Engine Rebuild, Part 3

This Month, We Work With the Valve Train and Then Prep and Paint the Engine

BY CURT McCONNELL

WHEN WE LEFT our 1939 Plymouth flathead six last month, we had *just started to rebuild the valve* train and had removed the old valve guides, the first step in the valve train restoration. This month, we'll pick up the project with the valve guide replacements.

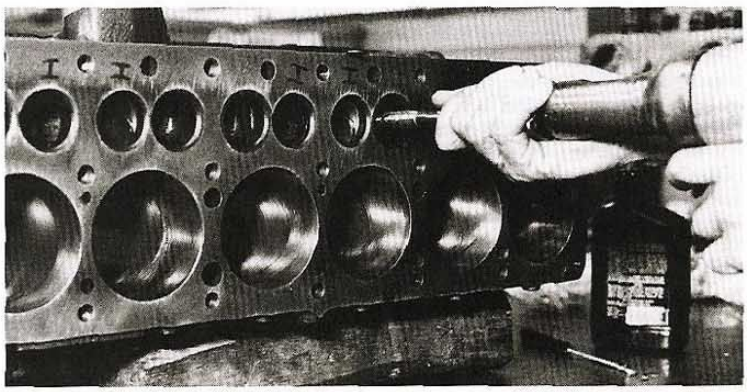
Step 2. Drive in new guides. I used the same heavy zip gun and driver shaft to install the 12 new guides. Though the guides appeared identical, the internal diameter of the exhaust guides was .001 or .002 inch larger than the intake guides. Unwrapping my new valves, I used them to sort the intake guides from exhaust guides. Then, in permanent marker, I placed an "I" on the engine top deck next to each intake-valve port. After all, I wanted to drive the six intake guides into their proper positions and ditto for the exhaust guides. Dipping a cylindrical wire brush in extreme-pressure lubricant, I coated the insides of the guide holes, after which the new guides drove smoothly into place. (Photo at right.)

Jerry, my instructor, warned me to press down hard on the zip gun as I drove the guides home. Letting the gun and its driver bounce would cause the new cast-iron guides to chip, crack or mushroom. I withdrew the gun periodically and placed a steel rule atop each guide until I drove it to its correct position of 7/8 inch below the engine deck.

3. Ream guides to size. Chucking a reamer (what looks like a large drill bit is actually a cutting tool) in a drill, I removed enough metal to bring the internal diameter of the guides to factory specs: .342 to .343 inch for intake guides and a slightly larger .344 to .345 inch for exhaust. Exhaust guides need more clearance because they run hotter and thereby expand more than intake valves.

The secret of reaming is to remove metal in tiny .001-inch steps until the valves just fit the guides. I used carbide-steel reamers dry because they don't require cutting oil.

When I finished reaming each guide, I test-fit a valve to ensure its stem could slide without binding. One test I performed was to grasp each valve by the head and rock it to and fro to make sure I could detect a slight wobble. This indicated that the stem-to-guide clearance was proper (.001-.003 inch for intake guides, .003-.005 inch for exhaust).



Using a zip gun, I drive a new exhaust guide into place after lubricating the hole with extreme-pressure lubricant.

A pop test can provide another seat-of-the-pants gauge of valve-to-guide clearance: 1) oil the stem, 2) insert the valve in its guide, 3) cover the lower guide opening with a finger, and 4) pull up sharply on the valve. If the valve makes a champagne-cork pop when it clears the guide, chances are that the clearance is proper.

I had already determined the valve-to-guide clearance mathematically, however, by subtracting the valve-stem diameter (measured with a micrometer) from the reamed size of the guides. A .341-inch valve stem in a guide reamed to .343 inch has—or should have—.002-inch clearance. Still, I used the rocking and pop tests as a rough check of my reaming (and subtracting) skills. A dial-indicator gauge placed against the head of the valve will yield a precise measure of the valve stem-to-guide clearance.

4. Grind valve faces. Like many other top-line valve grinders, the Kwik-Way machine I used allows for the truing of both ends of the valve. If I had reused my old valves, I would have made use of an attachment on the right-hand side of the machine; it holds the valve perpendicular to the side of the grinding wheel so that you can true the heel of the stem. A separate attachment will cut a slight 45-degree chamfer in the end, eliminating a sharp edge that could nick the valve guides as you install the valve.

