

396 version of yesterday's hot "Mystery" engine is available at last, with all the exciting pieces: big valves, high-flow ports, and up to 425 horsepower

BY ERIC DAHLQUIST/tech editor

Chevrolet's 427 engine that set Daytona on its ear in 1963 and was appropriately dubbed the "Mystery V8" because of the secrecy which enveloped the project has risen like the legendary phoenix from the ashes of GM's abandoned racing program to appear this year as a production option; albeit in less than all-out form. As most of you know from HRM's report two years ago (May 1963), the Chevys showed everyone the way around the track with 165.68 speeds during qualifications but didn't quite cut the mustard (the best finishing ninth) for the full 500-mile ordeal due to a variety of reasons, not the least of which was the fact that the front office put the lid on competition just prior to the race. And so it was that one of the most promising mills ever to see the heat of battle was laid to rest with the din of protest from Chevy fans still ringing in the air.

At the time when all these events transpired, we noted that it was a more-than-even-money bet that the so-called "mystery" design would turn up at some future date in Chevy's lineup, quite possibly within the next year. Well, we missed the mark by quite a few days but when word was passed along recently that a new engine was in the offing, anticipation was revived anew that the Daytona charger had returned. With all the necessary arrangements complete, we hopped the next great silver bird for Chevy Engineering to learn if our inclination was correct.

We knew, of course, even while turning up the wide driveway into the Corporation's spacious grounds at the ultra-modern GM Technical Center, that the non-racing policy still stood, so no matter what followed in the next few hours, no startling competition announcements would be forthcoming. Once inside the cloistered halls of Chevrolet Engineering, we were given the full scoop on the "new" engine and its applications, which went something like this: Named the Turbo-Jet 396, the mill will embody a 4.094-inch bore and 3.76-inch stroke which yields, as you might have intuited, 396 cubic inches. Lowest on the tuning totem pole, and for the full-sized sedan, will be the "street" version as it is termed by Chevy literature, a 325 horsepower engine (RPO L-35) that will ultimately replace the older 300 hp 327 and 340 hp 409 mills that have attracted a fair amount of attention over the years in their own right.

