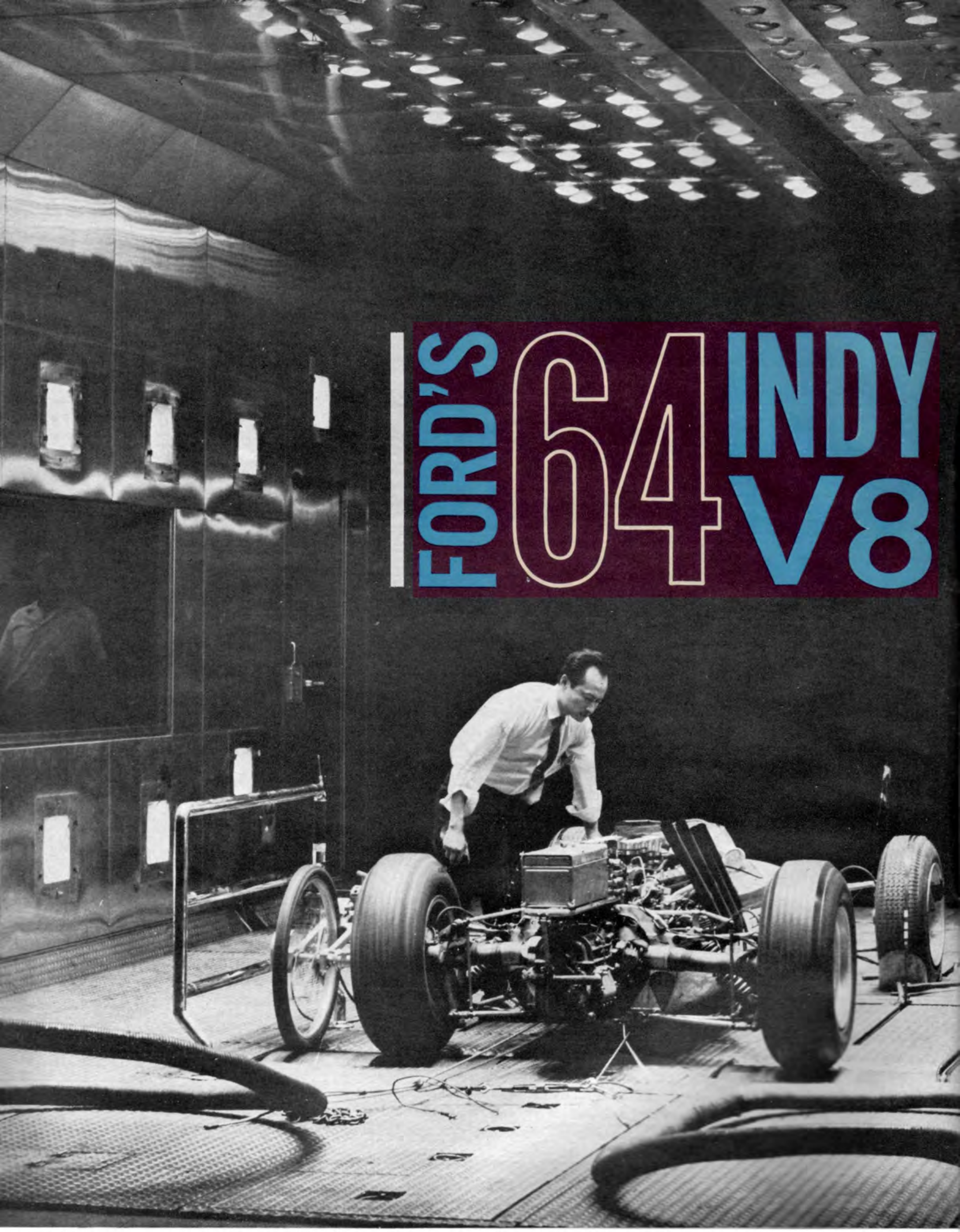
FORD'S 64 INDY V8



There's an old saying around race tracks which goes, "Nobody remembers who finished second." Usually this is the case, for, even though the race may be a hard fought battle down to the checkered flag with the winner and runnerup only a few feet apart as they cross the finish line, the guy who gets there first gets the lion's share of the money and the full share of the publicity.

An exception to the old axiom followed last year's Indianapolis 500-mile race as most speed enthusiasts have not only remembered who came in second but occasionally have to stop and think

Their debut in 1963 was impressive with a modified Fairlane V8 but for this year's big 500, Ford has pulled all the stops and come up with further modifications for a fantastic racing engine **by RAY BROCK**

photos by Ford Photographic, Ray Brock

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for a second or two to come up with the winner's name. The guy who won was Parnelli Jones, of course, and not only did he win in record time but he was also involved in "The Episode of The Leaking Oil Tank," which should have etched his name firmly in the memory of all racing fans. Immediately following the race, Parnelli Jones and his split oil tank were subjects of extensive press coverage but now, with the '64 Indy 500 just a few short months away, fans aren't talking about last year's winner and an oily track, they're interested in last year's runnerup and the car he drove.

To those of you who follow racing, it's no secret that Jimmy Clark, who finished 33 seconds behind Jones, went on to make a runaway of the 1963 World Grand Prix driving championship in Lotus racing cars. He drove a Lotus in last year's 500 too but it wasn't just the name Lotus or Jimmy Clark that made people remember the event so well. It was the fact that a modified production V8 by the Ford Motor Company powered the Lotus.

It's strange to think of the Ford Motor Company as an "underdog" in any venture for this is one of the world's largest corporations, but last year at Indy that was the case. This race had been won by Offy-powered cars in an unbroken string since 1947 and although there had been some minor challenges during that period by foreign and special U.S.-engined cars, the dual overhead cam, 16-valve four-banger meticulously manufactured in the small shops of the Meyer-Drake Company in Los Angeles, had dominated the Indianapolis 500 for almost two decades and had earned the title of the villain.

Their Offy engine was not the real villain, however. This distinction belonged to members of the racing fraternity who chose to copy a talented few with the result that almost all the cars fell within a narrow band of sameness. When the big Ford Motor Company joined with the little Lotus Car Company of England, the result was something entirely different in engine, appearance and sound. Not only racing enthusiasts but even people who had never thought much about racing were suddenly interested in Indianapolis. The combination didn't win but of the two cars entered, Clark's finished second, the other driven by Dan Gurney was seventh and the moral victory was complete.

So what do you do for an encore after such a spectacular debut? Ford, Lotus, Clark and Gurney teamed up in two more races during the '63 Championship season – Milwaukee and Trenton. At Milwaukee, Clark made a shambles of the track record and won by a country mile with Gurney third. At Trenton, Clark and Gurney ran away from the Offy-powered roadsters and appeared on their way to a sweep when a pinched oil line on Clark's car dropped him out of the race and a few laps later an obstruction in the oil pickup of Gurney's engine caused him to drop out. Again, although the Lotus-Fords hadn't won, the moral victory was theirs.

