ENGINEERING THE "W" 348-409 POWERPLANT

JUST as the 265-cubic-inch V8 of 1955 was making a big impression on both the general public and performance-minded car owners, Chevrolet was already thinking about an engine which might make it obsolete.

The immediate acceptance of bigger engines, more horsepower and larger "small cars" by those people who had previously been economy shoppers made it apparent to Chevy that their production of V8's would have to be stepped up if anticipated demands two or three years ahead were to be met. Whether to double up on the rate of manufacture of the 265 or develop an entirely new engine was a problem.

The 265, as we know, could be increased in displacement and upped in power output by applying the standard hot rod practices of increasing volumetric efficiency . . . and would have to be if the growth pattern of automobiles was to continue. However, the compact block had finite limitations, particularly as to stroke which could be accommodated. Torque, as a function of stroke length, was the one deficiency of the small V8. It was plain that no amount of hopping up, in the conventional sense, where rpm range is extended and the power curve moved up, would incerase low and torque to the point required for a much bigger, heavier car with automatic transmission. Nor, and this was important to Chevrolet, was the 265 really suitable to larger truck applications.

An engine which would not be too much larger in outside dimensions but have considerably more displacement and be strong in the 2,000 to 3.000 rpm range would fit both the requirements for anticipated bigger models and the truck line. Instituting production on such an engine would not cost appreciably more than increasing the volume of 265's being made, so the scales were tipped in favor of a completely new V8 almost as soon as the "new" V8 was really rolling.

It has been said that the "W" engine was a truck engine which was stuck into passenger cars to give buyers an option. The initial performance of the powerplant might have given such an impression, coming on as it did in the lower rpm range and running out of breath where the 265-283 was beginning to put out, but a look at the design parameters for the 348 will prove that it was, again like the 265, an attempt to compact a high-output powerplant.

The engineering team of John Rausch, Howard H. Kehrl and Donald H. McPherson worked to these objectives:

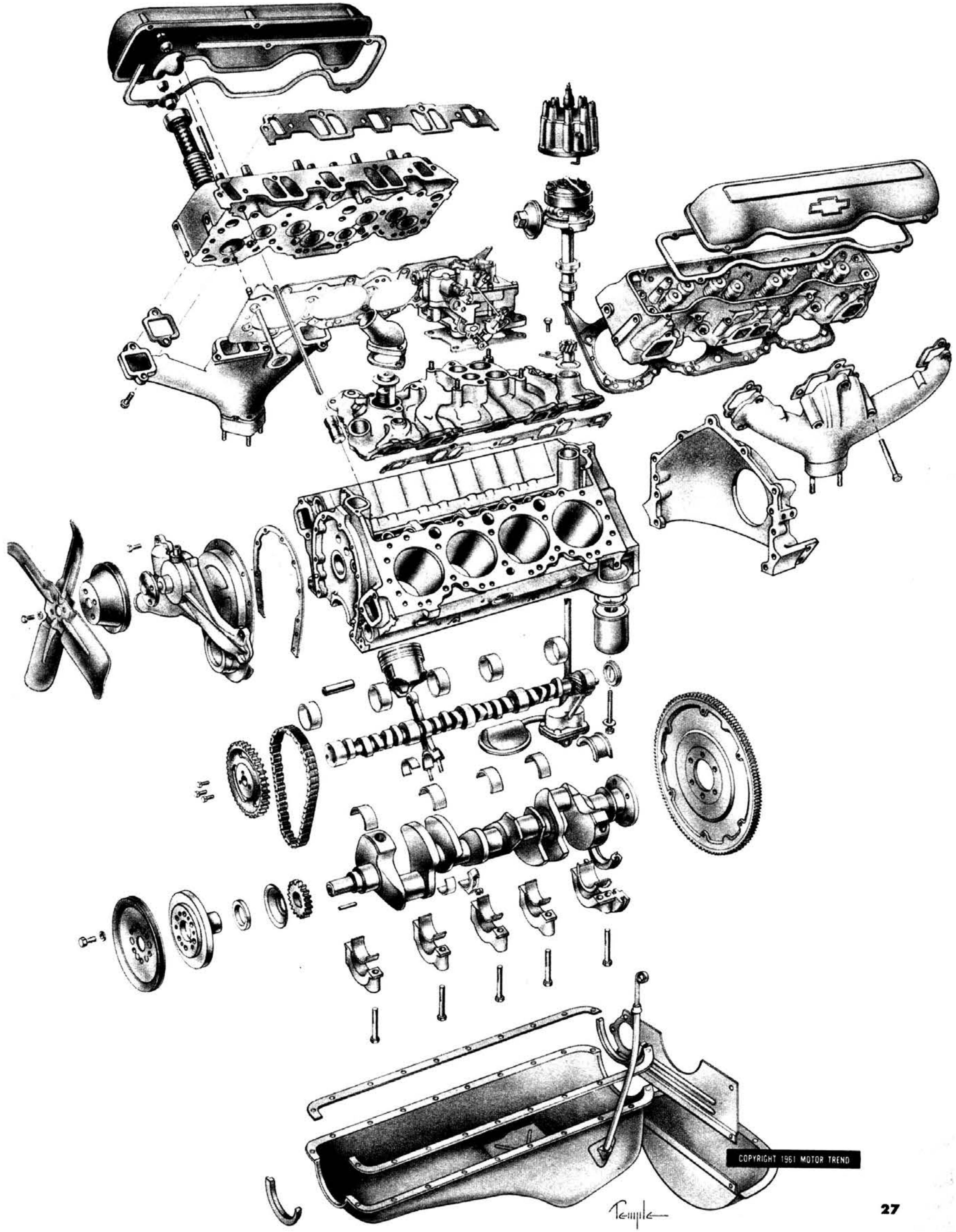
1. Adaptability to a broad range of displacement with a minimum number of different parts,
2. Adaptability to broad compression ratio range,
3. Dimensions compatible with the anticipated space limitations of passenger car design,
4. Provision for mounting both passenger car and truck accessories,
5. Flexibility of machine tools to accommodate future, engine modifications.

