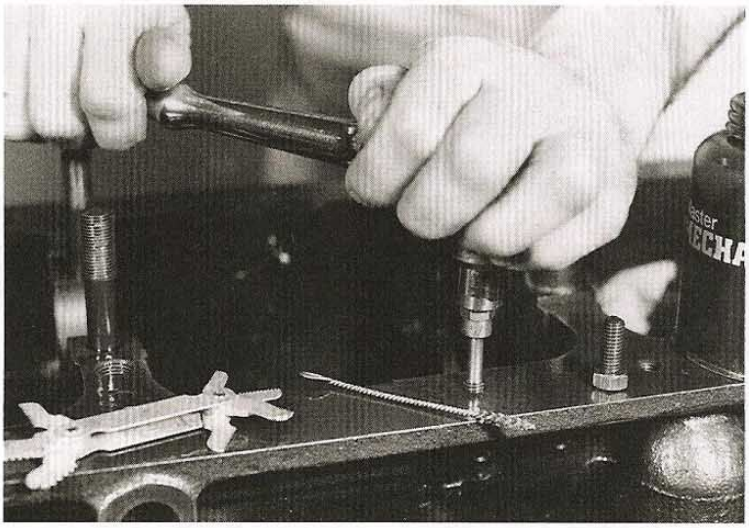
Engine Rebuild, Part 2

In This Second of a Four-Part Series, We'll Do Some Cleaning and Machine Work

BY CURT MCCONNELL

With the engine disassembly stage behind me, I launched into a cleaning and painting frenzy. Before degreasing the block, I used a razor-blade tool to scrape gasket residue from all mating surfaces. I also used thread chasers on all exposed stud threads and in all threaded holes. (See photo on this page.) Less aggressive than the traditional tap and die, which are designed not for cleaning but for cutting, thread chasers remove dirt, grease and rust from threads and also clean up any incidental burrs while removing virtually no metal.

If you neglect to use thread chasers, you might as well throw away your torque wrench: it won't give you an accurate reading unless the threads are clean. After chasing each hole, I cleaned it with a solvent-soaked wire brush, blew it dry with compressed air and, as a test, threaded a new bolt into it and out again.



Using a thread-chasing tap and a die on the block to clean up all threads and threaded holes.

Cleaning and Machining the Block

I machined my engine block during an eight-week engine-machining class sponsored by a local community college. Because the college's generally excellent machine shop lacked equipment for deep-cleaning blocks, grinding crankshafts and balancing engines, I had to farm out this work. To remove every speck of ancient crud from inside my engine, I sent it to the cleaners: an engine machine shop. They're professionals with the very best equipment.

The local Car Quest machine shop baked my block and head overnight in an oven at 700 degrees F., which turned the grease to dust. A short spin in a shot-blasting or shot-peening machine (*Auto Restorer*, August 2001) delivered the knockout punch to old grease and sludge. While the block rotated slowly, two paddle wheels at the bottom of the shot-blasting tank fired a stream of tiny pinhead-size stainless steel shot upward, cleaning everything in its path. After spending just a few minutes in the tank, my block and head emerged looking like foundry-fresh castings.

Machinist Randy Moore completed cleaning the engine by rodding out all passages with an assortment of special long-handled brushes that he chucked in a pneumatic drill. (See photo at the top of page 10.) He also used some disk-type wire brushes on flexible stems to remove any residual rust and carbon from the core-plug holes, intake and exhaust ports, and other similar-size openings.

Randy also performed a Magnaflux test on the block and head to search for cracks. He began by squirting magnetic powder on a small area of the block and applying an electromagnet to various points. A crack in the casting would break the magnetic field and, at such a juncture, would cause the metal particles to congregate and stand on end. Fortunately, my block and cylinder head both passed muster. (Photo on page 13.)

