INSIDE CHEVY'S SECRET ENGINES!

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CHEVY'S MOUSTACHE CURLERS

Knew all along, didn't you? And now Chevy pries the lid off their experimental engine box and everybody gets a look . . . including Ford, Chrysler, etc.

by Jim McFarland

Engineering time is a vital ingredient of any corporate effort. By time, we simply mean the technological edge that one corporate organization can achieve and hold on its competitors. Obtaining this position is a function of research and foresightedness, and without it, no major contemporary industry can compete with its rivals. Call the projects engineering exercises, special endeavors or whatever you like, they all boil themselves down to a common boundary: the gaining of advance information relative to a given product which will be built as a finished unit or utilized to obtain information applicable to a related product within the company. It's simply the current state of the art.

All major automotive concerns strive for progress, and looking at the record, Chevrolet seems to strive as earnestly as others. But as a hot rodder, you may find it somewhat frustrating as you pass your eyes over the next few paragraphs and discover for the first time in print (we believe!) that DOHC, SOHC, hemi and combinations of all these patterns have been built and evaluated by Chevrolet. The reason? Well, Chevy's major competitors have similar engine designs and do continuing research on them. So it simply would not make good sense commercially to ignore technical areas that others are exploiting.

It was explained that this does not necessarily mean any of these engines will go into production, and while we did not get very specific about this, we understand that experience with these "engineering exercise" engines always leads to refinements in Chevy's line-up of production equipment.

Of course, you can assume that when an "exercise" turns up a promising design, tooling and piece costs are investigated and a production decision (for or against) is made on the basis of cost versus market requirements.

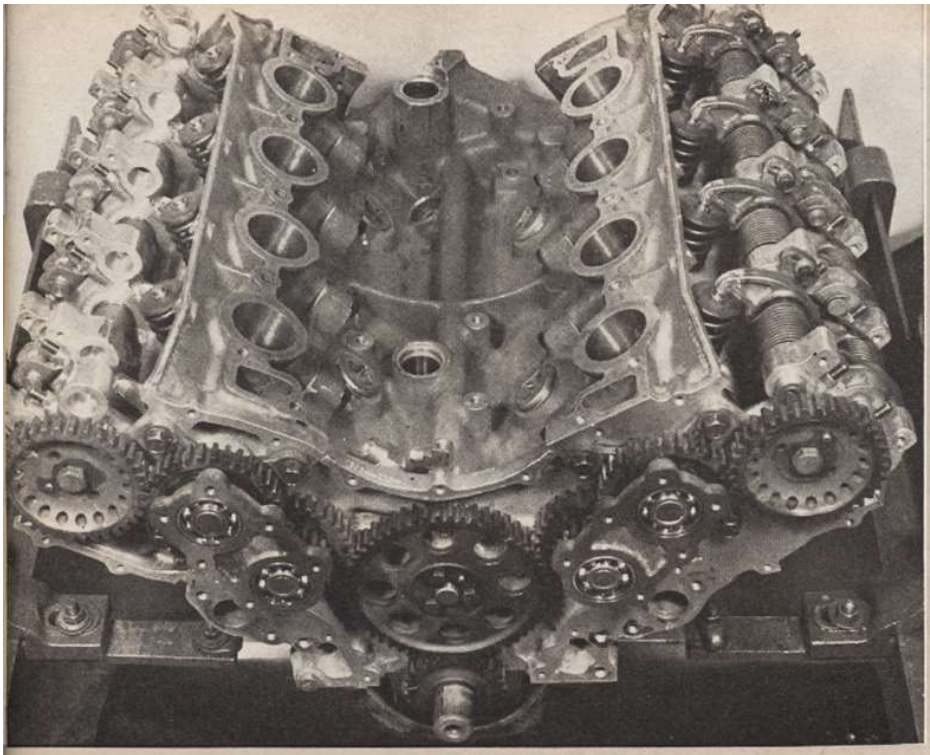
However, this point is academic here, for one of the engines to be discussed is ten years old, and time has already proven that the decisions made by Chevrolet regarding its engine programs have seemingly been in the right direction . . . even if they haven't included a DOHC or a SOHC engine type.