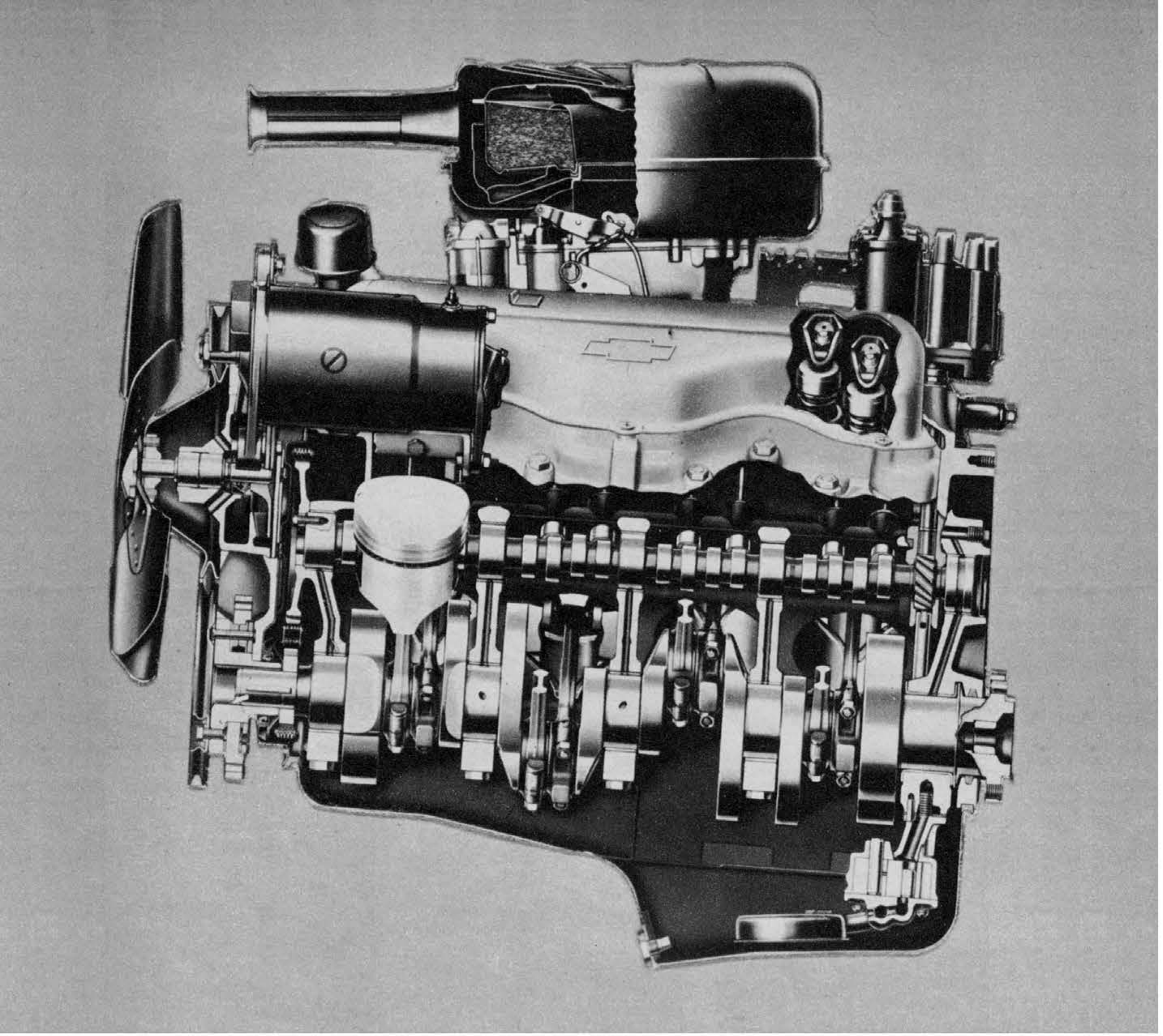
All of these points, with the exception of the fourth which makes little difference to the modifier, are important to the prospects for an engine which can be built into a competition winner. These goals, if they could be realized in exceptional fashion were identical with those of the drag strip enthusiasts who are continually searching for massive output in limited space and minimum weight.

The "W" engine, like the 265 Series, introduced a number of new ideas to rodders and, in its present form as the 409, has carried those ideas to a point where a whopping amount of power is making it one of the Kings of the Super Stock classes.

The 348-cubic-inch displacement engine was the third of a set of experimental models designed and built by Engineering. The "X" and "Y" designations were 300-cubic-inch versions of the 265. In "X" bore was increased to four inches while retaining the three-inch stroke, while "Y" was a $3\frac{13}{16}$ by 3.3 incher. Neither proved to be the answer and it appeared that the 283, with its 3.87-inch bore and three-inch stroke was about the happiest combination for production at that time.

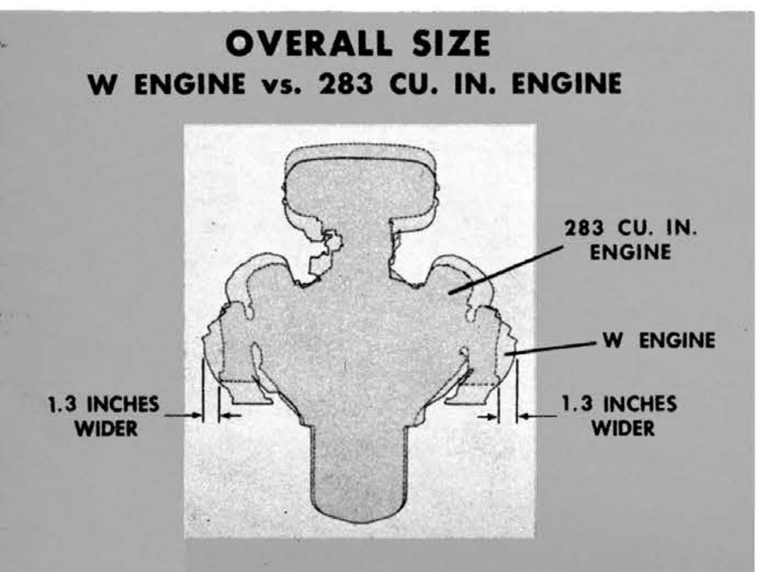
But, to increase displacement another 50 cubic inches without building an outsize block, and to in be able to go up from that another 60 or more, was a problem. It is no trick