Ford's engineers and Colin Chapman of Lotus had proven that they could compete on equal terms with the conventional Indianapolis roadster. Some owners of Offy-powered cars, their mechanics and drivers, could see the handwriting on the wall and raised an immediate wail that their territory was being invaded by unfair competitors. Other teams recognized they had been dragging their feet too long and started making plans to rectify the condition by changing their thinking and their cars. One of the best examples is the Vollstedt car featured on page 46. Rolla Vollstedt "got the message" in

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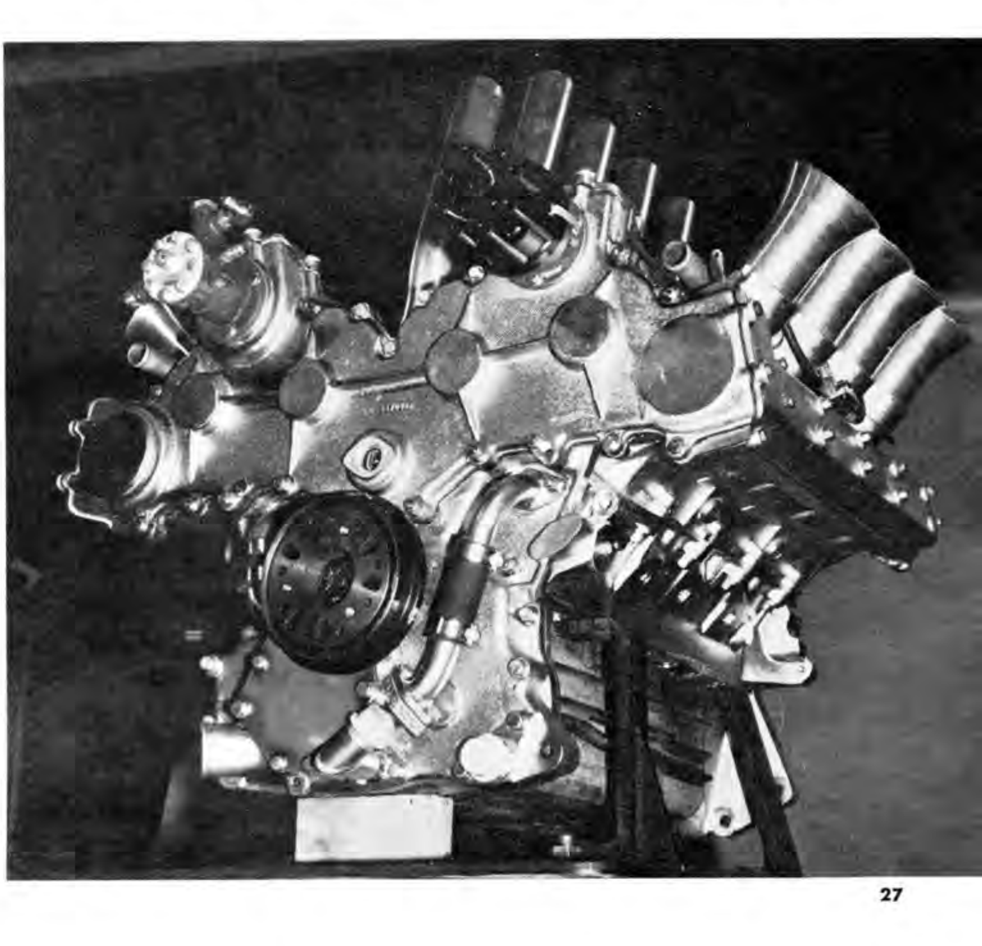
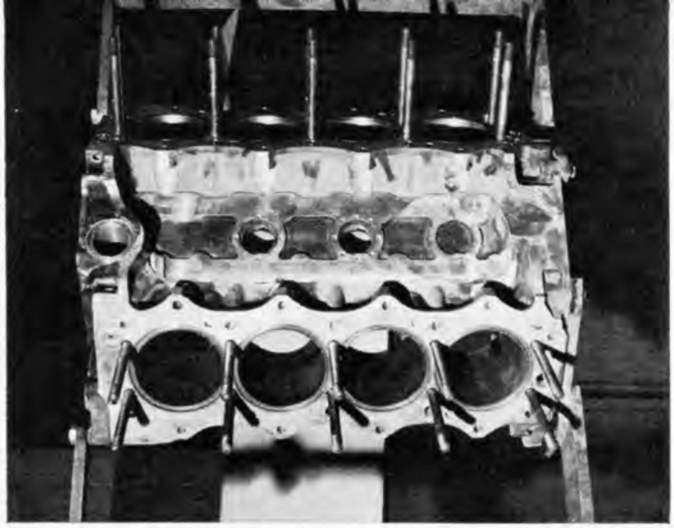
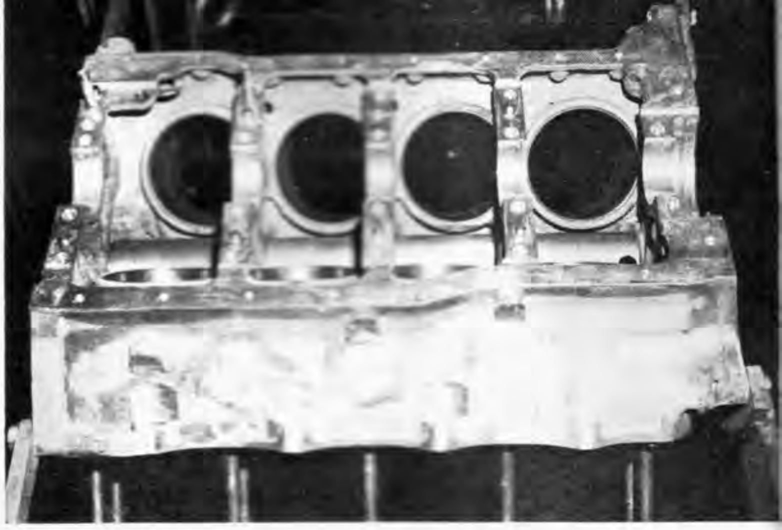


RIGHT – Latest series engine does not have ports in lower edge of head facing track so chassis clearance is improved.

LEFT – The first overhead cam V8 was placed in Lotus chassis which was anchored over dyno rollers in Ford's 150 mph wind tunnel. Carburetion expert Denny Wu adjusts Hilborn injectors.



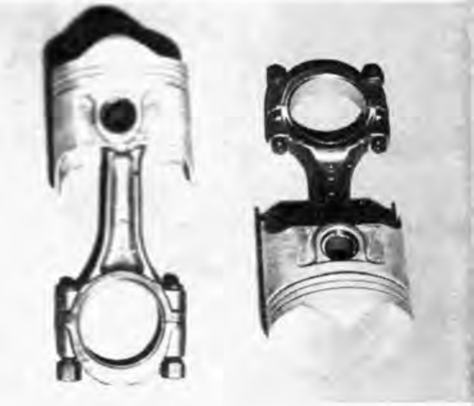


ABOVE LEFT – Aluminum block is very similar to '63 V8, is made from revised Fairlane 289 patterns. Cast iron sleeves press in, have groove for steel O-rings.

ABOVE RIGHT – Large diameter aluminum tube, just visible, fits through conventional cam bores, directs return oil from exhaust cams, controls crankcase venting.

LEFT – The forged steel crankcase has same stroke as standard Fairlane, extra counterweights for high rpm operation.

