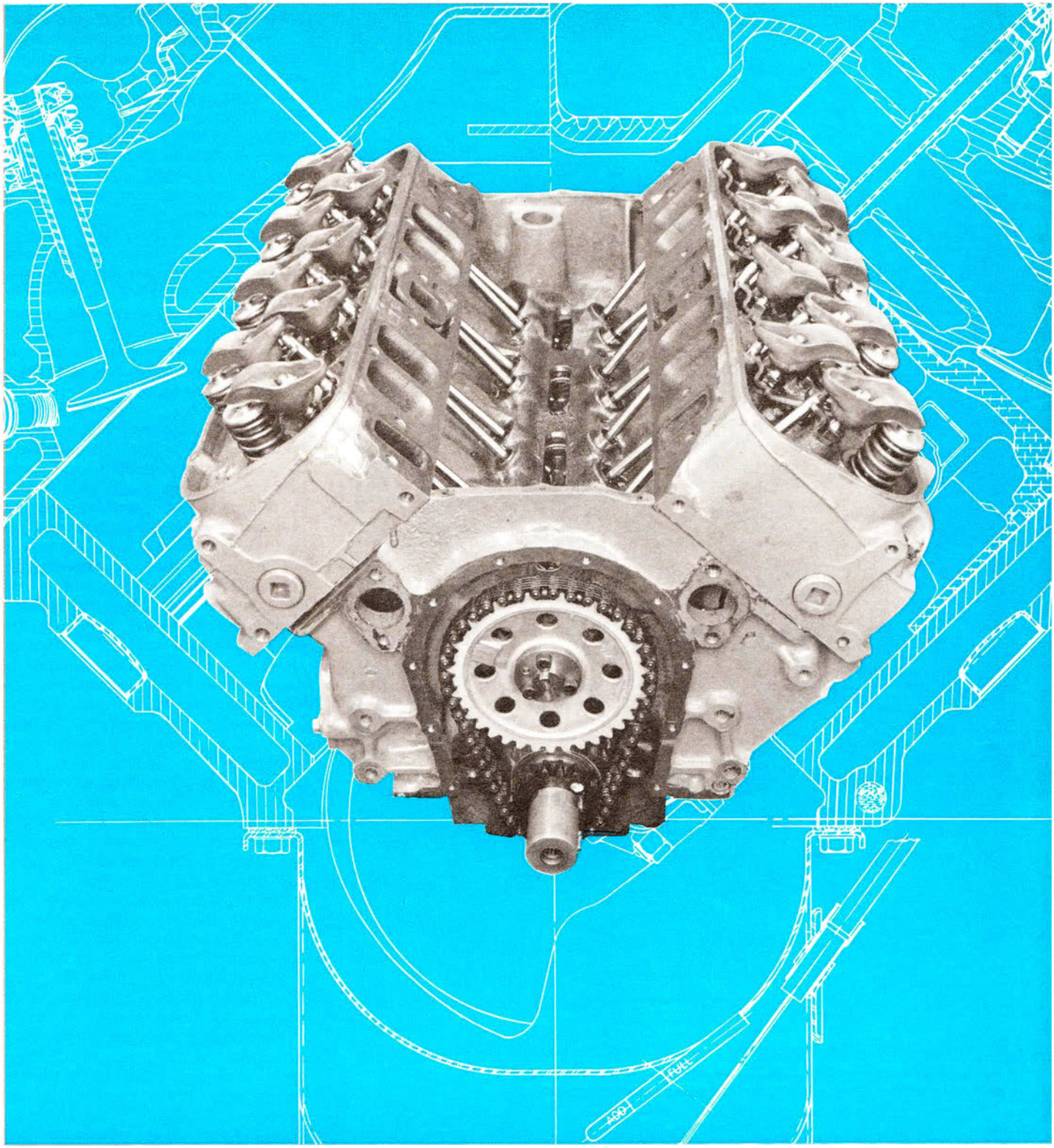