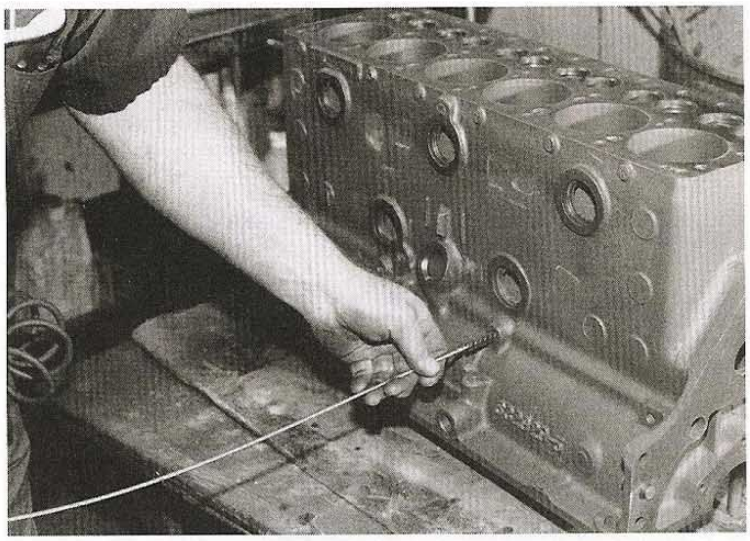
After Randy gave my block a final cleaning in a large parts washer, I took it home, squirted it down with WD-40 to prevent rusting and set it aside for a time. I should note that whenever I transported the block, I locked two nuts together to protect the end of each crankshaft main-bearing cap stud.

The 1939 Plymouth engine had a bore and stroke of 3.125 x 4.375 inches. But the engine number stamped on the upper left side of my block contained an "A" suffix. This designated an "oops" block, one bored .020-inch oversize at the Plymouth factory because some error prevented machinists from hitting the correct bore during their first attempt. (An "A" stamped in the rear of the block deck further alerted the assembly-line piston installer to grab for an oversize set of pistons when this block came into view.)

I, therefore, fully expected my cylinder bores to measure at least 3.145 inches plus wear—and possibly more, because mismatched head and oil pan bolts suggested that the engine had been rebuilt and possibly bored out. Even so, I was stunned to discover that the cylinders measured a tad over 3.250 inches, fully 1/8 (.125) inch larger than factory specs. This is a whopping increase when you consider that the largest factory replacement pistons available were .060-inch oversize to fit a 3.185-inch bore.

Modern thin-walled blocks couldn't stand to be bored so large. Nowhere does my 1939 Plymouth manual warn against boring the cylinders to such an extreme oversize, however. And practice has proven that the sturdy old block could take it: the engine had run that way long enough for the cylinders to develop a sizable taper (wearing wider at the upper end of the ring travel compared to the bottom) of .015 inches or more in every cylinder.

Was it a problem finding original-style pistons in such an extreme oversize? Fortunately, no, because Plymouth increased



Long-handled wire brushes remove dirt from the engine's inner sanctum.

its bore to 3.25-inch beginning in 1941. I simply bought post-1940 pistons for my 1939 engine. Given that my cylinder taper approached .020 inch, instructor Jerry Norris suggested that we would have to bore .030 inch oversize to clean up the cylinders. Or, rather, that we would hone the cylinders .030 inch. That's right—hone them. Jerry said we'd have more control (Read: "Less chance for making a fatal error!") and could perform the work faster using a honing machine alone versus boring to a certain size and then moving the block to the honing machine to complete the work.

Indeed, we set a dial on the college's honing machine and the honing bar did the rest. (Photo on the next page.) Sometimes, there's just no substitute for having the right tool for the job! We made the bulk (about .027 inch) of each .030-inch cut with a coarse stone and finished with a fine stone, leaving an approximately 60-degree cross-hatch pattern throughout the cylinder. Because of this cross-hatching, oil will cling to the cylinder walls, assuring the best possible lubrication.

Honing left a sharp top edge in each cylinder. Because these edges could make it difficult to install new pistons and rings or damage such parts, we lightly chamfered the opening with a cone-shaped sandpaper disc on a drill. We also checked the alignment of the main-bearing "saddles," the U-shaped bosses cast into the bottom of the block. When we placed a straight edge where the crankshaft normally sits, it contacted all four saddles so evenly that we couldn't push a .002-inch feeler gauge between the straight edge and the saddles. No problems with this block. If our test had discovered an alignment problem, at least one, possibly more, main bearing inserts would wear out prematurely because of undue pressure the crankshaft would put on it. A process called line boring can realign saddles.

