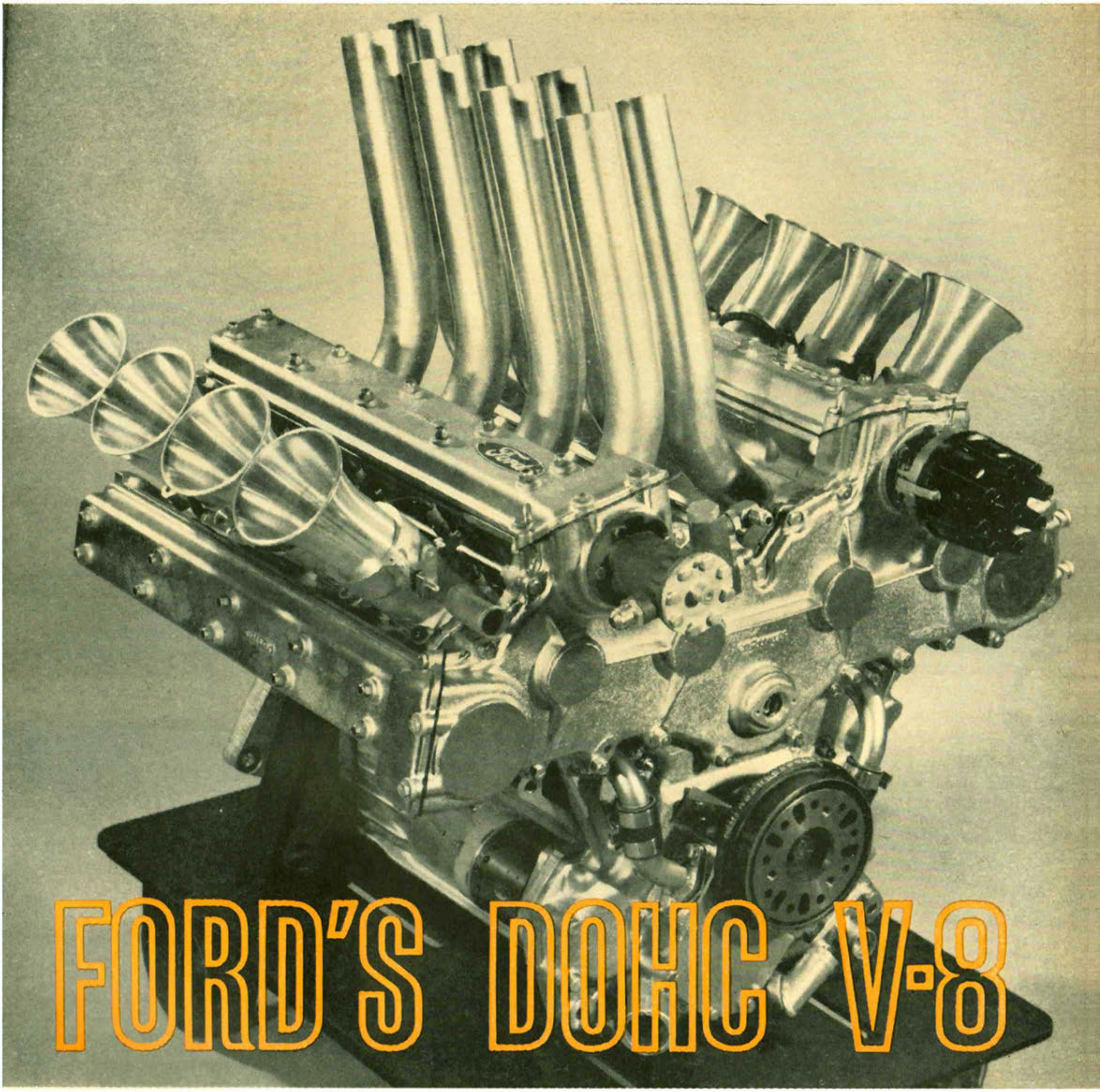


FORD'S DOHC V-8

Four Cams and a Startling Layout For the '64 Indianapolis 500

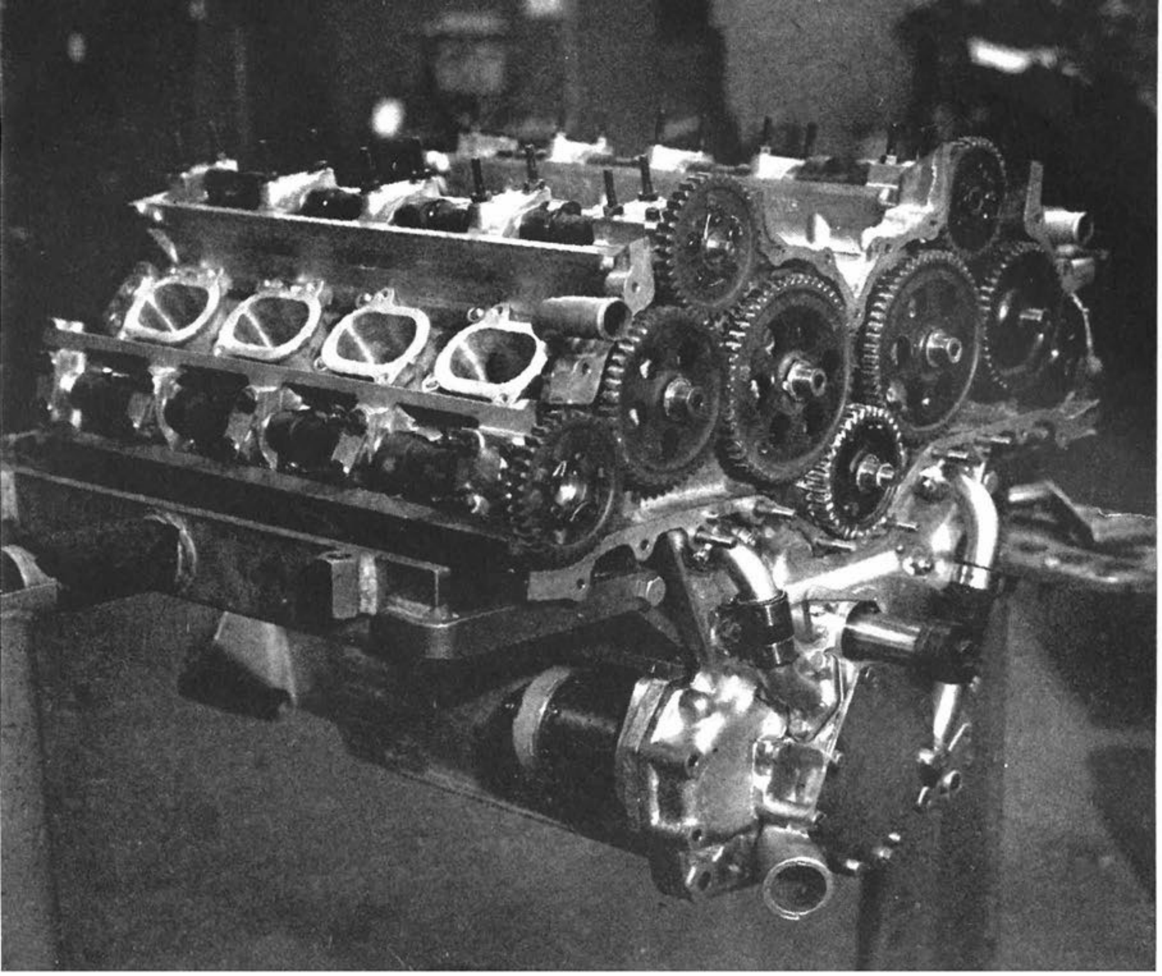
BY JOHN R. BOND

A LITTLE MORE than 13 years ago, *Car Life*'s associated sports car magazine (*Road & Track*, October 1950) published an article with the above title. At that time it was startling news, and true, but a little misleading; the article described the big 500 bhp/1100 cu. in. tank engine (it weighed 1500 lb.) designed and developed by Ford during World War II.