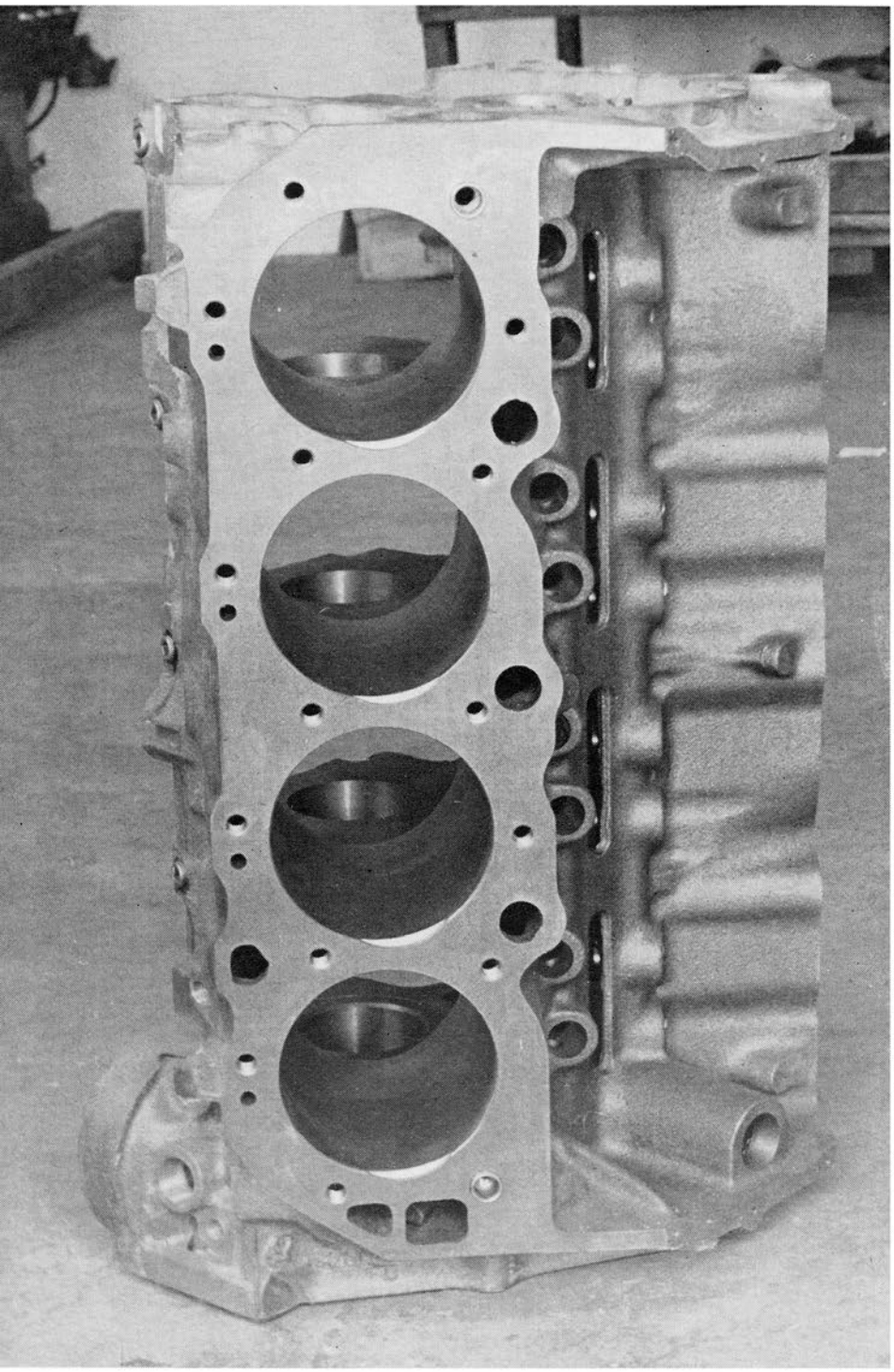