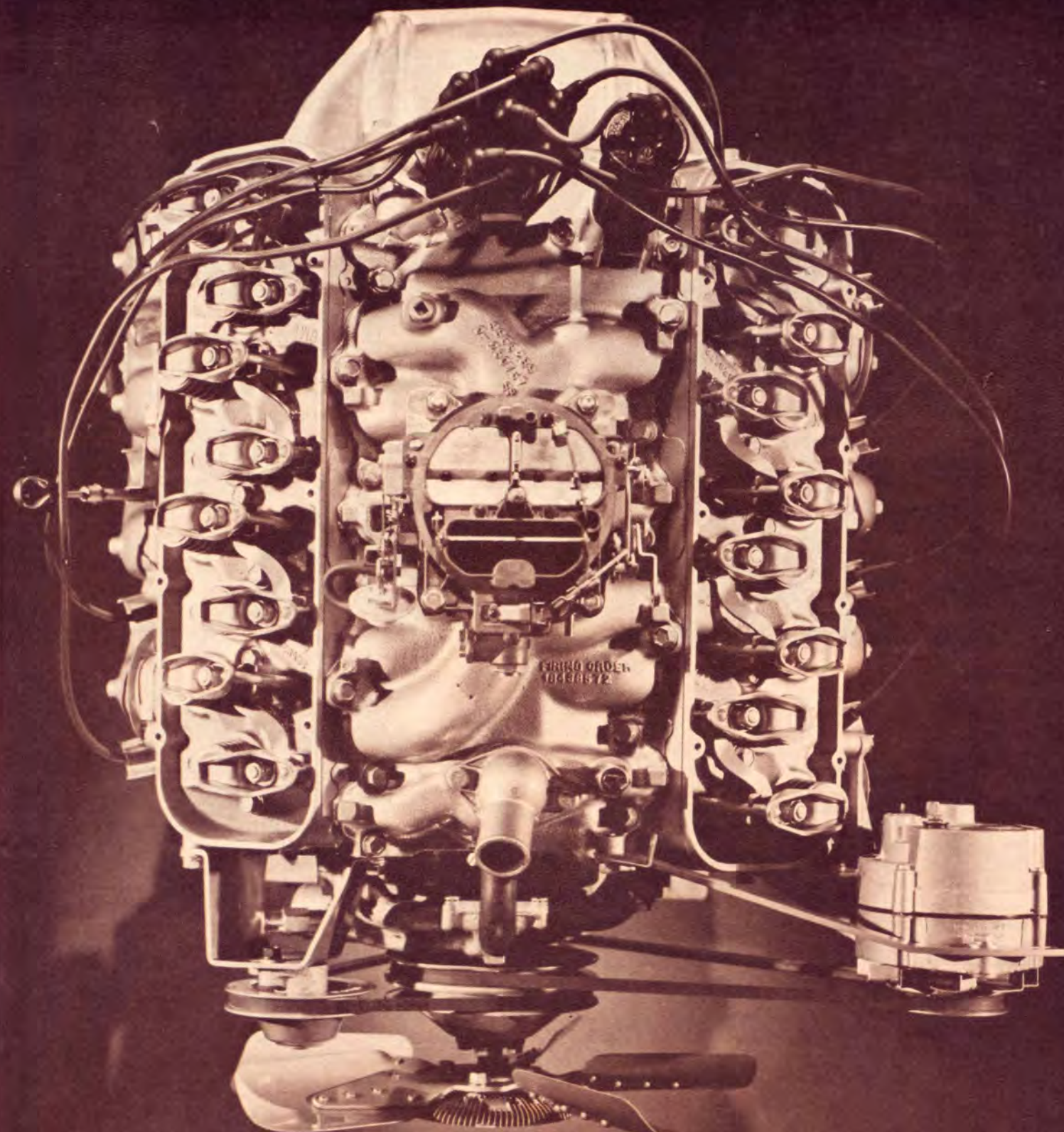
Next in order of succession is a 375 pony package (RPO-Z16) that winds up in extremely limited quantities dropped into certain Chevelles. Finally, last but certainly most interesting, is RPO L-78, which in layman's parlance means the 425 horsepower unit. This hustler takes over the spot formerly occupied by the 400 hp 409 and in certain cases will worm its way into the compartment confines of the Sting Ray, replacing the 365 hp carbureted 327. The FI 327 is retained. This engine will be offered with a single, large, four-barrel carburetor and solid lifters that enable a 6400 rpm power peak. If this proposed number of choices seems to offer great flexibility then the theme is carried on throughout the various components found on any particular engine of the three. As we press along from here on in, there will be some occasion to draw comparisons with the "mystery" engine of yore, so for purposes of clarification we'll simply refer to it as the M-427. Also, we shall be concerned primarily with the hottest of the 396's because it does after all represent a category close to our sphere of interest; and, besides, the engines are identical in many ways.

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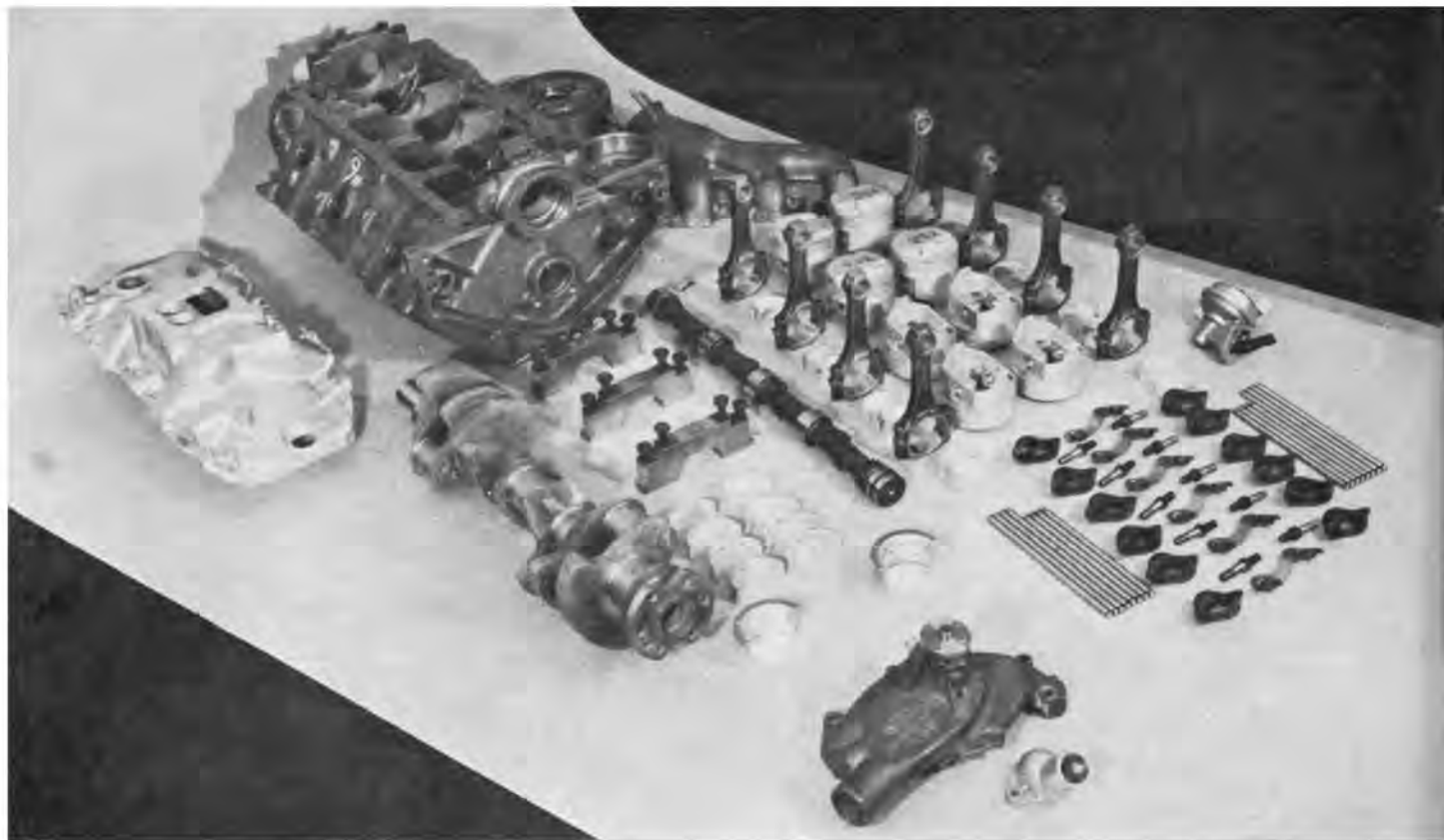


