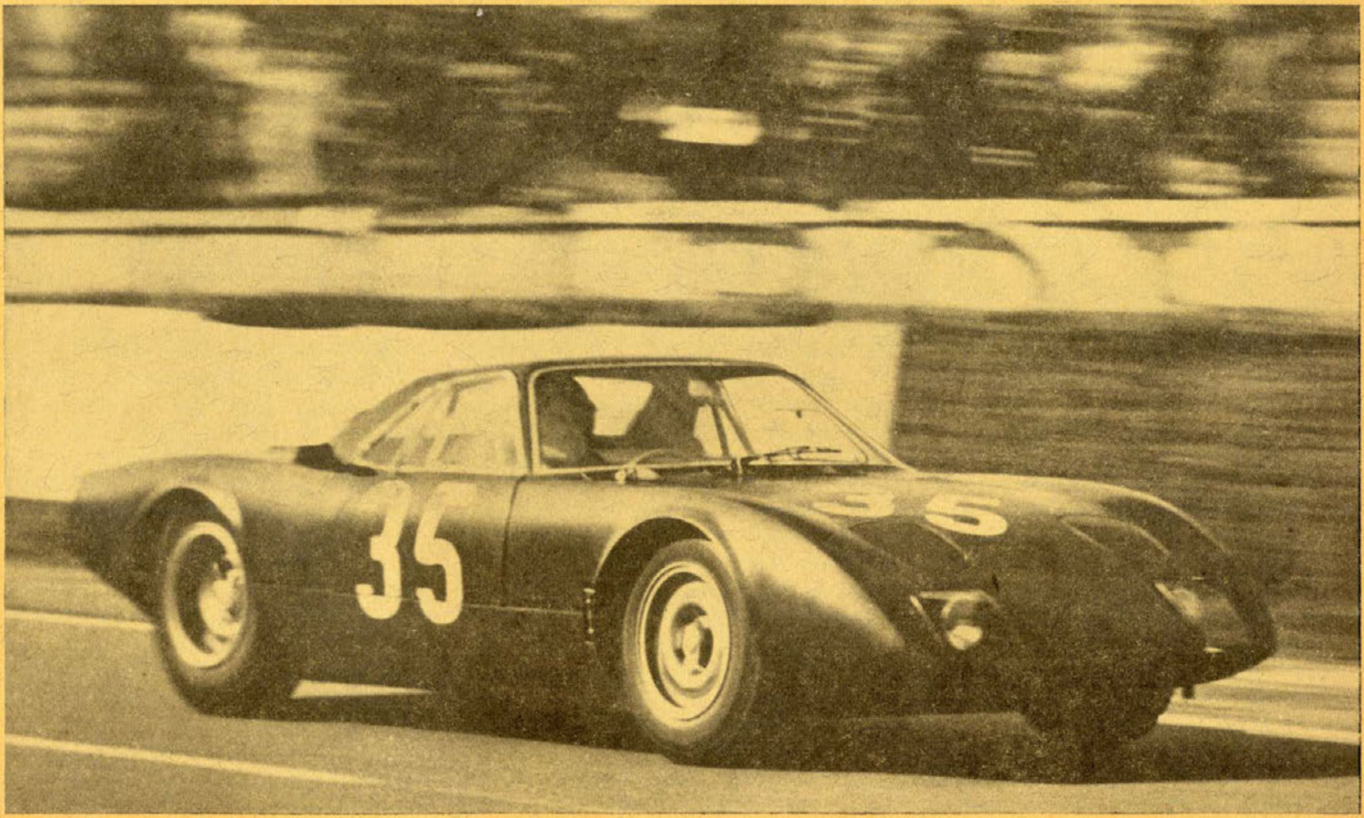
**HONDA'S SCREAMER, the 1965 injected V-12, as a 1.5-liter engine proved fast, though fitful. Could the 3-liter formula lead to Honda victory?**



**THE ATS 2.5-liter engine probably is to be enlarged for installation in GP cars, but Cooper may go to Maserati in search of 3-liter power.**



**THE ROVER gas turbine engine, which competed successfully at Le Mans in 1965 in a BRM sports car body, could be one possibility for Formula I racing. The engine ran well during the 24-hour event despite damage to its heat exchanger.**

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