In class, I used a special milling machine to surface the deck of the block—that is, clean up any rust pits, scratches and unevenness in the engine's top deck. This would ensure a good seal for the new head gasket. According to the 1939 Plymouth shop manual, a gap of .021 inch separates the tops of the pistons from the bottom of the combustion chamber. I'd planned to mill .010 inch from the head, which allowed me to remove up to .011 inch of metal while surfacing the block's gasket surface. Three light cuts in the milling machine removed a total of .009 inch, enough to leave the top of my block shiny and new. We judged that the only exceptions—some deeper rust pitting in a couple of combustion chambers and around several head-bolt holes—wouldn't harm engine performance.

Before driving in new core plugs, I used wax and grease remover (thinner or alcohol will work) to clean the edges of the core-plug holes. I then applied a thin bead of Permatex Aviation Form-a-Gasket compound around the lip of each hole to ensure a watertight seal. I placed the cupped plugs concave side down in the holes, centered the round end of a ball-peen hammer on each plug and smacked the other end with a wooden mallet. (Photo on the next page.) This slightly collapsed each plug, causing it to expand and seal the hole.

I will discuss the machining of valve seats in the "valve train" section to follow. The last step in machining the block thus takes us back to the procedure we started with: cleaning. This time, however, we're not degreasing the engine but cleaning to remove metal filings and grit from the various machining operations.

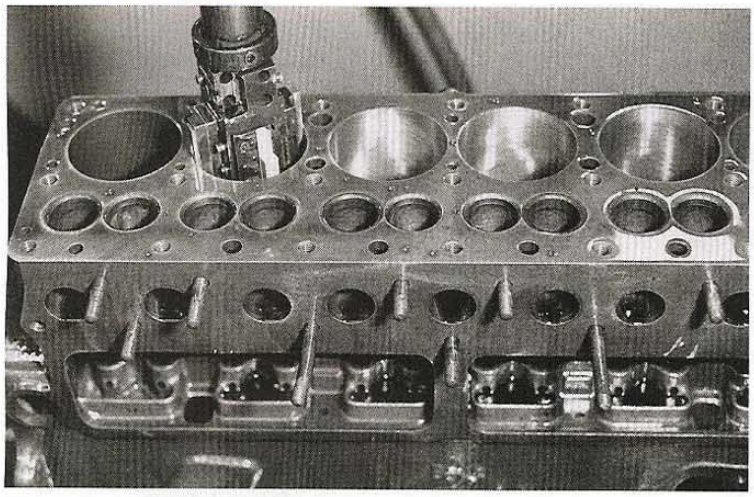
Here's how to do it: Pour some Tide or another liquid laundry detergent (I used Cheer and, boy, it sure brightened up my engine block!) into a bucket of warm or hot water. For this operation, I rolled my engine stand outside. On a nearby table, I lined up the various engine brushes, ranging from those small enough to rod out oil passages to a large one designed to scrub cylinder walls squeaky clean. I also set out a small nylon-bristle scrub brush and a sponge for cleaning the sides of the block and inside the crankcase.

Because I didn't receive any specific mixing instructions, I continued adding Cheer (perhaps three cups of it) to two or three gallons of water until the mixture produced copious suds as I swabbed out the cylinders. Before taking up the brushes, use a garden hose to soak the engine inside and out; keep it wet while you are cleaning to prevent rust from forming on the bare cast iron. Don't forget to rod out the tappet holes, valve guides, the block's intake and exhaust ports and all of the block's tiny oil passages. Perform each cleaning operation several times, dipping the brush repeatedly into fresh soapy water. Remember, a little extra care at this stage can save you lots of grief later on.

When you're done, rinse the engine thoroughly and immediately spray every inch of it with WD-40 or another non-silicone penetrating oil. (Traces of silicone can ruin your paint job.) The WD-40 will displace some of the rinse water but use compressed air and clean, lint-free towels to dry the engine. Coat the critical wearing surfaces—cylinder walls, tappet holes, valve seats and valve guides—with oil as further insurance against rust. When you are ready to paint, you can rub down the block with wax and grease remover to remove all traces of oil.

Working With the Camshaft

My camshaft's rearmost bearing is machined into the cast-iron block. The other three are bearing inserts similar to crankshaft or rod bearing inserts—except that there are no bearing caps to remove. Consequently, the bearing inserts do not snap in and out easily but are a press fit.