I set the machine to cut the valve faces at 45 degrees, precisely matching the valve-seat angle. I chucked up my new valves in the spirit of an exercise. I fully expected that the faces were both 45 degrees and concentric.

As a chuck spun each valve, I turned a wheel slowly with my left hand to bring the valve face into contact with a grinding wheel. Coolant flowed from a flex hose onto the valve head.

With my right hand, I moved the face of the valve back and forth across the grindstone. To my surprise, several of the new valves were not concentric. I could tell because the grinding stone made intermittent, not constant, contact with the valve faces.

With the left-hand adjusting wheel I fed the valve face into the grindstone .002-inch at a time until the stone made constant contact with the valve. This sound signaled a concentric cut. At this point, I used the right-hand control to move the valve face back and forth across the stone until it "burned out" (no longer was grinding). Then, as I continued moving the valve face back and forth across the stone, I moved the face slightly closer, by maybe .001 inch, and allowed it to "burn out" again. This gave the valve face an extremely fine polish.

5. Grind the valve seats. I purposely waited until after installing new guides to grind the valve seats. Why? Because it is necessary to press a tapered shaft into the guide to act as a pilot for a stone that grinds a new, concentric valve seat in the block. If I had ground new seats with an old guide in place and then replaced that

guide, chances are good that the new guide would place the valve in a slightly different alignment with the new seat. In other words, the valve wouldn't seal properly.

My engine came from the factory with hardened seat inserts for the exhaust valves—ideal for today's unleaded gasoline—and seats cut directly into the block for the cooler-running intake valves. To grind seats, I manually pushed the pilot as far into the guide hole as I could. Then, through a hole drilled in the top of the pilot, I inserted a six-inch piece of metal about half the thickness of a pencil. This acted as a T-handle. Pressing down on the pilot, I wedged it firmly in place by turning the T-handle a quarter-turn clockwise.

Now, as to the grinding stone. First, in a special grinder, I trued up a 45-degree stone. I then placed the stone on the pilot shaft and centered a pneumatic Sioux grinder tool on the stone's drive end. This isn't the press fit of a socket to a ratchet wrench. Rather, it is a "contact" connection. That is, you stop grinding merely by lifting the grinder's star-shaped drive gear from its loose union with the top of the grinding stone.

To begin cutting, center the grinder and make sure it "floats." That is, don't tilt the grinder, which is tantamount to drilling a crooked hole with a hand drill. A good way to avoid tilting the grinder is to refrain from leaning on it. Let only the weight of the tool bear on the grinding stone (photo at right).

Fire the grinder for three seconds, release the trigger and then immediately lift the grinder. This leaves the stone spinning freely on the pilot. Do not let the stone stop spinning: the chattering it makes as it slows will mar the seat. With your free hand, grab and lift the stone while it is still spinning briskly. If the seat looks uniformly clean and bright, you're done with the 45-degree stone.

With my old, neglected engine, however, I discovered that my first attempt at grinding each seat rarely touched all areas of the seat. I nearly always had to run the stone for a second or even third three-second interval. Beware the "China Syndrome": grinding and grinding until the seat sinks well below the top surface of the block.

The smooth, polished seat that you are preparing will determine how well the valves seal. The rule of thumb is that the seat width should be 1/16-inch for intake valves and a slightly wider 3/32-inch for exhaust valves. This wider point of contact helps transfer heat from the hot-running exhaust valves to their valve seats, which in my Plymouth are cooled by a stream of water directed by a water-distribution tube in the block.

Before removing the pilot shaft from the guide, I repeated the grinding procedure using a 30-degree stone. The 30-degree stone chamfers the top of the seat, preventing the buildup of carbon that can hold open a valve. Operate this stone in two-second bursts. If it cuts a concentric groove during the first try, fine. If not, run it an additional two seconds. If you overdo it, the 30-degree stone will reduce the width of your 45-degree cut to less than the ideal (1/16 inch for intake valves, 3/32 inch for exhaust). If this happens, you'll have to recut: first with the 45-degree stone, and again with the 30-degree stone. Be careful! It could be the China Syndrome all over again.

