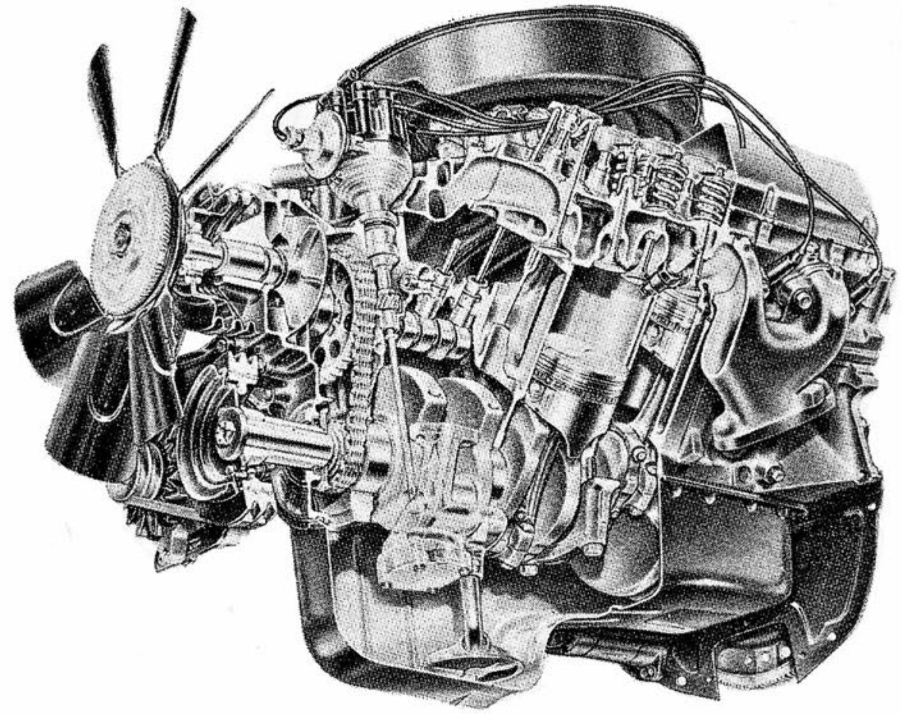
FORD'S NEW CLEAN MACHINE



Racing and research not only improve the breed —they also clear the air.

DENNIS SHATTUCK

Design engineers abhor having to tack on an extra system to do a particular job — they would much rather accomplish the same end through redesign, or by doing a completely new, more suitable design to meet the changed parameters. Control of smog-producing hydrocarbon emission is a good example because recent years have seen the Detroit car manufacturers add on several complicated systems to their cars' engines in an effort to reduce hydrocarbon outflow enough to meet the California, and now federal, air pollution regulations.

The purpose of the add-on systems, it turns out, was two-fold: expediency and deferment. The systems had to be added to make the cars saleable in a large and thus important market segment. Consequently, they are cumbersome, expensive and apparently inadequate. The deferment was deemed necessary to buy time for complete redesign. Optimistic engineers felt that emission control through better basic engine design was just around the corner — it just needed a little more developing. Unfortunately, it takes thousands of man-hours for the design, development and testing of something as complicated as a modern automobile engine.

Ford Motor Company is the first of the automakers to show what's been bought with that time, and thus is the first to show an engine fully designed with the current government standards in mind. The fact isn't ballyhooed in corporate advertising, probably because the company hates to admit that its other engines, which are still in production, might be greater contributors to the pollution problem.

At any rate, Ford has quietly unveiled its new engine in two forms for the 1968 model year. The smaller version, 429 cubic inches and 360 hp, replaces a 428 of older design as an optional powerplant for Ford Division's Thunderbird. The larger, prime design 460-cu.-in. V-8 is for the Lincoln-Mercury Division's Continentals, both sedan and the recently announced Mark III. It replaces a 462-cu.-in. engine. Though their displacement differs by 31 cubic inches, the only other major difference between the two new engines is in their stroke length, most other dimensions being identical. Power ratings are 365 bhp at 4600 rpm for the 460, and 360 at 4600 for the 429.

