November/December 2016 | V3 N6

PERFORMANCE TECHNICIAN

CARBURETION, 3
THE CONTINUING SAGA OF THE SEVEN CIRCUITS

IT'S A KOUL, KOUL WORLD...

PRESSURE: LEARNING TO LOVE IT!

Vehicle Power & Performance Knowledge for Professionals

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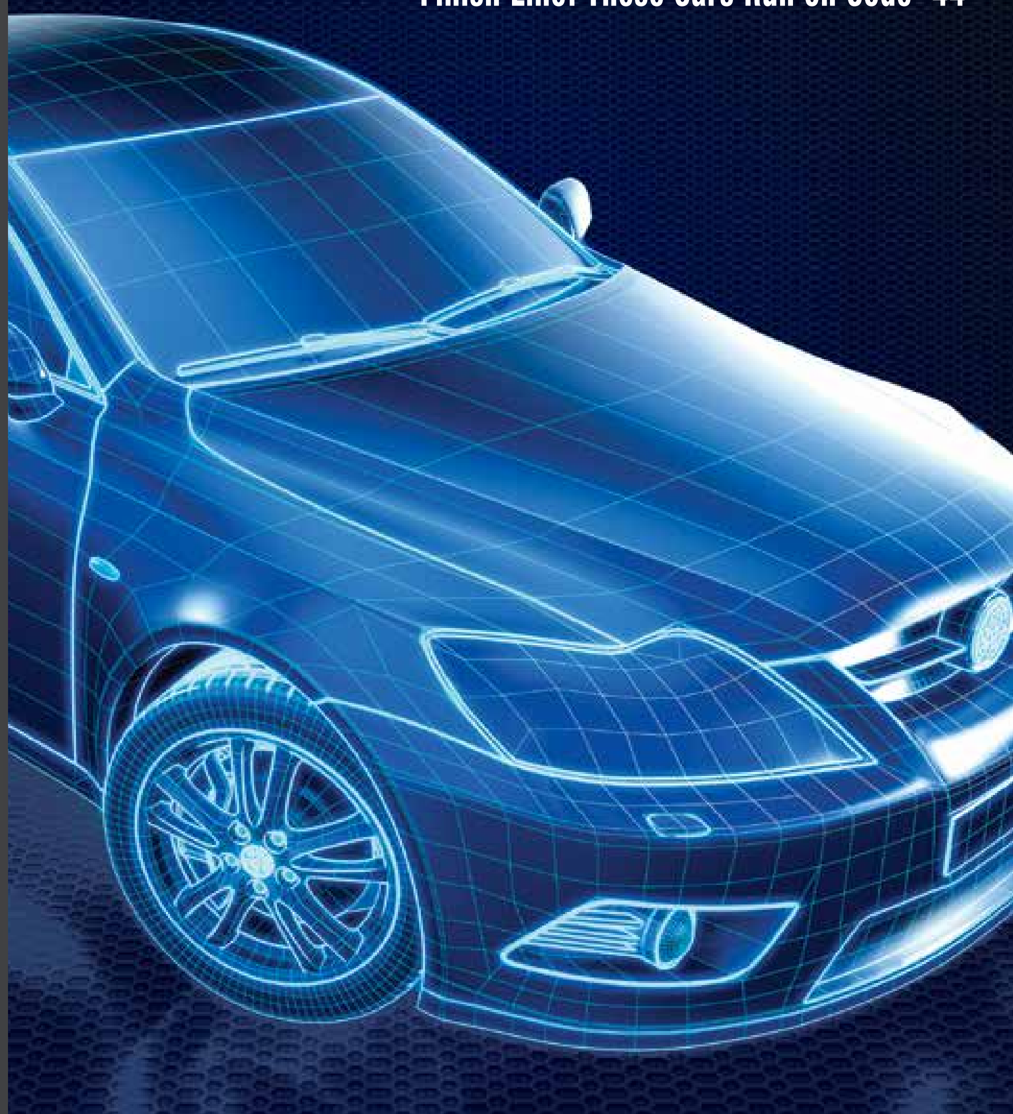
PERFORMANCE TECHNICIAN