Blueprint Thoroughbred

Making a Racehorse Out of a Workhorse

BY LARRY WORTHINGTON



CHEMICALLY CLEANED, with particular attention paid to water passages, a bare block is the starting point for the meticulous blueprinting task.

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RACING REQUIRES thoroughbred horsepower. Thus, building engines according to blueprint has become one of the more specialized operations in racing. Bill Thomas/race cars, of Anaheim, Calif., is known for Chevrolet powerplants and a number of fast production Corvettes, hence the Thomas shop is a good place to look at what goes into a thoroughbred stock engine as compared with an ol' workhorse to haul the family wagon.

The racing skeptic usually points his finger at stock or production cars and accuses them of not really being stock.

It is true that race-prepared cars are different from what the skeptic may be driving, but they are the ultimate projection of the line. With more at stake than the stop-light grand prix, for which most street-run high-performance cars are used, run-for-money machines receive the careful breeding that makes a winner. Most horse owners would not pay the price for a thoroughbred racehorse to keep him around the house for the kids to play with, just as most high-performance car owners would not pay the price of building a blueprinted engine to blast away from stop signs.

The difference between the bridle path and the race track is a matter of breeding. Just as there is nothing a breeder of horses can do to add to the basic traits of the breed, so it is with the blueprint engine builder who can only amplify the strong points of the design and hope that using the best of everything will leave no fatal flaw in the engine. If there is a flaw in the basic design, there is nothing the blueprinter can do to cull it out. In this way, blueprinted engines are best in breed, but they are representative of the breed and will demonstrate any basic weaknesses of the breed.

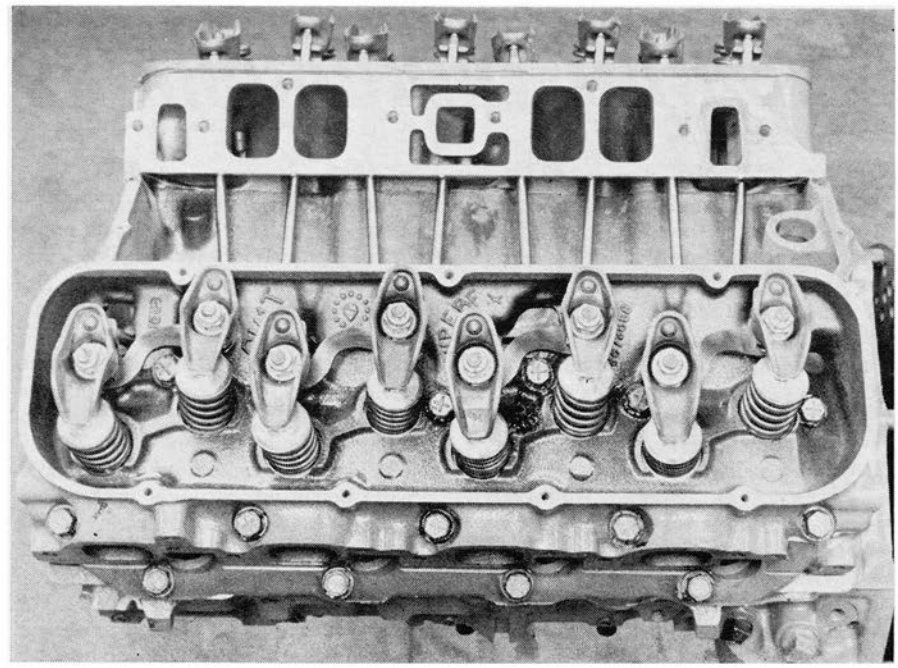
In breeding racing engines, the basis is selection done with investigative techniques that eliminate weak components, sort of mechanically tracing bloodlines. All major assemblies and components are subjected to careful technical scrutiny, including magnaflux and X-ray, to check for cracks, breaks and internal flaws.

The block is cleaned chemically, with particular attention to the water jacket, because it is important that coolant not be insulated from metal surfaces by corrosion which slows down the transfer of heat from the engine parts to the coolant. All flashes and burrs, results of the casting process, are ground away to assure that they do not fracture during loading and flake off to become caught in a critical assembly. All oil passages and galleries in the block are opened to maximum allowances and checked for blockage and leaks. The engine is "decked"—that is, the surfaces of the block to which the heads mate are machined to assure they are flat, at the proper angle, and both are the same distance from the crankshaft centerline. This is the first of many machine operations to assure that multiple dimensions match within thousandths of an inch, both for balance and attention to maximum volume of regulated components.

This super clean, carefully examined

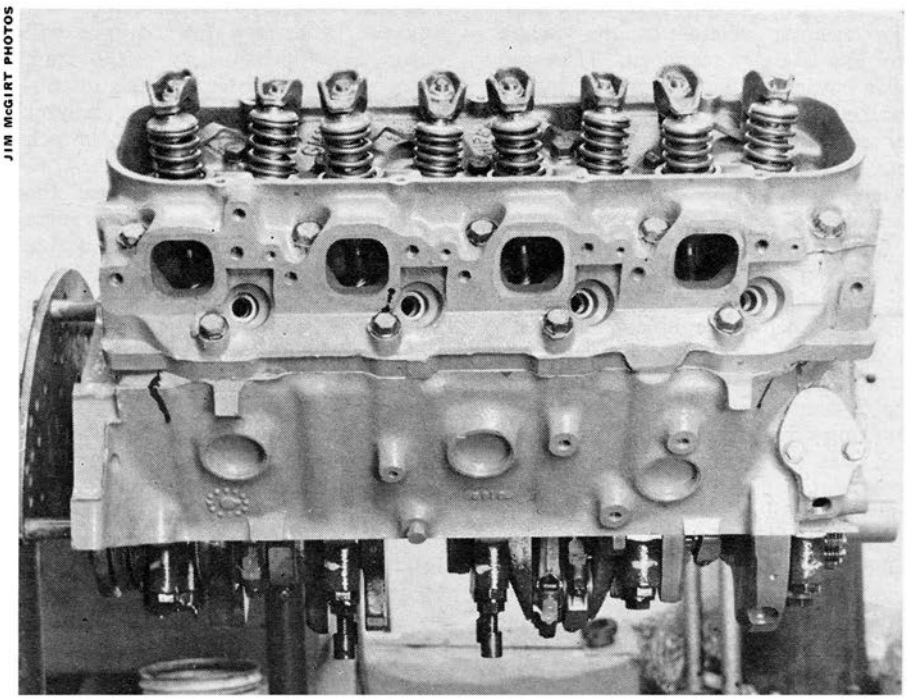
block now is ready to receive the crankshaft. The crank has been checked and has gone through a process called index grinding. Each throw of the crank has been ground to assure that each cylinder has the same stroke and that each throw is in the prescribed position for proper timing of the engine. This is not gross, heavy-handed work, but a matter of a few thousandths that makes a difference, and one of the reasons that blueprinted engines are smoother than street tuned high-performance engines. The main bearings are set for maximum clearances and caps are torqued into place.