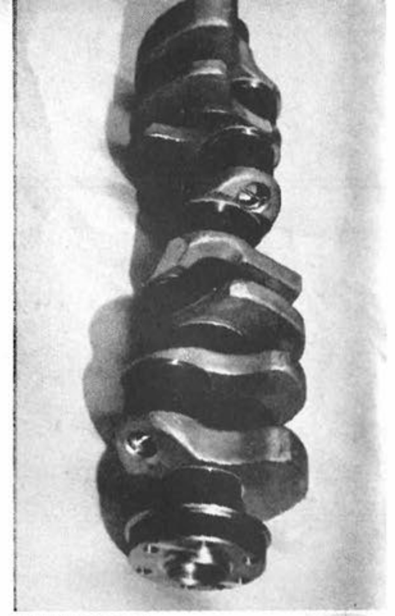
This month *Car Life* can show preliminary details on another double overhead camshaft Ford engine, the V-8 for this year's Indianapolis race.

As is well known, Ford vibrated The Establishment down to its button-top shoes last year with a pair of sensational Fairlane V-8 racing engines installed in British Lotus chassis (they finished 2nd and 7th). But Ford is not in racing just to have fun: All of the engineers and technicians interviewed by *Car Life* had one thing to say: "We are in this game to win!"

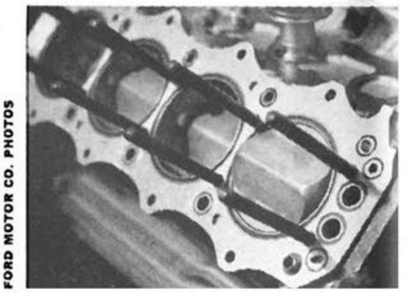
It is fairly obvious that last year's car could not win the 1964 500-mile race, except by a fluke. Cars get faster ▶



MASS OF MECHANISM required to drive four overhead camshafts in a V-8 engine; this is view with cams in place. Note the huge intake ports in the head, between the cams.



CRANKSHAFT is same as used in '64 Indy cars, is drop-forged steel.



FORD MOTOR CO. PHOTOS

PENT-ROOF pistons project up into head.

FORD'S DOHC V-8

each year and though the lightweight Lotus-Fords of 1963 were very nearly as fast as the best Meyer-Drake powered machines (in lap times) they were not nearly as fast on the straights where sheer brute horsepower is somewhat more important than car weight.