ABOVE—The unique rocker arm configuration incorporates the stamped steel guides to control push rod motion. Splayed valve arrangement is reflected by stem angle. Rocker studs screw in.

RIGHT—An eagle's-eye view of new 396 engine indicates that no space is wasted in layout. Manifold passages, or runners, are both short and as uncomplicated as possible. In addition, the structure is elevated so that the fuel/air mixture will "drop" quickly into large intake port.



CHEVY'S NEW FLYING WEDGE



CHEVY'S FLYING WEDGE *continued*

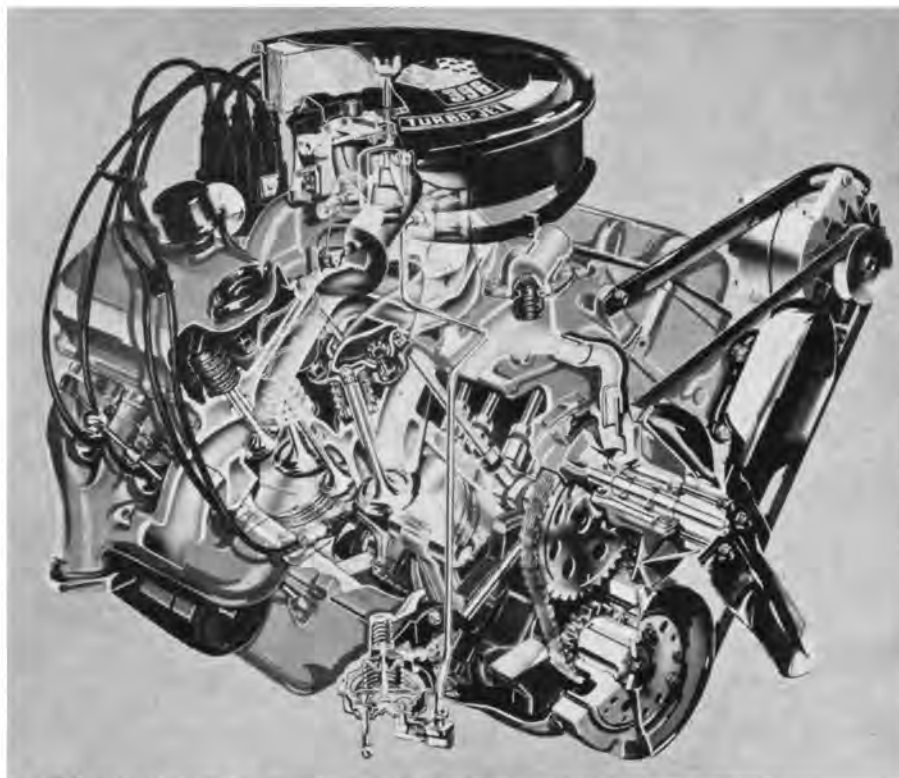
The first move we made was to latch onto a bare short-block to learn if any innovations had been incorporated in the last two years. Right off the bat, the beefiness of the lower end captured our attention, for the structure has been substantially strengthened by increasing the bulkhead cross-section above each main bearing support. The five main bearing caps continue the strong-song with more girth and a four-bolts-per-cap configuration. Reflecting on this point for a moment, we should qualify our observation by mentioning that only the 425 horsepower engines embody this multiple bolt feature. The cap screws for this have been selected from aircraft-quality stock, so they'll stand plenty of strain.