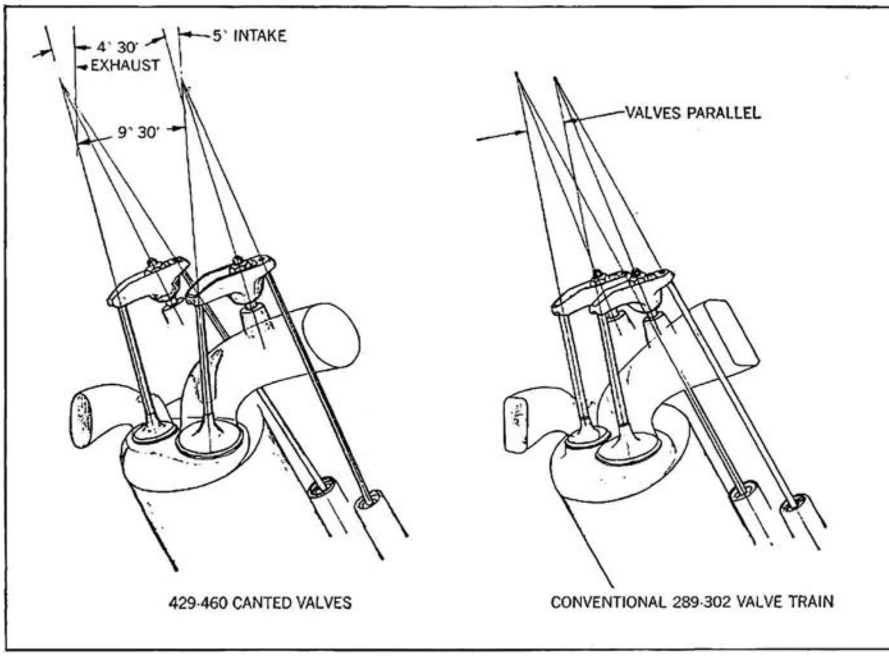
Both engines are products of a design project coded "385 series" that extends back six years. Though a 385-cu.-in. version never existed in test cell or on drawing board, that was the code name. "We called it '385' because too many of our suppliers get involved with these things and leak out information before we're ever in production," a Ford staff official explains.

The 429-460 is a hot, new engine all right, even if it isn't 385 and doesn't replace the 390s. It's hot in several ways, too, not the least of which is its emission control-oriented design. Along with being the first new engine family from FoMoCo in seven years, it also is the first to show direct benefit in basic design from the Total Performance program. If the influences of strong performance and superior control over hydrocarbon emission seem strange bedfellows, they nonetheless have turned out to be quite compatible when applied in their proper context.

The goals of both lowered hydrocarbon emission and optimum power production can have a common denominator in superior technological design. Emission control specialists need greater efficiency for cleaner engine operation while the performance types want the additional power of improved volumetric efficiency. Both goals were achieved through application of Ford racing- and research-derived knowledge. A brief examination of the engine's design history reveals how the two influences interwove, thus shaping the final, production configuration.

The design project had its beginnings in 1962 when Ford Engine and Foundry engineers looked ahead to the eventual replacement for the then current, big-displacement Lincoln engine. It had been introduced for the 1958 car models at 383- and 430-cu.-in. displacement and had become a Lincoln exclusive at 430 with the 1961 Continentals. It was increased to 462 cubic inches for the 1966 model year, and it was felt that at that size it had arrived at its maximum practical displacement in consideration of durability and power requirements for Lincolns. Thus, a new, large-displacement engine, with potential for growth to even larger sizes, was going to be necessary for future models.