FEATURES

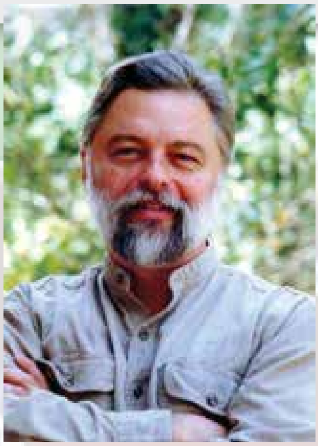
DEPARTMENTS



STARTING LINE

CARB-O-RAMA

-Robert Freudenberger



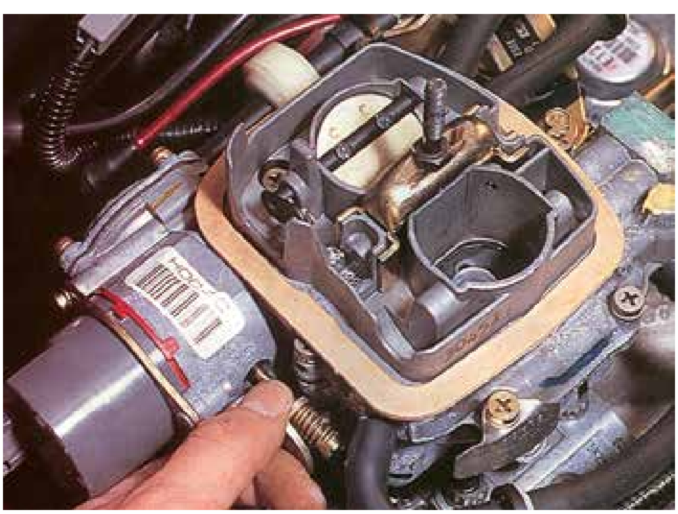
-Bob Freudenberger

This issue of Performance Technician has so much great content on carburetors, I decided to expand my regular column into a feature as an opportunity to share some facts, experiences, and observations on the "magical mechanical mixture maker" that I hope you'll find interesting. Our Exec Tech Editor and main contributor, Greg McConiga, says this piece is "A testimony to Yankee engineering and frugality – forgotten values for many – from back when we did what we had to with limited resources." So, there might be a little more nostalgia in here than you expect of a technical magazine, but, hey, it's my column.

Wretched excess?

I've always enjoyed working on carburetors, and still do in spite of the usurpation of their function by fuel injection. I started when I was a mere boy. Except for cleaning bowls and making adjustments, the first job I remember doing was fixing a sunken float from an old tractor carb — gasoline all over. The pontoon-type brass float had corroded through in spots at the bottom, so there wasn't enough air inside to provide sufficient upward pressure on the needle. It would've been quite a hassle and expense to find and acquire a new one, so I had to enlist ingenuity. I drilled out the pitted places, then let the gas drain onto a rag for a day or so. When I was confident that I wasn't going to blow myself up, I soldered over the holes I'd made. Worked fine.

I made a point of taking all kinds of carbs apart, from little ones on construction generators, lawnmowers, motorcycles, and outboards to big Quadrajets, Autolites/Motorcrafts, and Holleys, until I got a solid



This two-barrel on an '85 S10 2.8L was one of the latest-model carburetors I had anything to do with, but others were produced up to about 1990.

understanding of their theory and operating principles. My old-school favorite was the Carter AFB four-barrel, as might have come off a Chrysler 413 or 440, because I really got to know how to set it up.

MECHANICAL COMPUTER

I remember calling the carburetor "a mechanical computer" in a tech article long ago because it made "decisions" about the air/fuel mixture on the basis of input (temperature, throttle position, vacuum, and in some of the later versions, atmospheric pressure in the form of an altitude compensator). That's not really such a bad description, come to think about it again.

The latest-model vehicle I remember working on that came from the factory with a carburetor (non-feedback) was a 1985 Chevy S10 2.8L V6 — that's over 30 years ago! There were some later ones up to about 1990 on certain Oldsmobiles and Buicks, and the Subaru Justy, but we're still talking decades since EFI took over. That doesn't mean there aren't millions upon millions of carbs out there, however. Besides old passenger cars and light trucks still in service, there's high-performance and racing, vintage and antique, marine, industrial, etc.

So, the carburetor business is still alive and well. Recently, I had an interesting and pleasant experience getting to know National Carburetors of Jacksonville, Florida. It's core business is remanufacturing carbs to the highest standards I've ever seen, and

National Carburetors is the largest remanufacturer of carbs in the U.S., but it can also supply high-performance units, even for Ford flatheads.