The secure clamping kick was designed to complement the fully-radiused forged steel crank that has undergone the Tuff-Tride process for an extra margin of fatigue resistance. Main journals feature cross-drilling to furnish rods a continuous supply of oil for 360° revolution. Elaborating a bit on the oil system design for a moment, we noted that from the pump, lubricant gushes down the main gallery on the lower left hand side of the block and then feeds directly to the upper main bearing inserts via a passage from the main gallery to a short passage between each main bore and cam journal bore. From here, pressure feeds the mains, then is routed by the cross-drilled journals to connecting rod journals where it is aided in flushing out by generously chamfered holes. The four front main bearings for this 425 are of the M-400 series with an extra $\frac{1}{10}$ -inch aluminum thickness. The rear main insert is steel-backed babbit. Journal diameter at 2.75-inch on the mains, while similar to the M-427, registers a ten percentage point gain in area over the 409 series. By the same token, the connecting rod bearing surface is up some 12 per cent through the use of a 2.20-inch diameter journal.

The rest of the actual block is nearly exact in resembling the M-427 with the head face perpendicular to the bore. The bore in the 396 is naturally quite a good deal less than before (4.093 vs. 4.312), but the combustion chamber in the heads, as we'll see later, remains unchanged except that the valves are slightly farther apart. This created the odd situation where, with the chamber bigger than the bore, the intake valve would have actually come in direct contact with the block surface. The only alternative was to remove the interference, so a small section of the offending bore edge was fly-cut away. This looks odd in the block but works admirably. Any future bore job of consequence will, of course, remove most of the machining.

Pistons come in two types: one for the normal street engine with a 10:1 compression ratio and the other an 11-to-1 job for the high-performance boys. The former is cast aluminum type of the autothermic slipper-skirt design where the pin bosses, with generously supported upper ribs, have been moved inboard to increase head strength without a corresponding gain in weight. At the same time, though the piston pin is measurably lighter, it is more rigid than before. In 425 horsepower tune, an impact extrusion or just plain forged piston is used, and again the design is identical to that which was just described and for the same reasons. Heat expansion control is accomplished by a barrel-contoured piston shape that does away with the often used long slots in the skirt beneath the oil rings. This posture bolsters head strength while causing the upper skirt to be more rigid.

Cylinder sealing chores are handled by two compression rings and one oil ring but the coating on normal application is chrome while the hotter one is molybdenum. The combination of coating and barrel-shaped contour in both types of the cast iron alloy rings comprises a triple bonus of excellence — compression seal, oil control and longevity.



ABOVE — Cutaway drawing of the 396 discloses the relation of various parts in the design. Notice how valves favor smooth flow passages.

ABOVE LEFT — Individual manifold, here in cast iron, offers some indication of the relative height. Flange design is for street models.

LEFT CENTER — By way of contrast to unit above, this manifold, struck from aluminum, incorporates high-performance flange design.

LEFT — Laid to the bare bones, Chevy block impresses the viewer with massive appearance. Four-bolt main caps come on 425 hp model.

OPPOSITE PAGE — For the avid do-it-yourself buff, these are all the parts, save for the addition of an extra exhaust manifold and carburetor, necessary to construct a complete high-performance "396."

So that possible weak links in the crank-piston assembly would be phased out, the connecting rods have undergone reinforcement in the high-stress areas by adding ribs between the flange and the bolt boss head. Additionally, the rod caps have been manufactured so that the balance weight material has more uniform distribution throughout the part. The 425-horse rods incorporate these improvements but go them one better by being specially manufactured from an alloy of greater tensile strength to accept the brunt of extreme high-speed operation.