RIGHT – Modified production rods have floating pins. Pistons are extruded, have pent roof design, include valve reliefs.



FORD'S INDY V8 *continued*

1961 when Jack Brabham drove an under-powered Cooper-Climax to a ninth place finish and actually had a lightweight, Offy-powered car under construction long before the Lotus-Fords dropped their bombshell.

What about Ford in '64? There was some talk that the modified production V8 which had made such a sensational debut would be manufactured in volume and sold to anybody interested in such an engine. But then Ford's policy makers took another look at the complete picture. Ford was quick to point out that their engine alone did not make the Indy venture successful; the lightweight Lotus chassis with independent suspension was also very much responsible. They had stirred up a hornet's nest with the Lotus-Fords and it was a cinch that the smart boys weren't going to sit around and cry – they were going to make changes so that their cars would be lighter, handle better and run faster. The Lotus-Fords could not depend on fewer pit stops alone to whisk them into the winner's circle. More speed was needed.

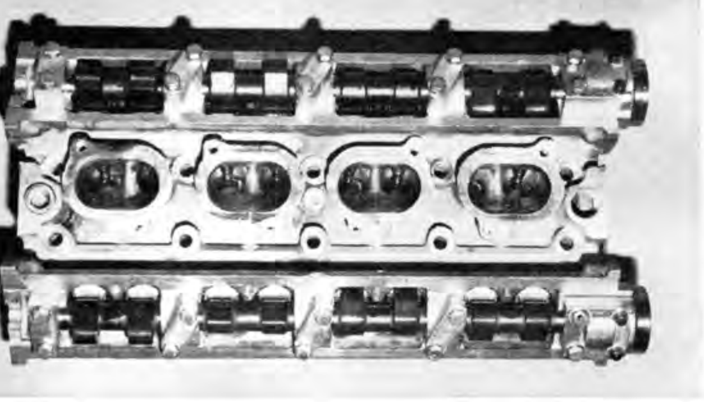
It is a very simple problem to gain speed on a track like Indianapolis. Just hand the driver more horsepower without increasing car weight so that he can accelerate faster leaving the corners and reach a higher top speed on the straightaways. When Ford built the engine for the '63 race, there were certain features which really aroused the imagination of American performance enthusiasts: conventional V8 design with single camshaft operating valves in a wedge-shaped chamber via pushrods and rocker arms; carburetors; battery ignition system; and the use of premium-grade pump gasoline instead of alcohol (methanol) and other exotic fuel blends.

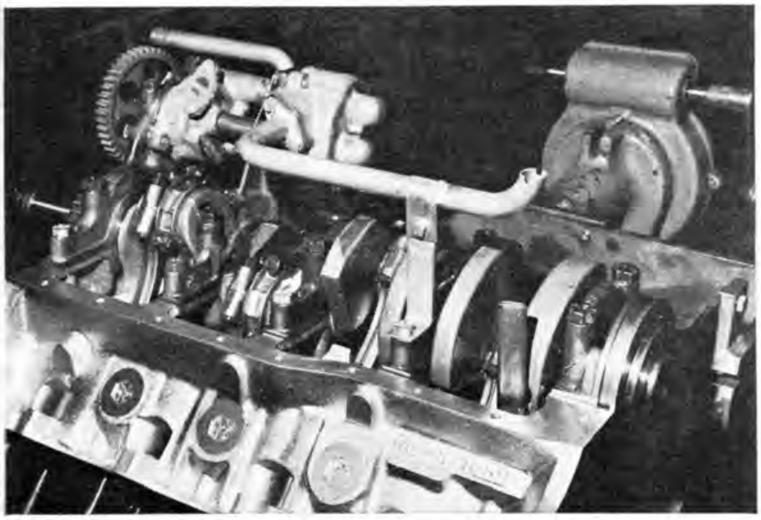
Now there are several ways to increase the power output of a production V8 and in the case of the pushrod Indy Ford, most of these methods had already been employed. The Fairlane 260-inch cast iron V8 rated 157 horsepower had been the starting point for the Indy Ford and after an extensive modification program, the final version contained 255 inches of piston displacement, had been trimmed to less than 350 pounds through the use of aluminum and magnesium, had vastly improved durability, and had registered a maximum of 376 horsepower.

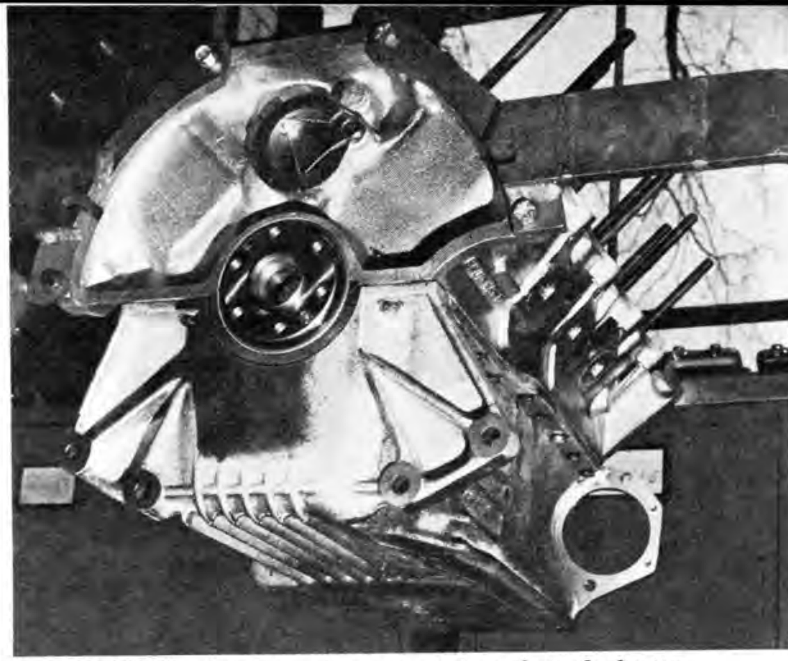
With increased displacement out of the picture, the only ways left to raise output were to improve volumetric efficiency for a heavier charge of air-fuel to burn, or use a different type of fuel. A change in fuel would have been a simple solution for a blend of methanol and nitro could have produced a quick 50 horses or so. Only one problem here though – tests in late 1962 had shown an alky-burning Fairlane got only one-third the mileage of the same engine on gasoline. So, instead of one stop per 500 miles, that meant three or more and that's where the Offys were paying a penalty. Exotic fuel was out! Gasoline was to remain the race fuel.

Since the maximum efficiency of the pushrod V8 had already been reached, or at least very nearly approached, the next step was to try a design which would permit more breathing efficiency than was available with a pushrod engine.