About the same time two more major influences became distinct — racing and California's pioneering smog laws. FoMoCo had embarked in mid-1962 on its "Total Performance" program which was to literally bring out the best in Ford engines through the constant improvement necessary to keep the products competitive in the demanding world of auto sports. At nearly the same time, amendments to California's state vehicle code made hydrocarbon emission controls mandatory for all new cars to be sold in the state. It appeared, even then, as if the California regulations eventually would become national in effect, so Ford engineers embarked upon a research and development program. The results it produced, if not as spectacular as those of the racing program, are equally as beneficial.



Canted stems and rounded ports (left) allow larger valves, smaller quench area, better breathing and cooling, and improved gas flow. Performance and emission are benefactors.

The final, production design program to put together all the elements into one producible engine, began in January, 1965. Parameters were established for size and block dimensions, and these were greatly influenced by the success of the 221-260-289-302 family of "small" V-8s. Cylinder head design, particularly in intake and exhaust gasflow region, was suggested by certain racing-learned factors. Combustion chamber shape and texture came directly from the emission control laboratory. Though design engineers in each area had to compromise here and there to make it all work together, the final outcome is nonetheless brilliant.

The cylinder head design particularly demonstrates the great influence of the two criteria of emission control and racing development. The heads promote extremely good "breathing" characteristics for high-power development, yet the chambers are clean and properly shaped for low emissions. Intake passages are round in cross-section for optimum gasflow, while the exhaust passages are oval, a reflection of both Indianapolis and stock car engine development. Valves are canted in two planes to facilitate the large gas passages, and also for more subtle purposes. And, the overall design was helped along by foundry experts who cast it in the Ford thinwall process for light weight.

Reducing the quench area between piston top and cylinder head had been found to be extremely effective in lowering hydrocarbon outflow, so this design was applied by the emission specialists. Smoothing out the gasflow in and out of the head also helped in this respect, so valve throats were machined in the normal seat-grinding process. The smaller quench area also made more space available in the chamber for the valve heads.

Several more advantages were achieved by canting the valves in two planes relative to the cylinder's centerline, in the direction of the gasflow. The tilted valves cause the heads to open obliquely into the combustion chamber, away from any shrouding effect that might be caused by the adjacent cylinder walls. The angled stems also created more space in the head for the round passages (see illustration) by splaying out the pushrod angles. It also gave designers the chance to move coolant passages closer to the valve stems, thus giving them better reliability and durability.

Stud-mounted rocker arms make possible canted valves in this new Ford design, just as it allowed Chevrolet to do similar gymnastics with the pushrods and valves on its so-called "porcupine" 390-427 V-8s. The studs are screwed into bosses in the heads and mount the rockers on spherical pivots. Pushrods from the hydraulic lifters seat in cups in the inboard ends of the rocker arms, the valve stem tips in the outboard ends. Miniature rails on the rocker face guide and retain the valve tip in its angular motion. Fulcrums and valve tips are lubricated through the hollow pushrod. The studs, pushrods and valves all are located on converging centerlines in a single plane to keep everything in a proper working relationship. Both intake and exhaust valves tilt off the centerline in the longitudinal plane, the intake being 5 degrees off vertical and the exhaust 4 degrees 30 minutes off in the opposite direction. They also tilt in the lateral plane, the intake about 13 degrees and the exhaust about 16 degrees toward the center of the engine. Conventional stud-mounted rocker systems usually only tilt in one direction.

A cast iron intake manifold matches the cylinder heads precisely, and this manifold has center cross-over passage for exhaust heating. The choke heat stove is on the right side of the passage for maximum sensitivity to changing temperature. Exhaust manifolding is conventional in cast iron and has provision on its right side for ducting hot air to the air cleaner for its air temperature-modulation system.

Two major criteria influenced block design: light weight and small package size commensurate with strength, and size to take care of subsequent displacement enlargement. A slightly longer stroke-bore ratio was asked for lower emission levels. Otherwise, the 429-460 block quite resembles the basic design used for the 221-302 family of Ford engines. Both utilize thinwall castings for their light, relative weight, and both are shallow and compact. The 429-460 is low in deck height, being only 10.3 inches from crankshaft centerline to cylinder head mating surface, and consequently is notably lower and narrower in overall dimension than its two predecessors.

