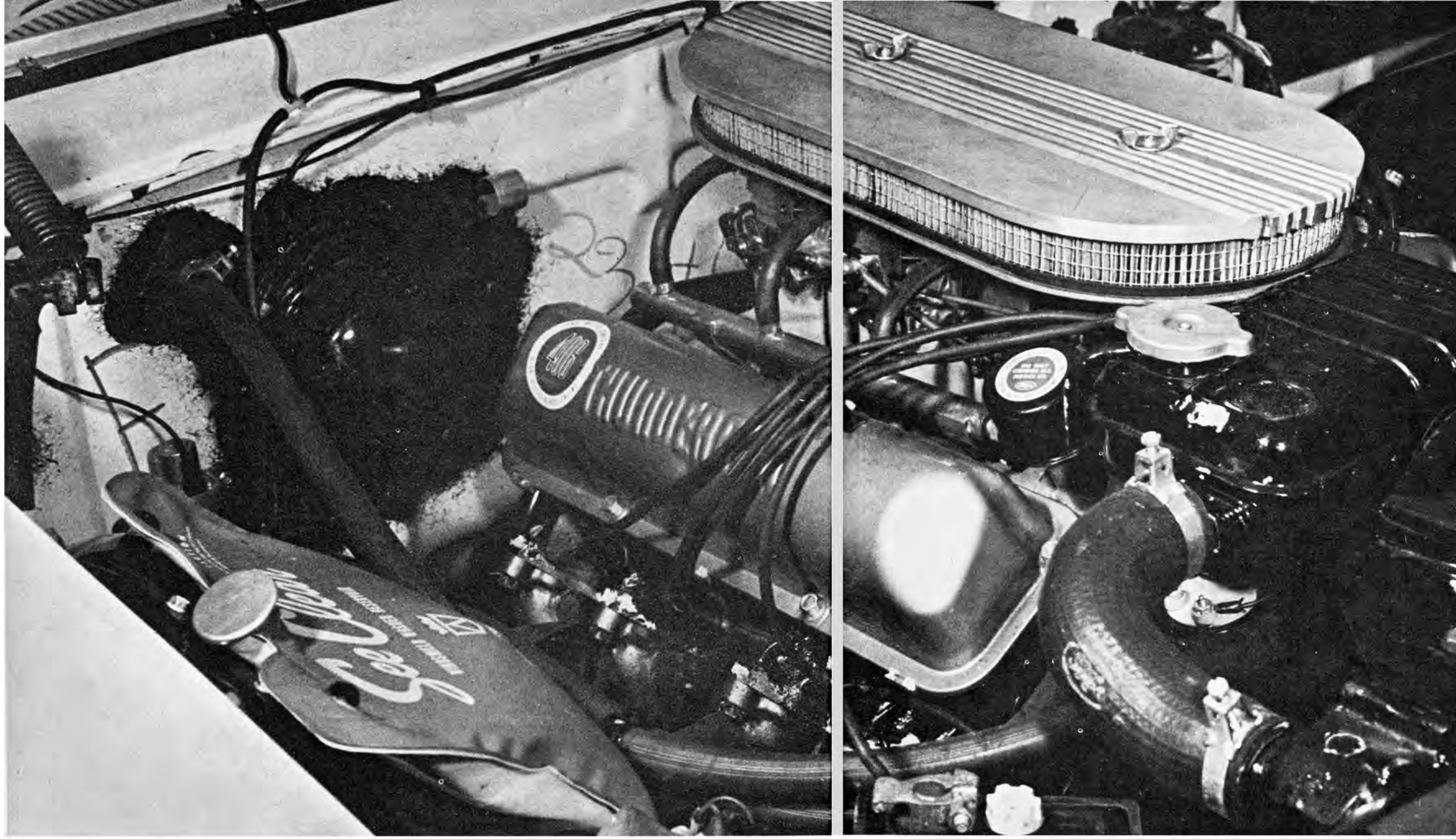
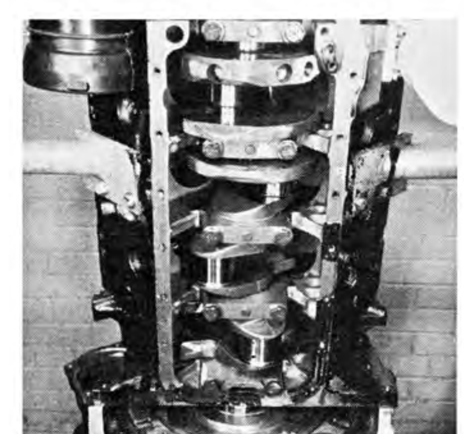