We began honing with coarse stones to quickly cut .027-inch oversize and finished the remaining .003-inch cut with fine stones, which left an oil-holding cross-hatch pattern on the cylinder walls.

I used the college's bearing driver to remove the old inserts but the class was over by the time I was ready to install the new bearings. Unable to rent a bearing driver, I bought one, a Lisle Model 18000 selling for $169—a good tool at a price much lower than the $400 and up of some other brands I looked at.

How worn is the camshaft? To find out, I cleaned the shaft with solvent. Then, with a micrometer, I measured its journals and lobes to compare with factory specs as given in the shop manual. My journals all measured out .002-inch smaller than the shop manual's specs for the inside diameter of the bearing surfaces. This ideal oil clearance suggests that the journals had scarcely worn.

The 1939 manual doesn't give lobe specs, so I simply looked for uniformity. Nine of my 12 camshaft lobes were either 1.532 or 1.533 inches tall. The three deviants measured in at 1.530, 1.527 and 1.521 inches.

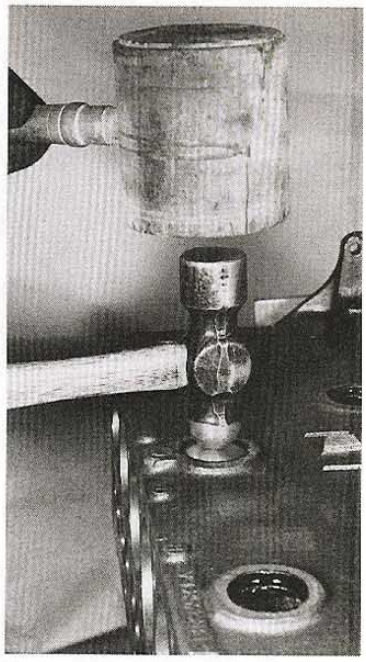
Naturally, I was concerned about the lowest lobe. But I don't think engine performance will suffer much if one valve rises .012 inch less than its neighbors. More important to me was the normal tappet wear pattern on each lobe: a narrow, smooth track on the lobe backside and a wider pattern where the tip of the lobe rose and fell under the mushroomed end of the solid tappets.

I inspected two other areas of the shaft for wear. The first, a spiral gear that operates the distributor and oil pump, looked brand-new. The second—a lobe that operates the fuel pump via a rocker arm—had a nasty scar in it. (Photo at the top of page 12.) What caused the damage? It was perhaps a flaw in the metal, an overly stiff rocker-arm spring or even a rough rocker-arm contact point on an earlier fuel pump used with the engine. (The pump I removed from the engine was smooth at its camshaft contact point.)

Machine shops routinely build up worn or scored crankshaft journals and grind them back to standard size, an easy fix with a steel shaft. But because my camshaft was cast iron, welding was out. Don Bley, a Car Quest machinist, suggested instead that we remove about .010 inch of metal from the camshaft's fuel-pump lobe in hopes of removing the damage. That did clean up the lobe (photo at the right on page 12) but the gouges were clearly deeper than .010 inch. We stopped there, however. Because the camshaft was originally surface-hardened, shaving more than .010 or .015 inch from the lobe could expose softer, faster-wearing metal beneath the hardened surface. I considered two solutions to the problem:

1. Make a brass "sneaker" to ride on the foot of the rocker arm, the theory being that the softer brass would gradually wear out instead of the camshaft lobe. I planned to make the sneaker wider than the pushrod's footprint so that it would bear on the entire width of the lobe instead of just its center. Or, 2. I could replace the camshaft.

I know of reproduction camshafts selling for $125 to $200 but I wonder about their quality. The same community college that offered the engine-machining class regularly offers a metal-working class in which I've completed various old-car projects over the years. Thus I decided that I will run the fuel pump as is for now but make a brass sneaker the next time I sign up for the metal-working class.