Once you've firmly locked a tapered pilot shaft in the new valve guide, place a chamfered grinding stone over it in preparation for grinding a new valve seat (left). The correct way to hold the grinder: 1. Center it on the drive end of the grinding stone, and 2. Place a hand beneath the grinder so you can quickly lift the tool off the stone at the end of each three-second cut.

My old shop manual recommends lapping intake valves after the grinding operation. This involves using lapping compound (a gritty paste, often from a tube) to polish a mirror-like finish in the mating surfaces of each valve face and its seat. (Lapping doesn't apply to exhaust valves, whose hardened seat inserts are difficult to polish this way.)

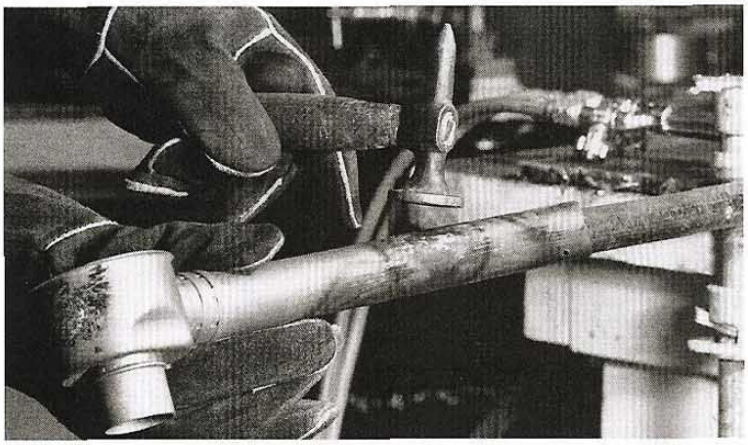
But things have changed in the 60-some years since my shop manual was published. Jerry, my instructor, says he never laps valves: it simply doesn't do any good. His reasoning is that valve heads expand several thousandths of an inch at operating temperature. In so doing, each valve will ride higher on its seat than it did when you ground it with lapping compound in your shop at an ambient temperature of 72 degrees. So, while it looks ever so nice, that mirror-smooth finish that you laboriously ground into each valve and its corresponding seat using lapping compound is for naught. At engine-operating temperature, these highly polished lines won't mesh.

When both your 45- and 30-degree angles look good, remove the pilot: slide in the T-handle and lift on it while turning the pilot counterclockwise. Let's test to be sure the valve and seat will make an airtight seal. First, you must true (grind) the valve faces as previously described. Then, using a finger, smear a coating of Prussian blue on the face of a trued valve.

Drop the valve into its guide carefully to avoid wiping off the blue with your fingers. From a height of an inch or two, smack the valve hard onto its seat one, two, three, four times. Lift the valve each time by placing a finger under the valve stem. Don't be shy. In normal use, a valve is subjected to much greater abuse than this.

Now remove the valve by placing a finger under the valve stem; this will lift it high enough so you can grasp the top of its stem. Again, don't touch the blue or you'll spoil your test. On the valve face, look for a smooth, concentric band of bare metal where the two parts made contact. The seat should display a reverse image: a smooth, concentric band of blue around its perimeter. This represents the tight seal you're after.

6. Test springs for squareness and compressibility or buy new ones. My shop class had a machine similar to an arbor press, comprised of a lever and scale. It could compress valve springs to a particular height (indicated by a simple ruler on the right-hand side) and show



Using an oxyacetylene torch (background), I heated a dent in the breather pipe, shoved the piece over an anvil pipe and hammered around the perimeter of the dent with a bodyworking hammer.

the amount of force required to do so. My springs are supposed to exert 77 to 83 psi when compressed to 1 7/16 inches. (One book I consulted said old springs should have at least 90 percent of their minimum rated strength. In my case, that would be 69.3 psi.)

I didn't test my old springs, however, because I replaced them with new ones. I should have tested my new springs while I had the chance, just to be sure they were within factory specs. I did, however, test the new springs for squareness. To do so, I placed each spring on a flat surface next to a square, turning the spring upside-down to repeat the test.

7. Hone tappet holes. I would have replaced the tappet guides except there are none: the tappet holes are drilled directly in the block. Instead, I ran a 180-grit Flexhone, dipped in honing oil, for four or five seconds—the time it took me to run the hone three times in and out of each tappet hole. Honing produced a fresh oil-holding crosshatch pattern for the new tappets I would install.