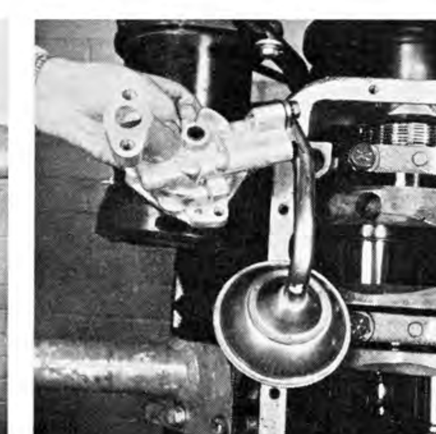
THE HOT SUPER-STOCKERS

406

POTENT INCHES FROM FORD



Extra ribs have been added to the engine's main bearing webs and its crank counterweights are more beefy to balance bigger rods and pistons.



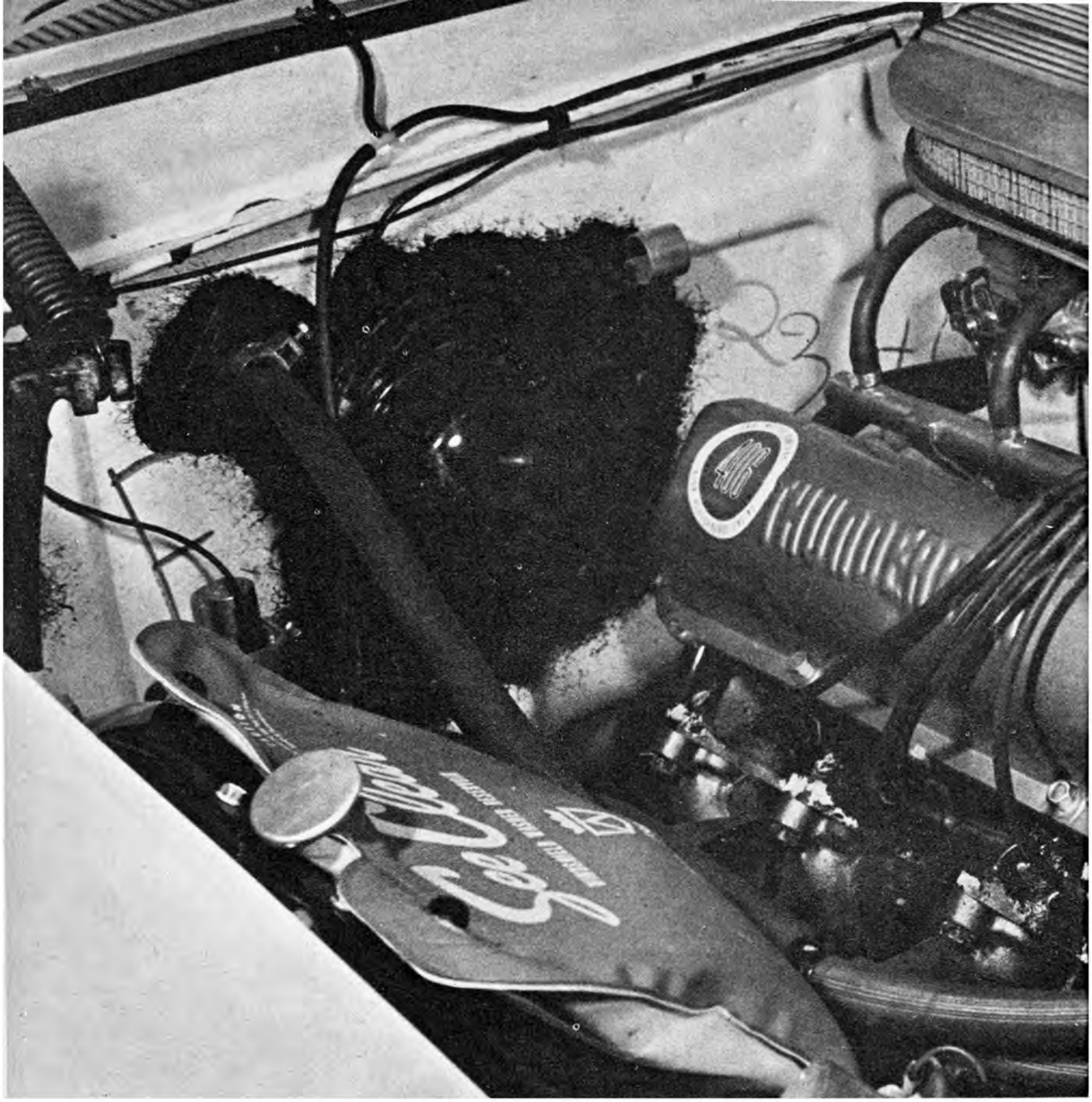
Shoulder at side of 406's oil pump houses long relief valve and spring set for 110 lbs/sq. in. New oil pick-up tube was made heavier.