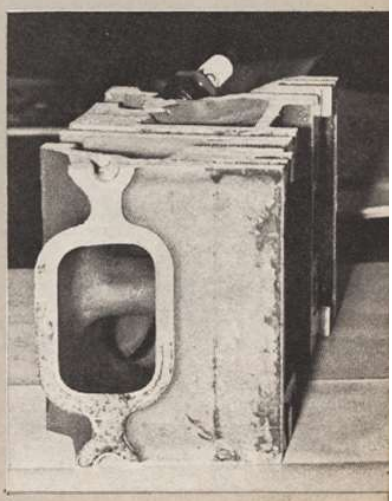
In any case, Chevrolet consented to let us examine with you some of their non-production engines. Many of the features of current experimental designs are based on engines and thinking of the type you will now discover. To better acquaint you with these processes, and to give you a look into the inner workings of special Chevy engine design, we approached Chevrolet Division of GM. A meeting with Zora Arkus-Duntov (who's a real friend of hot rodders, whether you know it or not) was arranged to get that look we've been promising. Here, we'll hand the mike to Zora.

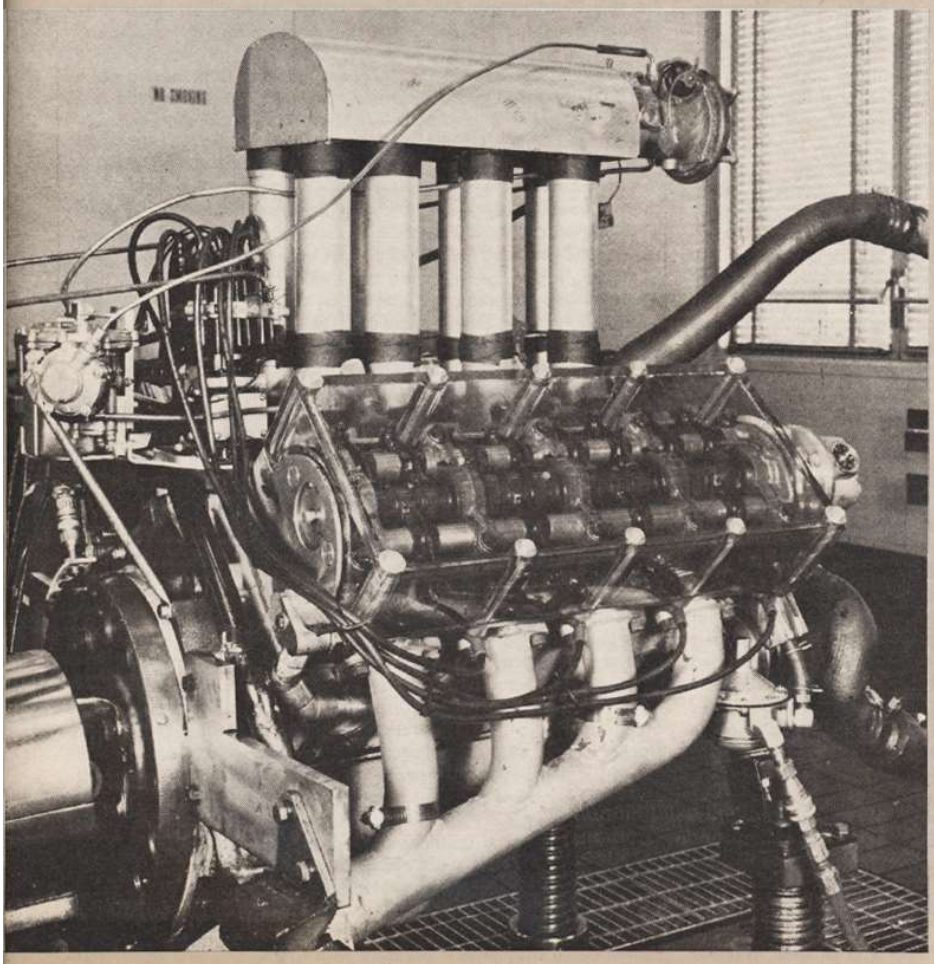
"First, I would like to point out that the exploratory engines under discussion represent only a fraction of Chevrolet engineering efforts in this area and are a partial output of the Corvette engine group. As in all our endeavors, the result is a product of a team effort with contributors on all levels and in all sectors of Chevrolet engineering activities. The engine we will now talk about was a high-performance SOHC unit designed as a bolt-on kit on the 283 block. Of course this engine was Corvette-oriented at the time (1957), and our practice was to make Corvette engines available in passenger cars.