Engines used in the Lotus cars for the '63 Indy race were called series 3 versions but something most people never learned was that there was actually a series 4 engine which could have been rushed to completion had the pushrod series 3 failed to meet design specifications. The big difference between series 3 and 4 engines was the use of overhead camshafts and four valves per cylinder for the series 4. These special heads were designed to fit on the series 3 block with only minor modifications. Actual running tests of the pushrod series 3 were so successful that aluminum castings for the overhead cam job were never finish-machined before the race. With the realization that some of the sharper Indy veterans were not going to take







ABOVE LEFT – Intake ports are routed up through the top of the head between cam towers. Each large oval port feeds a pair of intake valves. Cams rotate in saddles bored in head casting, actuate radiused cam followers fitted over each valve. LEFT – Four-bolt main caps are used on bearings one through four. Extensions on first two provide mounting flanges for oil pressure pump, front, and sump scavenge pump, rear. Both pumps are driven by gear which engages water pump gear. ABOVE – The cast magnesium oil pan is baffled internally to prevent oil windage. Ears provide chassis mounts. The flange at lower right is where small alternator fits to engage gear.

the Lotus-Ford invasion lying down, the set of castings for the series 4 engine was dusted off in the months following the Indy 500 and a new test program started.

As built for the initial phase of Ford's '64 Indy program, the V8 engine reached a stage of development to where it is a misnomer to continue calling the powerplant a modified Fairlane engine. Although many of the components used within the engine originated or are still used in similar form for standard Fairlane V8's, Ford engineers now refer to this overhead cam V8 as the Indy engine, so we'll do the same.

The first '64 V8 was actually assembled by using a block from one of the pushrod practice engines used prior to the '63 race. The ten main head studs, equally spaced around the cylinder bores in the pushrod engine, were squeezed together toward a theoretical center line down the four cylinders in each side of the block. This is so these studs will extend through the new head between the cam towers in a position that permits easier nut placement. The bosses for these relocated studs had been placed in the series 3 block castings in anticipation of the twin-cam heads for each bank.

These series 4 heads were cast aluminum, used a pent-roof chamber design with two intake and two exhaust valves per cylinder. The four-valve arrangement was quite similar to that used by the Offy and many other racing engines and is not a new idea. This layout is practical only with overhead cams since large oval ports can be used to each pair of valves and pushrod location precludes this type of arrangement with a cam-in-block engine. The ports for these heads were routed from the underside of the valves to the edge of the head castings in a conventional manner, intakes toward the center of the engine, exhausts to the outside, or lower edge of the head as it sits on the engine.

Camshaft drive was by straight cut gears in the same manner used by Offy and most other overhead cam racing engines, but was somewhat complicated by the fact that two banks of cylinders and a total of four cams had to be supplied with motion rather than one bank and two cams. Gears were contained in cast magnesium cases on the front of the block. Cams fit directly over the two rows of valves on each head and actuated radiused cup followers Ford purchased from Meyer-Drake. By late last summer, this first four-cam Ford was on the dynomometer at Ford being subjected to a wide variety of tests to prove camshaft design, carburetion, gear trains and many other features. In its earliest stages, the engine produced approximately 410 horsepower on gasoline and showed considerable promise.

One drawback to the overhead cam engine, as compared to the pushrod version, was the unavoidable extra weight that joined the program along with the gear train, heavier head castings, extra camshafts, heavier pistons, more valves, etc. Early estimates showed the four-cam V8 would be approximately 60 pounds heavier than the pushrod model. So to offset the weight increase and also improve power to where car speed potential could be raised several miles per hour, Ford's engineers arrived at a design minimum of 425 horsepower with a broader, higher torque figure than had been available with the '63 engine. Last year's V8 produced a maximum of 365 to 376 horsepower.

In '63, special 58 mm Weber carburetors were used on the pushrod engines and had proven to be on a par with injectors. For the '64 engine, these same Weber carburetors were used in early tests and performed quite well but injectors were again tried for several very good reasons.

First of all, the 58 mm Weber downdrafts used in '63 were the only ones of that size ever made by the Italian manufacturer and they didn't want to

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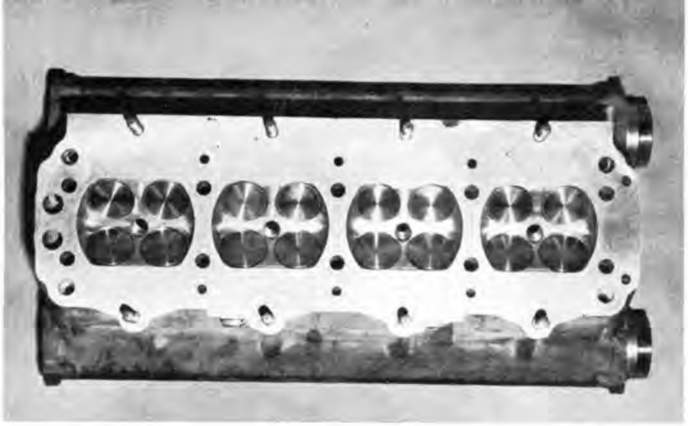
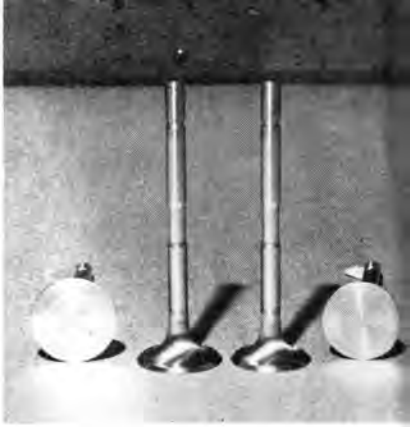




FORD'S INDY V8 *continued*

get involved in making up a large quantity of the 58 mm or even larger carburetors for Ford this year. Secondly, carburetors weigh considerably more than injectors. Third, they were not as easy to calibrate as injectors. Fourth, carburetors, with their float bowls, were prone to slopover on the 1G-plus turns at Indy. And last but not least, Ford discovered that they could get almost the same mileage with injectors and gasoline as with carburetors.

Ford rushed their first four-cam V8 off the dyno and into one of last year's Lotus chassis for track tests late in October at Indianapolis. Dan Gurney drove the car and although the runs did not look spectacular to the railbirds because speed was never up to the 150 mph mark, the purpose was to check out carburetion, injection, camshaft and other features which could not be readily evaluated on the dyno. Just how much power was being produced by this particular engine, Ford doesn't say, but they left Indy well pleased and with a better idea as to the direction they wished to take.

One thing firmly decided was that injectors would be used in place of carburetors for '64. Gasoline would still be the fuel. Three types of injectors were considered by Ford's engineers. Colin Chapman, "Mr. Lotus," preferred the English Lucas since he had experience with this unit. The German Bosch injection was also considered since it had been well proven on racing engines. The third unit considered was the American Hillborn unit. Both Lucas and Bosch injectors use timed injection with extremely high fuel pressures. Nozzles were located in the port rather than in the cylinder. The Hilborn unit was a low-pressure, constant-flow type, also with nozzles in the port.