Overall weight was reduced by 60 pounds from its Lincoln antecedent, but by only about 20 pounds from its Thunderbird predecessor. The major weight-saving came from thinwall casting, and from the elimination of the deep pan-rail skirt that characterized

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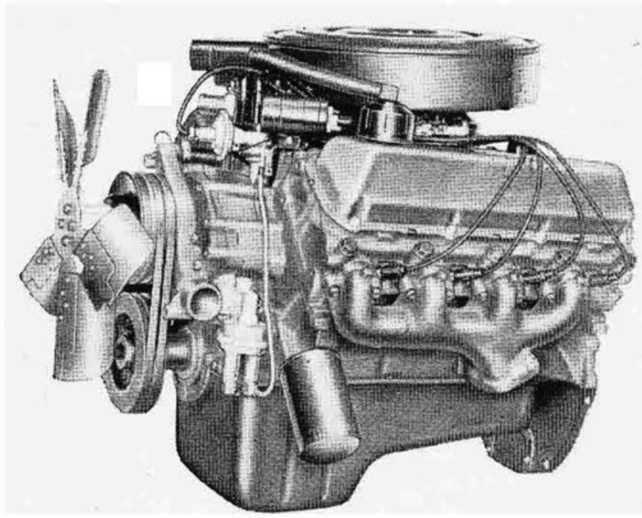


the 462. Wise-cracking engineers have dubbed the new design the "mini-skirt engine."

Ford's foundry people, who pioneered the thinwall process, have developed yet another technique that should prove very nearly as important. This is casting the block right side up, that is, with the head faces upward rather than in the traditional, head faces down manner. Right-side-up casting gives greater metal density and least porosity in the area which requires the greatest strength: the crankshaft webs and block bulkheads. When molten metal touches the sand casting molds, it forms gases which try to rise upward. However, these gases don't always rise fast enough to escape and when they are trapped, they form pockets, or porosity as the foundry men call it. Heads-up casting puts the hottest metal in the bottom of the mold, where it forms the most dense material for the webs and bulkheads. The more extensive machining operations necessary to finish the upper block also are more likely to reveal such flaws before the engine is completed. A single-piece crankcase core facilitates this casting method.

The crank is cast nodular iron and runs in five generously sized bearings, 3.00-inch diameter by .945-inch length. The center main is machined to take drive thrust. Connecting rod journals are 2.50-inch diameter and the rods have a new strap-type of cap which gives greater strength with less weight.

The 3-ring pistons are autothermic in design, with slipper skirts. Their top surfaces have cast-in valve pockets and are dished for clearance volume. Piston pins are shrunk fit. The upper ring is moly-filled for optimum compression sealing, the bottom ring is chrome-plated for oil control.

Provisions for mounting both power steering pump and air conditioning compressor were designed into the engine, because all Thunderbirds and Lincolns are equipped with 100% of the former and about 90% of the latter. Mounting pads are machined on the front of the left head for the compressor and the power steering pump attaches to the die-cast aluminum front cover plate. This eliminates extraneous brackets and makes a neater, more accessible engine compartment.

The front cover also mounts water and fuel pumps, and, on brackets, the alternator. Dual 15/32-inch belts drive the coolant pump and fan, as well as the alternator. The cooling system has a 19.3-quart capacity, and crossflow radiators are used with both installations. The water pump has a ceramic seal bonded to its impeller face. Though a more costly design bit, the seal greatly improves pump longevity, particularly where sand or grit might be introduced into the system.

Ford continues the hot-and-cold air cleaner system it pioneered on the 1963 Lincolns, though the device now has broader application. By controlling the temperature of the air flowing into the carburetor, more efficient leaner mixtures can be specified, thus lowering emissions. In operation, air heated by the stove on the right-side exhaust manifold is ducted to the 17-inch air cleaner where it is mixed with incoming colder air from the breather snorkel. A thermostatic valve controls the air supplies to keep the carburetor air temperature at a nearly constant level.