The cylinder heads are, in spite of everything else, the singly most captivating concept of the 396 engine following the spectacular precedent of two years before. With the wide valve covers removed, for instance, the sight of the rocker arms resting slightly askew from common placement is almost unnerving if you haven't been exposed previously to the M-427. Chevy has used this approach, with each cylinder's intake and exhaust valves tilted away from one another in both axes to improve induction and exhausting of gases. Visualize, if you will, the intake valve tilted a few degrees toward the intake manifold edge of the head while the exhaust is just the opposite, favoring the exhaust manifold side. At the same time, the valves lean away from one another. The ramifications of this design are manifold, no pun intended. First, each valve in the combustion chamber

favors the port feeding it while opening away from the chamber and cylinder walls. Secondly, with valving arrangement as described, the ports don't require the usual sharp bend into, or conversely, out of, the combustion chamber, enabling a straighter and more uniformly large route. Although the "splayed" valve concept debuted in the M-427 and displayed exceptional promise, it has been altered slightly for the 396 in that the exhaust is a little less inclined and both valves have been spread outboard $\frac{1}{16}$ -inch more from the chamber center. This will provide a greater area between the two valves, enabling, one supposes, an adequate margin of leeway should the occasion arise to install larger valves. Sizing of the present units has been pegged at 2.190 inches on the intakes (2.065 on 325 and 375 hp versions) and 1.720 inches for the exhausts, a range which offers an excellent starting point for greater adventures.

Chevrolet changed its course of thought on where optimum combustion placement is because in the old 409 it was in the block and now it has moved into the head entirely. The elongated cavity is turned from the longitudinal head axis about 18 degrees and the actual shaping of the pocket provides a large quench area for quick-charge cooling with a near centrally located spark plug for fast flame travel. The long reach plugs are set in from the outside at an angle
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and, because they are close to the exhaust manifold, are surrounded by aluminum heat reflectors.

In the rocker arm department, we met some old familiar friends in the tried-and-true stamped steel versions that Chevy has used with such success since '55, though these new units are wider and stronger. This, incidentally, seemed one of the overall keynotes of the engine. It was just that there was a conscious attempt to leave no stone unturned toward the ends of longevity. With a working ratio of 1.7-to-1, and motivated by tubular steel pushrods whose ends are fitted with punctured ball bearings to pass upper lubrication oil, the assembly promises to be a high revver that will stay together for a while. Lifter action will be handled by hydraulics in the everyday engines and solids for the hot one. The pushrod guides, which were formerly found in cast iron form on the M-427, are now hardened steel but perform the same function, allowing fore and aft travel in relation to rocker arm motion while negating side movements.

Retaining the rockers on the head is the typical Chevy stud layout, though these are of screw-in design instead of the pressed-in type which invariably loosened under the force of valve float with higher tension valve springs. No chance of that here, though, because the studs have about an inch of $\frac{7}{16}$ -inch N. C. thread that turns down tightly into the head. And in view of the 303-327 pounds of spring pressure when open, the point is well taken.

Camshaft design is not anything too exotic in comparison with what's available over the counter these days. Lift is .497-inch, matching nicely with a total duration of 348°. In this area especially, a somewhat wilder grind would no doubt be of value in exploiting the engine's inherently good breathing characteristics.

One of the prime reasons why the old M-427 ran off and hid from the troops was its uniquely efficient intake manifold concept and it has been brought forward in its entirety to the 396. The design is of 180-degree type, with four-cylinder feed from each side of the carburetor in such fashion that any particular induction stroke is one-half full crankshaft rotation away from the next. The mixture path falls most directly through quite high "runners" into each intake port, ensuring maximum efficiency through a distinct lack of obstruction or bends. Atop this lofty perch, which will come in either aluminum or cast iron depending on engine class, three different carburetors have been provided for, all four-barrels. In the 325-horse range either a Holley or Rochester unit will be fitted. The Holley will have 1.562-inch primaries and secondaries and the Rochester 1.388-inch primaries with 2.25-inch secondaries. Holley is again used, this time as the sole choice, in the high-performance mill. It is an entirely different unit from the 325 hp with 1.686-inch primaries and secondaries. Despite what you might think, the most intriguing of the lot is not the hogged-out Holley but rather the Rochester of the first group that is a vastly improved design and, though space limitation forces us to forego a deep discussion, we promise a story on it in the near future.

