CHEVY'S 427 ALUMINUM "BETTER MOUSETRAP"

Gather 'round, Chevy lovers. Now it's all aluminum. Horsepower and rpm abound . . . "rat" now ☐ by Jim McFarland It all began in 1965 . . . well, 1961. At that time, Chevrolet called it the Z-11. Some people called it the "Mystery Engine," and later they called it the offshoot that produced the 348 "truck" engine. But now it really doesn't matter, for in keeping with their continuing series of "Z" engines, Chevrolet Division is pulling the wraps off their newest offering: the ZL-1. No, it isn't just a revamped L-88. Yes, it has an all-aluminum block. And no, Chevrolet wouldn't permit us to divulge exact power levels . . . but 625 from a single 4-bbl gasoline "consumer" is probably more than you'll see sprouting out of your neighbor's Rider-Mower. (And it's about 160 pounds lighter than its cast iron brother.)

With the cooperation of Chevy's Bill Polkinghorne (Chevrolet Engine Section) and GM's Stovebolt public relations dean Walter MacKenzie, we got the piece-by-piece treatment of this newest of Chevrolet engine offerings . . . sprinkled with a quick ride in an automatic-transmissioned (Turbohydro with "tricked" converter, throttle-body, etc., on which a near-future *Hot Rod* story is coming) 'Vette equipped with a painted-block ZL-1 engine. (And all those guys at the '69 Chevy preview thought it was an L-88. Forgot your pocket magnets, right, guys?) So here it all is: piece by piece, photo by photo.

By way of comparison with the '68 L-88 offerings, the cylinder heads represent a major design change. Port direction, cross-sectional area and contour have been subjected to alteration. The included line drawings and pics should serve as partial explanation, but we'll include a couple of additional points of interest.

Total mixture flow capability is up by almost 30%. ("We go for all we can get!") We said 20% in the captions, but we sometimes forget when caption-writing time comes. Directional characteristics of incoming flow is greatly enhanced by the removal of the sharp radius (of the L-88 heads) located at the mouth of the intake ports. This, added to the reshaping of the exhaust porting to a more nearly circular cross section and the filling in of some runner "pockets," is generally responsible for the aid to flow capability. Combustion chambers have also been altered to a so-called "open" design, bearing similarity to the earlier small-block