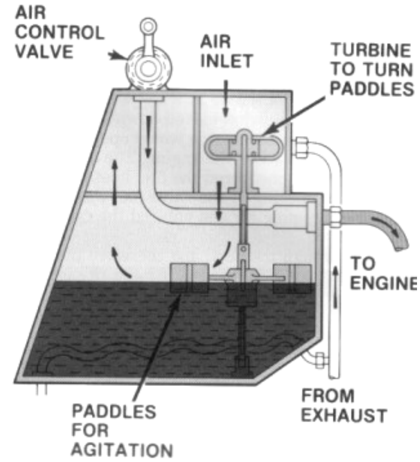
every one is actually engine tested before it's shipped. With $30M in inventory, it has the largest stockpile of carburetors in the U.S., and ships them under various brand names. Volume has actually been growing as people are starting to restore cars from the '70s and '80s. About 30% of the business is high-performance with surprisingly affordable new and remanufactured Holley and Edelbrock products, and even three-deuce set-ups for Ford flatheads.

It was a lot of fun to tour the factory and showroom, and talking to the C.E.O. Eddie Obi, whose dad founded the business out of a service station/repair shop in 1954, and his assistant, Ryan Edenfield. They really understand the inner workings (and weak points) of any carb you can name. Visit nationalcarburetor.com and you might save yourself some money and frustration.

IMAGINE USING A WICK...

The word "carburetor" is derived from the French "carburer" for adding carbon (in this case, the familiar liquid hydrocarbon).

The surface-type carburetor was used on most early automobile engines, although some actually used wicks!



- In the late 19th century, some carbs actually used a wick — intake air flowed through a piece of woven fabric that was kept soaked with what was called variously "petrol" or "benzine" in those days. How was the air/fuel mixture controlled? It wasn't. In that same period, there were also the "surface" types — air passed over gasoline in a bowl and picked up the flammable vapors. In some cases, the liquid was kept in an agitated state by either bubbling engine vacuum through it, or by a little vacuum-powered paddle wheel, believe it or not.
- In about 1885, famous German inventors Gottlieb Daimler, Wilhelm Maybach, and Karl Benz all came up with the same idea: a float system to control the fuel level in the bowl. In 1892, Mayback produced the first spray carburetor, which used the venturi principle to make enough vacuum to induce gasoline to move into the air stream through a jet.

RANDOM CARB ITEMS

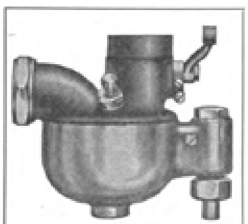
- Maybe my childhood experience with that sunken tractor float mentioned above was what made me an early discoverer

THE HOLLEY

1908 Model "W" CARBURETOR

The Simplicity of Perfection is embodied in the 1908 Model "W" Holley Carburetor. The only movable parts are the float and the throttle valve. There are no springs or other wearable parts to get out of order. For this reason it will give you the same satisfaction after a year of service as when entirely new.

There is but one adjustment—a needle regulating the spray opening, and this may be adjusted from the seat, an advantage which will be readily appreciated by the automobilist.



TOP OUTLET

With the **Holley Carburetor** you can drive your car at a slow speed in high gear and the motor will accelerate instantly when the throttle is opened. The **Holley** is the only carburetor which will give perfect flexibility and instant responsiveness at slow speeds as well as high. The **Holley** has been on the market for years and has always been standard.

Following are the sizes and prices of carburetors for various cylinder dimensions:

3¼ inch to 3½ inch bore motor, use ¾ inch carburetor, price $11.00
3¾ inch to 4¼ inch bore motor, use 1 inch carburetor, price 12.00
4¼ inch to 5 inch bore motor, use 1¼ inch carburetor, price 13.00
5 inch to 5½ inch bore motor, use 1½ inch carburetor, price 16.00

Special models for Fords, Maxwells, Olds, Ramblers, Mitchells, Wintons and other standard makes. Write for catalog.

HOLLEY BROTHERS CO., Detroit, Mich.

AGENTS

Pacific Coast: San Francisco—Geo. P. Moore Co.; Oakland, Geo. P. Moore Co.; Los Angeles, Geo. P Moore Co.
New England: Hartford—Post & Lester Co.; Boston, Post & Lester Co.
Italy: Genoa—Italian Import & Export Co.
France: Paris—C. M. Sauerbach, No. 12, Rue Portalis
Belgium: Brussels—Henry Wilford Co.