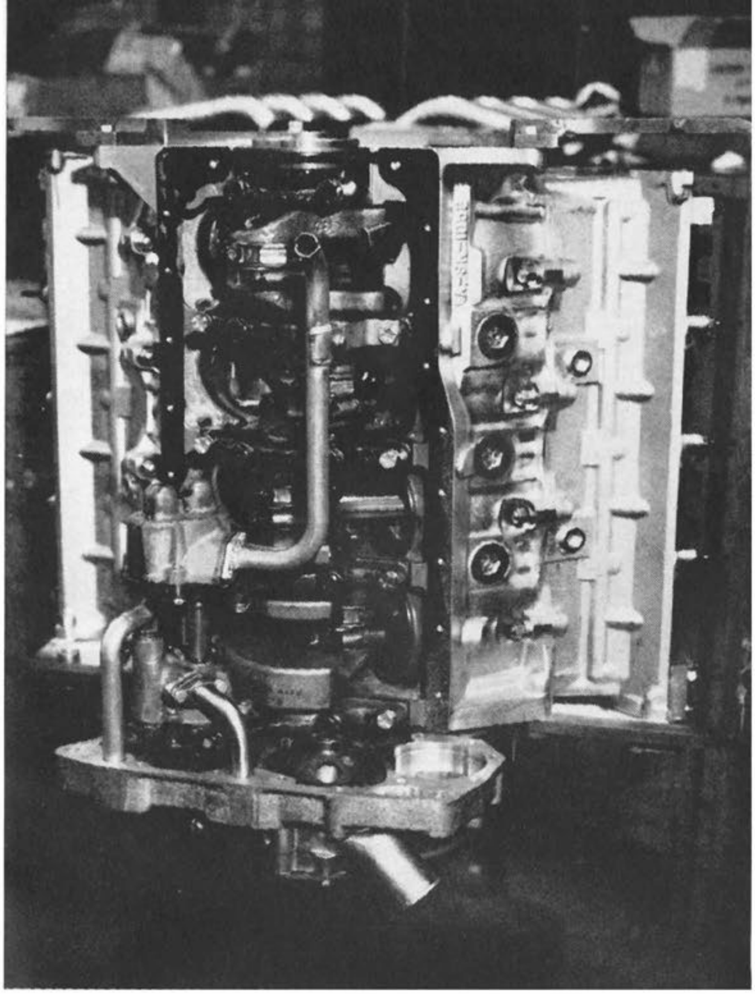
So, Ford engineers have embarked on Phase IV of the Fairlane engine racing program. In 1963, they pulled 376 bhp at 7200 rpm with gasoline fuel vs. 400-plus bhp of the dohc Meyer-Drake engines running on methanol. An easy way to get more power from the rocker arm V-8 would have been to switch over to methanol. However, refueling stops are time-wasting and methanol fuel consumption is almost exactly double that of gasoline. An extra heavy load of fuel could have been carried, of course, but this would have negated some of the lower weight advantages of the Lotus. Methanol fuel is much more dangerous in case of an accident and, perhaps equally important, the use of methanol dilutes the opportunity of applying lessons learned from racing to ordinary passenger cars. (Significantly, Phase IV at Ford Engineering specifies gasoline fuel.)

With more power needed to win, and no exotic fuel allowed, the only answer was to go for the traditional double overhead camshaft valve arrangement. Actually, there was a temptation to stick with the more stock-type pushrods and rockers. With concerted effort something like 400 bhp at 8000 rpm could be anticipated. But rocker-arm engines are not really well-adapted to continuous high-rpm usage. There are more stressed pieces bouncing up and down, high valve spring pressures are required, which cause tappet and cam scuffing, and the slightest accidental over-speeding above valve-toss rpm means engine failure. In short, the simple, direct-acting dohc design is extremely reliable and imposes no limit on crankshaft speed. Also, Ford engineers said they wanted the opportunity to learn something about dohc engines: "If someone ever comes up with a cheap and reliable system of getting the drive from the crankshaft up to the top of the engine, we may be taking a closer look at overhead camshafts for production engines."