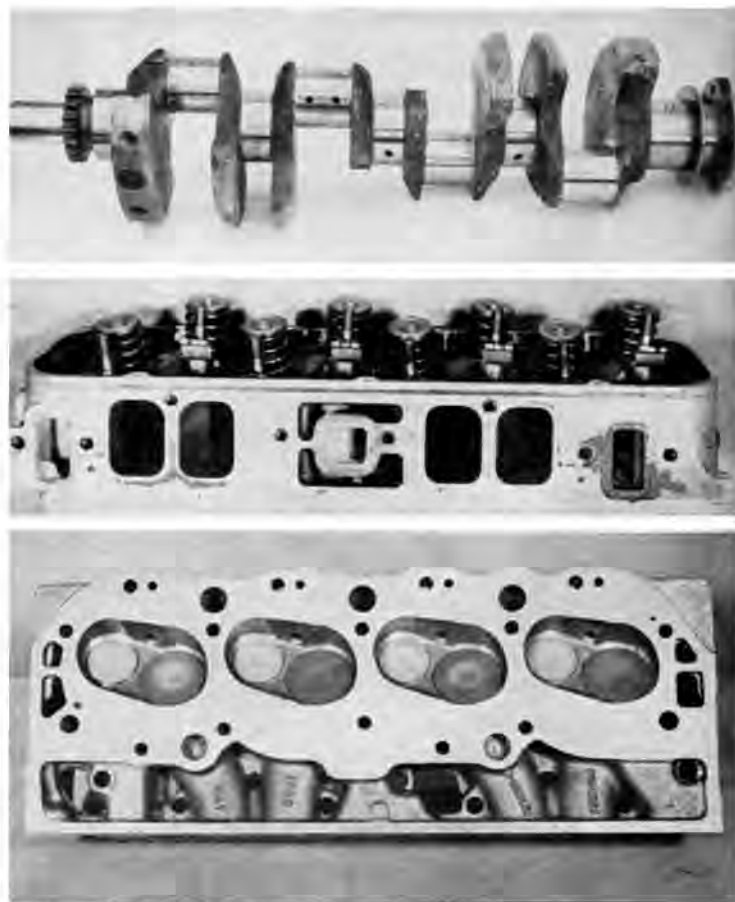
One part which rarely receives the attention it deserves but nonetheless rates in any case is the oil pump which usually functions unheralded in the bowels of the block. Chevrolet engineers, however, really got into the heart of things in the 396, for they sought to quell the forces which limit pump life and efficiency. In the normal pump it seems that oil pressure continually exerting force on the gears tends to cause abnormal wear characteristics. So a system, hydrostatically balancing the oil gear to relieve the "bending moment" ordinarily thrust upon the drive shaft, was designed. By a clever series of passages worked into the pump housing and base the high pressure of the pump's

outlet side and low pressure on the inlet are counter balanced around the gear. As a nostalgic note, the bottom pump plate is still secured by $\frac{1}{4}$ -inch "stove bolts."

Oil pan capacity is only four quarts for all engines except the Corvette, which is five. Drag enthusiasts who have already discovered that deeper pans keep the oil from sloshing up onto the crank, thus causing drag and correspondingly losing horsepower, will no doubt want to give it a quick section job to add some depth. Another oily note is that Corvette blocks will come with a place around the filter where two holes can be drilled out and tapped to accept oil cooler lines. By a little fancy footwork, engineers allowed for the possibility of hooking up the hoses by using the check valve from the standard Chevy "6" truck engine.

Still two other pumps, this time for fuel and water, have been the object of some careful attention. In order, the petrol pumper was given a shot in the arm by adding about 50 per cent additional capacity to maintain uniform fuel flow and decrease the likelihood of vapor lock. In the 396's the pressure to the carb will fall between $5\frac{1}{4}$ and $6\frac{1}{2}$ psi.

(Continued on page 108)



TOP — The forged steel crank, having undergone the Tuff-Tride process, is one of the Chevy bottom end highlights. Notice radiused journals and chamfered oil holes.

CENTER — The porting is generous, to say the least. This, combined with distinct lack of a passage obstruction, equals hp.

BOTTOM — Combustion chambers are 18 degrees off the longitudinal head axis and of the slightly modified wedge design. The spark plugs are nearly centrally located.



ABOVE — Forged aluminum piston incorporates three-ring design; two compression, one oil. The piston pins have been shortened, bosses moved inboard.



LEFT — The complete 396 valve train is displayed here in relative order of installation. Component parts are light throughout, contributing to high revs.