"We felt the 'bolt-on' approach was important because in that form it would become really a hot rodder's dream, and in serving the hot rodders' needs, attraction of their imagination to Chevrolet could not help but increase Chevrolet's appeal to the more youthful segment of the population. Looking back, it did happen without this project becoming reality. Actually, 'youth market' is a very worn expression today, but very few thought about it constructively at that time. For purposes of this story, I will concentrate on explaining the reasoning and thinking behind the SOHC design, since I feel this to be more instructive than detailed description.

"Fortunately, more often than not we were on the same wave

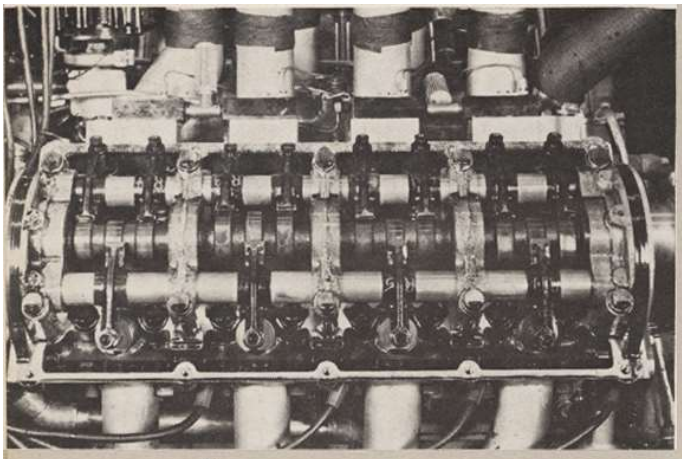


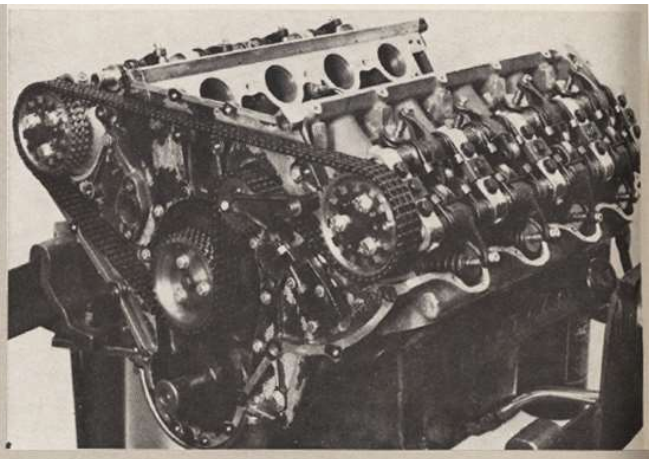




While Zora (opposite page) checks his notes on the engines we weren't permitted to show, you can examine the ones we could: 427 SOHC gear-driven valve train; 327 SOHC 3-valve with GM "hobby horse" fuel injection system (date 1961!); and a chopped section of the 3-valve head design, showing port-runner divider that separated each pair of intake passages. On the big-block engine, note method used to adjust gear train lash; pivotal gear arm designed to swing into camshaft sprocket. Valve lash adjustments on the same engine reveal a slotted ear and locking screw mounted on the rocker shaft (each one). Most all packages have been designed as bolt-on kits. If you study the big-block shot, you will recognize block.

photography: Chevrolet Photographic and Jim McFarland





If you'll look closely, you'll detect small holes located in each camshaft lobe. Actually, cams were hollow and carried lube to rockers via internal pressure. Base of operations was the 327-inch small-block. Chain-driven valve gear was a later version of the OHC design for little blocks. Chain lash was taken up by adjustment of threaded stop-screw (shown). Roller rockers.

CHEVY'S MOUSTACHE CURLERS

length with Ed Cole (General Manager of Chevrolet at that time and a brilliant engineering mind), and the project to explore the design was approved. In contrast to the other engines pictured here (all designed and developed later when Semon E. 'Bunkie' Knudsen, an MIT-trained engineer who succeeded E. N. Cole), the engine in question was first planned as a test unit rather than complete package ready for vehicle installation.

"It was natural that the first lines put on paper represented two-valve layout geometrically similar to Ardun Ford. However, they did not stay there long. Large intake valve and corresponding enormous port were aiming right at the existing cylinder head hold-down bolt. So we needed something more. I do not have a clear recollection as to when the idea of three-valve (two intake, one exhaust) occurred; possibly it was preconceived, but possibly by looking at the unwieldy divided port leading to a single intake valve, it appeared as the logical solution.