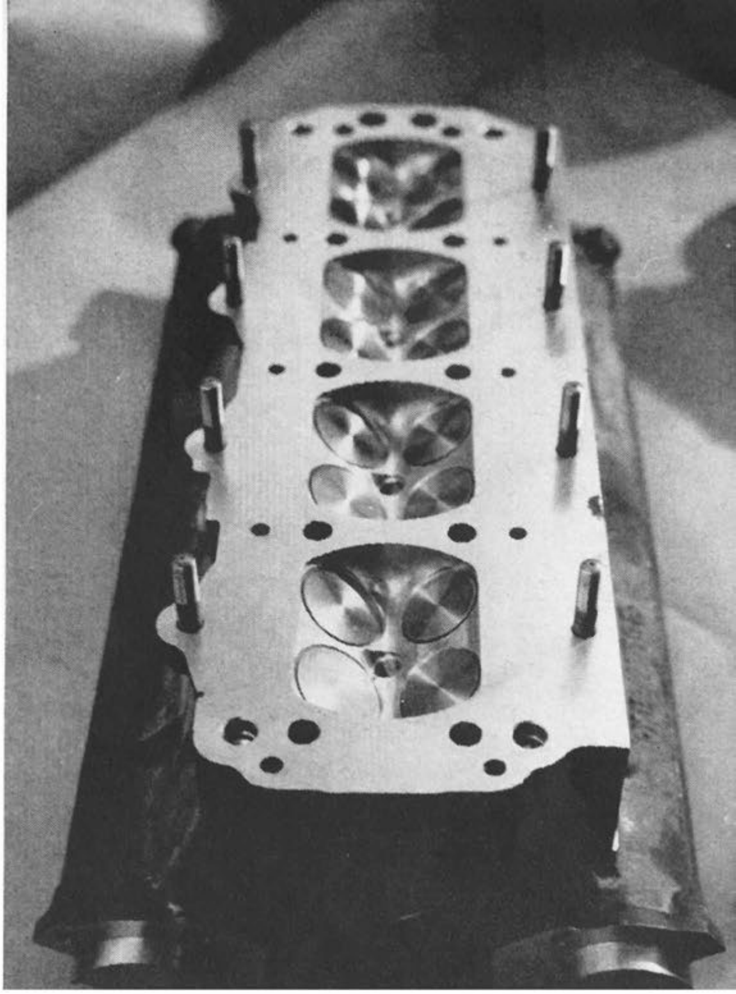
Because the race is still some time away, Ford engineers are not talking exact horsepower figures. However, by mid-May they expect 425 bhp at 8000 rpm and calculate an over-speed down the chutes of 8500 rpm, maximum. The torque peak will probably be around 6000 rpm. Obviously these are speeds unheard of around The Establishment but, for the record, well below the 11,000 rpm figure of the tiny 200-bhp, 91-cu. in. engines being raced in Europe.

The bottom end of the Phase IV engine is substantially identical to last year. The cylinder block was (and is) sand cast in aluminum via patterns reworked from the standard-stock Fairlane V-8. Changes, aside from material, include thicker walls in the critical spots and 4-bolt caps for all main bearings except No. 1 (in front). For 1964, the material surrounding the camshaft-tappet bore area has been reworked so that it becomes a simple, solid wall. Some of the first blocks were actually "converted" by merely cutting out this area and welding in a flat piece.

The crankshaft is identical to last year. This assembly is the same as a



BLOCK AND BOTTOM-end components of Phase IV Ford engine are virtually the same as used in the '63 version. Main bearings have 4-bolt caps.



CYLINDER HEAD has four huge valves in each of the pent-roof combustion chambers. Head is cast aluminum.

production Fairlane shaft in all dimensions. However, the material is drop-forged steel instead of cast-alloy iron. The crankpins are bored out to save weight and the counterweights are accordingly also modified for proper balance because of the bored pins. Cross-drilling is used for both mains and pins so that the holes themselves can be smaller and the crankpin cavity is closed by steel plugs further secured by swaged-steel pins.

Connecting rods are identical to production parts (dimensionally), except that the wristpin end has been enlarged to allow a larger diameter pin. These rods have the larger bolts first developed for the '63 racing engine and which are now used in standard production engines. Naturally, the rods are shot-peened, polished, inspected and balanced more carefully than production.

The Phase III engine used straight-cut spur gears in front to drive the single camshaft, the dual oil pump, water pump, fuel pump, distributor and tachometer. These gears were originally laid out so that the extra gears required for the Phase IV dohc design could easily be added. New front covers are required, of course, and these are cast of magnesium and given the usual electrolytic surface treatment for corrosion resistance.