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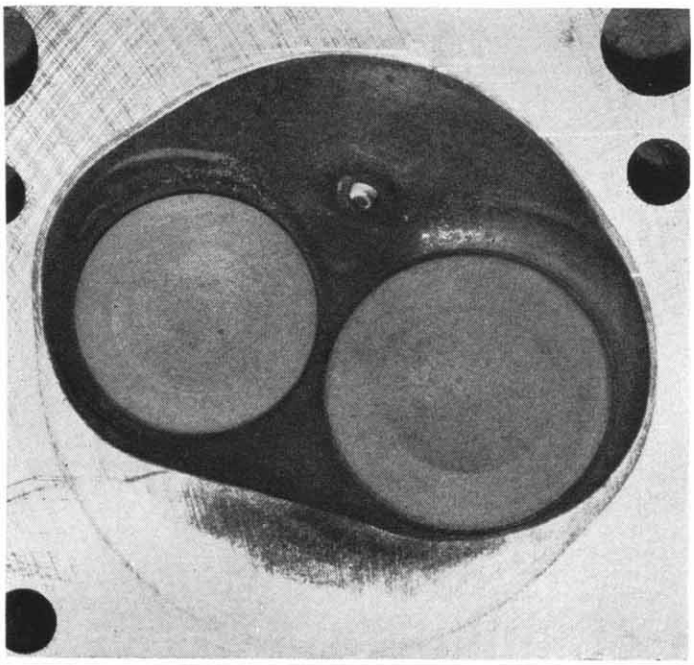
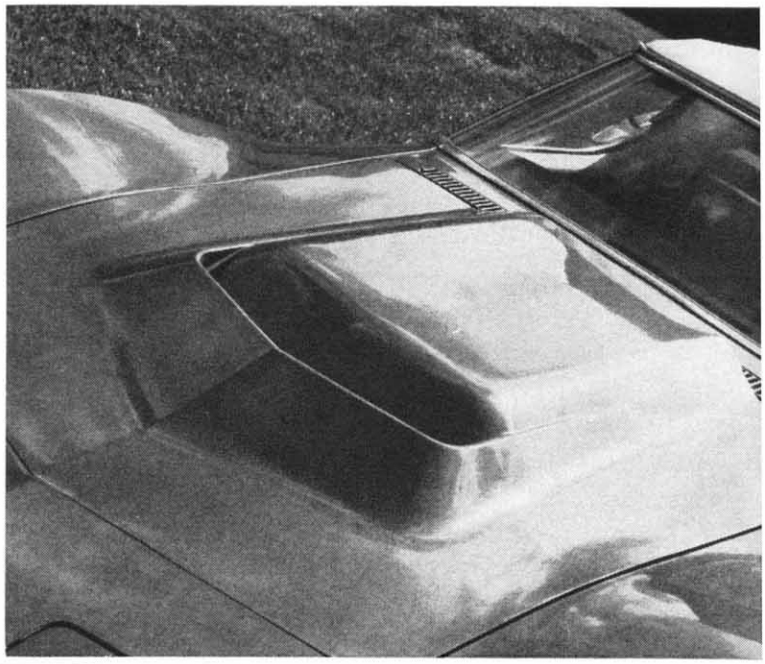
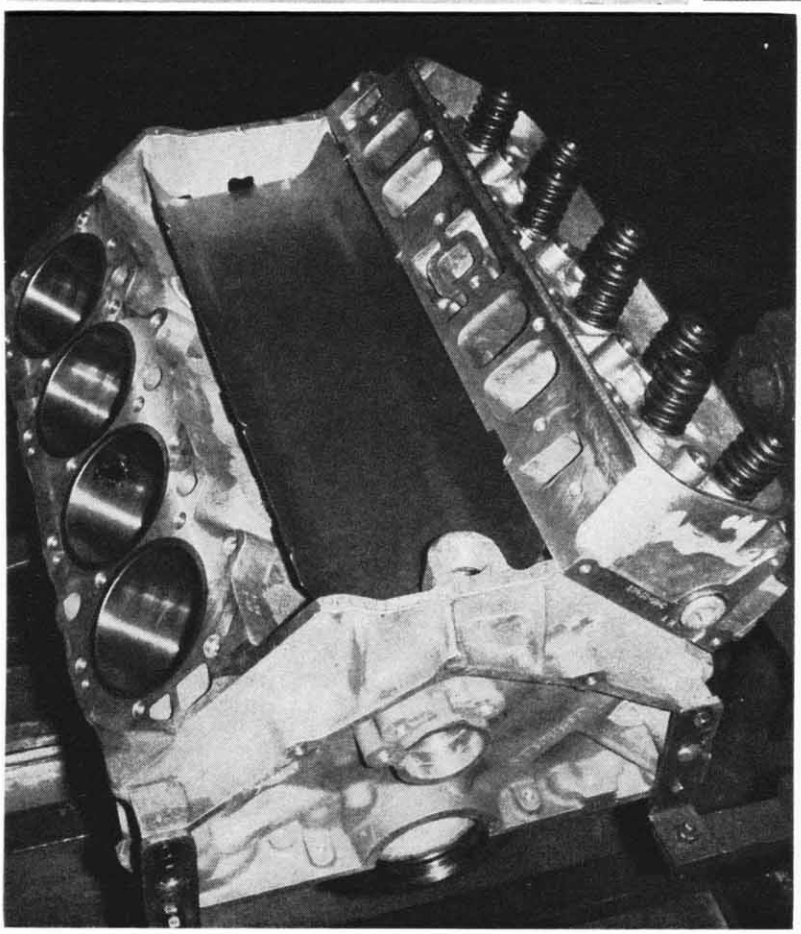
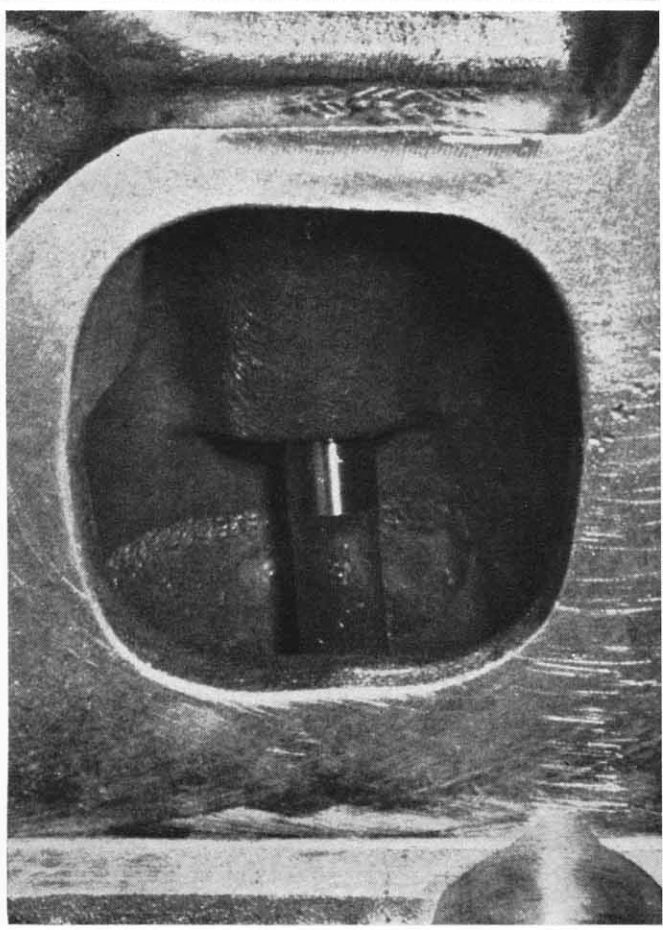
"Open chamber" heads are the new approach (in '69) to 427 combustion chamber design. As opposed to '68 L-88 pattern, spark plug area is opened up to resemble small-block head design. Total flow is improved measurably. New hood design is provided for forced-type induction (sealing ring and jam-type air cleaner aids maximum cylinder packing). Stamped splash tray and cylinder block/manifold heat transfer retarder is represented by thin-sheet oil gallery tray. Tray snaps into head-to-head dimension. Might be a wise selection for any big-block Chevy engine. Air flow routing is basic change from L-88 engine to ZL-1 design. Direction and aim are of vital importance to maximum volumetric efficiency values. It's claimed that ZL-1 head patterns have improved upon "old" L-88 air routing. New chamber design (of ZL-1) appears to provide less valve shrouding.