Preliminary tests showed all three units to be nearly equal in ability but the Lucas pump and flow-directing unit

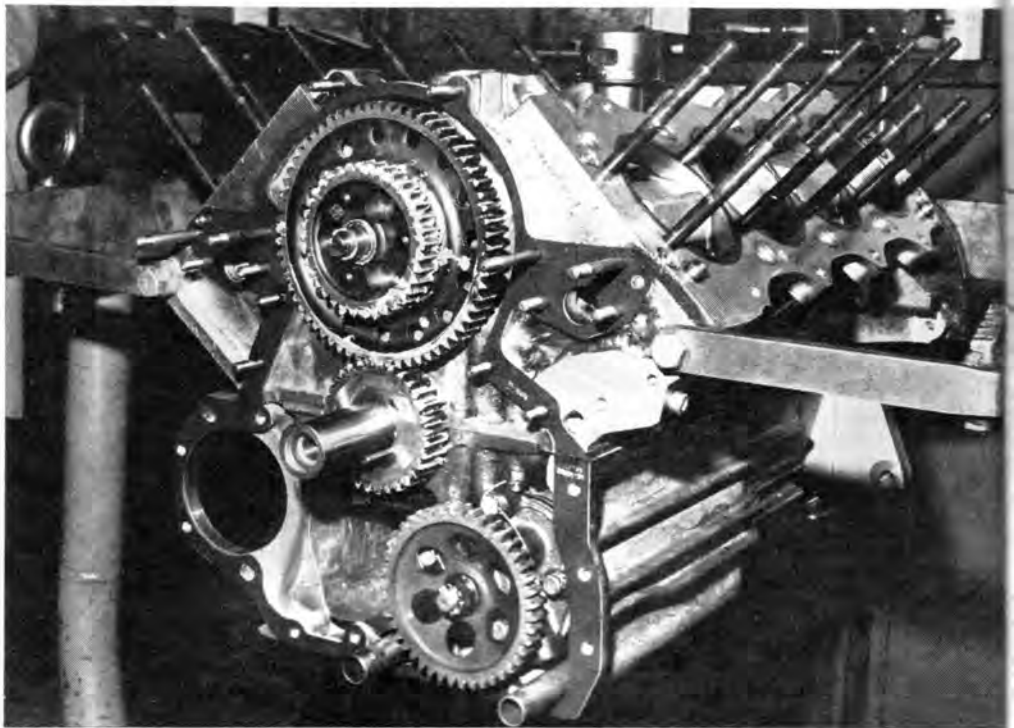
LEFT – Each head has 16 valves, four per cylinder. Spark plug location favors intake side. Note extra holddown studs. CENTER – A pair of coil springs are used on each valve. Meyer-Drake cam followers fit over springs, keyed to head. RIGHT – Intake valves, left, and exhaust valves are quite similar in appearance but intakes are .100-in. larger.

was physically large, heavy, and did not readily fit the Ford engine. Two extra gears would have been needed in the already crowded front gear case. The Bosch unit presented somewhat the same problems. Both of these units with their timed flow to the individual cylinders, required complicated metering devices which meant extra weight, more bulk, and less ease of repair or mixture change.

The Hilborn unit, on the other hand, was lightweight, used a small, simple, low-pressure fuel pump which could be easily mounted on the engine, and was constant-flow so had no complicated timing mechanism. A simple change of bypass jet changed air-fuel mixture, it shut off clean on deceleration, accelerated clean, and best of all, if a part was needed, a phone call to Stu Hilborn in Santa Monica, California, got pieces delivered in the next morning's mail. So, at this writing, Hilborn injectors appear to be part of Ford's '64 Indy project.

On the first overhead cam V8, ignition problems were also thoroughly investigated. In last year's pushrod V8, a battery-powered transistor ignition was used and performed flawlessly but Ford and their Autolite Division tried a variety of arrangements on the new engine just to make sure. First, the spark plug was located centrally in the peak of the chamber between the four valves. Then spark plug holes were placed in the top of the peak on either end of the chamber, and dual ignition used for each cylinder. Then all three plugs were fired at the same time with a triple ignition system.

Power output varied only slightly



Ready for front cover installation, the double gear above crank reduces speed. Gear at lower right is for oil pumps. It engages water pump gear on front cover which also acts as idler for alternator.

with the single, dual and triple ignition arrangements and the only actual difference that could be noted was that the more plugs used, the less initial advance needed. Three plugs fired the charge from three different positions within the combustion chamber so the flame front required less time to ignite the whole charge. Using last year's single ignition system with more initial advance, so the flame front had more time to travel, gave excellent results and eliminated the problems inherent with multiple ignitions; extra parts and more weight. Reliability has never been a problem with Ford's Indy V8 ignitions.

Among things discovered on the first overhead cam V8 were: excessive oil seepage between castings; fuel pump drive trouble when located at the rear of a camshaft; poor exhaust outlet location for the Lotus car and also for grouping the exhausts for tuning; too large exhaust valves; and many minor problems. The first engine, following track tests and more work on the dyno, had met the design specifications of 425 horsepower minimum, so now Ford's Engine and Foundry Division was ready to build engines which could actually be put into chassis and raced.

The most radical change in the revised four-cam V8 was to reverse the intake and exhaust valves from their previous arrangement so that exhaust valves are closest to the centerline of the engine and intakes are to the outboard sides of each head. A further change was to re-route the intake ports so that they pass vertically up through the heads rather than to the outside edge, thus eliminating ports facing down toward the track as were the exhaust ports in the earliest model. The new intake port openings are directly between the cam towers, right next to the spark plugs. Injector castings, made to Hilborn specifications, attach directly to two-bolt flanges at each port.

The new exhaust location is ideal for any pairing or grouping of exhaust pipes for horsepower gains due to "tuned" scavenging. The first set of headers for dyno work exit nearly straight up with just a slight rearward rake but later models can be routed in any manner desired. Injector intake horns can also be made any length necessary and project from the engine at 45° angles so that they do not interfere with the chassis or the driver's view to the rear.

Fuel pump drives were somewhat of a problem with the pump's original location on the first engine. At first, the Hilborn pump was mounted on the rear of one of the cam towers and was splined directly to the rear of a camshaft. After breaking a few of these, Ford's engineers learned that valve spring loads caused the camshafts to have uneven rotating motion and placed impact strain on the pump drive. Relocation of the pump to the front of the cam eliminated this problem.

Exhaust and intake valves were the same size in the first four-valve-per-cylinder heads, approximately 1½-inch head diameter. For improved torque at the engine speeds to which the cars would slow while going through the corners on the Indy oval, about 6000 rpm, many valve sizes were tried. Valve head diameters on the latest engine (Ford is constantly making revisions on these engines so we can't be definite but we won't be too far off) are 1.460-inch for intakes, 1.360 for exhausts.

The front gear case on the first overhead cam engine had screw-on plates to cover bores for bearings that carried idler gears and no matter how much sealant was used or how tight the screws were torqued, there was always oil seepage at high rpms. The same condition occurred where the cam covers and gear cases mated. So, on the latest version, the only openings on the front gear case are for distributor, fuel pump and tachometer drive. All other bearing bosses are bored from the back side and not fitted with cover plates. Cam covers are cut at a 45° angle where they meet the front cover so a more effective seal can be used at this point.

There are a host of other refinements in the latest version of the Indy V8 and you only need to look at the old and the new side by side to note them. The latest engine is much cleaner in appearance, which is only natural because the first was strictly a workhorse. But down under the revised castings and changes to intake and exhaust, etc., the innards of the latest V8 are quite similar to the first version.