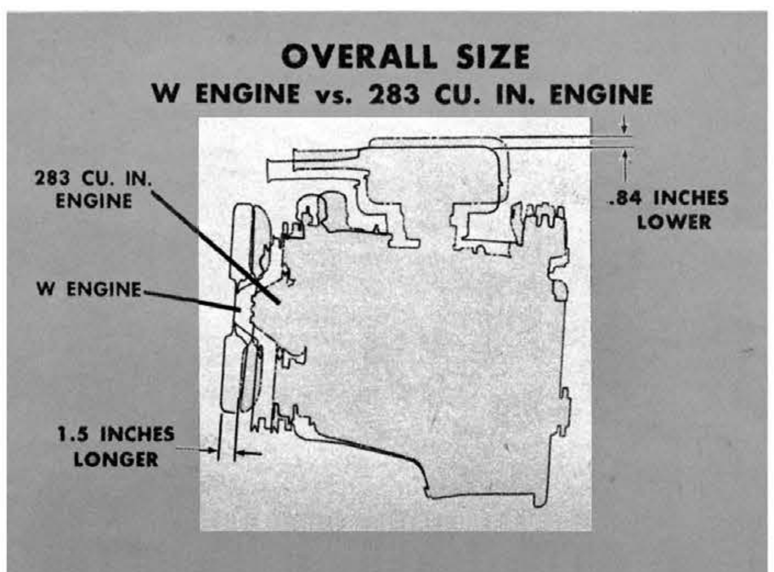


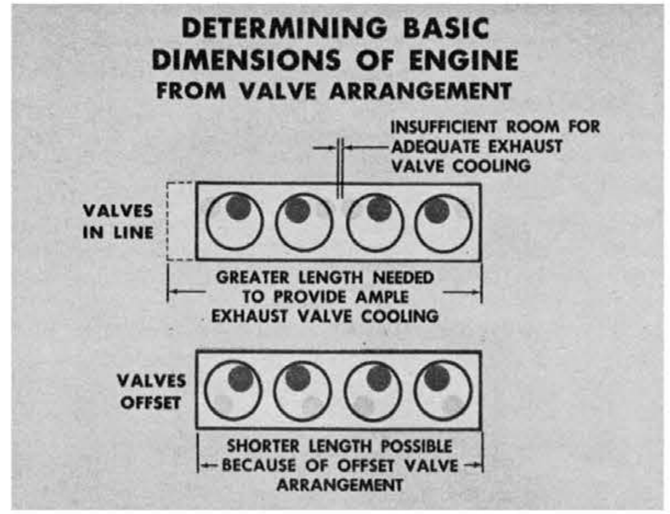
Although "W" engine is often referred to as real "truck" design, it was successful attempt to compact cubic inch powerplant.

Only 2.6 ins. wider than 283 Chev, "W" displaces 409 cu. in.

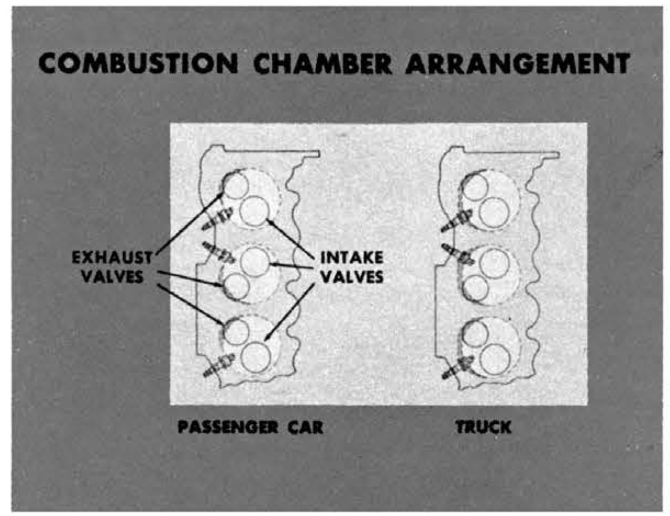


Despite small dimension increase, "W" is heavier engine.