Spray-type carbs had taken over by the early 20th century and just kept getting better until supplanted by fuel injection.

of the plague of heavy foam floats that occurred in the late 1970s (I still have the cool little scale one of the carb parts makers made available — I later heard that the reason so many were sold was that they were convenient for weighing out marijuana). Newer float materials are more resistant to gasoline absorption, but I've heard that new blends (I've called them "Frankenfuels) can attack them, too.

EPOXY? REALLY?

- I once had a Mercuiser 3.0L four that wouldn't run over idle. The bowl was literally full of pinkish aluminum oxide, and when I cleaned it out thoroughly I could see daylight through pinholes in the bottom of the casting. A new part was hundreds of dollars, and I've never learned how to weld aluminum, so what was the expedient fix? You can't have a gas leak in a boat, after all.

So, I investigated epoxies. Most said on the label, "Impervious to motor oil, transmission fluid, and antifreeze, RESISTANT to gasoline." Not satisfactory. Then I read the claims on the J-B Weld package: "Impervious to gasoline. Use on gas tanks." That was worth a try, so I smoothed a nice, neat coating of the stuff inside the bowl filling and covering the pinholes (I've heard since that some rebuilders do the same thing — from the outside/bottom, too). Not a drop for five years that I know of, then the boat got shipped to Denmark, if you can believe that.

- Another marine problem illstrates something else. A 2.3L Volvo had sat for a year in a hot climate. It started up fine, but wouldn't rev over 2,500 — it leaned out before it got the boat up on a plane. Naturally, the first thing I did was examine the jets. Held up to a strong light, their borings looked fine with no visible deposits. But the float level and everything else was okay, so it had to be the jets. I have a nice collection of drill bits down to very small diameters, so I started trying them until I got to the size that required a little force to twist. Out came a spiral of hard varnish exactly the color of the brass. I moved up in drill size until I was actually into metal, and that engine hit 5,200 rpm with ease.

LANGUAGE BARRIER

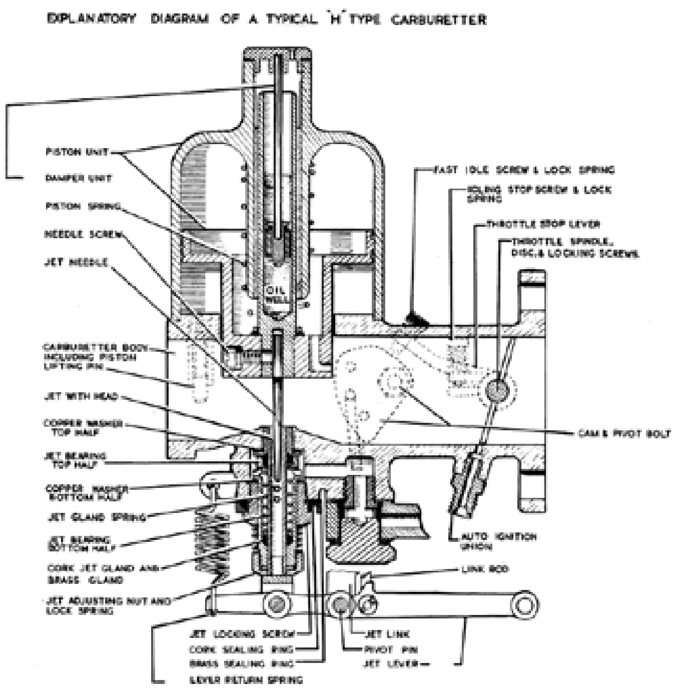
- My dad's '55 Ford 272 V8 developed severe hesitation/bog when I was a kid. One of my Swedish cousins, a brilliant, inventive engineer, happened to be visiting the U.S. on business and was staying with my family. When I popped that ponderous hood, he removed the air cleaner, worked the throttle, and immediately pronounced that the problem was the "fuel pump." I was confused because the engine ran fine otherwise. Didn't that mean the pump that forced gas into the bowl was working? So, this was a language thing. His English was good, vastly better than my Swedish, but he didn't have "accelerator pump" in his vocabulary. He said, "the fuel pump in the carburetor." I finally got it, and the fix on that two-barrel was easy. That old "Y-Block" carried us around for years and years afterwards.