"However, I do remember the tinge of excitement, when after taking the first two decisions (one, the head to have three valves; two, the centerline of the combustion chamber to be offset from cylinder centerline), things began falling into place. We knew of three-valve designs where valves are parallel to cylinder axis, but three inclined valves were a novelty. Eventually, we found that offsetting the chamber from the centerline provided maximum space for intake valves without overriding cylinder bore. It also gave a modest 'squish' area."

The resulting combustion chamber consisted of one inclined plane, half a pent-roof (on the intake side) and a spherical hemi-hemisphere on the exhaust side. After the valve diameters were selected (dual 1.60-inch intakes and a single 1.63-inch exhaust), the resultant throat areas were 2.62 square inches and 1.44 square inches versus 2.02 and 1.18 for the stock 283 engine. The increase at the exhaust valve was moderate but felt to be adequate. Power outputs in the vicinity of 500 hp have been handled by this 1.60-inch valve on 327-inch engines.

"The exhaust port was designed as continually expanding up through the exhaust manifold mounting face with the diameter of 1.72 inches versus 1.44 diameter (equivalent area) of the current engine. Intake ports (in a plan view) were almost circumscribed by surrounding hold-down bolts, slightly divergent to reduce flow interference in the area where valve stems and guide bosses were adjacent to each other. Flow tests on plastic models indicated 60% higher flow capacity and subsequent flow tests on machined but not hand-reworked castings showed gains of 40%. It was felt that the heads would be produced in a conventional manner; i.e., with 40% increased flow capacity, and that individual owners could bring out maximum potential by hand-reworking the ports."

It can be noted that the hold-down bolt boss was used as the beginning of the port separator, creating two individual intake ports per cylinder.

At this stage, it was apparent the intake and exhaust systems would insure that a large quantity of mixture would be processed through the engine. The question then became: Would the mixture processing be efficient?

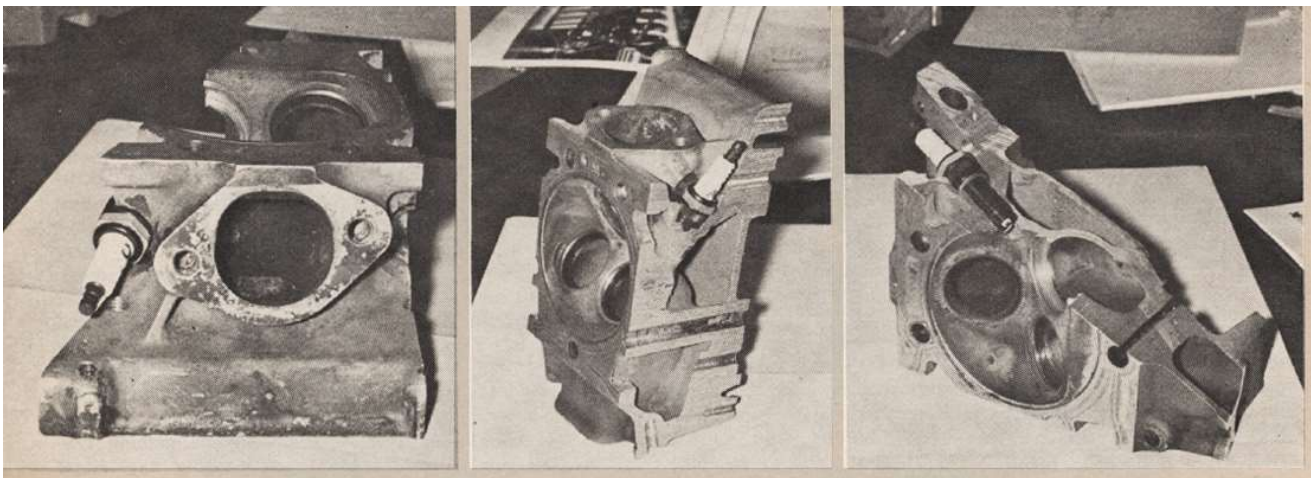
"There was reason for some concern. The intake flow would be slow, and unless the modest squish area was sufficient to induce turbulence, combustion would be slow and inefficient. Another area of concern directly related to the efficiency of combustion was spark plug location. For the induction system and the chamber type described, we felt spark plug location should be near the center so that flame travel could be shortened and combustion accelerated. A design with central location was explored where inclined spark plug was barely missing the camshaft and was impinging on the intake ports. Accessibility was poor and oil insulation projective tubes and related seals were required. Alternative location was adjacent to the exhaust valve. This provided design of lowest cost and best accessibility — the spark plug being in the open as on conventional engines.