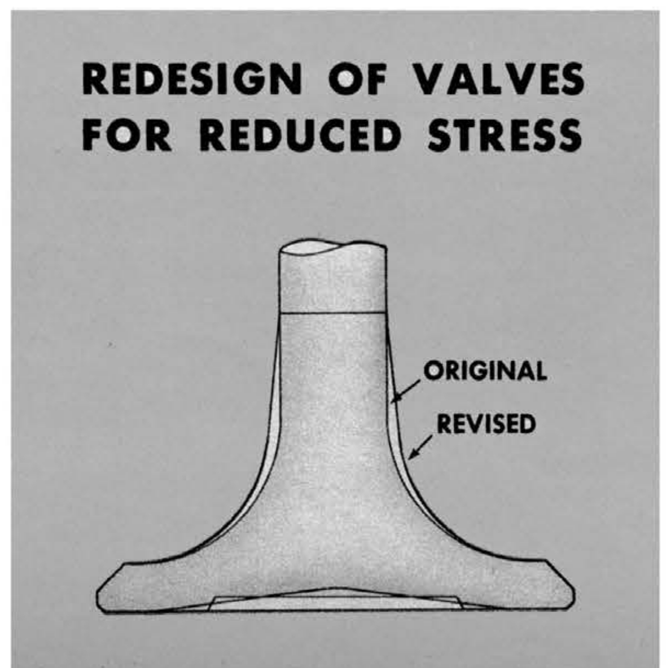


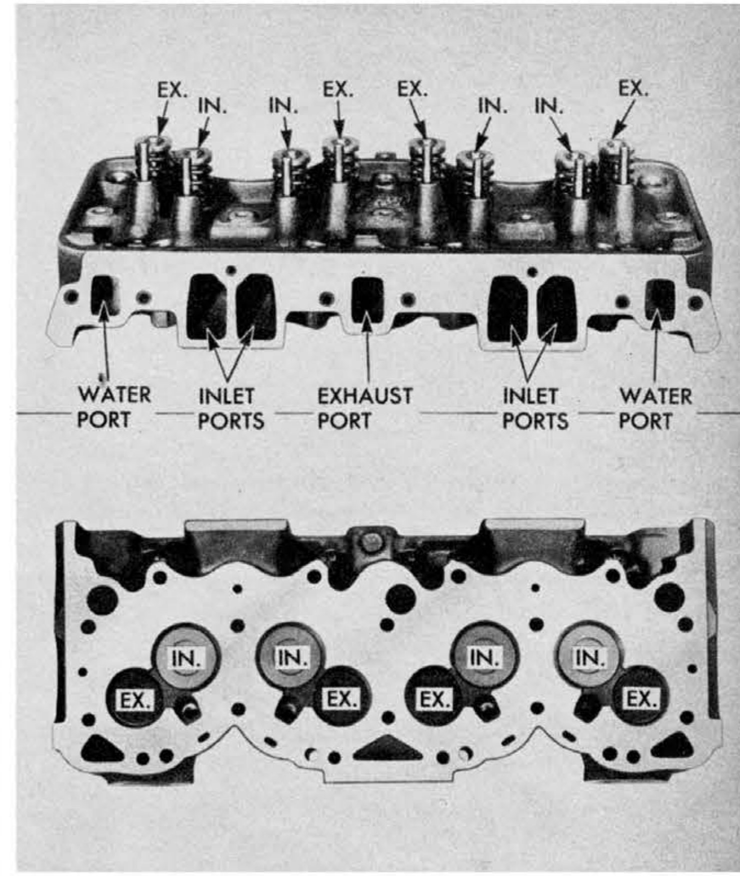
Two factors enter into the staggered valve arrangement: (1) shorter length of block and (2) improved cooling for valves.



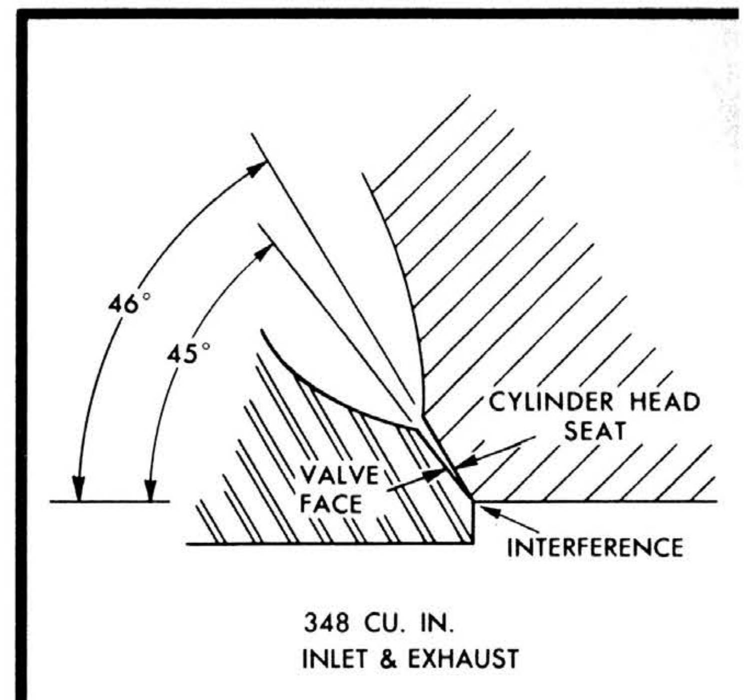
ABOVE: Shaded areas of cylinder indicate recesses milled for variations in combustion chamber volume, compression.

Valves were redesigned during testing of "W" engine after original contour of stem-to-head blend proved weak point.

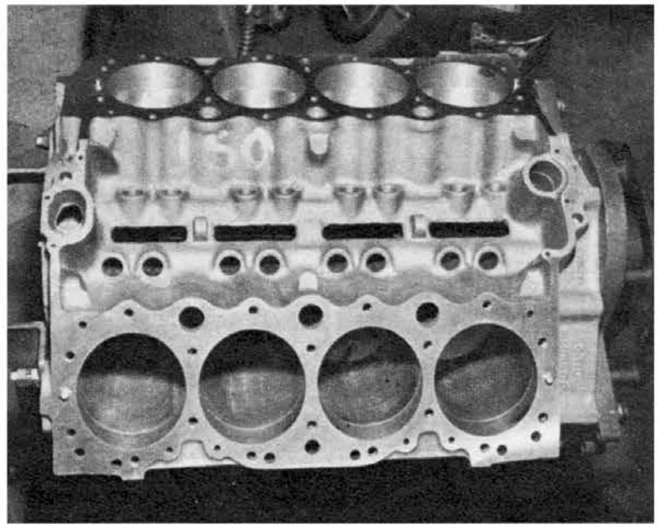




Exhaust port designated in photo is for intake manifold heat. Valve arrangement results in short ports. Head surface is flat.



Valve seat in head milled at 46° for interference fit for 45° face, results in longer period between valve grinds.



Top of block is milled at 74° angle, rather than usual 90° to establish combustion chamber. Cylinder cutouts can be seen.

to build a big engine. But it certainly is an accomplishment to make one that can displace well over 50% more than the 265 and have it only 1½ inches longer, 2½ inches wider and ⅞ inch lower . . . and that is the 348-409 exactly.