- When I worked as a line mechanic in a Ford dealership after college, I dealt with "elastomer" valves frequently. Just a small, molded-rubber part, it was the one-way valve for the accelerator pump on those old carburetors. Nothing to replacing them when they dried out or cracked. Today, they're mostly made of silicone rubber so should resist even the destructive, corrosive gasoline of modern times.

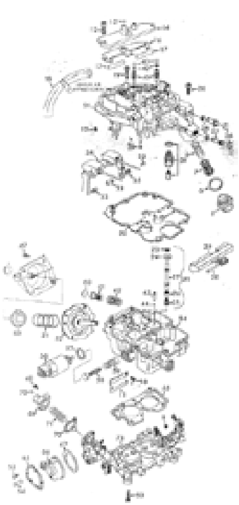
Some of my early experiences with carburetors were on Ford Y-Blocks, like the one in this '55. Note the oil-bath air cleaner.

When the "elastomer" valve in the accelerator circuit failed, you got bog.

- I once drove a 1973 Ford Torino 351 Cleveland (big top-loader four-speed) across the U.S. pulling a 15-foot Scotty travel trailer. Everything was going okay, but when I crossed the Western continental divide in Wyoming at about 10,000 feet, things got really rich. Less oxygen per cubic foot of air. The nice, white paint job on the front of the trailer was covered with black soot. No altitude compensation with that carb. An aside: There was a Porta-Potty in the Scotty. When I stopped at the apex of the divide to check things out, I found it rolling around. It had assumed the shape of a huge basketball because it was full of Bar (short for "barometric," some prefer it all upper-case — BAR —in other words, sea-level atmospheric pressure of about 15 psi). It didn't burst, thank goodness, but its seal was sorely tested.



SU variable-venturi carburetors were popular for decades. Fun to work on, and their instant throttle response was impressive.



The Ford/ Motorcraft VV 2700/7200 that was introduced in 1977 was a great concept. Too bad it had so many reliability problems.

- One of Performance Technician's regular contributors, Henry Olsen, is the proprietor of Ole's Carb in California. He's the most gifted tuner I know of, and has also invented various products that fix carb problems that are inherent in their design or materials. He's a great resource. You can contact him through olescarb.com.

- When I was unhappy with how the vacuum-operated secondaries of an Autolite four-barrel on a 351 Windsor-powered Mustang opened, I made up a small-diameter steel cable to do it mechanically. A little drilling of levers and clinching of attachment points and I had secondaries controlled "real time" by my right foot.

VVS

- Did you ever tune up an English sports car with twin SU variable-venturi "carburetters," as the Brits call them? They worked very well indeed providing good performance and efficiency, but synchronizing them so that all the cylinders received the same CFM was a bit of a challenge. One method was to hold a piece of hose to the same spot in each carb while you held the other end to your ear, and adjusting until the volume and pitch sounded the same, which was too subjective to be very accurate. A better means was the use of a Uni-Syn or similar device that actually measured and displayed the amount of air flow. You can still buy these, and they're useful on any multi-carb set-up. They're available through Edelbrock, among others.

- Speaking of variable venturis, the Ford/ Motorcraft VV 2700/7200 was introduced in 1977 on 2.8L and 5.0L California cars. It provided instant response and increased mpg slightly while lowering emissions. Except when it didn't. Lots of trouble with it, especially during starting and cold-weather operation. I may still have the OTC service kit in my tool "archives" somewhere. ■

IT'S A KOUL, KOUL WORLD...

-Greg McConiga

Have you ever nearly bled out from a thousand tiny cuts suffered while stuffing stainless braided hoses into their respective fittings?

Or ended up red-faced and panting like a ditch digger with a short-handled shovel while trying to shove socketless barbed fittings together? Or chased a leaking flare fitting — tightening it up until you split the line, forcing you to make it up all over again? Well, have we got tools for you this month!

I was introduced to the Koul Tool lineup by a friend and racing partner over two years ago. Anyone who has spent any time making up custom stainless –AN lines for race cars knows just how painful the process gets. Those tiny diagonally woven stainless steel wires spring out of shape once cut and they can slice you to pieces if you're handling them during assembly. Of all the jobs I learned to do, making up hoses was the one I most dreaded because I knew that by the time I finished a full set of lines for the fuel, water, and oil system I was going to be covered in Band-Aids and in need of a transfusion. This year I decided to call Koul Tools and get my own tooling, and I was pleasantly surprised to end up talking with the owner and inventor, Dick Raczuk.