Balancing the Engine

Mechanics at Spanel Engines removed metal as necessary so that all rods and pistons weighed the same. They also spun the crankshaft, pulley, flywheel and clutch on a dynamic balancer. This special lathe-like machine uses a strobe light to pinpoint heavy spots for the operator, who can eliminate a heavy spot by drilling a crankshaft counterweight.

Engines, like tires, can be balanced to eliminate vibration and consequently improve performance and engine life. Tires are balanced by adding a weight to the rim opposite a heavy spot. Engine parts—the rods, pistons, crankshaft and pulley, flywheel and clutch—are balanced by drilling or grinding to remove weight.

An engine's reciprocating parts—pistons and the I-beam portion of the rods—should have identical weights. Likewise, revolving parts (the rod caps, crankshaft, pulley or vibration dampener, flywheel and clutch) should have no heavy or light spots or else, like an unbalanced wheel, the crankshaft will thump at every revolution. Such thumping can gradually pound bearings out of round and cause other problems. Incredibly, my new Badger pistons (Badger Pistons, Downers Grove, Illinois), came from the factory weighing an identical amount. The rods were various weights and most had to be ground.

Straightening Sheet Metal

Three metal-straightening jobs and three fabrication projects remained in the machining phase of my rebuild. First, I had to straighten dents in the crankcase breather pipe and clutch pan and inspect the oil pan for flange irregularities that could cause oil leaks.

In my inventory of scrap metal, I found a pipe slightly smaller in diameter than my dented breather pipe. This would act as my "anvil." With an oxyacetylene torch, I heated the dented areas cherry red, quickly shoved the breather pipe on my makeshift anvil and hammered around the perimeter of each dent while pressing down on the piece. (Photo above.)

Hammering off-dent while applying upward pressure on the center of the low spots had the effect of raising the dents. Though not perfect, the straightened pipe looked reasonably good. A larger anvil—a pipe that fit inside the breather pipe with no clearance to spare—would have produced better results. With a tighter fit I could have heated the dents and forced out the low spots by simply pushing the breather pipe over the anvil pipe.

My other dented piece of sheet metal was a clutch pan, crushed and torn from contact with the ground. After welding the tear, I used a Bull's Eye bodyworking pick, along with a hammer and dolly, to begin bumping out the dents. (For more on working with a Bull's Eye pick, see the August 2001 issue.)

I'd intended to metal-finish the pan by straightening it so thoroughly that it wouldn't require body filler. I am a slow worker as I learn to be proficient at metal-bumping, however. "This alone could take me all day," I fumed to myself when, at 7:30 one morning, I began repairing the pan. Right then I got that low-down panicky feeling that occasionally preys on all do-it-yourselfers: I have much to do; can I find a shortcut?

So, abruptly, I changed my mind, deciding that in the interest of time I would try using a polyester body filler on this under-engine pan that no one would see anyway. Accordingly, I bought and mixed some Evercoat filler, dry-sanding by hand with a small sanding block and using 80-grit paper between three relatively thin coats. I finish-sanded with 220-grit paper.

I should have followed up by applying a glazing putty designed to fill the few pinholes that remained in the coarser polyester putty. I didn't, though. My decision saved some additional time and affected only the appearance of the pan, not the durability of my repair. I also used the polyester putty to fill the minor low spots remaining in my breather pipe.

Now, I am sorry for not metal-finishing the pan. It was certainly the greater challenge, so I would have learned more. I also didn't save a lick of time using body filler because of all the sanding it required.

While my hammer and dolly were still at hand, I held a straight edge along the upper edge of the oil-pan flange. Overtightening the pan bolts, which causes the sheet-metal flange to bulge upward around the bolt holes, can produce oil leaks. My oil pan was in fine shape, however.

Fabricating Filters and Seals

For my first fabrication project, I fashioned two concentric cylinders out of hardware cloth and stuffed a stainless-steel pot scrubber between the two, thus replicating the wire-gauze filter in the newly straightened crankcase breather pipe.