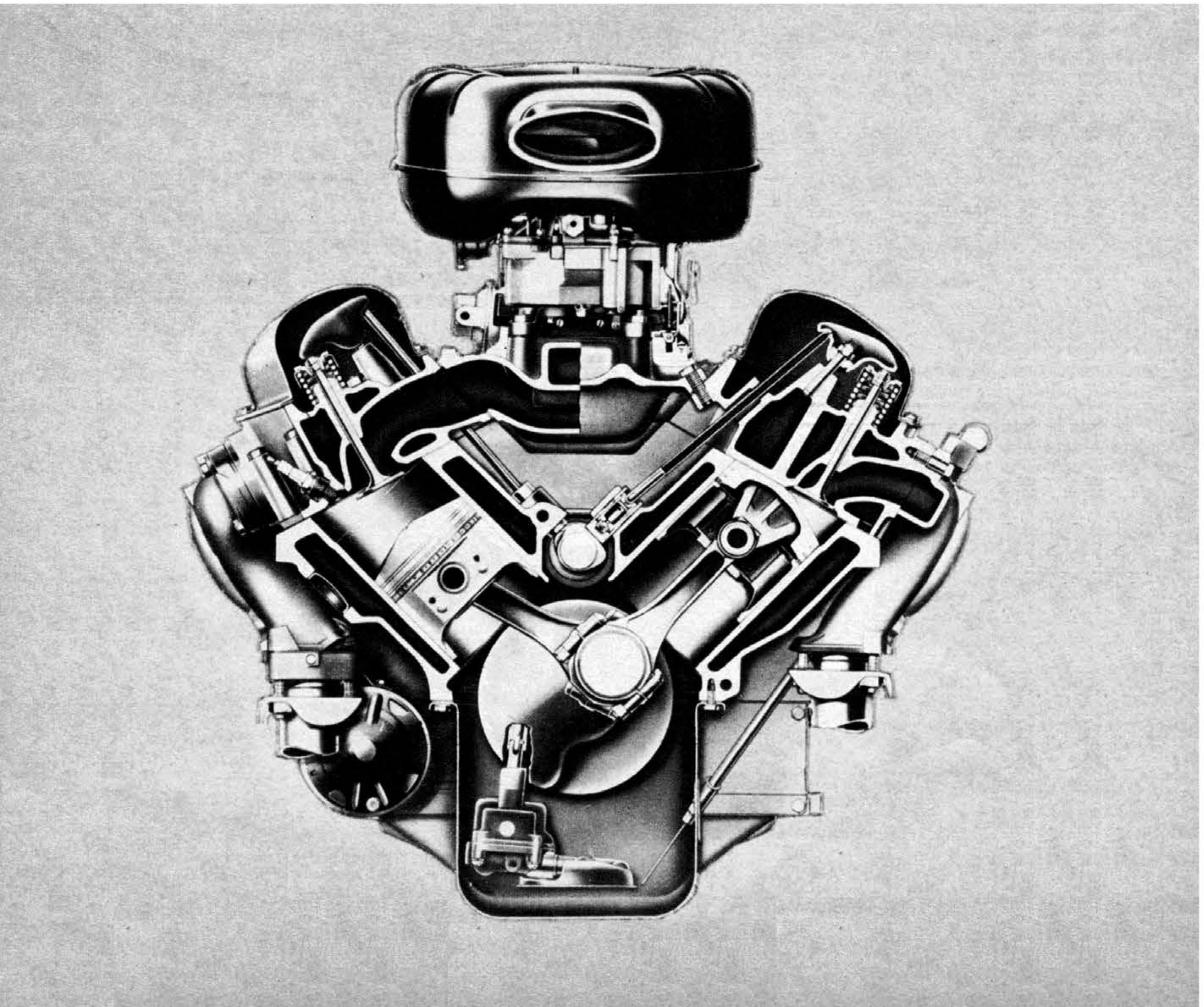
THE CYLINDER BLOCK

That the 409 was thought of while the 348 was the immediate objective can be seen in the center-to-center distance of the cylinder bores, 4.48 inches. This allows nearly ¾ inch for walls and water passage between bores in the original engine with its 4.125-inch cylinders. After going to the 4.312-inch bore of the 409 (with different cores, of course), there is still adequate separation and wall strength.

The center distance did not, however, determine the length of the block. With displacement approaching 50 cubic inches per cylinder, the diameter of valves must increase considerably. With the increase in size and weight, exhaust valve cooling becomes a big factor. The only time during the cycle when a valve can dissipate its heat is while it is firmly held against the seat and the contact area between seat and valve head does not grow in direct proportion to the mass, so an ample flow of coolant at this point must be provided. If two valves are too close together, a difficult cooling situation arises. And, to provide enough space for in-line valves of the size required would mean a long block.

So the design team staggered the valves across the cylinder head and gave the "W" engine one of its most distinguishing features. The scalloped rocker cover identifies the 348-409 at a glance.

Smooth port routing, improved later, plus adequate water distribution, high exhaust manifold are advantages of "W" idea.



THE VALVE TRAIN

Exhaust valves are placed nearest the outside of the head, intakes toward the centerline of the engine. The individual rocker arm arrangement of the 265 engine was carried forward in the "W," being a perfect complement to the staggered valve configuration. Holes drilled at different angles in the head slant the pushrods out to the right degree to engage the rockers carried on studs pressed into the head.

A rocker ratio of 1.75-to-1 is employed on the 348. The pushrods are 5/16 inch in diameter with coined ends and openings for lubrication.

Speaking of the basic engine, introduced to the public as a regular production option in 1958, the valves were made from high alloy steel, probably 864-5 in the intake valves and 21-4N in the exhausts. These were aluminized in the later optional cam-solid tappet engines, which we will cover further on.

Intake valves are 1.94 inch in diameter, exhaust, 1.65 inch. Single springs are fitted with 78 to 86 pounds pressure on the seat, 184 to 196 pounds open, on both valves.

Some difficulties and failures were experienced in the early testing of prototype engines when valve guides became excessively worn and lifters with an eccentric leakdown rate were encountered in combination. This resulted in abnormally high seating pressures and valve heads were snapped off where the stem blends into the head. A revised shape stiffened the point and no production engine seems to have given trouble along these lines. However, with big valves (and the later 348's and 409's are bigger) this blend area is critical and care must be exercised in removing weight.