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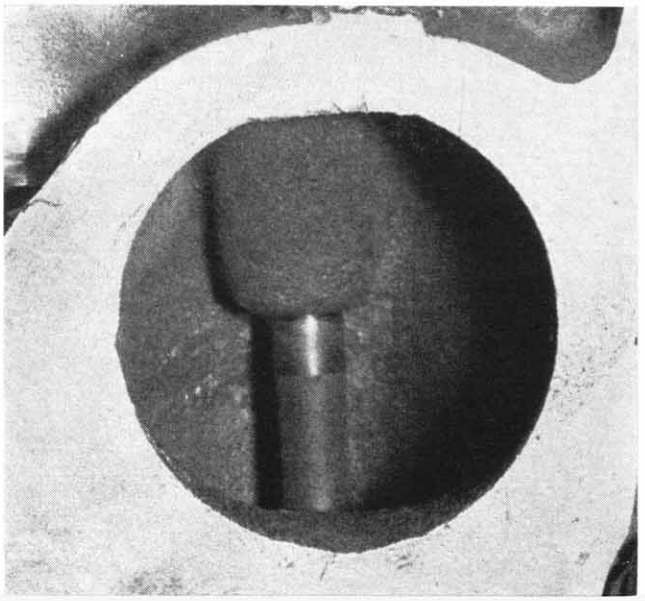
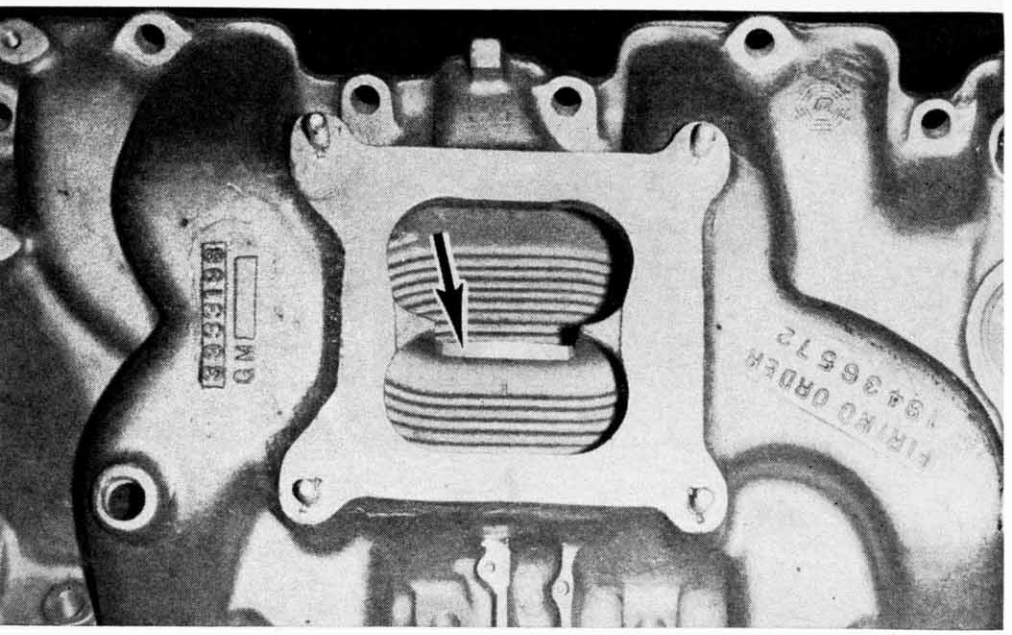
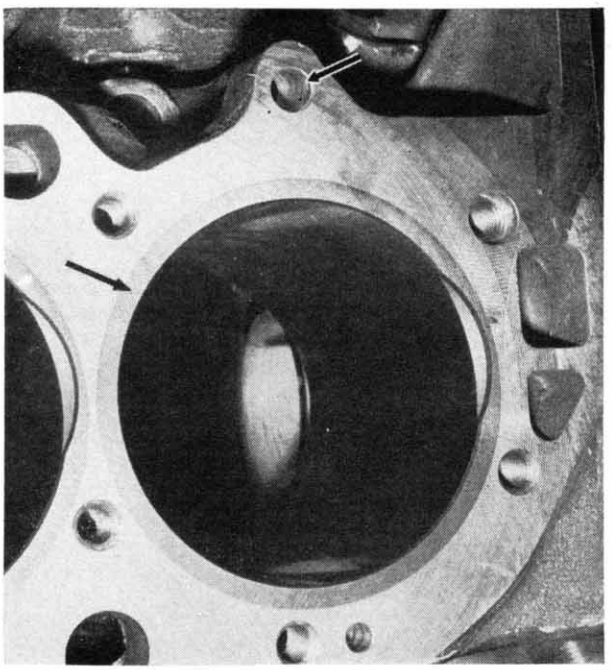






Exhaust port design is now circular. Maximum air flow is theoretically obtainable through circular port throat cross section. New ZL-1 heads are reportedly best yet from Chevy. Intake manifold sports removed section in plenum chamber. Drag racer's trick? Cylinders are fitted with liners, notched for required valve clearance. Two additional "ears" are provided on each side of head surfaces for added head-holding cap screws. Four-bolt main bearing caps are not cross-bolted, run with parallel cap-screw axes.