I also had to make two bell-housing seals from scratch, my final projects before

painting and assembling my engine. The first seal was the leather boot that covers the opening where the clutch-release fork enters the bell housing. (See the September 2001 issue for an article on how to make that boot.)

The second was a rubber plug that seals a 1⅝-inch-diameter hole in the top center of the bell housing—apparently an inspection hole. A visit to my usual hardware haunts produced a big fat zero. Instead, I began seeking ideas at auto-parts stores. A Car Quest counterman suggested that I use a rubber oil-filler cap they stocked. Though just 1½ inches in diameter, the top flange of the part (item no. 36007, about $2.50, which fits a range of GM cars) easily covered a 1⅝-inch hole. With a handheld grinder-buffer, I ground off the raised design ("OIL" with a circle around it) and used a knife to trim most of its length. A bead of 3M black Super Silicone Sealant glued the plug in place.

Sandblasting and Metal-Etching

The most daunting task of my engine restoration had nothing to do with turning a wrench. I spent far more time sandblasting and painting engine parts.

Parts large and small needed painting: the bell housing, block and cylinder head, manifolds, oil pan, timing chain plate and cover, air cleaner and clutch pan were some of the larger parts.

But I also prepped and painted a slew of smaller parts, from the crankshaft pulley nut to the valve-cover thumb screws. Everything was black except for the Purolator permanent oil filter canister (orange) and the cylinder head. My "silver dome" Plymouth has its cylinder head, water-outlet elbow and related parts painted silver.

My procedure for painting started with thoroughly cleaning greasy parts in my solvent tank until I had enough clean parts to fill my homemade rolling paint rack. Although I invested 60 hours of time in the cutting, grinding, drilling, welding and painting of this rack, the result was well worth it. I encourage you to build one and will write an article on its construction in the coming months.

Next, after degreasing each batch of parts, I sandblasted them in the driveway in front of my shop. (Put down a large sheet of plywood because sandblasting will quickly chew up concrete!) My set-up includes a two-stage, 5-horsepower compressor that produces plenty of air to run a pressure-fed, 100-pound-capacity sandblaster made by Truman Industrial Products of Truman, Ohio. If I wanted to, I could blast away indefinitely at a relatively high pressure of 80 psi.

Silica sand has such sharp edges, however, that when propelled at 80 psi it produces a rough surface. Generally, then, I sandblast at 40 or 50 psi. This slows me down but produces a more paint-friendly bare-metal surface. To avoid warping sheet metal (the clutch pan, a fuel-pump heat shield and other such parts) I found it necessary to use even lower pressures—20 to 30 psi. Regular halts to inspect parts, refill the blaster and replace the plastic lens in my protective hood all caused further delays.

To avoid the boredom of long, uninterrupted sandblasting sessions, I typically cleaned just a few parts at a time and then stopped the machine, walked over to a table I'd positioned nearby and treated the newly stripped parts in an acid-etching solution. I used one of many brands on the market, Sherwin-Williams Met-L-Etch, diluted in a 1:2 ratio. Met-L-Etch and similar solutions primarily etch metal surfaces, giving paint a better grip. But they also act as cleaners by removing any grease or wax residue that survived sandblasting.

When etching metal, be sure to wear goggles—better yet, a full-face shield—chemical-resistant gloves and, if possible, a respirator. Before treating the part, wet it with water from a hose or bucket. The best way to apply the acid-etching solution (more commonly called "metal prep") depends on the size and intricacy of the part. My arsenal includes toothbrushes, larger parts-cleaning brushes and even a sponge for wiping large surfaces and hard-to-reach areas.

Instructions for Met-L-Etch say to brush each part for up to three minutes, keeping it wet for the duration, before rinsing off the solution. The acid produces a light white froth as it works. I mistakenly used steel wool to smooth the sandblasted surfaces of several parts, particularly the cast-iron manifolds. Belatedly, I noticed that the instructions advise against this; they recommend using a nylon scuff pad instead. Fortunately, the steel wool didn't create any problems.

If rinse water beads off the cleaned metal, the part is still contaminated with oil or wax. Treat it again. Rust stains will form if you allow the parts to air-dry. I use paper towels to remove most of the water and a few shots of compressed air to finish the job. Manifolds and other intricate castings can trap water in hidden places. Bake them in an oven or place them in the sun to dry.