BIGGEST and newest of the Ford engine lineup is a 406 cubic inch mill which puts out 405 horses at 5,800 rpm breathing through three two's. It also delivers a very respectable 448 lb/ft of torque at 3,500 rpm, which would prompt most people to think in terms of matching the 406 to Ford's new four-speed box. If you prefer the single four-barrel version, 385 horses come to life at 5,800 rpm while torque remains virtually the same, 444 lb/ft at 3,400 rpm. All of this is achieved on a very modest 10.9-to-1 compression ratio which is listed in Ford specs as nominal, meaning that the actual compression is less but may reach 10.9 with sufficient deposit buildup.

The 406 cubic inch mill has a 4.13-by-3.78 bore and stroke. This represents a ⅛-inch bore increase over the 390 cubic inch V8 that immediately precedes it in the Ford engine family. The block, itself, has been considerably reinforced by adding metal to critical areas such as the main bearing webs. The only engineering limitation on the addition of extra ribs and metal was the need to machine the 406 block on the same production lines as the 390.

When a mechanic wants to punch out a cylinder he thinks in terms of a few passes with a boring bar. If the original cylinder walls don't have enough excess metal, sleeves can save the job. A factory, on the other hand, must think in terms of providing adequate cylinder wall thickness from the outset. Thus the increase in bore size is achieved by changing the water jacket cores at the foundry to make room for bigger cylinders. Since one increase had already been made within the confines of this existing block when displacement rose from 352 to 390 cubic inches, the present increase must be viewed as something of a foundry miracle.

Ford engineering considers siamesed bores (where two cylinders stand together without a water gap) as poor practice, since it can lead to bore distortion and cooling problems. This house rule made it even more difficult to fit the 406 block with its