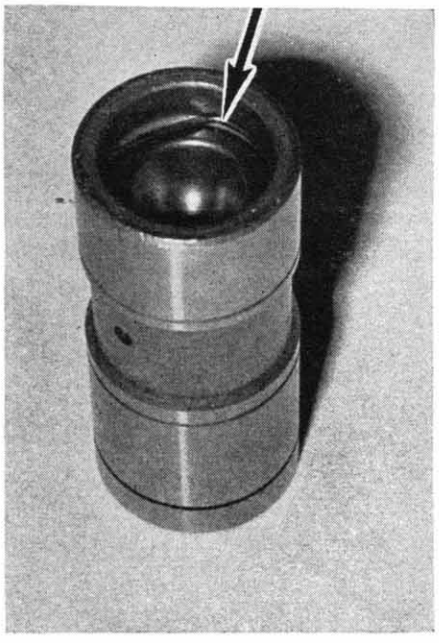
engine chamber patterns. Correspondingly, piston top shape has been changed to blend with the flattened chamber roof, providing a piston that resembles the '68 302-inch engine piston top. Quench area is moved slightly toward the spark plug, valve edges are somewhat more unshrouded and, in general, mixture flow across the top of the operating cylinder is improved. Volumetric efficiency goes up and so does gross horsepower.

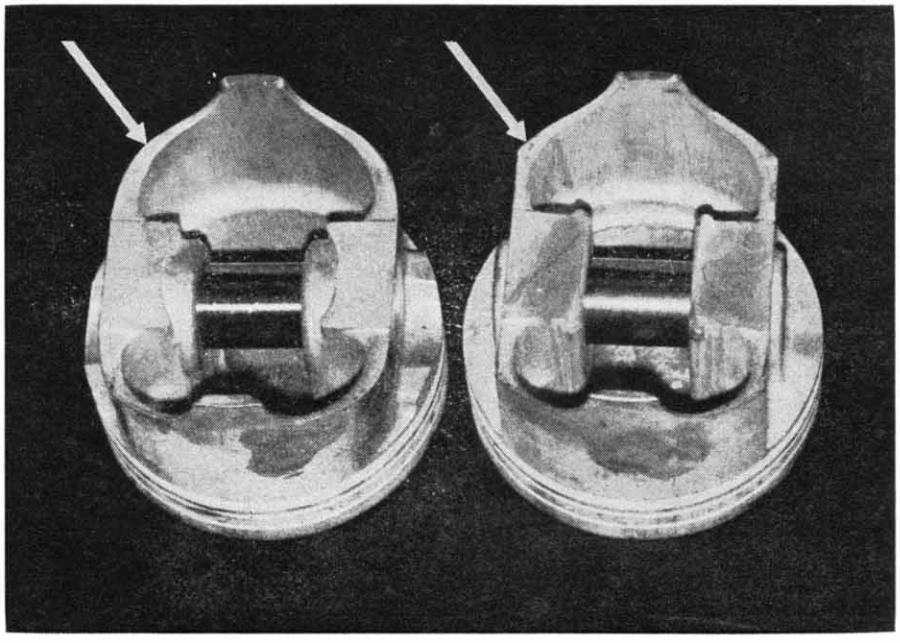
It's interesting to note that the present aluminum heads are fundamentally parallel in design to the cast iron heads offered for big-block Chevy engines of 1965. In fact, the two programs of development were running side-by-side at that time, despite the fact that the current head pattern was released only during the last couple of years. And even though the 396-inch engine was the largest available (in '65), work was progressing on the L-72 "street performance" engine from which performance service package parts were to be made available on an over-the-counter basis at local Chevy agencies. You may recall this effort as a 12.5:1 piston, performance camshaft package for the "Woodward Avenue-type set." In '66, the inlet valve size was increased to a 2.3-inch head size, exhaust went to a 1.84 head diameter, and subsequent testing revealed that the intake size produced best flow at 2.19 inches. Development continued until '67 when the aluminum heads were finally introduced. And according to Polkinghorne, manufacturing interpretations "in the aluminum head made it entirely different in the port area from the cast iron head."

Of course, as early as '66 the aluminum cylinder case was under research. Actually, the L-88 was an outgrowth of these exercises, continuing to the present ZL-1 form and incorporating quite a number of design refinements over the construction level of the L-88.

Not too well known is the fact that in 1966 there was a cast iron head produced which (although not made publicly available at any time) was slated to be offered for the entire big-block engine line. In terms of engineering design, it was then what the present ZL-1 head is today. Finally, at some point, design completion of the cast iron head initiated an aluminum duplicate, since all the bugs had been removed from the basic pattern of head. The only real change required in switching from the cast iron to aluminum units was in specific port configuration, due primarily to the fact that there was a degree of "chamber tilt" in the aluminum castings.