The basic 348 camshaft with hydraulic lifters gives .398 inch lift at the valves. It has 266° duration on the intake side and 274° on the exhaust, with 44° of overlap.

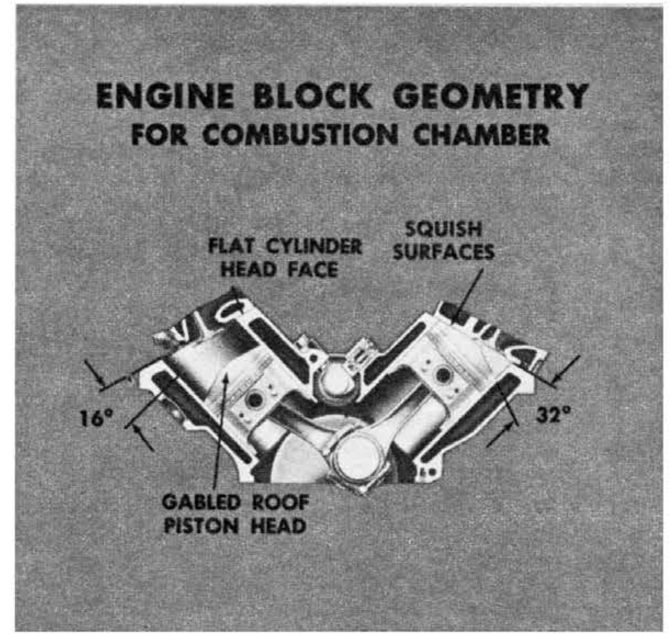
THE CYLINDER HEADS

Aside from their unique indented shape, the 348's cylinder heads are also notable for their depth. Each of these cast iron units is a substantial chunk and helps contribute to the fact that a 1958 Chevy equipped with the "W" outweighs its little brother by 141 pounds. The depth is attributable to a huge water flow capacity and to big ports required to supply the outsize valves. The heads also seem more massive because they have no combustion chambers in the conventional sense. A slight recess around the vertical valves is the only indentation in the otherwise smooth flat underside. The combustion chamber is actually formed by the upper portion of each cylinder.

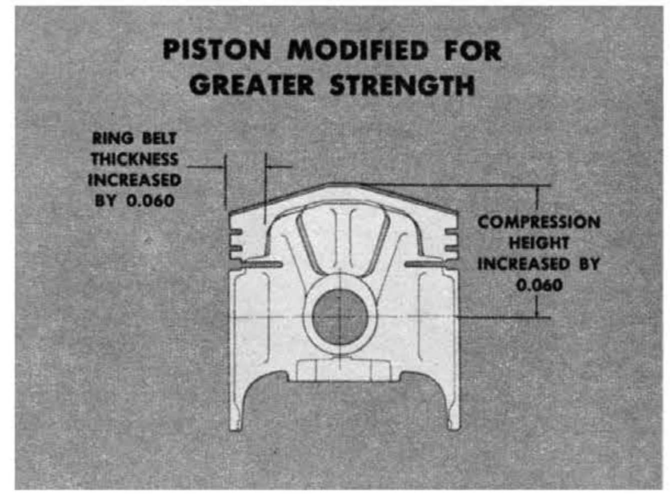
THE COMBUSTION CHAMBER DESIGN

Part of the success and many of the limitations of the "W" engine can be traced to the unique combustion chamber design which required a major amount of study and development.

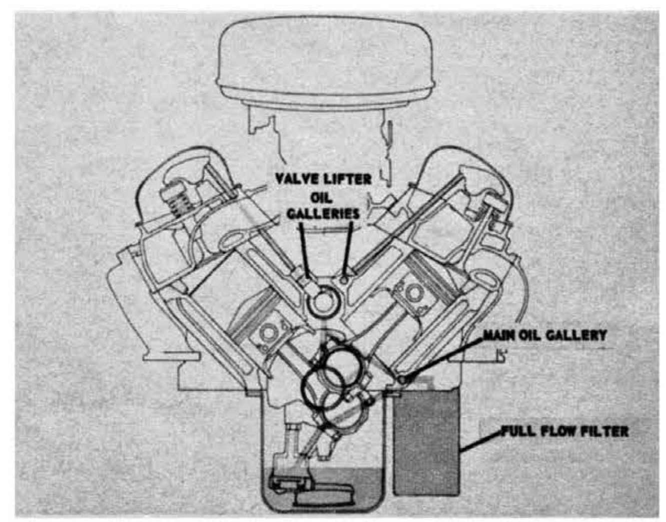
Spurred on by the knowledge that Chevrolet was in production on *eight* different heads for the various compression ratios and models of the 283, the "W" engineers reasoned that here was an expensive production area which might be



Cross section shows gabled roof of piston, flat head and angle-cut block to form wedge-shaped combustion chamber.



Original gabled roof piston, was "auto-thermic" design, steel strut-alloy aluminum. 409 uses impact-extruded all-aluminum.



Full-flow filter is feature of "W". At bottom of sump is fixed oil pickup, better for high-performance than floating type.

eliminated if some way could be found to avoid the conventional combustion chamber variations and make all heads identical.

It can be seen that if you cut across a cylinder bore at an angle to its centerline, a wedge shape results in relation to a line drawn at right angles to the centerline. The flat top of a piston would form the line drawn at right angles, of course, and since the wedge is a recognized combustion chamber shape, merely trimming the top of the block off at an angle would enable a flat-surfaced head to complete the chamber.

Because a quench area of reduced volume is necessary and the wedge should occupy only a portion of the area over the piston, it was only necessary to use a pent-roof piston to produce the same general cross section shape as that used in the 283. By cutting the block at 74° instead of 90° and putting 16° gabled roof on the piston, a 32° wedge and a quench area over 50% of the piston resulted.

To change the compression ratio, either the piston roof could be altered or, as the original design called for, cutouts could be milled in the upper portion of the cylinder wall to increase the size of the chamber.