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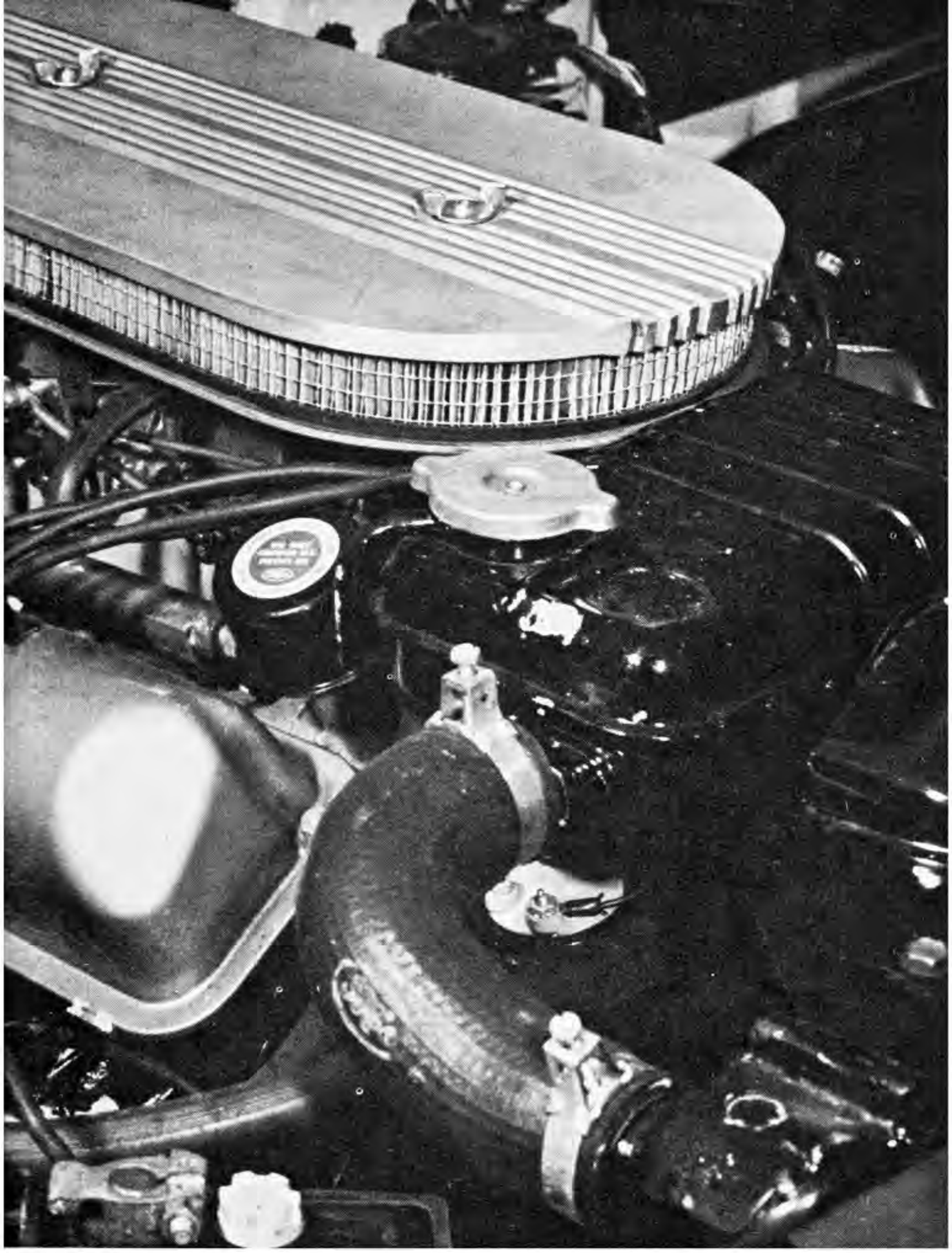

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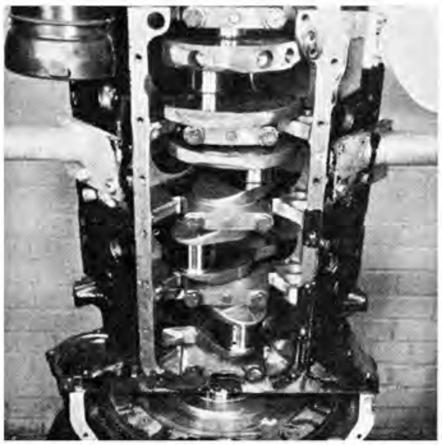

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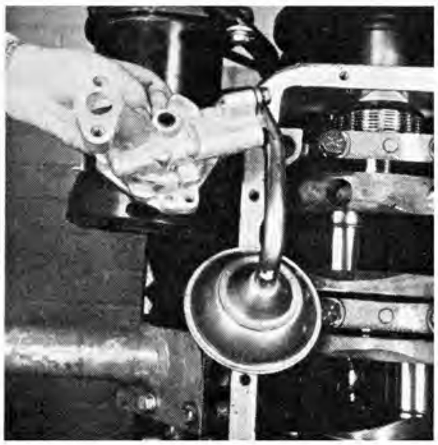


Shoulder at side of 406's oil pump houses long relief valve and spring set for 110 lbs/sq. in. New oil pickup tube was made heavier.

Flat-topped pistons, of steel strut type, are used in mill. Deck's just ½-inch wide between cylinders.

Rod at right, used in 406, has wider beam, 1/16-in. bigger rod bolts and longer nuts; is beefier all around.

Oil squirt groove at parting line of 406's cap was eliminated. Tapered bearing shells thin out for clearance.

Heavier true arc ring locks full floating pins. Pin length is controlled to avoid any "battering ram" effect.

bigger bores. Only the extreme accuracy of Ford's shell casting process made it possible to position and cast thinner wall cylinders and solve the problem. Even on the 390 engine, setting the boring bar over .080 inches was considered inadvisable, and on the new 406, .040 to .060 inches seems like the outer limit when reworking the engine.