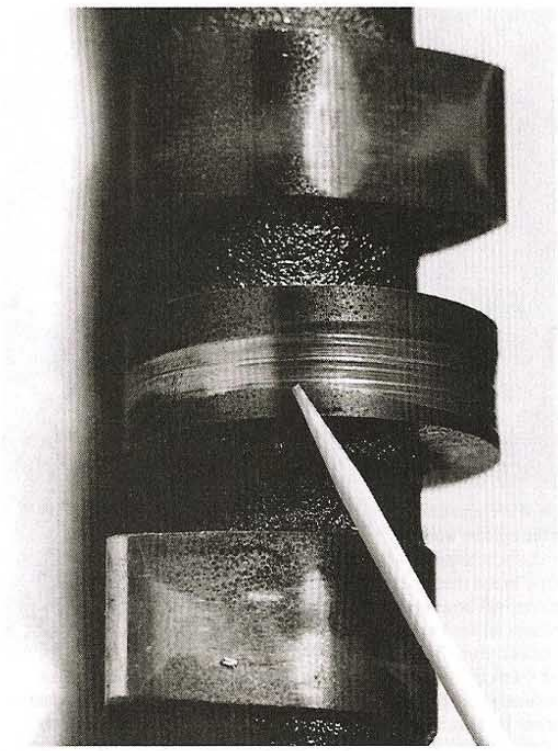
Two hammers—one wood, one steel —are necessary to expand core plugs in their holes. The shiny dark bead around the two empty core-plug holes is a sealer, Permatex Aviation Form-a-Gasket.

Clutch Renewal

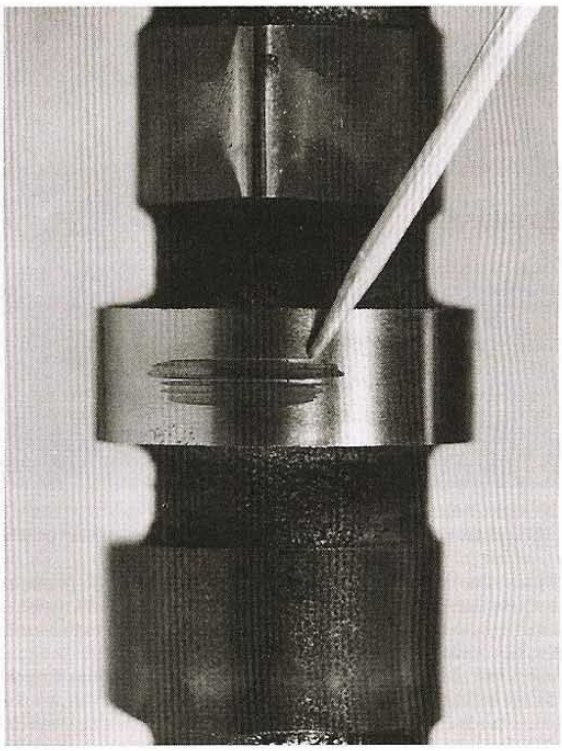
Rebuilding the clutch was the easiest part of my engine rebuild: I dropped off the old parts at Lincoln Clutch & Brake and stopped in later to pick up their shiny new twins. Lincoln Clutch disassembled and rebuilt the clutch, which included surfacing (smoothing to remove scratches and unevenness) the pressure plate, refacing the clutch disc and surfacing the flywheel. The clutch disc is the meat of a sandwich with the pressure plate and flywheel acting as the two slices of bread. If the pressure plate and flywheel have rough, worn surfaces, your clutch will chatter—guaranteed! Now what's the point of spoiling a silky-smooth engine with a jerky clutch?

Crank Welding, Straightening

After giving the crankshaft a quick cleaning in solvent to wash off the worst of the gunk, I used an outside micrometer to measure journal wear. The main-bearing journals (2.25-inch when new) had all worn .003 to .005 inch. Five of the



Deep scratches reveal that something damaged the camshaft's fuel-pump lobe.



Grinding .010-inch from the camshaft's fuel-pump lobe removed most, but not all, of the scratches.

six rod-bearing journals (1.937-inch when new) had worn a scant .002 or .003 inch. The journal that had lost its bearings (so to speak!) had been severely pounded and gouged by the No. 5 rod. At the point where the No. 5 spark plug fired and drove the piston and rod crashing into the crankpin (rod journal) with hammer-blow force, the journal had flattened pancake-style to 1.921, or .016 inch less than the as-new dimension.

Other parts of the crankpin had worn just .002 inch.