Valve size, by way of comparison with the L-88 engine, has been changed from the previous 2.19-inch intake and 1.84 exhaust to a 1.88-inch exhaust (intake valve head size remains unchanged). "The Mark engines have always been responsive to exhaust alterations," so this





BASIC CLEARANCES AND SPECIFICATIONS FOR ALUMINUM 427 ENGINE

Camshaft (L-88): Intake lift, 0.540, open 62° BTC, close 115° ABC, duration 364°; exhaust lift, 0.560, open 110° BBC, close 74° ATC, duration 357°; valve lash 0.022 (intake) 0.024 (exhaust) hot. (Duration specs in crank degrees.)

Camshaft (ZL-1): Intake lift, 0.560, open 64° BTC, close 114° ABC, duration 358°; exhaust lift 0.600, open 108° BBC, close 76° ATC, duration 364°; valve lash 0.022 (intake) 0.024 (exhaust) hot. (Duration specs in crank degrees.)

Header design: 2¼-inch o.d. tubing, 41 inches long, dumping to 23-inch collectors of 3½-inch o.d.

Rod bearing clearance: 0.002-0.003-inch with 0.015-0.025-inch side clearance.

Main bearing clearance: 0.002-0.003-inch with 0.005-0.007-inch of end-play.

Piston-to-bore clearance: 0.007-0.008-inch measured at the centerline of the wrist-pin hole and perpendicular to the pin axis.

Connecting rod torque loadings: 50-55 ft.-lbs. (65-70 ft.-lbs. for 7/16-inch rod bolts).

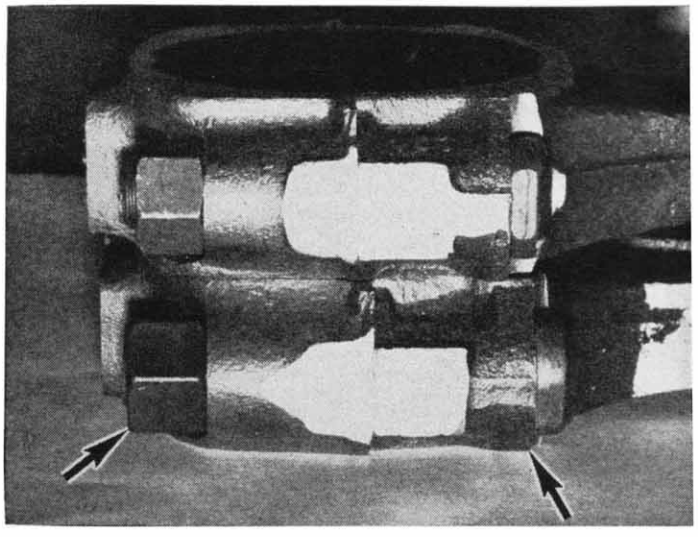
Spark advance: 14° initial advance with a total of 38°-42° at 3000-plus rpm.

Cylinder torque loadings: 65 ft.-lbs (short bolts), 75 ft.-lbs. (long bolts) with hardened steel washers (3899696) under all head bolts.

CHEVROLET ZL-1 427 ENGINE PARTS AND PARTS NUMBERS (Those fundamentally different from basic L-88 engine package)

Gasket, Cylinder Head	3935458
Shim, Valve Spring (0.065-inch-thick)	3891521
Valve Stem Key	3947880
Rod Assembly, Connecting (floating pin)	3959187
Bolt, Connecting Rod Cap	3959186
Shim, Valve Spring (0.015-inch-thick)	3875916
Retainer, Piston Floating Pin	3942423
Cooler Assembly, Oil (Thru-flow)	3013648
Camshaft Assembly (Chain-driven)	3959180
Rocker Arm (Long slot)	3959182
Pump Assembly, Oil	3963594
Manifold Assembly, Inlet	3947083
Valve Lifter (Improved pushrod retainer)	5232695
'69 L-88 Engine Assembly	3935499
'69 L-88 Short-block Engine Assembly	3958675
'69 ZL-1 Engine Assembly	3946061
'69 ZL-1 Cylinder Head Assembly	3946071
'69 ZL-1 Bare Head Assembly	3946072
'69 ZL-1 Piston Assembly	3947886
'66 L-88 and ZL-1 Fuel Pump Assembly	6440718

Among the several "hidden" refinements embedded in ZL-1 engine is this trick with valve lifter inner body retention. In the place of the semi-circular spring clip, a 360° clip substitution has been made. Also, new piston design resembles '68 302-inch engine pattern, with contoured skirt and beefier pin bosses. New connecting rod carries 7/16-inch bolting, longer bolt grip length and greater area bolt head landing area.



is one of the reasons behind the valve head size change. Oddly enough, this condition is "seen" from the combined standpoints of exhaust valve size, porting, exhaust system, and even camshaft design. As released, the L-88 engine incorporates a 0.540-inch inlet valve lift and a 0.560-inch exhaust. You may have noted in the spec chart that the ZL-1 engine carries a camshaft with 0.560-inch intake lift and 0.600-inch exhaust, a camshaft which will fit earlier big-block engines (including the L-88 which will continue to be in production).

And as a point of clarification, you might note that the ZL-1 is provided as an option on top of the L-88, much like the L-71 'Vette engine (cast iron 427 with triple carburetors) compares with the L-89 option. The L-89 version is simply the aluminum head option for the L-71, and the ZL-1 will be an aluminum cylinder block option for the L-88. No matter. They all seem to run like L-whatever, in excess of 600 horsepower . . . and with a single, gasoline-fed 4-bbl carburetor (an 850 cfm Holley).