While the passenger car connecting rod weighs from 25.25 to 25.68 ounces, the 406 rod tips the scales at 26.64 to 27.20 ounces. The web at the large end of the 406 rod is distinctly broader, hence more beam stiffness. Rod bolts are 1/16-inch bigger and the nuts are longer so that the rod may be torqued to 53-58 ft/lbs as opposed to 45 ft/lbs for the passenger car rods. High inertia stresses at peak rpm will cause the big end of any rod to deform and stretch, pulling in the sides. On the 406, the steel back, copper/lead bearing inserts have a tapering wall thickness and thin out toward the rod-parting faces. As a result, even when the "hoop" formed by the big bore is stretched the bearing sides still have adequate clearance.

On the 390, an oil squirt passage is provided by a groove through the shell and the rod-parting face. The 406 rods eliminate the squirt hole since, presumably, an engine "clearanced" for racing throws off more than enough oil to lubricate the cylinder walls. The caps, as on most Ford-made rods, are piloted by thick portions of the connecting rod bolt shanks.

Flat top pistons are used in the 406 and have been fitted with heavier Tru-Arc rings to retain their full floating pins. Also, the pin length is even more carefully controlled than on the 390 to avoid having the pin exert a battering ram action on the retaining clips. A glance at the piston will reveal a small step along the top land immediately above the oil ring. Another step is provided between the top and second lands. The steps simply provide extra clearance for expansion control, with the smallest diameter at the top and nearest the maximum heat. The piston-to-deck clearance has been increased to provide more stretch room between the piston and the cylinder head at very high rpm.

To balance out the increased piston and rod weights the crankshaft counterweights have been increased. Any crank has a critical speed at which torsional amplitudes can impose excess stress, or cause early failure. The stiffer the crank, the higher the rpm at which this condition occurs. As an additional means of controlling torsional vibration, the crank is fitted with a rubber-cushioned damper weight at the front. The rubber and weight oscillate out of phase with the crank, and as a combination they damp out each other's vibrations over the engine's normal operating range. On the 406, which is a revving engine despite its large displacement, the damper has been revised to push up the crank's critical speed.

Engine lubrication is pretty much a carryover from that of the 390 cubic inch High Performance engines. The oil pump is fitted with a 110-pound-per-square-inch relief valve. This is primarily to protect the oil filter from overloads during cold starts. When the longer, heavier spring was first introduced experimentally within the company, it would surge and break. The remedy was to modify the pump housing and make room for a longer spring, and to include a dashpot arrangement which damps out the valve action. A raised shoulder on the pump body accommodates the relief spring and offers a simple way to distinguish between stock and High Performance pumps. Located at the end of the main gallery farthest away from the pump is another relief valve which opens at 40-60 psi. This insures an adequate minimum pressure at the end cylinders, yet protects the oil

Combustion chamber at left is for High Performance 406, will fit 390 and 352 mills. Chamber's smaller.

Area around valves was opened, corners were smoothed. 406 head, left, allows much freer breathing than 390's.

Additional pressure relief valve added at end of main oil gallery opens at 50-60 psi, protects system.

Exhaust valve stems are same size and shape, but 406's, right, has hardened Silchrome top, won't wear.

system from overload.

The shallow section of the oil pan has been deepened to avoid backsplatter and allow a better flowout of the oil returning from the engine to the pump. This is essential to allow entrapped air bubbles to work out of the oil stream before they have a chance to enter the pump and cut down the effective oil supply to bearings and other vital parts. The deeper pan also lowers the level of the oil going past the crank, reducing whipping and foaming. A stripper baffle tack-welded to the shallow end of the pan is curved so as to shear off oil carried by the counterweights.

For race useage only, there is a special pan with a 7½ quart (as against the standard five-quart) capacity. This pan has a bustle bottom which you can duplicate from sheet metal if you feel a special need for it. It certainly offers no use on the drag strip. The oil sump pickup tube is much heavier this year, eliminating the need for a special brace. If you still insist on the bracket for rough track use, apply only local heat or the furnace braze holding the sump to the pipe may break and cause an air leak. One interesting sidelight is that the combination sisal and cotton oil filter used on Ford passenger cars is also favored among competition users.