"However, not willing to gamble on possible exhaust seat distortion, a water passage between the exhaust port and spark plug boss was incorporated, the plug being pushed farther away from the center. Actually, it landed in the corner of the chamber. Of course, there were examples of other extremely successful hemispherical two-valve engines which had the spark plug in the corner, but their cylinder bores were in the 2-inch-diameter range and ours was almost double that. We decided to take a calculated risk and gamble on a fundamentally wrong but practically desirable location in the hope that our squish-induced turbulence would overcome fundamental flame travel deficiencies."

Moving on to valve train mechanisms, you can see that there were not too many hesitations in the design decisions regarding camshaft location and valve gear elements.

"Camshaft rocker arms and rocker arm shafts were mounted as a subassembly on five bearings which would bolt to the head as a unit. Five bearings permitted selection of low-diameter shafts with justified expecting of stiffness and freedom of annoying deflections. Lubrication was through hollow camshafts with discharge holes on the base circle immediately preceding the ramps. Rocker shafts were tubes carrying oil to the rocker bearings. Of course, it can be questioned at this point why the roller was not selected instead of a curved follower on the cam-end of the rocker arm. Actually, for the anticipated lift curves, we did not recognize a distinct functional requirement for rollers, so as a simple solution, curved followers were selected.

"As straightforward as the design of the valve gear was, being designed for low-volume manufacturing simplicity, design of the camshaft drive mechanism presented many problems. It must be remembered that experimentation with timing belt drives was not



Chopped sections of 3-valve small-block head reveal some of the port layout used. Of particular note is the location of the spark plug. Hold-down bolting and pushrod locations dictated initial (which became final) position of plug. At the time of test program, special plugs had to be constructed; a feature that delayed partial completion of program. Mickey Thompson?

yet showing satisfactory results; therefore, the basic choices were chain gears or shafts with bevel gears."

From a design standpoint, it was fairly clear that even for low-volume, mass-produced engines, the cam drive should not demand new or costly manufacturing techniques; i.e., a mechanism unaffected by the existing manufacturing tolerances with regard to cylinder block deck height and cylinder head location. So the chain drive seemed to be the most natural answer. But applied to the OHC 283 engine (with the necessity of keeping water passages clear on the front face of the cylinder block), the chain drive looked neither simple nor very promising.

"The first drive unit was designed as a pre-assembled unit contained in a single casting which was bolted on in place of the normal timing gear cover. The drive went as follows: from crankshaft to the old camshaft (a unit which then served only as an oil pump and distributor drive) and from there via spiral bevel gears and shafts to the overhead camshafts. Torque to and from drive unit was transmitted by self-aligning short spline shafts so that manufacturing tolerances of cylinder case and head assembly could be handled.

"When the first test engine was run, the drive was not without considerable clatter. We found that cumulative clearances in the pre-assembled drive unit and the clearances in the self-aligning spline shafts were the source of the noise.

"After about ten hours of running (during oiling investigation), and during run-in preliminary to the first power run, the production-type chain from the crankshaft failed. As I recall, we were braced for a failure in one place or another of the drive train since the analysis of instantaneous forces, late in coming, showed potentially high levels of stress. So the design which followed was a cleaning up of the whole area."

Instead of the pre-assembled drive unit (desirable for "kit-type" installations), the gears in mesh became individually adjustable. In addition to this, they were solidly mounted on their respective shafts. The quill shaft was redesigned to carry splines in an effort to take care of minor clearance variations. Also, to improve reliability, the chain was replaced by gears in the drive from the crankshaft to the intermediate shaft, and quill shafts to the camshaft were speeded up by a 2:1 ratio — thus halving the torque.

"Although it is customary to associate two small valves instead of one big one (in terms of inertial and spring forces), as far as the drive elements saw it, this was a load increase. To reduce that, inlet valves were made of titanium, with a consequent reduction of spring forces and masses. The drive had somewhat lost the 'slap-on' quality and did not give any further test trouble. Valve opening and timing were those of our high-performance production camshaft."