The connecting rods are now due for extensive work and some lightening. The big end of the rod is redone and the small end bushed, so that the distance between the centers of all the rods is the same to assure equal stroke and that the cubic displacement of each cylinder is exactly the maximum allowed. This also is an important part of balancing the power impulses of the engine for smoothness and high rpm performance. The rods are machined to the same weight, including making the small end and big end of each rod equal to the others in the set. This gives the builder a set of rods that are not only of equal weight overall, but a set of rods with such closely matched static balance that it contributes to dynamic balance when the crankshaft is rotating.



TOPSIDE ARE valve springs of absolutely equal tension, rocker arms matched for multiplication of lift and equal lift characteristics, and pushrods of exactly equal length and weight. Ports also are carefully matched.

JIM McGIRT PHOTOS



UNDERNEATH IS a power train made up of components chosen for lack of flaws, then balanced perfectly. All dimensions are at maximum allowable limits.

AFTER WORK on the rods is completed, the pistons and piston pins now come under the knife. The pistons are checked first for weight and brought to equal weight, within a few tenths of a gram. The pistons then are checked to assure that all pins are the same distance from piston tops, according to factory specifications, to make sure the pistons do not intrude into the combustion chamber where they could strike the valves or the head or raise the mechanical compression ratio to exceed stock classification rules. Also, this is directly related to the power impulse balance and the attempt to correct positioning of the pin in relation to the crankshaft at the time of combustion. Piston skirts are checked for clearance with the cylinder wall and again the setting is at maximum clearance. Rod bearings and caps are torqued into place.

With the power train in place, attention is turned to the breathing characteristics of the engine. Starting with the heads, which have been cleaned and checked in the same manner as the block, the combustion chambers are carefully matched with respect to cubic displacement with valves and spark plugs in place. This is a check of the mechanical compression ratio. Measurement is made by placing metered amounts of oil in the chamber until it is full. For proper balance, the amount of oil required to fill each combustion chamber should not vary more than 0.1 cc. The check of cylinder displacement is to guarantee that the engine is not over the allowable size for its class. The check of the combustion chambers is to assure that they are not smaller than the allowable limit, which would raise the mechanical compression ratio and exceed the stock specifications of the engine. Each component of the engine is brought to maximum limits, but careful attention must be paid to insure that no component exceeds specifications, thus violating stock regulations and resulting in disqualification of the car.

THE VALVE seats in the head are ground, then the seat is narrowed, using a deep angle cut below the seat. ▶

Blueprint Thoroughbred

The valve is ground with the seats out to the edge of the valve head. The manner in which the valves are ground is of prime consideration. The proper seal must be maintained, but the seat must be ground so that the disruption of the gas flow into the cylinder is held to a minimum and gas flow is cut off at the last possible instant, as the valve comes to rest on the seat. The proper valve grind can increase the output of an engine 25 bhp as opposed to a lesser technique, depending on the engine and its gas flow characteristics.

The valve stems also receive some attention. They are turned down at the head, re-chromed, and their clearances in the guides are increased. New guide seals are installed. Before installation the valves are checked for equal length, weight and head size. The meanest villains in the engine now are carefully examined. These are valve springs. Each valve spring is checked for maximum tension and for equal tension with others in the set. Having valve springs that are exactly alike is important to the predictability of engine performance. When a driver is given a certain rpm range to work in, he usually exceeds it on the high side rather than the low.