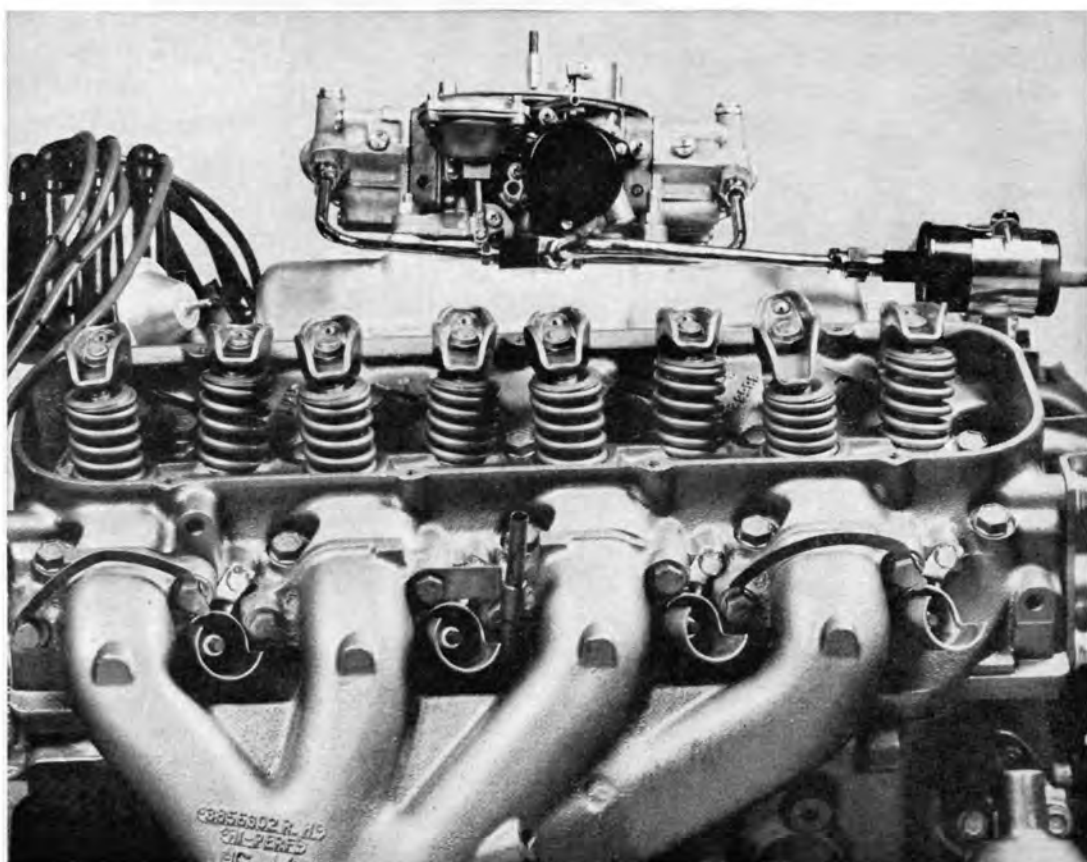
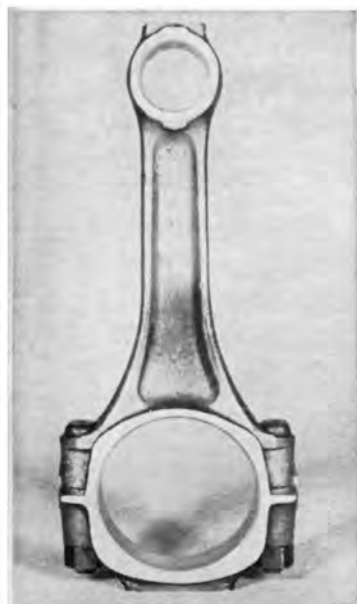
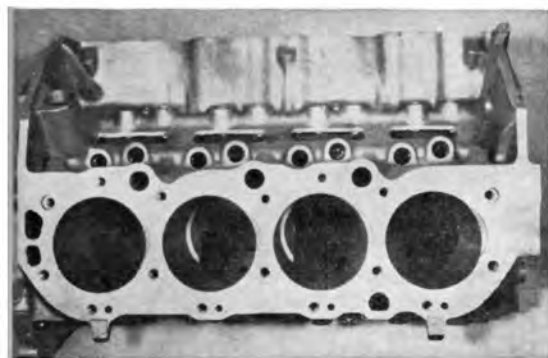
RIGHT — Stovebolt valves are sized at 2.190 inches for the intakes and 1.720 on exhausts. Intake specimen pictured here has undergone a swirl polishing.