Mr. Raczuk is a long time hot rodder, inventor, and car and motorcycle guy. He's the man who was behind two companies you've likely heard of: Kerker Motorcycle Exhaust Systems, and Kendick Engineering go-kart headers and exhaust. I called in to just purchase the –AN hose assembly tools, but once we started chatting I realized that he also had tools for the socketless press-on hose as well as the Surseat tooling for steel line flare lapping. Since I work on both race cars and also perform restoration work, I ended up buying all of it — and I've used it all with outstanding results.

The glass-filled nylon –AN hose assembly tool holds the socket portion of the fitting and the mouth of the tool forms a long, smoothly-tapered cone that forms a lead or transition into the base of the socket. A tiny bit of lube wiped into the funnel before inserting the hose can help as you twist the hose into the mouth of the tool and into the socket up to the point where the threads start. Once done, just mark the hose to make sure it doesn't back out of the socket as you tighten up the fitting end of

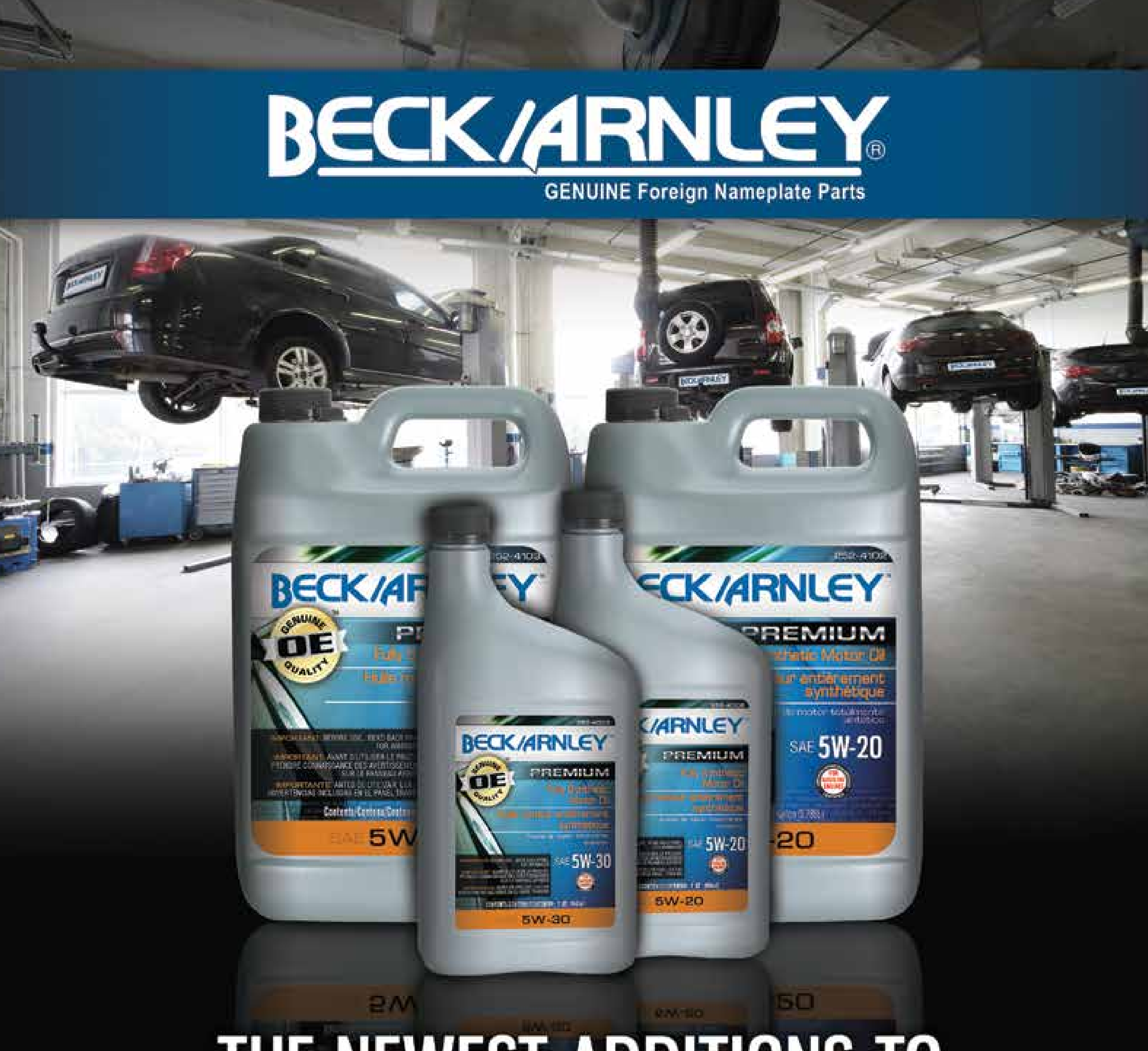
The lapping pilot on the P-51 Surseat is removable and comes with a 37 degree for AN and JIC fittings and a 45 degree face for SAE fittings. The diamond abrasive that is bonded to the pilot face should last a lifetime with proper care.