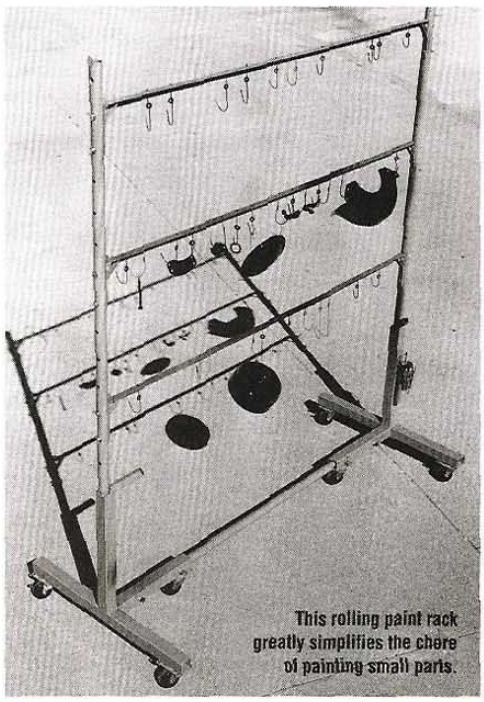
The parts are now ready for painting. Henceforth, handle them only while wearing plastic or vinyl painter's gloves or you'll leave oily fingerprints on the bare metal, thus jeopardizing your paint job.

Painting for Permanence

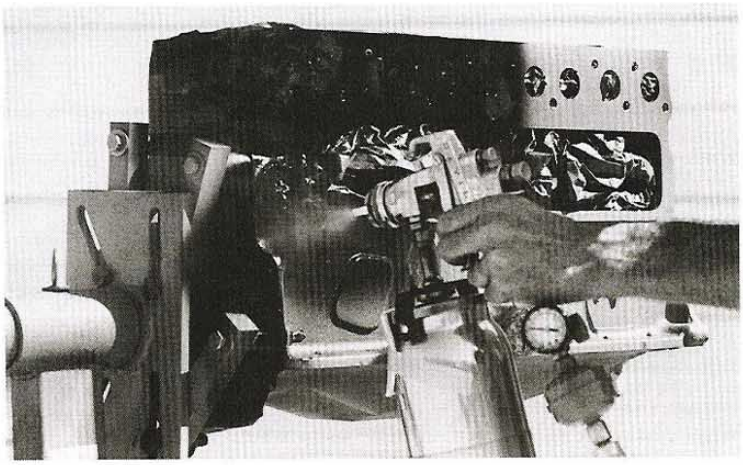
After spending loads of time and money meticulously rebuilding the innards of my antique engine, I wasn't about to cut corners with the exterior restoration. An engine compartment is a hostile environment; thus spray cans were out, professional auto-body paint was in.

Unhappy with the Ditzler acrylic enamel I have used for years—it chips if you so much as look at it cross-eyed, in my opinion—for this project I experimented with Sherwin-Williams paint. My goal was to select and apply paint that would stand up for the life of the engine, using my good-quality standard—not HPLV (high pressure, low volume)—DeVilbiss spray gun.

Therefore, I used an etching filler-primer—Sherwin-Williams GBP E2-G980. An etching primer supposedly forms such a tight bond with bare metal that rust cannot migrate under healthy paint adjacent to the nicks and scratches that



This rolling paint rack greatly simplifies the chore of painting small parts.



The block looked very businesslike, even dignified, after receiving its first coat of glossy black.

my engine parts will inevitably receive in use.

I didn't particularly want the "filler" portion of the filler-primer, which caused the undercoat to go on heavier than I needed. But, thankfully, it didn't fill in my engine number or other codes stamped into the block. I wanted to preserve these.

Because filler-primers tend to be heavy, they often spray on dry, leaving a rough surface. The Sherwin-Williams product, however, generally flowed out well. Still, after it set up I did use a fine scratch pad without water to smooth out some rough spots.

My only other objection was with the filler-primer's color. Most of my parts would be topcoated with black; accordingly, I wanted a black primer, not the olive green of the E2-G980. (Nobody would notice chips in a black topcoat if I used a black undercoat.)