The valve train has benefitted from just those attentions that keep your car running while a competitor starts pulling his hair out at the strip. We can begin with a cam that is induction-hardened to prevent lobe wear from developing. Valve timing, with .025-inch clearance set cold, is given at:

Intake opens 24° BTDC
Intake closes 72° ABDC
Duration 276°
Exhaust opens 72° BBDC
Exhaust closes 24° ATDC
Duration 276°

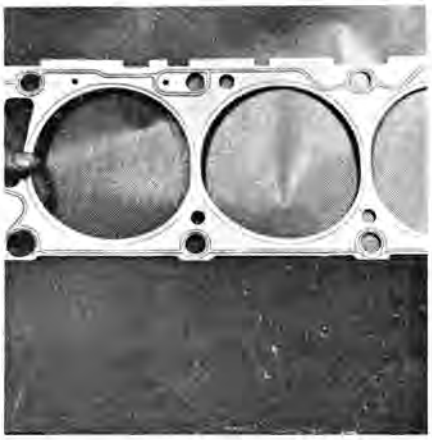
In actual practice, valve lash is set at .25 inches with the engine hot (warmed up for at least 30 minutes at 1,200 rpm). Since long ramps are likely to induce reading errors, Ford Engineering suggests that valve timing figures at .100-inch cam lift be used, using the following table:

Intake opens 15.1° ATDC
Intake closes 29.5° ABDC
Exhaust opens 32.9° BBDC
Exhaust closes 18.5° BTDC

Mechanical valve lifters, hefty push rods and adjustable rockers with 1.76-to-1 lift ratios are a carry-over from the 390 cubic inch High Performance engine. Exhaust valves, though of the same size as on the 390, promise much longer life. The stems now receive a coating of hard chrome applied by a special process to avoid hydrogen embrittlement. As a result, valve guide wear is negligible. Incidentally, more oil is now being delivered to the guide by dint of using a shorter umbrella seal on the exhaust valves. A Silchrome tip is butt-welded to the exhaust valve stem and hardened, extending rocker arm and clearance life.

Valve springs have the same design as on the 390, but are heat-treated under a compressive load. This results in pre-setting them and avoiding a loss of tension after a short period of initial operation. With good pieces in the valve train, the 406 has been run at an honest 7,400 rpm, a limit which certainly exceeds the peak power point. We might add that there is often a great deal of difference between honest rpm and the readings of an optimistic tach which has never been recalibrated over a season's running.

To fathom what happens in the 406 combustion chamber let's glance back a few years, to right about the time when Ford Motor Company was respectfully abiding by the AMA resolution and getting trimmed at drag strips and tracks by any of its competitors who cared to try. The upshot was a decision to soup up the 352. Just to make things interesting, the job was done "yesterday" and on a "budget." Among other improve-



New cylinder head gasket design includes flanged section that's double cylinder bore area's thickness. Beaded section seals oil passages.

Redesigned, heavier crank damper assembly and bigger generator pulley are featured. Water pump's impeller is cast. Three blades are available.

Exhaust headers are best single investment among 406 parts, will fit 352 and 390 mills. Exhaust pulses of cylinders 7 and 8 are separated.

Oil pan on 406 is deeper, has curved stripper section that shears oil off counterweights, directs it to pan. Curved baffle prevents oil-whipping.

ments there was a need to raise the compression ratio, and since domed pistons would require much extra development and cost, it was decided to simply change the contour of the combustion chamber, adding a few humps and protrusions to take up extra volume. This called for only a minor change in one pattern at the foundry and was promptly carried out. By the time the 390 came along, dished pistons were adopted to maintain the same compression ratio without having to change the head once again.

A mid-year change without fanfare brought flat top pistons to the 390 and the combustion chamber was smoothed-out considerably by grinding out protrusions and reshaping the head so as to unmask the valves. The 406 has benefitted from these changes, and now sports flat-top pistons plus some really free-breathing heads with generous clearance between valves and combustion chamber walls.

Maintaining an adequate seal between block and combustion chamber is not a new problem on any engine. However, on the 406 it became even more acute since the distance between cylinders is down to a mere ½-inch, which doesn't leave much room for the head gasket. Ford solved the problem with an ingenious head gasket that promises to come in handy on a number of applications over and above the 406. They modify a normal beaded steel construction by flanging over the area adjacent to the cylinder bores, making up a little more than a double thickness gasket. The remainder of the gasket is of single thickness and has a bead around its outer section to prevent coolant from leaking out of the engine. A separate bead seals off the oil transfer drillings to the head and rocker arms.

When the head is tightened, a high unit pressure sealing area is obtained around each bore due to the double thickness gasket material. The beaded section is squashed down at the outside of the gasket and the remainder of the gasket is water cooled. The water cooling has the advantage of removing heat from critical cylinder bore gasket areas, preventing burn-through. It would be extremely interesting to see a gasket of this type in operation on some of the free-standing-bore aluminum engines, where the blocks lack upper decks. Also, this type of gasket idea may be applicable to extreme sealing problems where copper ring inlays are now needed.