A weak valve spring could "float" a valve early. A floating valve, in turn, could contact the piston and cause destruction of the engine by breaking down at what the driver was told was a safe top rpm limit with some safety margin. Rocker arms and pushrods also are checked closely, particularly the rocker arms for multiplication of lift and equal lift characteristics throughout the set. Pushrods are checked for equal length and weight. If the pushrods are oil carriers, oil flow is limited to prevent flooding the rocker chamber with oil at high engine rpm. Which camshaft is selected to drive this assembly depends on the intended use. In all cases it will be the flat tappet variety, as rollers are not stock components. Cam bearings, as are the remainder of the bearings in the engine, are installed at maximum clearances. The camshaft is "degreed in," that is, given optimum alignment.

After the heads themselves have been finished, the manifold ports are matched to ports of the heads. This matching is done so that gas flow is not disturbed and no turbulence is caused in passing the gas from the intake manifold to the head and from the head to the exhaust manifold or header. Turbulence at the wrong point, particularly on the intake side, prevents the port from passing its full capacity and the engine cannot develop its full power potential. The carburetor is checked and re-jetted to enrich the mixture. This completes the attention to the breathing characteristics of the engine.

The ignition system now is placed on the bench and brought up to standard. The first consideration is the distributor, which is checked for the correct placing on the shaft of the lobes which operate the points. The advance mechanism is rebuilt to change the advance profile. The cap also is checked to make sure the contacts are in the proper position, which is critical for the timing of the engine. The distributor, when installed, will advance faster and full advance will occur at approximately 3000 rpm. Also, after final assembly, the distributor is checked on an ignition analyzer for point dwell and timing. Stock ignition wiring is replaced.

Before the pan is put in place, the oil pump is taken apart and clearances are reduced to minimum allowable end play of the shaft. One addition to the lubricating system can be considered as a racing option—an oil radiator. The oil radiator on the Chevrolet high-performance engine is easily installed because threaded ports for oil lines are located near the oil filter at the rear of the block. There also is a mounting point adjacent to the radiator in the body of the Corvette. The procedure for the installation is in the high-performance parts list. Hence the oil radiator may be used by anyone who owns a high-performance 427 engine, but it would be a rare option for street driving. Also the pan usually is enlarged to increase the capacity by a quart or two.

Throughout the building of the engine, all clearances are extended to the maximum allowable limits for one reason, to reduce drag. Drag steals power from the engine and produces heat. There are problems enough with cooling a racing engine without adding any unnecessary temperature. This requires careful attention to the cleaning of the water passages before the engine is assembled. A Cheetah, prepared by Thomas to test the chassis, was run with its 396 engine not blueprinted. After blueprinting, a heating problem that had plagued the car during the tests was completely eliminated. Nothing else was changed in the car, yet the blueprinted engine ran cooler and produced more power in a usable range, although it retained stock specifications.

The entire execution of the engine assembly, as done to really microscopic dimensions, is one of careful handwork and machining. The major portion of the high cost of blueprinting engines goes into labor, because of the number of hours that go into one engine and the rate per hour paid to a man who has the experience and skill required.

THE T-SHIRTS, now popular among fans, that claim the car being worked on is "powered by money," are more truthful than most racers would like to admit to themselves. This is because of the extreme care and caution that go into any race car, but particularly true of production racing, because the engine builder must not only be a first rate breeder, but also part lawyer. What the customer is paying for is not only mechanical skill, but also a thoroughbred and registered engine, with the emphasis on breeding.

Bill Thomas referred to one individual or another, during discussions of the blueprinting process, as believing in the Easter Bunny. By this Thomas meant those people who buy stock engines, or all-out racing engines based on stock blocks, and believe that there is some hidden secret or black magic involved in holding together a stock block engine under racing stresses. The secret, of course, as shown in Thomas' shop, is careful selection and a feeling for the details that make a difference. Like a well bred horse, a well bred engine does not have to cheat or to fudge to win, the winning is built-in from the start. Too often people will refer to an individual as having a touch with this or that kind of engine. That touch is either experience or luck, because it takes more than a touch to assemble winning production engines. Most of all, it takes money to build winning engines and cars.

The high cost of racing results from one factor; there are people who will spend that kind of money for a winner. The more money that is available, the more the engine builder is able to do to assure that the engine he produces is an example of perfect breeding within controlling regulations. When the cost of blueprinting a production engine is lightly discussed, a price of $900 usually stops the discussion, but the time and the equipment required to produce that kind of breeding are expensive. It is just a matter of whether an owner wants to win $900 worth, because that is what he is getting, a winner. ■