Next, after the proper dry time, I applied the recommended single coat of sealer over the filler-primer. (I bent the rules a bit by applying Ditzler sealer over Sherwin-Williams primer. Paint makers warn against mixing brands. In this instance, at least, I encountered no problems—and saved myself a pile of money by using a sealer I already had on hand.)

I followed up with my topcoats: various colors of Sherwin-Williams Ultra One Stage acrylic urethane paint. Using this system involves mixing the paint with a reducer and a hardener. Though I sprayed the paint in direct sunlight during several days of high humidity when the temperature climbed into the mid-90s—all undesirable conditions—I got excellent results. Did I consider using one of the specialty engine enamels that I've seen advertised in hobby publications? Yes, I did. But the advice I received at my auto-paint store was that modern auto urethane enamels stand up to heat, abrasion, oil and antifreeze as well as, if not better than, the so-called engine enamels—and come in a wider variety of colors, besides.

High-temperature paints are a different story. For the manifolds, I ordered a pint of "space-age black" paint ($25 plus $7 shipping and handling) from Bill Hirsch Automotive (396 Littleton Ave., Newark, NJ 07103; 800/828-2061), advertised as not a paint but a "coating" capable of withstanding 1800 degrees. The instructions recommend brushing it on. For better flow, I sprayed it and got a great finish. I'll have to weigh in later regarding its durability.

In matching original colors, the Plymouth Owners Club didn't have any recommendations to assist me—or at least I wasn't aware of any. Therefore, I matched the colors on my own. Because my Purolator filter canister was badly faded, I had my auto-paint store match the color from the photo of a better-preserved can on another Plymouth.

I looked through a paint-chip chart of "fleet colors" to find a bright silver that resembled my original. I chose a glossy black for the block and the other parts so painted (photo above). A pint each of orange and silver was more than ample; I used up my first quart of black, however, and had to buy a second.

Full disclosure requires that I reveal the price of my primer and paint. But first, let me get this off my chest: OUCH! It hurts! Is it any wonder that the root of "paint" is "pain"? My etching primer ($32.87 per quart) and its reducer-activator ($23.39) cost me $56.26 overall, and I had to go back for refills—$112.52 total. Pints of color cost $26.03 for silver, $31.85 for orange—$57.88 total. I spent $68.46 overall for a quart of black ($27.20), with its associated solvent ($7.66) and hardener ($33.60), and I went back for seconds—$136.92 total.

The grand total for etching primer ($112.52), silver and orange ($57.88) and my black-paint system ($136.92) comes to $307.32. Again, I say OUCH! My salve is knowing that I got a much better paint job than the guy with a spray can. And because I just barely ran long on primer and black, I have nearly enough of those items to spray a second engine. With my silver and orange, I have more than enough remaining to complete a second engine. In reality, then, $307 was my up-front fee for two paint jobs—not so bad.

Decals and Cadmium Plating

Applying old-style decals and replating parts to match the originals are two finishing touches that spell the difference between an engine rebuild and an engine restoration. From Jim Osborn Reproductions (Lawrenceville, Georgia, phone: 770/962-7556), I ordered reproduction decals for the air cleaner and oil-filler cap. I am still looking for original-style decals for the car's Purolator can and the wire-mesh filter on the breather pipe.

As my engine disassembly progressed, I expanded my list of parts that were originally plated with a tough, whitish-silver protective coating called cadmium. Such parts look tinned; older cadmium-plating looks like clean bare metal. My list ultimately contained the radiator cap, throttle-control linkage, a transmission shifter-cable bracket, clutch-release fork and the adjustable tip of its control rod, double-wire hose clamps and the dipstick. Other parts, such as the oil pan drain bolt, were so rusty that I'm merely supposing they were plated.

I called my usual plating shop, in a city 50 miles away, for a quote on the many small parts I needed cad-plated; the throttle control alone comprises 13 pieces! "Oh, it's not very expensive at all," the owner told me. I erred by taking this at face value. Had I questioned him further, I would have learned that his employees would need to bead-blast every part—a considerable task. I don't yet own a bead blaster but I could have arranged to borrow one. The result: The parts are beautifully plated but the price of $192.50 was far more than I expected.

Next month's final installment covers assembling, installing and starting the rebuilt engine. ■