Ford engineering is quite unequivocal about its suggestion that the gasket be installed dry (the same recommendation applies to all of its High Performance engines). The surface against which the gasket bears is also quite important. Original finish is obtained by broaching at the factory, and is just rough enough to provide a good gripping surface at the gasket without creating voids that cause leaks. If you must cut the head, *don't* use a grinder. It produces too smooth a finish. Instead, we received the good advice to use a mill and a very slow tool feed to duplicate the desired head finish. This should insure that the head surface will have a good bite on the gasket.

Manifolding of the 406 follows the general Ford High Performance pattern. Long branch, cast iron exhaust headers, interchangeable with the 352 or the 390 High Performance mills, offer a morked power increase over the fairly restricted passenger car manifolds. A choice of three two's or

Special intake manifold gasket is available for blocking-off heat riser passage. This has effect of allowing a small gain in total horsepower.

On passenger version, water-heated aluminum pad sits under carb. HP mill has insulator pad. Small, wrapped mesh section prevents oil pullover.

Single-action fuel pump of 406 delivers 5-6 psi under load. Pump's arm has revised spring that follows cam better at high engine rpm's.

Dual braker distributor points are fitted with 28-30 oz. springs. Maximum advance is 13° at distributor, 26° at crank. Initial advance is 8°.

a single four-barrel on precision-cast aluminum manifolds is available. Overall performance and tractable street manners speak well in favor of the three two-barrel version.

Ford avoided most of its competitors' past mistakes by going to a progressive mechanical linkage on its three two-barrel manifold. Instead of the water-heated pad under the four-barrel of a stock 390, a heat insulating pad is used on the High Performance engine. Further power can be gained by substituting a High Performance intake manifold gasket which blocks off the exhaust crossover passages. This change is intended for drag strip use and a warm engine, since it certainly is not going to improve street or warm-up performance. Unlike the original manifold for three two-barrels which had equal height risers, the new ones are cut so that the carburetors are leveled instead of being angled back with the engine. It is very doubtful that one could detect any perceptible difference from this modification.

Four-barrel carbs tailored for the 406 flow 600 cubic feet per minute, have 1.250-inch primary venturii and 1.56-inch primary bores. Secondary venturii are 1.3212 inches and secondary bores measure 1.56 inches. On the three-two's (or 6V, as Ford calls them), the center carb acts as the primary and flows 310 cubic feet per minute, has a 1⅛-inch venturii and 1½-inch bores. The end carbs act as secondaries, flow 350 CFM, have 1 3/16-inch venturii and 1½-inch bores. All three carbs are fitted with acceleration pumps, but only the center one has a choke.

Vacuum advance is not used on the High Performance engine. The dual breaker unit has stood up well but some thoughts are in progress about getting rid of the unbalanced rotor in favor of one with a fantail. Balancing cannot be done by adding metal parts, but you can cement or fiberglass a balance weight into position. To minimize point bounce, spring pressure at the points is up to 28-30 ounces. Initial timing is eight degrees BTDC, crankshaft. Maximum distributor advance is 13 degrees distributor, or 26 degrees engine, which brings the total advance to 34 degrees maximum. If these figures do not agree with your spec sheet, it's because they are the latest poop. BF 32 Autolite plugs are used for normal and intermittent high speed driving. For prolonged high speed driving BTF 1 Autolite plugs are recommended.

A number of small but significant modifications put the frosting on the cake. A choice of three fans is available, six blades, unevenly spaced, with an 18-inch diameter; an 18-inch, four-blade fan, and, finally, a four-blade, 14-inch unit designed to relieve the engine of excess load at very high speeds. The small fan is also a handy item to have when struggling for space in an engine conversion. A fan clutch is optional and the water pump is fitted with a cast iron impeller instead of a plastic unit. Also, the number of blades has been reduced to cut down on cavitation. The fuel pump is of the single-action type (no vacuum) and delivers between 5½ and six psi under load. It is also fitted with a different return spring at the arm so that it can follow the cam at high rpm. The generator has an extra dust shield and a heavy duty adjusting bracket.

All that remains for you to do now is to get a 406 engine, preferably with a new car wrapped around it, and go out and win yourself trophies.