To establish one "fixed point of departure," valve timing was based upon known data, reserving a more suitable design for a future time and after some background of test information was accumulated. Fuel induction was based on the system similar to the production fuel injection engine of that time. Nozzles were placed close to the ports, in conformance with then-current production practice, to provide quick engine response.

"The air induction system consisted of the long ram tube feeding into the ports, which you should recall were dual-passage

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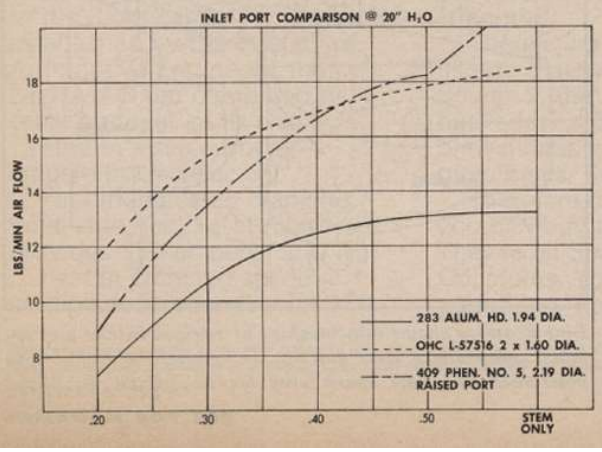
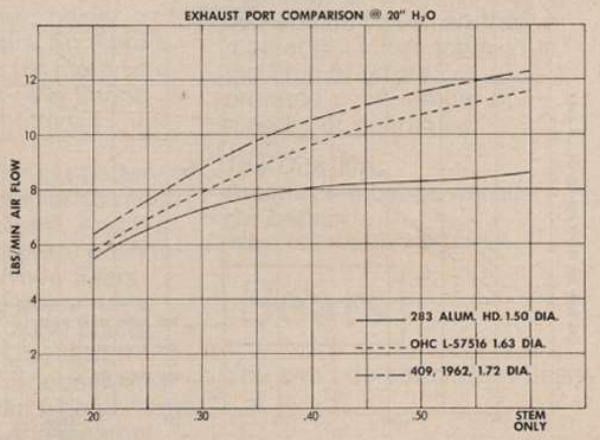




Spend a little time with these graphical plots. Note how port flow efficiencies are altered by improved port design. Small-block head flow is compared with OHC design (heat type shown) and that of early 409 engine heads. "Stem only" values indicate flow with the only port obstruction being that of the valve stem.

ports. Nozzles could be placed upstream, thus providing a homogeneous mixture. However, upstream location we knew would result in poor engine response during car operation. So, having placed two nozzles close to the port (similar to the production engine), we soon discovered that we don't need two nozzles, provided they discharge into the port and opposite the spark plug. Fuel discharge into the port (and not aimed at the spark plug) would cause the engine to run erratically or not at all.

"Study revealed that there was no mixture movement in the combustion chamber parallel to the longitudinal axis of the cylinder, and if somebody would set out to design an engine for stratified charge operation, this was obviously it.

"Having a highly combustible mixture in the vicinity of the spark plug did not result in short enough combustion times. The next move was to bring the spark plug more onto the combustion chamber surface. As it was, it was firing from the retracted position (sometimes called cartridge firing), and we did not know if this arrangement was bad, good or indifferent.

"Bringing spark point onto the surface resulted in considerable shortening of combustion time, reducing spark advance requirement from 50° BTDC to a very tolerable 40°. It began to appear at this point that at least as far as the high load operation was concerned, the gamble on a fundamentally wrong but practically desirable spark plug location had paid off. It is regrettable that development was stopped at this point, but the engine was competing for attention and dynamometer time with the projects of a much more pressing nature."

As a matter of fact, shortly after the project started, it was shelved for considerable time. After resumption, it was continued only on a "fill-in-time" basis. Power outputs were encouraging: 425 hp at 5800 rpm and 385 ft-lbs of torque at 5600 rpm. High-speed testing and subsequent power increases would have been carried out as the next step, but the project had to be postponed. As it turned out, the postponement became indefinite and the engine was scrapped . . . but not the ideas derived from the "exercise."