Block patterns are the same for the '64 engine as those used in '63 except that bosses for oil supply and drainback holes to the overhead cams have been revised. Also, with cams topside, the lifter bosses have been eliminated from the valley section of the block. It is possible that further modifications will be made to the patterns originally

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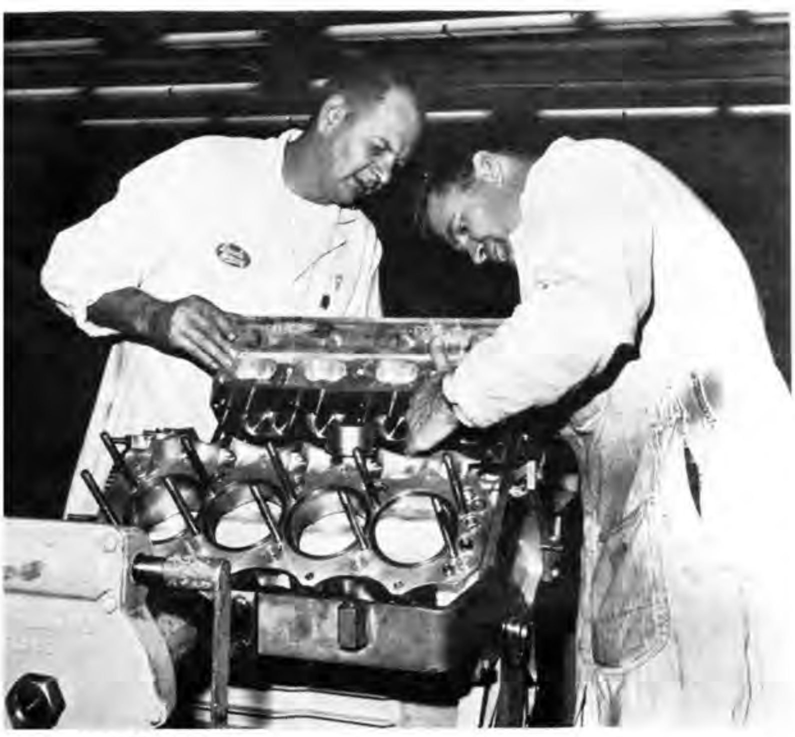
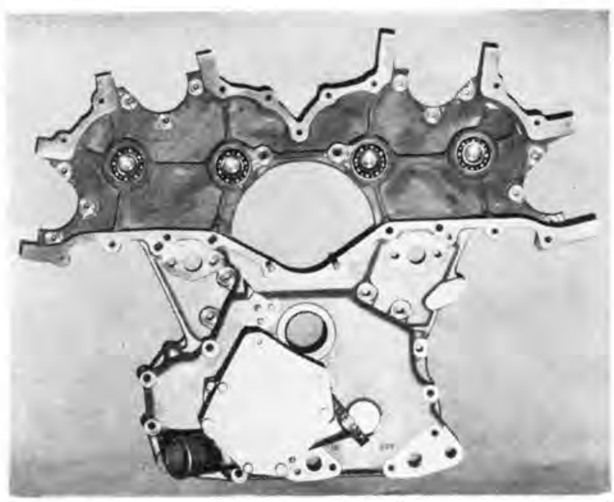




Back half of magnesium two-piece front cover closes off front of the crankcase, too. Water pump mounts below crankshaft, gear is on back side. Ball bearings in upper section of case are for shafts on each of the idler gears.

LEFT – Bob Weeks, left, and Jerry Nine slide one of the heads over holddown studs. Note that the exhaust ports, like the intakes, are large oval-shaped. Laminated steel O-rings seal cylinder gases; rubber O-rings, fluids.

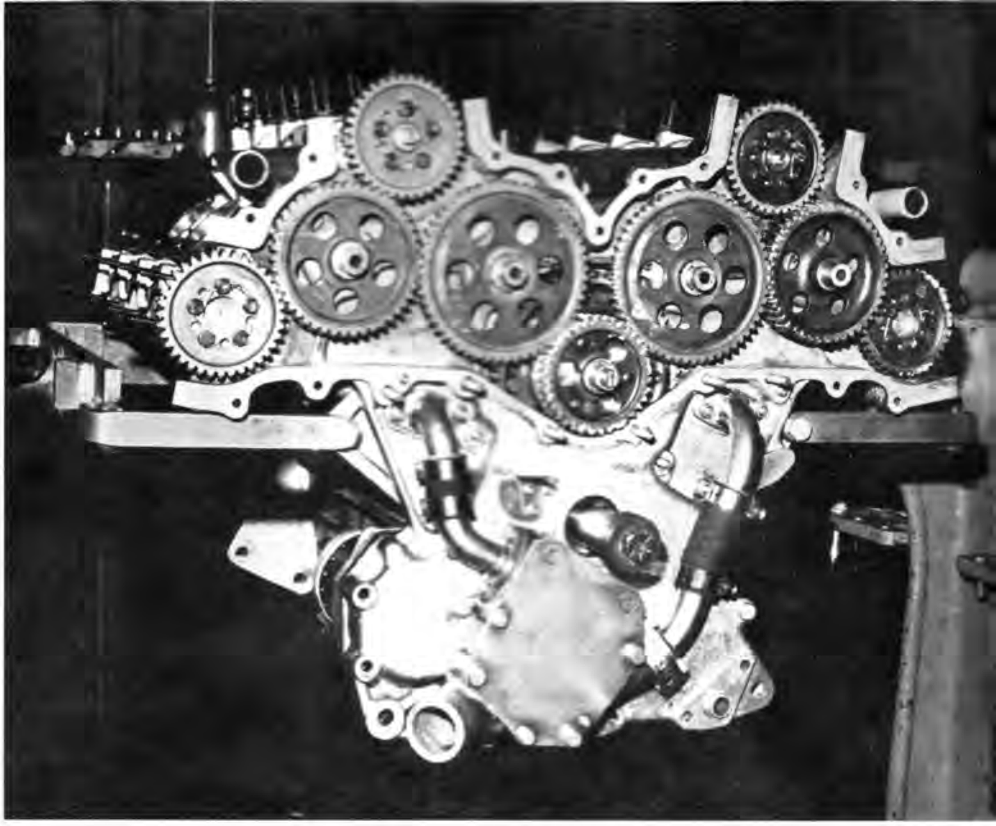
borrowed from the production 289 program to eliminate the stock distributor bore and crankcase breather pipe boss. These last changes, if made on later engines, would only be made to "clean up" appearance and possibly eliminate a slight amount of weight.

The blocks are sand cast aluminum and are fitted with cast iron cylinder sleeves. Sleeves are flanged and have a circular groove machined on their upper end to accept a special Cooper laminated steel O-ring gasket. This is the same method as used in '63. As mentioned earlier with the first overhead cam engine, the ten main head studs on each bank of cylinders are squeezed toward the centerline of the bank. An extra pair of holddown studs are used for each cylinder, one in the inner edge of the block, the other on the outer edge. In '63, one of these extra studs was in the block, the other in the head. For '64, both extra studs for each cylinder have been placed in the head castings.

Water routing is the same in the '64 engines as in '63 and conventional head gaskets are not used between block and heads. The laminated Cooper O-rings take care of cylinder gas pressure while grooves for neoprene O-rings around each water passage hole in the block, plus similar arrangements around each oil pressure or return oil hole, seal the fluids. There is actually about .010- to .015-inch air gap between block and head faces. In '63, a sealant was used between these surfaces during assembly to prevent oil seepage from the lifter chamber. Without lifters, this area no longer contains oil and is in fact left open, acting as the top cover for the engine. So no sealer is used between block and heads, just O-rings.