Like all fine lapping surfaces the diamond abrasive can load up with use and you absolutely must use WD-40 on it every time you use it to keep the surface open. If it loads up you might not be able to clean it enough to make it work for you again.

Using WD-40 good practice for any lapping tool, because if kept clean they last much longer and produce a much cleaner and smoother surface.

Right: The seating area is smooth and nicely dressed. There are some forming marks left on the surface where the line folds over and doubles, but this normally doesn't keep you from getting a good seal.

Keep an eye on your flare tooling and replace any part of the forming tooling that shows damage because it'll transfer damage to the tubing as you make the flare. I've lapped all my flares on several projects now and I've not had a leaking assembly since I started using it.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GENUINE Foreign Nameplate Parts
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PREMIUM
SAE 5W-20
5W-30
5W-20

the assembly and you're good to go. Look! No blood! I'm telling you, these things are the best thing since sliced bread (Note to self: Don't say "sliced" in this story again... brings back bad memories).

For those using the new socketless hoses on applications like water and transmission fluid coolers, the EZ-On hose press is another must-have. Assembling the special hose over those barbed fittings is all but impossible without the hose press — Arnold Schwartzeneggar on his best day couldn't do it. Even with the tool, it's important to have a compatible hose lubricant to aid in assembly. I found mine at the same vendor that sold me the hose and fittings I needed, and since a tiny bit is all you need I'm guessing I'll be leaving it to my kids (just one more thing they'll inherit, look at, and say, "What the heck is this??")

The last little bit of brilliance coming out of Koul Tools is the Surseat steel line lapping tool kits. There are two of them that I ended up purchasing, one that works on the car with the brake lines, and the other, larger tool better suited to off-car work done before reassembly. The lapping pilot is covered with a diamond abrasive and works quickly to smooth up the 45 degree steel fitting virtually eliminating leaks. I use it on all my fuel, power steering, transmission, and brake lines. The little bit

The smoothly tapered lead in the Koul –AN hose assembly tool guides the cut end right into the socket end of the fitting with very little pressure, effort or blood (a very important consideration for the squeamish among us!) A wipe of lube and a twisting motion makes the whole process a bit easier.

The biggest problem is that you often end up with the hose pushed in too far and you have to back it out slightly to expose the base of the socket threads. This fitting shown in the photo is a special ferrule type with a long lead that extends down into the hose, used on the pressure side of the power steering system. It has a Teflon liner in it, so when fully assembled this particular socket and fitting ended up lightly touching.

On a standard –AN socket and fitting assembly there's normally a bit of clearance between the socket and the fitting end... they don't have to be driven all the way together to prevent leaks, in fact, it's not recommended that you drive the fitting in that deep. Moderate hand pressure is really all that's needed because the tapered end of the fitting exerts increasing pressure as it's screwed into the socket and you can overtighten them deforming, splitting and crushing the hose causing a leak.

of time invested has paid off because it's worked perfectly every time — zero leaks. Just make sure you read the directions on all of the Koul Tools, because they have some very helpful instructions on how to get the most out them without damaging either the tool or the parts. For example, they recommend using WD-40 on the abrasive pilot of the Surseat to keep it from loading up (that's actually good advice on any diamond abrasive tool). I've done the same with a spring chamfer tool from PAC and it really helps tool life.