But it isn't all past history yet. "Yes, I regretted scrapping this engine, but we have had other projects to do." Indeed. One such "project" was concerned with the 327 SOHC engine you see pictured here. Notice the provisions for gear lash adjustment in the front-mounted gear towers. The small double-bearing flanges on each side of the dummy camshaft (actually, the drive gear) can be pivoted (as per the photo) in such a manner that proper gear clearance can be provided regardless of how much metal might be removed from head block surfaces or whatever the gear lash requirement might be. Slick, right?

Also, in the same picture, you might study the methods used for both rocker arm return assist (the torsion springs) and the provision for valve lash adjustment (the slotted ear located at the edge of each rocker and the ones through which pass a locking screw). The rockers in this design are mounted on an eccentric which rotates to provide valve lash adjustment. The locking screw holds the eccentric in position once the valve lash is set.

In the department of large-block engines, you'll probably be interested in the chain-drive, SOHC aluminum-headed version also among the photos. As another circular-ported head design, this package also incorporates a front-plate in which are housed the required drive sprockets and chainery. Notice the set of three sprockets mounted in front of the stock-located timing gear. In this particular array, chain lash is taken up by the manipulation of a swinging arm and sprocket package held in its adjusted position by a threaded shaft and locking nut. These heads also incorporate roller-tipped rocker arms and "helper" springs. You can draw your own conclusions regarding why more information is not at the moment available on these and other Duntov-oriented engine hardware. Just rest assured that the individual who's been providing much of the impetus toward their design remains with Chevrolet and that, as per our personality sketch of September '67, he seems to be gaining momentum with each passing day. Hope you'll pardon us for intruding; Zora was still talking.

"Power figures relating to some of the other engines are still pretty much a matter of confidence, but we like to think we have been getting something for our efforts. It takes time, and you must understand that we cannot hit the ball park right away. I can say, however, that we've seen well over 600 hp out of some of our big-block experimentation."

"Injected?"

"Yes."

"On gasoline?"

"Yes."

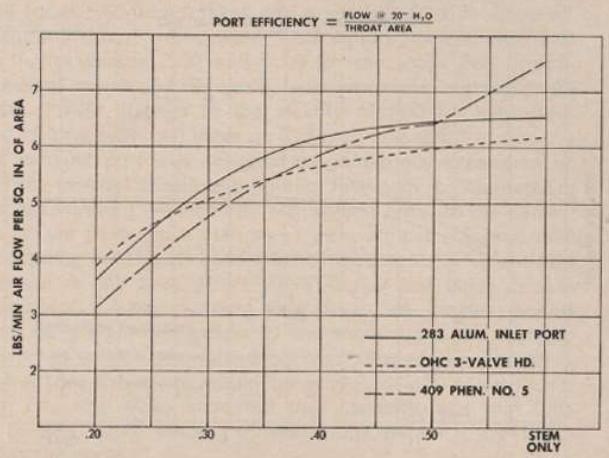
"That should be a sufficient answer right now. Incidentally, do you want to explain the model chamber I saw sitting on your desk this morning? It had what looked like the next step beyond the multi-valved engine you've been discussing."

"I'm afraid I'm not at liberty to discuss that right now."

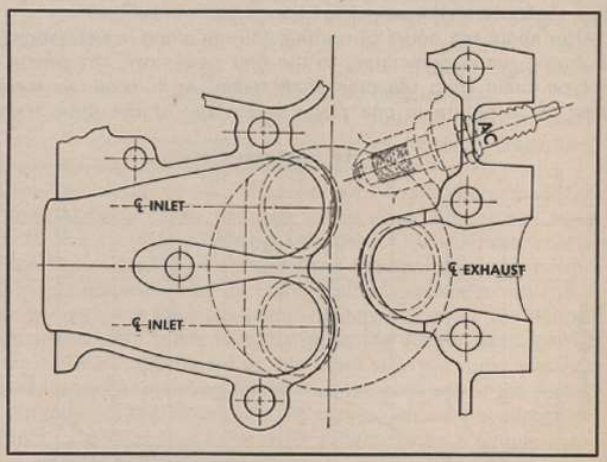
"Later, perhaps?"

"Perhaps."

What Ford-lover of two decades past would ever have thought it would come to this? ■■



A slight deviation from the graphs comparing ports, this chart shows comparison of porting efficiency in terms of air flow per square-inch of porting area. Admittedly, efficiency was down.



Line drawing shows relationships of various intake and exhaust components. Here you can see how intake divider was positioned and how spark plug location fitted in. Slick?

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