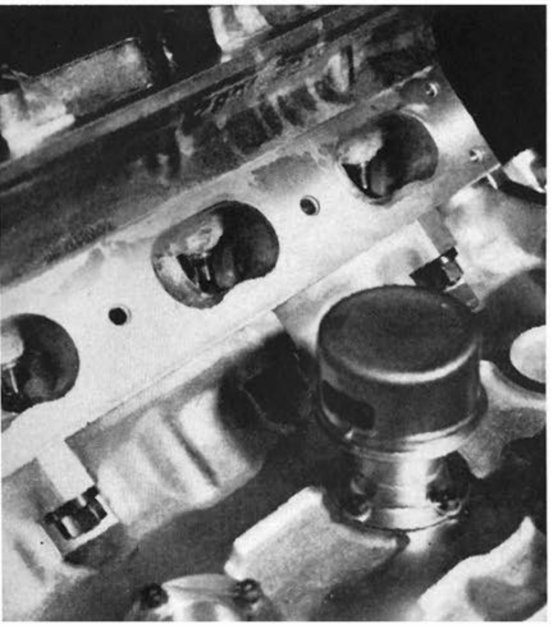
The new cylinder heads are cast of aluminum alloy. A rather surprising feature is the use of four valves per cylinder, which necessitates a pent-roof type of combustion chamber. Queried on this point, Ford engineers stated that the extra port area so obtained more than offset the skin friction losses of the dual port design. Extensive flow-bench tests were still under-way and shapes, dimensions and valve diameters were still not finalized. However, the intake valves are slightly larger than the exhausts and with relatively small valves (in comparison with a 2-valve head). The reciprocating weight also is less, allowing lighter valve springs with less tappet scuffing problems. In this connection, the tappet design is identical to that of Meyer-Drake engines, but some changes are anticipated including, perhaps, the development of a means of adjusting tappet to cam clearance without removing the camshafts.

A special nickel-copper-iron alloy valve seat insert is pressed into place for each valve and the valve guides are bronze for good heat flow. For initial development work, the compression ratio has been kept low, in the vicinity of 10.0:1. This was done to avoid any possibility of detonation with the rather poor combustion shape and awkward roof-shaped piston dome. The desired power will come from the good breathing ability inherent in the design, rather than by an ultra high compression ratio.

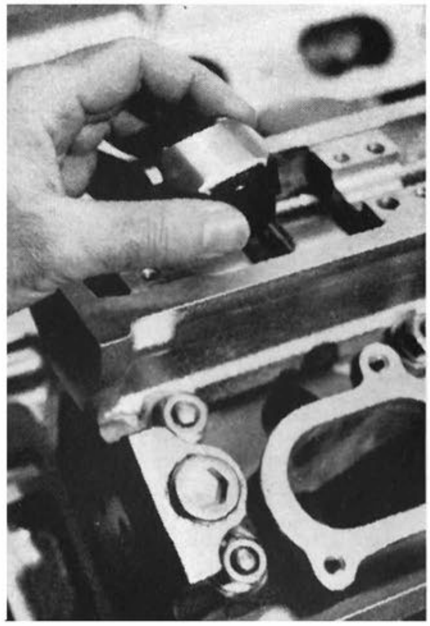
The first head castings had provision for three spark plug holes per cylinder, but extensive tests showed that a single 14 mm plug located square in the middle was unquestionably the best. The plugs, by the way, are normal Autolite racing types with solid copper seating gaskets.

The heads are designed so that they can be switched from one side of the block to another. The first dohc engine in action at Indianapolis during tests last fall had the exhaust system set outboard. But later track tests will be made with the exhaust ports turned inboard—all more or less contained within the V, this making a neater installation with much less wind resistance.

Carburetors will not be used. Last year, Italian Webers, with throat diameters of 58 mm, were used at Indianapolis, but at Milwaukee and Trenton it was found that the smaller 48 mm Webers worked better for the 1-mile tracks. We were told that Ford could find no carburetors large enough for the anticipated 425 bhp. Rather than go through the long, painful process of designing and testing new carburetors, the decision was made to use fuel injection. The first test engines have been ▶

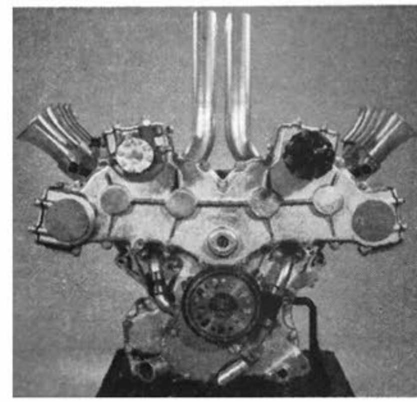


EXHAUST PORTS are nearly as large as the intake ports, exit on top side of head.