Clearly, this crankshaft needed professional help. Don Bley, crankshaft expert at the Car Quest machine shop (and the same machinist who cleaned up my gouged camshaft lobe), had a remedy: weld the No. 5 crankpin to fill the gashes. After doing so, he ground the journals to clean them up and renew their concentricity. This meant grinding .020 inch from the rod journals (new journal size: 1.917 inch) and .010 inch off the main bearing journals (new journal size: 2.240 inch). I ordered .020 inch undersize rod bearings and .010 inch undersize journal bearings.

Don bead-blasted the shaft before machining it and also rodded out the oil passages drilled through it, leaving it looking shiny and new.

I don't know if it was heat warpage due to the welding, the pounding of the No. 5 rod, or both, but my crankshaft had a slight bend in it. Don used a press to straighten the crank. I knew the crank would sit at my shop for several weeks before I installed it, so I protected it from rusting by spraying the entire shaft with WD-40 and coating the journals with motor oil.

Two Heads Are Better Than One

My engine's later-model cylinder head (indicated by a cast-in part number of 952083 versus the original 632955) was the only non-original part on the engine. Still, I had to use it until I could find a correct head. When a Magnaflux test showed that the head was free of cracks, I prepared to return it to service. But while bead-blasting the head in preparation for painting, I uncovered a tiny crack radiating from the water-outlet opening (photo on next page). Packed solid with rust even after cleaning in the Car Quest shot-blasting machine (the crack was too small for the stainless-steel shot to penetrate), this fissure had escaped detection. Thus my search for the correct cylinder head began unexpectedly early.

At about this time, I followed up on a friend's tip and for $100 bought a 1938 Plymouth coupe that in the early 1960s had been cut down to create a homemade pickup truck. Though sporting a cracked block and two broken leaf springs, the battered workhorse was mechanically complete. What's more, the number cast into the top of its cylinder head was the magic one: 632955, correct for all 1935-40 Plymouths.

Before I paid $42 to have the mating surface of the new head milled smooth, I set my sandblaster on a low 40 psi to blast off decades of exterior surface rust and water-jacket rust scale. My low-pressure blasting also removed built-up carbon from the combustion chambers, leaving them shiny and smooth. The result? No cracks; this 1938 Plymouth head was a keeper. I painstakingly blew all the sand from the head's bolt holes and water passages and wiped all surfaces clean. Next, I ran a thread chaser through the spark plug holes, hammered a new core plug into place and, at the completion of the milling procedure prepared to paint it silver.

Machining Rods, Fitting Pistons

I was retiring the pistons but reusing the rods so I needed to separate the two. Technically, the piston pins (hollow cylindrical pins that attach the pistons to the connecting rods) are the "floating" variety. In reality, they attach to the pistons with what my shop manual calls a "thumb press fit at 130 degrees F."

To remove the pins, I heated water in an old saucepan to 130 degrees, as indicated by a meat thermometer. When I dipped each assembly, the aluminum-alloy piston expanded more than the steel pin, thereby loosening the press fit that held the ends of the pin in the piston. Bead-blasting the rods magically removed their brown, oil-stained patina and left them looking like newly-cast parts. To prevent rust, I sprayed them afterward with WD-40.

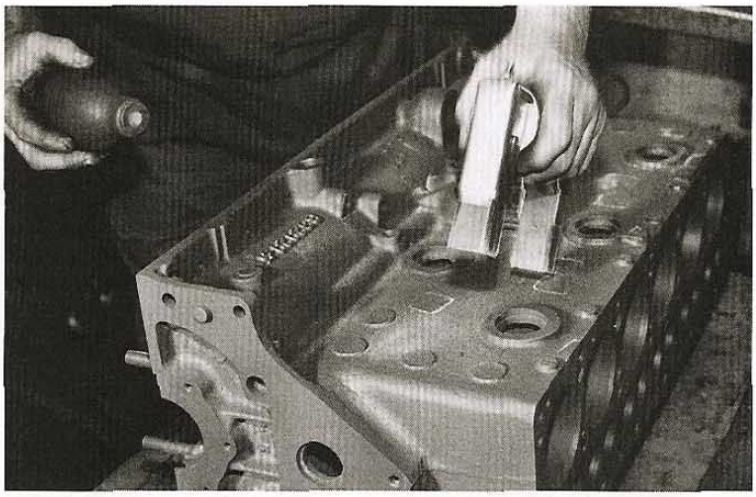
Unfortunately, my eight-session class flew by so quickly that I didn't have time to recondition the rods. I sent them instead to Spanel Engines, (402/421-8410), which also balanced my engine. Though Chuck Spanel specializes in building race-car power plants, he agreed to help me with my 1939 Plymouth rebuild. His machinists pressed out the old piston-pin bushings; pressed in new ones and swaged them firmly in the rod—that is, expanded the ends of the bushings (manually with a tapered mandrel or by using a machine designed for this task) to lock them in place so they won't spin with the pin; and reamed the new bushings so that the pins would be a "tight thumb press fit at 70 degrees F."