Both versions of this new engine are equipped with Ford's new IMCO (for Improved Combustion) emission control system. This basically provides leaner, more precise fuel-flow calibration for the carburetor and improved distributor setting accuracy for more efficient engine operation under all conditions. New equipment at Ford's Lima, Ohio, engine plant gives distributor settings within 1 degree, while fuel-air calibration is accomplished in an elaborate new facility at the Rawsonville, Mich., carburetor plant.

The flow-test room is a sealed, constant temperature and pressure chamber in which all the carburetors are checked for air and fuel flow rates at five levels of operation representing idle, 15-20 mph, 30, 60 and wide-open conditions. Plastic seals are affixed to the two screws which regulate incoming fuel flow; the seals permit subsequent adjustments for a leaner, but not a richer fuel-air-mixture.

If Ford engineers seem greatly pleased with this new engine design, it is for a variety of reasons. They find it a much better way to achieve the necessary emission control, and they like its impressive power production. They like being able to use knowledge gained in racing to do a better job with a production, luxury car engine, and they like the potential the engine has for future growth. But, talk to them about high-performance versions and they only smile and say, "Just wait!"

FORD ENGINE MAJOR SPECIFICATIONS

	460	429
TYPE	90-degree V-8, ohv	
DISPLACEMENT	460 cu. ins.	429 cu. ins.
BORE x STROKE	4.36 x 3.85	4.36 x 3.59
COMPRESSION	10:5:1 max.	
CARBURETION	Autolite 4300 4v	
BHP @ RPM	365 @ 4600	360 @ 4600
TORQUE, LBS.-FT. @ RPM	500 @ 2800	480 @ 2800
BORE SPACING	4.90 ins.	
DECK HEIGHT	10.3 ins.	
OVERALL HEIGHT	29.375 ins.	
OVERALL WIDTH	27.687 ins.	
OVERALL LENGTH	33.375 ins.	
OVERALL WEIGHT	676.8 lbs.	674.5 lbs.
VALVES	hydraulic lifters	
timing sequence	16-60, 55-21	16-60, 70-20
open duration	256 deg.	270 deg.
opening overlap	37 deg.	36 deg.
diameter, intake	2.000 ins.	
diameter exhaust	1.595 ins.	
length, intake	5.28 ins.	
length, exhaust	5.075 ins.	
stem diameter	.342 in.	
CRANKSHAFT	nodular cast iron	
bearing diameter	3.00 ins.	
bearing length	.945 in.	
MAIN BEARINGS	5	
thrust taken on	3	
CRANKPIN	2.50 ins. dia.	
bearing length	.861 in.	
bearing material	over-plated copper lead alloy	
CONNECTING ROD		
length	6.60 ins.	
weight	572 gr.	
PISTON		
bare weight	797 gr.	807 gr.
pin dia. x length	1.04 x 3.30 ins.	
number of rings	3	
OIL PUMP	Gerotor, cast iron body	
capacity	67 psi/1.1 gpm @ 2000 rpm	
drive	.3125 hex	
DISTRIBUTOR	single diaphragm	
drive	.3125 hex	
FUEL PUMP	mechanical	
capacity	5-6 psi static	
COOLING SYSTEM	19.3 qts.	