LARGE RADIUS cam followers are used under overhead 'shaft to control wear.

A SPECIAL fixture is used to ream tappet bores, to insure alignment.



AIR INTAKE horns jut out between the cams, exhausts between the heads.

FORD'S DOHC V-8

running on Hilborn fuel injection type carburetors (not true fuel injection), but tests are being made on port injection schemes from several outside suppliers, including the British Lucas and German Bosch firms. Given enough development time on the dynamometer, the fuel injection system can also provide an advantage in that the actual chassis installation will not upset the air-fuel ratio quite so much as happened last year when a number of last minute carburetor corrections had to be made at the track.

Another feature of these new heads is that water jacketing is carried completely around each valve port and seat. This is absolutely necessary with gasoline fuel even though it means slightly smaller port areas. In contrast, the Meyer-Drake has very poor water jacketing in this critical area and depends on the extra latent cooling ability of alcohol-base fuel to be successful. All of this leads to the question; if the fuel is restricted to gasoline and the Ford ports are also restricted—where and how can Ford get power comparable to that of the Meyer-Drake? While Ford did not supply us with any data on port area (because the exact dimensions were still in flux) it is easy to compare piston areas which have a direct relationship to possible port area. Piston area of the Phase IV engine is 88.6 sq. in., 51.5% better than the M-D's 58.5 sq. in. If we assume that the Ford's water jacketing layout cuts down on port size, it is still reasonable to say that the Ford engine will be 30-40% better in breathing ability. This theory is borne out by the goal of a peaking speed of 8000 rpm, 33% higher than that for the Meyer-Drake.

In essence, then, the new dohc V-8 will breathe well enough to induct about 33% more mixture. This will just about offset the fuel differential and, though the rpm is also 33% higher, the smaller, short-stroke pistons will produce no higher bearing loads at 8000 rpm than the big 4-cyl. does at 6000 rpm.

Summarized, the V-8, as described, just about equals M-D performance and the engine package weighs about 150 lb. less. As it is, the Phase IV engines weigh 400 lb.—a weight penalty of 40 lb. over last year.

Two entirely new chassis are being built to take this engine, by Lotus of England, which will enter the cars as "powered by Ford." (At least 20 engines will be built, some of which will be "loaned" to certain other American constructors.) The new Lotus chassis will be very similar to the two cars which ran last year and which were originally designed to the extra-wide dimensions required by the then-unavailable dohc engines. Detail refinements will be incorporated in the new chassis and last year's cars will probably be used as practice or stand-by cars.

Some aspects of the weight problem have been mentioned, others have not. The new engines weigh 40 lb. more, the fuel is economical gasoline. It is possible that the complete cars may weigh the same as last year, about 1100 lb. or roughly 300-400 lb. less than the contemporary all-American combination of chassis and Meyer-Drake engine, regardless of engine location. One reason for this difficult-to-understand situation is that Lotus has a head start in chassis design—this company is years ahead of our rather amateurish chassis-builders. But there is much more to it than that. The Ford V-8 engine alone weighs 150 lb. less than the Big Four, as we said. The size and weight of all driven parts, such as clutch, gears, shafts and universal joints, are all dependent on the torque per cylinder divided by the rpm. In other words, the V-8 torque per cylinder is roughly half that of the Big Four and the peak rpm is higher—a further "lightening" factor. Even a Lotus/M-D, to be reliable, would have to weigh 300-400 lb. more than the new Lotus-Ford combination. All this consideration of weight takes on added significance in view of the possibility of new tires which may be able to go the full distance without replacement (both Goodyear and Firestone are close to this goal).

It therefore seems highly probable, with the usual "breaks of the racing game," that Indianapolis will no longer be a dull procession of California Welding and Shipping Specials parading around the famous old oval. ■