At any rate, breathing capabilities have been improved and, in conjunction with attending design changes, the engine (ZL-1) can be considered a relatively high-torque-peak engine in the range of 5200 crankshaft rpm for maximum torque values, 6800-plus for horsepower peak. But by design, lower engine speed power has been retained so that the engine is still "something that can be used on the street." Just remember that this is a *production* engine (although somewhat limited), even though the Tonawanda Engine Plant has been most cooperative in overall quality control, specific parts inspection (on a 100 percent basis), and general enthusiasm concerning the production of a liveable engine that has a recognizable degree of "intestinal fortitude."

Working on down into the engine, there are several other items which represent departures from previous "Z" series engines. For example, crankshaft selection is closely controlled. Material is a treated SAE 5140, and the shaft is

(Continued on following page)

trimmed (in the area of counterweight swing-diameters) to fit inside the all-aluminum block. Connecting rods are heavier through the beam section and carry 7/16-inch rod bolting that lands on beefier and longer-grip-length shoulders. Full-floating pins are retained by spiral-type locking "washers."

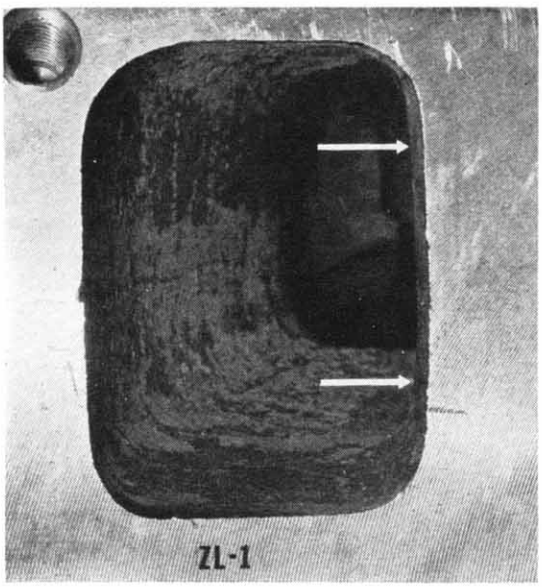
Valve lifters have been equipped with a 360° retainer clip (retention of the lifter's inner-body plunger) in the place of the earlier semi-circular retainer. There's a stamped steel oil galley cover that's intended to prevent heated oil from contacting the underside of the intake manifold (thus improving mixture density through prevention of higher-than-wanted internal manifold temperatures). Rocker arm slots (through which the rocker stud passes) have been slightly elongated to accommodate increased pivotal movement of the rockers used in conjunction with the 0.560/0.600 lift camshaft. The newest rocker now appears to be marked with the previously known stamping in the valve tip end of the rocker, covered by a dab of white paint.

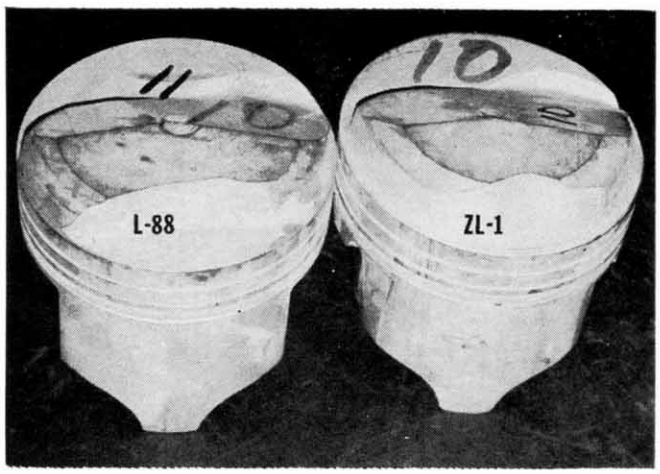
Head gasket design now incorporates a slightly raised area near the contact lip around the edge of the cylinder. In this fashion, a semblance of an O-ring effect is created (more gasket crush), solving the basic problem of cylinder sealing often caused by dissimilar cylinder block and head materials (not too critical in the ZL-1 engine since only the cylinder liners are of a non-aluminum metal). Actually, the current L-88 engine (cast iron block and aluminum heads) is sometimes more prone to have this ailment than the ZL-1, but the new gasket now appears to have solved the last few sealing difficulties, particularly when used with the short-bolt shims now being provided with the new gasket for the ZL-1 blocks.