An interesting feature is that although the camshaft is no longer required in the block, the conventional cam bore is retained and used for a crankcase breather vent and oil drainback control. A large diameter aluminum tube fits through the cam bearing bores, the length of the block. Oil drains from the inboard exhaust cam towers are routed through holes bored in the block directly into this tube. This drainback oil collects and is then carried back to the bottom of the sump by a steel tube. The reason for the controlled return of this oil is to keep it away from the rotating crankshaft so that it won't be aerated and forced out of the engine by crankcase pressures. The tube through the cam bearing bores is vented on the top side in several places to pick up crankcase pressure, then a single stand pipe with breather cap sticks up in the valley of the engine to exhaust into the atmosphere.

The lower end of the block is the same as that used in '63 with four-bolt



With fourteen gears in place, counting those not visible, train is complete between crankshaft and four cams. Gears are straight-cut, have little backlash.

main bearing caps for bearings one through four. Main bearing material is copper-lead, the same as last year and journal sizes are the same as standard Fairlane 289. The crankshaft is also the same stroke as the 289 Fairlane V8 but is forged steel instead of cast iron. Again, crankpin sizes are the same as those for the stock 289 but they have been slant-drilled from the ends of the journals to remove weight and provide a reservoir for lubricating oil. The ends of the journals are fitted with pressed-in cup plugs backed by swaged pins. Instead of conventional single oil holes per bearing, each crankpin has two oil feed holes cross-drilled for each bearing to improve lubrication.

Extensions to main bearing caps number one and two provide mounting flanges for the oil scavenge and pressure pumps. The oil pressure pump mounts on main cap number one and is driven by a gear which meshes with the front gear stack. Oil is pulled from the remote supply tank, then fed into the conventional block gallery through holes in the front wall of the engine.

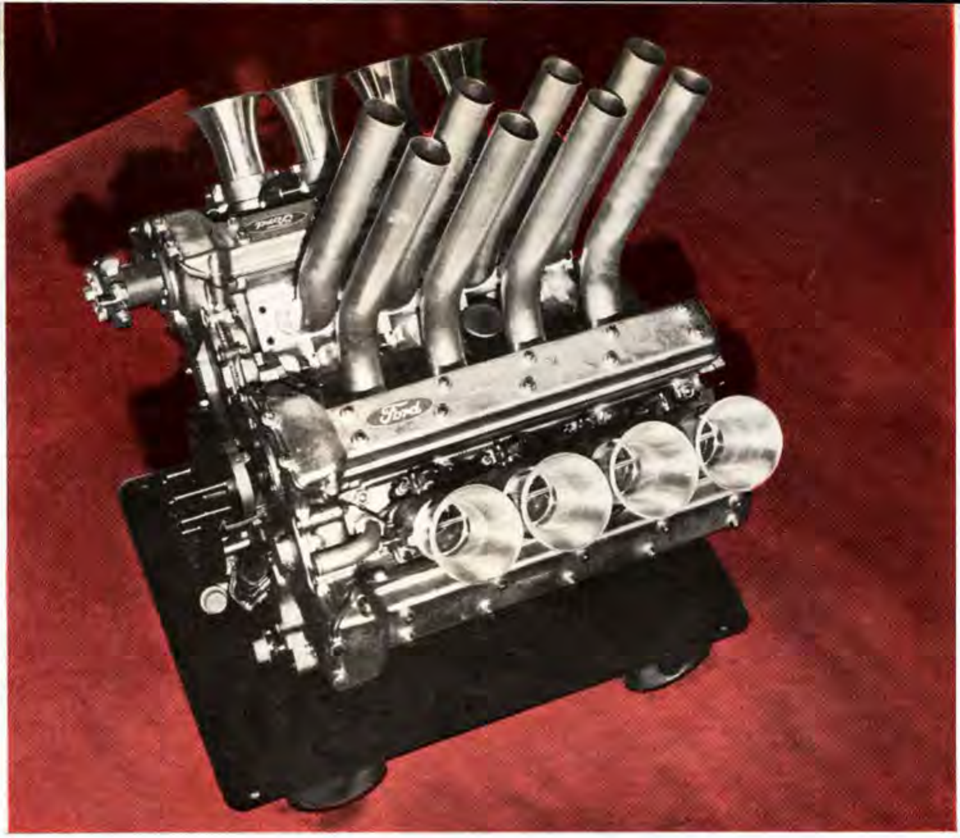
An extension of the pressure pump drives the scavenge pump mounted on number two main cap. The scavenge pump has a 50% larger capacity than the pressure pump and picks up return oil through a pickup tube fixed near

the rear of the cast magnesium oil pan. It directs the return oil through a tube, out the front cover, to a hose connection that carries the oil to the external tank. The larger capacity scavenge pump ensures that oil will always be returned to the tank faster than it can be fed into the engine thus making the system a "dry sump" type.

Rods used in the Indy V8 are the same as those used last year and are actually modified production 289 high-performance rods. Instead of a press-in pin, they've been reamed and fitted with bronze bushings for floating pins. The rods are carefully selected, shotpeened, polished and checked many times during their processing. Pins are standard 289 high-performance items. Rod bearing inserts are also copper-lead.

Pistons are impact-extruded aluminum with a pent-roof design to fit up into the head chamber as closely as practical for maximum compression. The peaked pop-up section has the same angle as the chamber but valve relief cutouts are required in the deck section of the piston for clearance. Last year the pushrod Fords used a round piston with .014-inch skirt clearance but for '64, the pistons will have a cam-ground skirt and less clearance. The cam grind gives a closer fit between piston and wall on the thrust plane, thus improving stability and giving better ring contact. Grooves in the pin bores are designed for double helical retainers.

The head castings are quite impressive looking when raw and doubly so



TOP – Breakerless transistor ignition is driven by camshaft, uses standard distributor cap. No mechanical advance.

BOTTOM – Small alternator is made by Ford, is gear-driven. Output is ample to supply ignition, charge a small battery.

RIGHT – Here's the package that could make a lasting impression on spectators at the '64 Indianapolis 500. Cap nestled amidst exhausts is the engine breather.

when finish-machined. Head and cam towers are all one unit. The method used to finish the chambers is a fantastic new creation of the modern age and permits chambers of very precise dimensions. The head castings have cast chamber shapes but they are much smaller than when finished. After the head surface has been machined to within just a few thousandths of the desired dimension, a special electrical discharge etching method is used to convert the chambers from rough casting to their smooth finished shape.

Special zinc male patterns are cast from a precision mold. Four of these zinc patterns are mounted on a fixture guided by dowel pins in the head and with a special electrical discharge directed through the fixture, the zinc patterns are lowered into the rough chambers. They etch into the aluminum head in the same shape as the patterns. A total of four operations is needed but after the fourth pass, the chambers are exactly the same shape as the zinc patterns and have a dull, but glass-smooth finish. Then the valve seat bores are cut in the heads, the rest of the machining operations completed and finally, a light clean-up cut is taken across the head face to finish the chambers to the exact depth specified. All eight chambers on an engine check out to less than 1 cubic centimeter of equal capacity with valves installed.