The shop also placed the rods on an alignment gauge to check for twists and bends (and, I know, straightened at least one of them). I supplied a new rod to replace the No. 5 rod, which had overheated to a blue-black color. Another machine at Spanel Engines resized the large ends of the rods to ensure their concentricity. I would assemble the pistons, rods, rings and bearing inserts myself when I rebuilt the engine.

Renewing the Valve Train

As much as possible, I wanted to replace parts in the valve train. Therefore, I bought new valves and valve guides, tappets, springs and keepers. Restoring the valve train was a seven-step process that I undertook in this order:

1. Drive out old valve guides. It is possible to drive out the valve guides (removable sleeves that the valve stems travel in) with a heavy hammer and a steel rod. I've done it; I don't recommend it. You will certainly whack your hand a time or two when a mighty hammer swing goes astray. And if you hit your block with a four-pound hand-held sledge—what then? No, the manual method is risky.



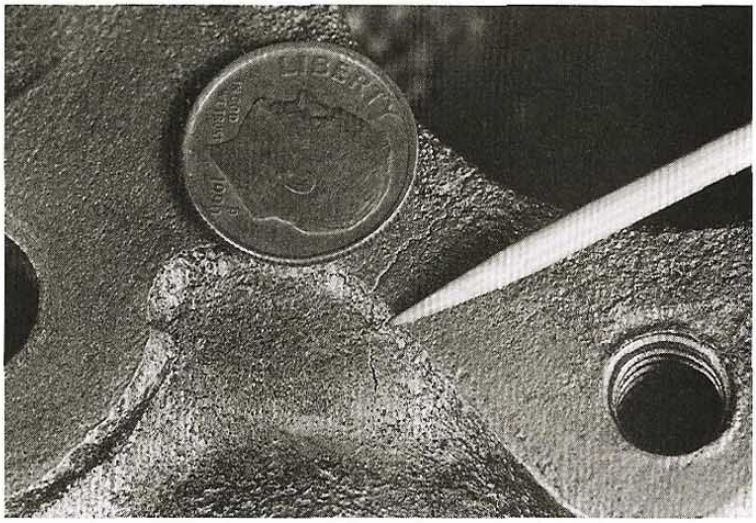
Machinist Randy Moore performed a Magnaflux test on my engine by sprinkling magnetic powder on the block and moving a horseshoe-shaped electromagnet up and down the surface. No cracks appeared, although I found a small one later on. (See photo below.)

But the special tool I used to drive out the guides safely and easily disappointed me. The first time that I attacked the valve guides in class, I took in hand a pneumatic zip gun, or air hammer, fit its driver shaft through the top of a guide, pulled the trigger and eagerly awaited the results. The gun hammered, as advertised, making a truly awful racket. But like the pig in the brick house, the guide stood pat against the onslaught. I tried another guide, and another. Out of 12 guides, just three came out that night.

What the heck happened? Well, I had picked up a lightweight zip gun. During a later class, I grabbed a leviathan of a zip gun, one with a long stroke and a 3/4-inch-diameter piston in it. Wham, bang! The rest of the guides popped out lickety-split.

Warning: the first guide that popped out jammed in the top of the tappet hole directly beneath it. Ouch! My quick-and-dirty solution to prevent this was to cut a strip of metal from a tin can. Presto, an instant cover for the tappet holes.

Next month, we'll continue with the valve train, balance the engine and do some metal work. ■



Magnafluxing missed this tiny crack, which showed up only after I bead-blasted the head.