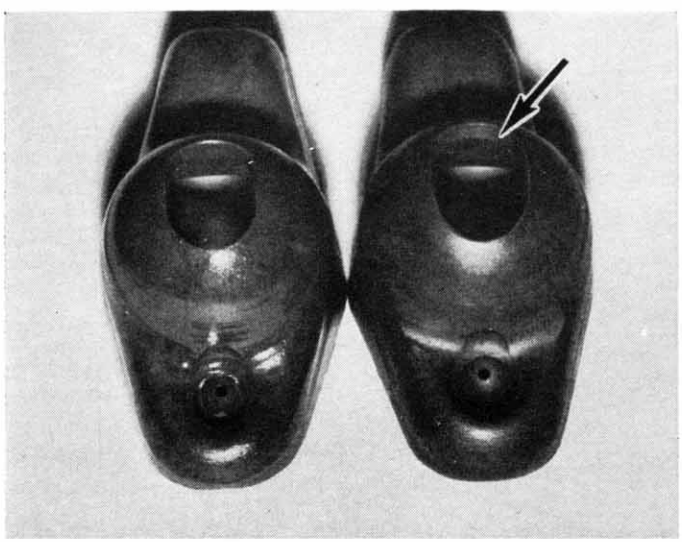
Piston design (especially the piston top) has been altered so that the ZL-1 piston now resembles the '68 302 unit. Reasoning behind the changes is stated to have been related to the prevention of skirt cracking, a problem of some of the L-88 slugs. The move to the open chamber design in the cylinder heads required additional piston top material to reinstate the 12.5:1 static compression ratio without increasing the overall weight of the piston. Consequently, considerable rework was required on the underside of the piston, and as a result, the finished ZL-1 unit weighs the same as its L-88 counterpart (767 grams now as compared to a high of 820 for early "Service Pak" engines). Pin bosses are also a bit beefier.

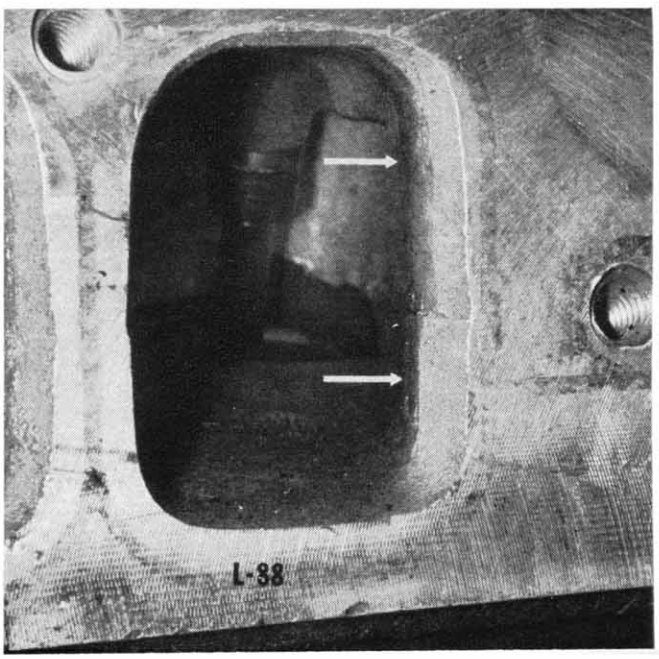
Of course, the 12.5 ratio is a relative thing. "We know we can get the most horsepower by decking." Actually, you need to go as far as possible without contacting the cylinder heads. On the cast iron blocks, this figure was about

New routing of intake port runners shows less-sharp radius of runner near intake mouth. As a result, incoming charge is aimed more nearly toward back of intake valve head, improving material break-up of mixture and aiding total volume of flow into cylinder. Cross-sectional area is also larger than L-88 aluminum heads. Open-chamber combustion chamber design requires piston-top shape change. Bump is moved nearer to the spark plug area, reducing quench area, improving flame travel and control. Ultra-high-lift camshaft profile of ZL-1 engine requires lengthening of rocker arm stud slot, since extreme lift generated would bind stock L-88 rocker. Newest of all markings on rocker arms is on ZL-1 rockers and is a dot of white paint located on the valve cover side of the rocker and at the valve top end. Rockers are heat-treated.









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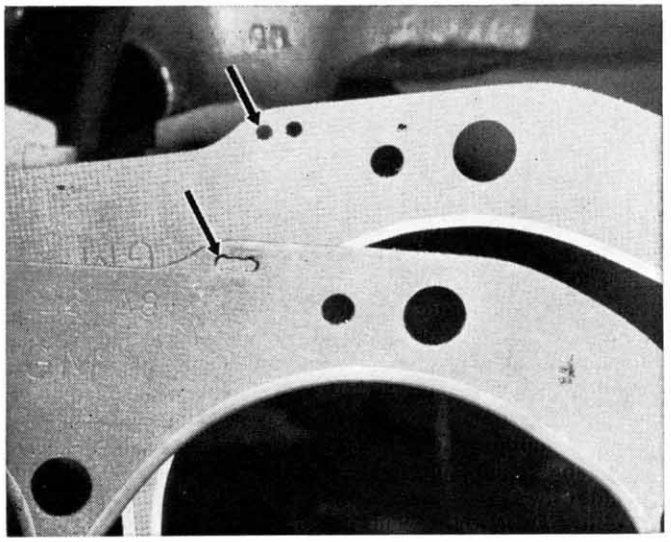
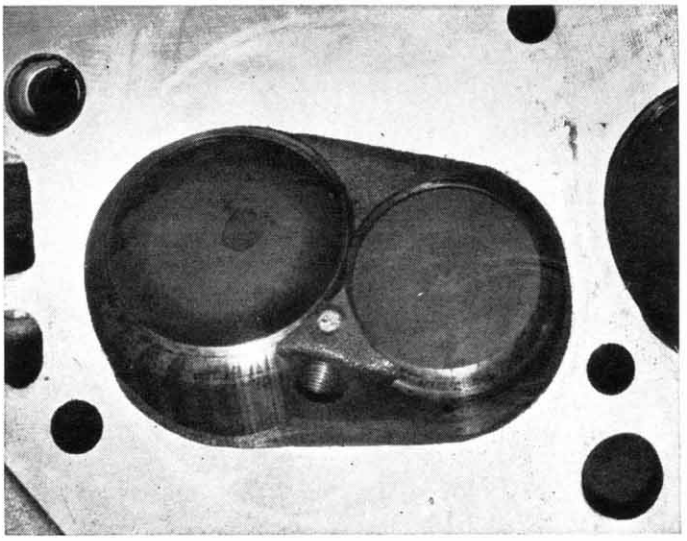