The pent-roof chamber has an included angle of approximately 108° between the plane of the intake and exhaust valve seats. This obtuse angle prevents shrouding by the opposite chamber wall when the valve is open and also permits long duration camshaft timing without valve interference on overlap. As mentioned earlier, the latest heads use 1.46-inch intake and 1.36-inch exhaust valves. Spark plug location is in the top of the chamber and favors the intake valves slightly. Compression ratio for the latest engine is 12.5:1.

Special alloy cast steel valve seat inserts are shrunk into the aluminum heads and aluminum-bronze valve guides are pressed in. The upper ends of the lightweight valves are fitted with inner and outer coil springs recessed in an individual well for each valve. Aluminum spring retainers are used with conventional split keepers. Meyer-Drake "Offy" cam followers fit over the tops of the valves and springs. They are radiused on the face that contacts the camshaft and have a guide key on their outer diameter to match a slot broached into the head casting. This guiding method keeps the cups properly aligned with the cam lobe.

Each valve must be individually ground for length to get the clearance required for valve lash. The whole head-valve-cam components must be completely assembled, lash measured and noted for each valve, then the pieces disassembled as needed to grind the valve ends for extra clearance or replace with longer valves if necessary, a very tiring process but one that eliminates adjustment methods that might add weight or pieces.

Each camshaft rotates in bores directly over its row of valves and they have no special bearings for their journals; they use the aluminum of the head casting for bearings. Cams are hollow and pressure-fed with oil through the front bearing saddle of the head. Lubricating oil passes through the hollow cam to feed each bearing journal, and each cam lobe has a small feed hole just at the leading edge of the ramp to lubricate the lobe and cup follower at the beginning of each lift period.

A total of fourteen gears fill the cast magnesium cases that cover the front of the engine and oil sump. Starting at the main source, the crank gear is number one. Below the crank gear, mounted on the water pump shaft in the lower part of the front cover, is the water pump gear which also acts as an idler for the oil pump drive gear and the alternator drive gear. That makes four to this point.

Above the crankshaft drive gear are a pair of gears bolted together which

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reduce speed and drive idler gears directing flow to each cylinder bank. These idlers in turn drive another set of idler gears which each drive a pair of cams. The final idler gear on the left bank is double thickness to compensate for cylinder bank offset and the fact that the left bank cam gears do not extend as far forward as those on the right bank. If you don't believe our count, check the pictures yourself and don't forget the water pump gear which mounts to the back side of the front cover and the alternator drive gear. Fourteen, right?

Gear lash is a very critical point on the overhead cam engines because excessive lash means untrue cam settings which could not only lead to less than maximum power but also a possible interference between valves, or valves and pistons. Not enough lash means excessive driving power required. We do not have the exact lash figure used but it is less than .010-inch total from crankshaft to cam. The individual cam gears have ten mounting holes, 36 teeth around their circumference and there are five holes in the cam flange. This permits the cams to be timed within less than 1° of crankshaft rotation. All gears are straight cut. The five idler gears (six counting the pair running on the same shaft) are supported by ball bearings recessed in the front and rear halves of the magnesium front cases.

The alternator, which mounts into the rear of the gear case, along the right side of the oil pan, is made by a division of Ford Motor Company and is much lighter than the modified outboard motor generator used on last year's engines. This alternator will charge a small Autolite battery which will be mounted in the car. Unlike last year's engine, which required power for three electric fuel pumps as well as the transistor ignition, this alternator will only have to supply power for the ignition alone. The Hilborn injection system has a pump capable of delivering ample supply without boost pumps.

We had the opportunity to watch the assembly of the first of the revised overhead cam engines last December and it is really a very interesting powerplant. We witnessed the first weigh-in of the new baby when com-

During late season tests at Indy, the first four-cam Ford was tested in a '63 Lotus chassis by Gurney. Speeds were generally under 150, much was learned.

pleted as you see the engine in photos accompanying this article. Complete less fuel lines, ignition wiring and fluids, the 255-inch V8 weighed 406 pounds. This represents 60 pounds more than the '63 pushrod engine, exactly as predicted.

After completion, the engine went on the dyno where it went through a break-in period prior to shipment to Kingman, Arizona, where it was dropped into one of last year's Lotus' for test runs on the 5-mile banked track. The track was marked off to simulate straightaway and corner lengths like those at Indy and Bobby Marshman drove the car in a test program.

The car was driven full throttle down the simulated long straights, shut off for the "corners," back on the throttle again going into the "short chutes," off throttle through the next "corner," on again for the "straights," etc. It is difficult to duplicate the four-cornered Indy track on a five-mile oval but Ford engineers were happy with the results attained. The "reversed" intake-exhaust flow, reshaped intake ports, and injectors all worked perfectly. The car was actually clocked in excess of 190 mph at the end of the long "straights" and even considering the possibility of too-high "corner" speeds on the Kingman track, this still shows plenty of muscle. Straightaway speed on the Indy track has rarely been clocked much over 180 mph.

This "cammer" will turn in excess of 9000 rpm without any indication of valve toss, or float, and reaches its maximum power at 8000 to 8200 rpm, with corner speed expected to drop to not less than 6000 under ideal conditions. The engine has very good torque throughout the rpm range in which it will run. Maximum rpm at the end of the straightaways will probably be between 8300 and 8500 rpm, slightly over the power peak but still well within the safe range.

There were two Ford-powered cars in last year's Indy 500, and for '64 things look a lot brighter for a win. Ford had many requests for engines from car owners and drivers but due to time lost redesigning the engine and inability to produce these precision engines in quantity, they've had to limit the number to about 8 in all. When choosing those teams to whom they would furnish engines for '64, they took into consideration the people who had helped them after the '62 race, when Ford engineers were trying to figure out just what it would take to build a winning car.

At that time, they interviewed some top drivers to find out how they drove the track, where they got on the throttle and where they got off, rpm's leaving the corner and at the end of the straights. Car builders like A. J. Watson contributed thoughts of chassis design. Car owners permitted Ford to clock their cars during tire test programs to find speeds being attained at various spots on the track. A lot of people helped Ford and they are the ones who will get Ford engines for '64.

Ford will probably enter three cars themselves. Two will be new Lotus' for Clark and Gurney, and another will probably be one of the '63 cars updated and with Bobby Marshman driving. A. J. Watson will build one car for Rodger Ward plus maybe another one for a top driver. A. J. Foyt will have a car. Mickey Thompson will have at least one, and there's another one or two rumored for other teams. Ford has not made official announcements as to the complete rundown on owners and drivers but the entire list should be impressive.

These overhead cam engines will all be fitted into lightweight, mid-engine chassis, some English but most American. With 425-plus dependable horses, 7 to 8 miles per gallon economy, and good-handling independently-sprung cars, the Ford Motor Company should be well represented in '64. They won't be a cinch to win the event, though; consider the fact that there are reputed to be about ten Offy-powered cars with the four-banger behind the driver under construction.

The Indy 500 has always been exciting even when there were 33 Offys in the starting lineup, but with the variety already promised for 1964 – get your tickets early! ■■