CENTER LEFT — Looking down the bore, 4.094 inches worth, one notices the valve notches fly-cut in the block.

BOTTOM LEFT — High-performance con rod has noticeable beef over earlier counterparts. The bolt boss strength has been increased and bolts are now of aircraft quality. Also, the balance weight material is equally distributed.

BELOW — Unusual angular tilt of 396 valve setup is clearly indicated in direct side shot. Heat is deflected from plugs by utilizing aluminum shielding.





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CHEVY'S FLYING WEDGE

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One bugaboo that seemed to be Chevy's nemesis in '63 was the water pump, or rather lack of a durable one. This deficiency was taken care of by designing a unit that pumps more water but requires less effort to do it than, say, the 409. The pump is also the heart of a most thorough campaign to equalize cooling and minimize hot spots. Large passages between the cylinder bores will help prevent block distortion.

Distributor functions are provided by a not unusual unit with vacuum advance. Engineers indicated that a Delco breakerless transistor outfit (RPO K-66) would no doubt be of measurable value in continual top rpm operation. Since drag rules are very liberal about igniting the fire, numerous accessory models will probably vie with varying attraction once the engine becomes popularly available.

After examining all the data just presented, you're probably pondering the potential of the new 396 as far as competition capability. As you might have guessed when we mentioned that the combustion chamber is larger than the bore size, and in fact overlaps it, the engine can easily be hogged-out to 4¼ inches, thus producing the seemingly magical 427 cubes. But there is a word of caution with this message to be remembered. The 325 hp model cannot safely withstand the punchout program so the 425 is the block for big-bore battalions. And continuing, the stock cast iron exhaust manifolds, though they are relatively clean, obviously leave something to be desired because Chevy has listed with SCCA and FIA an optional header for Corvette. The snag here is that these will no doubt be hard to come by, being limited production and also, cast in iron, they're apt to be pretty weighty.

However, a ray of hope shines through the gloom. We got a close look at a set and made some rough measurements before they were tucked away. The individual pipes appear to be about 36 inches long from the manifold flange, 1½- to 2-inch inside diameter, and square off into a 4-inch collector that is close to 10 inches in length. Since pipe lengths and collectors were identical for both sides, we will make an educated guess that they are tuned for utmost performance. It would be a simple matter for the drag artist, or anyone else for that matter, to fashion a steel set for himself that would be lighter.

NEXT MONTH:

Road testing the 427 Ford Galaxie
with HRM Tech Editor Eric Dahlquist.
April issue on sale March 30.

When Chevrolet officials told us of the 375 hp 396 Chevelles, the low production figure sounded at first hearing like some kind of drag edition, since racing machines are usually offered in small batches like this. They're not. Rather, the cars will be plush buckets, gilded as much as possible to attract attention to the new 396. They also hinted that these combos would be quite expensive, so if the enthusiast desires his own 396 or larger Chevelle it would probably be just as easy and cheaper to build one.

It is taken as a matter of course that speed merchants will pump out a whole series of hop-up items, so with such things as dual four-barrel pots and exotic camshafts in the offing, the engine looks like a natural for the modified production class and especially match racing. We had a ride in a 396-equipped Sting Ray and, understated, it was anything but slow through the gears. It would be natural to anticipate that a bigger chunk of iron dropped into the "glasser" would make it prove to oversteer due to excessive front-end avoirdupois, but this is not the case and the car seems as roadworthy as ever. This notwithstanding, Chevy recognizes the fact that 396-inspired 'Vettes are not

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likely to overpower the Cobras in one grand swoop on the race circuits, though they'll probably give 'em a spirited run for the checkered flag.

Under NASCAR regulations, the 396 will be eligible to run, and in the full blossom of 427 inches at that. The M-427 of two years ago was putting out an estimated 500 horsepower and turning laps in the upper 160's. Since the new 396 high-performance already delivers 425 hp, it is not unreasonable to expect that with 31 additional cubes, a compression hike when the larger pistons are installed, a free-breathing exhaust system, plus a few tricks still up the tuner's sleeve, the engine will surpass its earlier cousin. These mills would have to participate installed in the full-size Chevy sedan but the smooth fastback shape is a definite advantage and the car isn't all that weighty.

There are a lot of ifs involved in the 396 as far as competition goes but "stove bolt" enthusiasts have never been found to let their passion remain too long out of the winner's circle. Who knows, this may be the beginning of yet another glorious chapter for the machine that runs with the pert bow-tie symbol. ■ ■