So, as the 348 emerged, its 9.5-to-1 compression ratio for passenger cars was induced by milling one cutout and lowered to 7.5-to-1 for truck use by milling two. This part of the cylinder is also overbored .055 inch to make ring installation a simpler problem.

This took care of production problems and a couple of the design parameters. It also resulted in an engine which produced an advertised 250 bhp, equivalent to .7 bhp per cubic inch, and 355 ft./lb. of torque at 2,800 rpm. This was good by comparison with the original 265 in its lowest stage of tune, giving .6 bhp per cubic inch, but as it developed, the 348 did not respond to hop up techniques as suddenly as the 265-283 had.

That engine, by 1958, when the 348 was made a companion, was putting out as much as 290 bhp with fuel injection and the factory optional cam. With only a single four-barrel, it delivered 230 bhp. But, in April of 1958 when the first hot options for the 348 were made available its maximum advertised rating was 280 bhp with three two-barrel carburetors. And, rodders found out that the 283 would come closer to living up to its rating than the 348. Moreover the 283 would go right on up the rpm scale with increased cam timing, but the bigger mill seemed to bog down in the range above 5,000.

The combustion chamber created when the 74° cut is taken across the bore is, as can be seen, elliptical or oval, in shape, rather than circular. This means that the wedge and quench areas do not have the same relationship as in the conventional head chamber. In addition, much of the nominal squish area is directly beneath a valve head, rather than being completely between piston and head surface. The spark plug placement, too, since it must be in the head, cannot enter the wedge from the side, as it does in the 265 Series. All of which results in a different flame front and combustion pattern and explains why a number of man-hours have been expended on modifications in this area . . . with success, it must be added.

THE PISTONS, RODS AND CRANK

Gabled roof pistons were new to Chevrolet, and while shaped-crown pistons are no novelty to racing mechanics and engine designers, or limited production piston makers, they could well be approached with caution where huge numbers are involved and part rejection is a criterion. The gable moves the crown farther away from the pin and its increased area can pose a heat problem, considering the potential bore size and the compression ratios planned. Remember this is not merely a big engine, it is a big hot engine, a performer. So, it is not surprising that the staff found temperatures in the pistons exceeding those of the 283 and that original designs were modified somewhat before production was turned loose.

The 348 pistons were, like the 265 Series, slipper skirt, auto-thermic (steel strut) types weighing nearly 27 ounces set up with .0395 as the high clearance in the bores. Two cast iron compression rings, with the top ring flash chromed, were employed with a multipiece oil ring with steel rails, stainless steel spacer and chrome o.d.

Although it might be expected that 348 rods would be substantially larger, they are in fact only ½ inch longer in the center-to-center distance and weigh less than an ounce more than those of the 265. Rod bearings are .867 inch wide and the file-hard pin is pressed in, being offset .060 inch toward the major thrust side of the piston.

The forged steel crank is substantial, with good overlap at the webs and hefty counterweights which bring its gross up to nearly 60 pounds. The front four main journals are 2.4985 inch in diameter by 1.042 inch in width. Rear journal which takes thrust is 1.810 inch wide. The rod journals are 2.2 inch diameter. Steel backed babbit alloy Moraine 100 bearings are to be found in the standard engines, Moraine 400 type, a steel-backed aluminum alloy matrix with a thin lead overplate, are part of the optional, "special camshaft" equipment.

LUBRICATION SYSTEM

A conventional gear-type oil pump drives off an extension of the distributor drive from the sump via stationary pickup through a full flow filter (optional but found on most engines) to a main oil gallery drilled the length of the block low on the right hand side (from the front of engine). Passing upward through the rear main and an annulus on the rear cam journal, the oil is directed into two galleries serving the tappets.

Main bearings and rod bearings, served by the drilled crankshaft, cam bearings, tappets, and timing chain receive full pressure lubrication. The piston pins are splash-lubed and cylinder walls receive their oil bath from a jet in the rod caps. Normal oil pressure is 35 psi at 2,000 rpm.

From the tappets, oil travels up the hollow pushrods to the rocker arms and splashes over the valve springs and stems which are protected from excess lubricant by caps. An oil separator plate beneath the intake manifold keeps droplets from being vented out the breather along with vapors.

CARBURETION AND IGNITION

As with all modern engines, the "W" type began life with a simple offering of one carburetor, a four-barrel WCFB Carter (#3744082), with either a Carter (#3744081) or a 4GC Rochester (7011108) as optional with the Powerglide or Turboglide transmission. (The latter, although not interchangeable with the synchromesh transmission model carburetor, are essentially the same, aside from linkage.)

Supplied by a mechanical fuel pump at 5¼ to 6½ pounds pressure, the carburetors (individually speaking) are basically two dual-throat types in a single casing with the front throttle butterflies under mechanical control from the accelerator pedal and the rear throttles operated by secondary linkage from it.

Firing order of the "W" engine is: 1-8-4-3-6-5-7-2 with a Delco Remy distributor directing current to standard AC-44 plugs. Several part numbers are included in the list of distributors fitted to early 348 engines, but they vary only by a half-degree in the amount of advance reached at 800 rpm. Both centrifugal and vacuum advance are employed. A maximum of 11° to 13° is realized with the centrifugal weights, 6.5° to 8.5° occurs at seven to nine inches of mercury. Idle advance setting is 4°. Significantly, although the spark advance requirement for the 283 engine rises to well above 40° at 5,000 rpm, the 348 advance curve levels off at 3500 at a total of 34° for best torque, indicating that peak cylinder pressure is at or past TDC rather than leading the crank.

As in all Chevy production engines spark plug high tension leads are non-metallic. A linen strand impregnated with carbon carries the current. This is an efficient conductor when new but is fairly easily broken as it grows older.