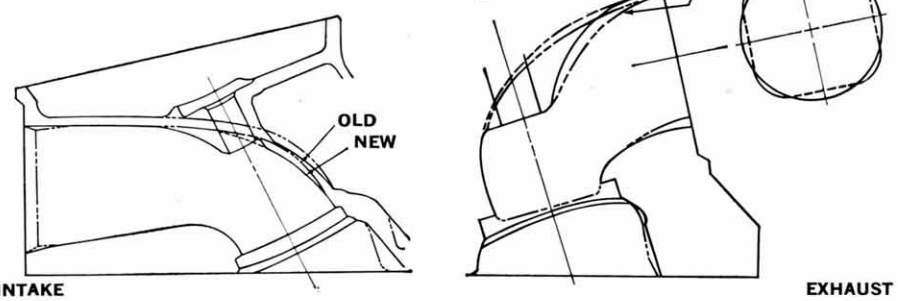
zero deck clearance (height). Graphical plots of compression ratio vs. deck clearance indicate that this is a reasonable figure for the aluminum blocks, with the factory specified value of 12.5 not obtainable until decking operations put the clearance at or near zero. If you begin trimming, make certain that you follow along with sensible and frequent clearance checks that will compensate for rod stretch and head movement during high rpm operation, bearing clearance take-up, gasket stack, etc. Nominal production deck clearance will run near 0.25-inch, so at least you have a starting place. Just make certain that you know *exactly* which head gasket will be used before the block-cutting business begins. For example, the newest gasket being used with the ZL-1 is about 0.010-inch thicker than the previous (L-88) material, so a double-check is a sensible move to make before the machinery goes to work. The factory suggestion is that you maintain a finished, everything-installed air gap of about 0.035-inch between the closest points of head and piston top.

Fillet radii at the end of each rod bearing journal are increased for improved oil volume and pressure control and there is a parting chamfer at the junction of upper and lower rod cap halves (a cut which is designed to remove any rod material smear caused by unidirectional grinding of the rod/cap which could later lead to improper bearing fit and crush).

Intake manifolding is changed very little from that of the L-88. And except for the streamlining of the intake runners (inside the cylinder heads), few changes have been made in the overall induction system, in comparison with the basic L-88. In fact, the usual laws of "Chevrolet parts interchangeability" prevail between the L-88 and ZL-1 engines. For example, you could slap the ZL-1 heads onto an L-88 short-block assembly and can, with no attending changes or compensation for the approximate 1.0 drop in compression ratio, expect about a 20-horsepower gain. Of course, of prime importance is some form of performance-type exhaust system, but when you consider that horsepower by this amount was *gained* despite the loss of static compression ratio, you can see that *something* must be right with the new head pattern. Possibly you heard that the L-88 aluminum heads weren't exactly what Chevy designers had hoped they would be, but the ZL-1 versions would appear to have found the mark.

Two new head gaskets are available for big-block engines. One is denoted by a double-dot pattern, the other by an elongated hole. Both indicators are located on a tab extension of the gasket and can be spotted with the gasket installed on the engine. A slightly raised bead around the cylinder sealing lip gives somewhat of an O-ring effect. "Old" L-88 combustion chamber shows "closed chamber" comparison with ZL-1 '69 heads.

So there's a new "bolt in the stove." Lending authority to the entire developmental program are four new "durability cycles" which have been devised to abuse new engine pieces. One simulates a sports car course, one a basic road course, another a drag course, and one a street type environment. Upshifts, downshifts, partial- and full-load conditions, deliberate missed gear cycles . . . the works. And although numerous small- and big-block engine exercises have been programmed through this type of test facility, it has been from these evaluations that a majority of the refinements incorporated in the ZL-1 have come. Of course, Ford pulled this trick a few years ago when they put their 427 Le Mans engines through simulated "race cycles" prior to bagging the '66 event. And Chrysler's inertial wheel dyno (which closely matched a quarter-mile drag run) was used in the development of blown fuel hemi engines as far back as 1965. But it's interesting to note that this approach has been expanded to include "street type" conditions. Nevertheless, the ZL-1 makes a rapid street unit. And with the inclusion of an automatic as a dealer option (not *for* the dealer, *from* him), you may still be able to pass the combination off as a painted 375-horse 396 . . . till you fire it up. Suddenly it isn't 1965 anymore. ■ ■



Line drawings show graphical differences between L-88 port runner design and that of ZL-1 heads. Note how cross-sectional area has been made more circular (for exhaust porting) and how intake ports have been "aimed" to provide improved flow toward back of valve heads. Flow is reported to be improved by about 20%.