HOW THE 429 REALLY PERFORMS

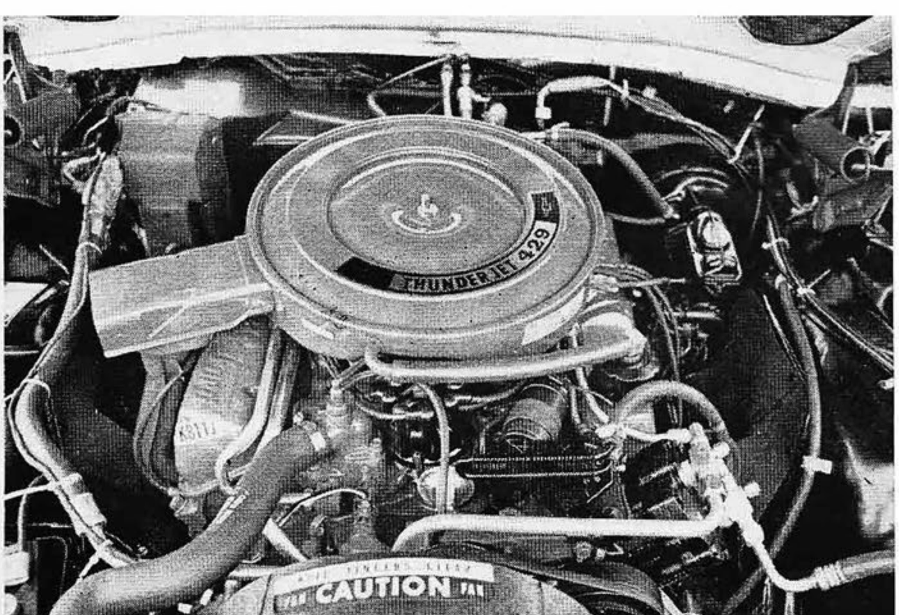
The merits of a new design can only be proven with success in application. We garnered a fresh-off-the-line '68 Thunderbird with the new 429-cu.-in. V-8, and with this in mind, set out for Ford's Dearborn test track. Less than 500 miles were on the odometer at the start of testing, and this "stiffness" hindered performance slightly.

The new engine doesn't reveal itself from inside the car. The only difference we could detect from earlier engines was the sound coming from the exhaust pipes — a rich tone unlike that from any other FoMoCo product we've driven. The engine is an exceptionally quiet performer at high speeds as well as low, and operating noise is practically nil at idle.

We left the transmission selector in "Drive" during all our runs. All shifts came at 4700 rpm. We experimented with manually running the selector, but our hand wasn't as reliable or as accurate as the transmission's vacuum control. Our test 'Bird had a 2.80:1 final drive ratio allowing it to cruise at 27.6 mph per 1000 rpm, keeping engine speed down and gas mileage up.

An abundance of power is available from the 429. Torque rated at 480 lbs.-ft. at 2800 rpm can develop excessive wheelspin with only a slight press of the accelerator. We quickly learned to feather the throttle, to the benefit of acceleration times and rear tire life. Our recorded times were registered with two aboard, 150 pounds of test equipment, and a full tank of gas which is worth about 150 pounds itself. The times were very good, but below those of a 428-cu.-in. V-8-powered 'Bird tested in the August, '67, MT. The 428 car, though, had nearly 5000 miles of careful break-in, and from what we learned of the new engine from behind the wheel and from the engineering department, we can safely predict that the 429 will reveal itself a better performer than the earlier 428.

Over a dozen full throttle runs were made on the car, and we noted no oil consumption whatsoever at the completion of testing. In our judgment, not only is the new 429 V-8 a breakthrough in low emission design powerplants, it is an amazingly good performer with reserve power and reliability. — *Steve Kelly*



Once installed in T-bird, 429 V-8 exposes regular maintenance items for easy service. Chamber from right exhaust manifold to air cleaner is part of IMCO emission control.

PERFORMANCE

ACCELERATION
- 0-30 mph .... 4.0 secs.
- 0-45 mph .... 6.5 secs.
- 0-60 mph .... 9.5 secs.
- 0-75 mph ....13.9 secs.

STANDING START 1/4 mile:
17.4 secs., and 84 mph

PASSING SPEEDS:
- 40-60 mph ....4.9 secs.; 358.6 ft.
- 50-70 mph ....5.5 secs.; 484.0 ft.

SPEEDS IN GEARS @ SHIFT POINTS:
- 1st. ....53 mph @ 4700 rpm
- 2nd ....87 mph @ 4700 rpm

MPH PER 1000 RPM IN HIGH GEAR: 27.6