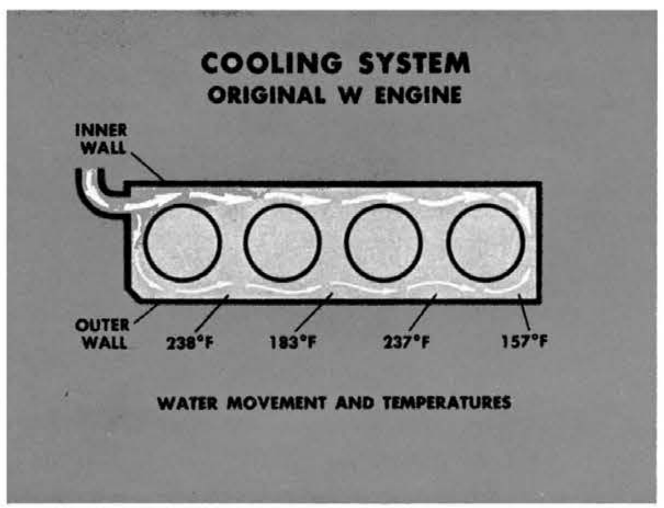
THE COOLING SYSTEM

A total of 23 quarts of water (including a quart in the car's heater) is carried in the 348's cooling system. A centrifugal pump, driven by the fan belt supplies circulation and a 13 pound pressure cap is standard on the radiator. Normal production engines were equipped with four bladed fans, but the viscous-coupled five-blade type which are limited to 3,200 rpm were fitted to air-conditioned cars. These fans are a natural for the performance-minded, since they free-wheel in the upper rpm range.

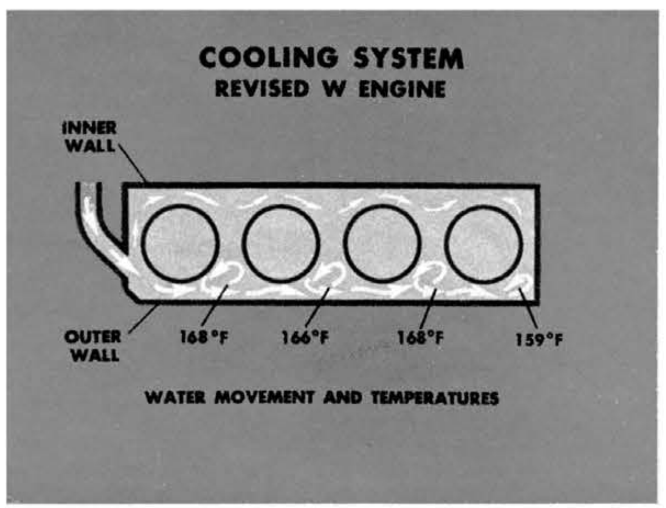
DURABILITY

The "W" series was well tested for reliability and weakness before production. Over a period of 18 months more than 40 engines were put through severe regimens. One ran at wide-open throttle for 200 hours, equivalent to 20,000 road miles at 100 miles per hour, without difficulty. Others were run at varying speeds for as much as 1,000 hours, well over 50,000 miles in road use.

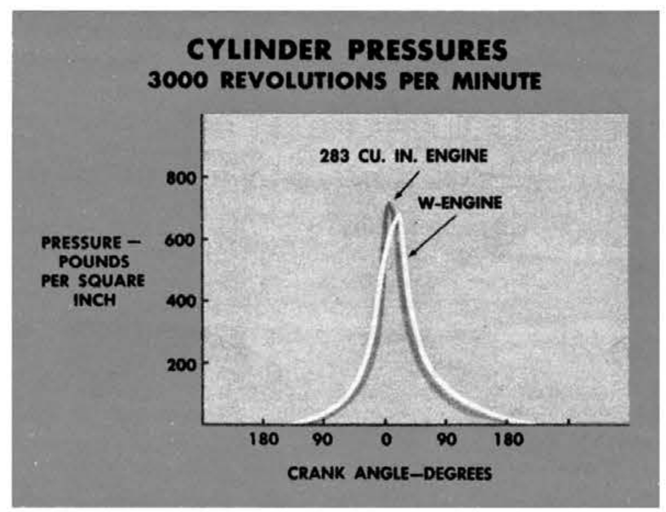
Rodders, too, found that the 348 was rugged, if a bit heavy for engine swaps. It lent a great deal of emphasis to the growing interest in stock sedan classes and, as developed into the 409, it has proven to be a sturdy, worthwhile powerplant. As a 348-cubic-incher, quite a bit of tinkering by individual mechanics and speed equipment experts helped to enhance its value to the competition enthusiast and the factory's continuing program aimed at increasing performance was a boon to the buyer who wants to get something hot right off the showroom floor. ■



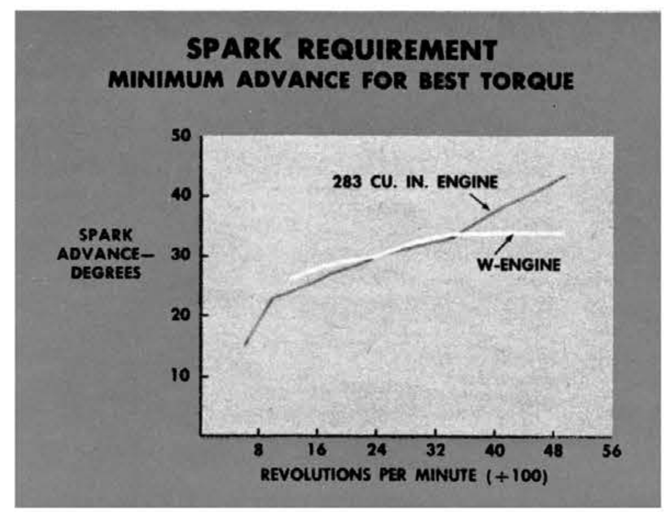
Cooling of high-performance engine is important factor. Conventional water inlet at inside of V allowed excessive temp.



Altered water inlet, to outside of block and across exhaust ports, lowers overall water temp., allows use of stock radiator.



"W" engine compares favorably with 283, admittedly one of the finest stock car engine designs, shown in indicator diagram.



A number of distributors were used with "W", but optimum advance occurs at relatively low speed, remains constant.