If you're like me and the idea of committing self-sacrifice isn't appealing to you, or if you just want to tip the odds of a successful repair more in your favor, surf on over to http://koultools.com and check out the lineup and the on-line videos. Or, call 928-854-6706. You never know, Dick himself might pick up! If he does (and he's got time), you'll have to ask him about his hot rodding career — he's got some great stories to share! All just part of what makes our world such a koul place! ■

Right & Opposite Page: If you don't have a large pair of hose cutters capable of cutting through braided stainless hose you can use a thin cut off wheel. Just tape off the outside of the hose and cut through the taped portion to keep the ends from fraying up, then use compressed air and a solvent (I like alcohol personally and it doubles as an antiseptic!) to clean the hose out before installing the end. It's not as clean as using a cutter, but it takes a pretty robust tool to cleanly cut through that stainless braided wire! It's as tough as it is to prevent rub-through under the extreme conditions found in motorsports.

In fact, you need to think about your hose routing for two reasons… one to protect the hose, and two, to protect anything the hose comes in contact with because that braid will act like a saw when it's rattling and vibrating as the engine runs and over time you can wear through softer materials like aluminum.

Eaton makes specifically formulated hose assembly oil that I use although I'm sure that other lubes would work just fine. I use what they recommend because some additives cause swelling or softening

of rubber and I don't have the time or inclination to become knowledgeable in the chemistry involved. They make it… it works… why go off in the weeds for no discernible benefit?

Soft jaws are an absolute necessity… and a pair of sharp wire cutters can help trim up any wild wire ends that won't be tamed. I also use and recommend the thinnest possible cut off wheel you can find. I think this one measures about .045". A thin wheel produces a faster, cleaner cut and you'll lose less material to the cuts you make.

Above: The socket end fits into the tool's female hex receiver and the halves assembled so that the aligning pins engaged and the assembly is then clamped in a vise so that the socket portion can't spin.

There are spacers provided with each tool to space the socket back firmly against the taper if the socket design requires it. Once the hose is seated up into the socket, the tool is removed, the hose depth is set in the socket to just below where the threaded portion of the socket starts, the hose is marked or taped even with the bottom of the socket so you can ensure that the hose doesn't walk out of the socket as the tapered end of the fitting is installed and the socket threads, fitting and hose is lubricated and screwed together. Aligning the soft jaws off the end of the vise jaws so that the soft jaws float will allow them to hold both the socket and the hose making it harder for the hose to push out of the socket as the fitting is screwed in.

Opposite Page: Motorsports requires so much field modification and assembly that while it's tempting to just order up pre-assembled hoses you quickly learn that it's just not practical. It might LOOK like a 45 degree fitting with work, until you try to stuff it in there and you have to change to a ninety or a one-twenty to get it all to fit. For moderate pressures and temperatures the socketless hose systems work great… with temperature rating from -45 to +300 degrees and a pressure rating of 250 PSI and sizes from -04 to -12 it's rated for fuel, water, lubes and air and vacuum rated up to 28 in Hg (18 in. Hg for the -10 and -12 sizes.) The specially designed barbs and hose require no clamps, and once assembled you have to cut them apart if you want to change them. A drop of hose assembly oil and the EZ On Hose press makes putting these hoses together a snap. If you've ever tried putting them together without this tool once I guarantee you won't cheerfully try it again. There's a reason the assembly doesn't leak up to 250 pounds and it's not because the hose and barb don't aggressively engage! I use these on nearly all my transmission coolers and anywhere I can where I have to plumb for water, lube system, fuel, air or vacuum. Very quick, very convenient, less expensive than either the braided stainless and the Aramid or Kevlar braided offerings and if you don't need that kind of pressure and temperature rated hoses and the -12 size limitation works I'd suggest you look at using it. It'll save you time and money.


TOOLS ARE SHIPPED DRY
LUBRICATE ALL MOVING PARTS


Soap
Leak
Solution
WD-40
LUBE
EZ-ON

This page & opposite: This is another tool I wish I would have thought of. Over the years I've chased all kinds of leaks on flare fittings. I ended up using a tool I had for chamfering valve spring ends a few times when I got in the trick bag with leaking flare lines but the results were inconsistent and I often was forced into redoing the entire line… a real pain in the hindparts if you're talking a brake line that winds its way from the front to the back through a half dozen obstructions. There are two tools and I bought them both. One, the P-45 Mini is built to fit into tight places and lap 3/16" and ¼" lines on the car. The P-51 line lapper will lap 45 degree and 37 degree flared lines up to ½". Even though the P-51 is a bit larger, it's well designed and should get into most tight spots although the split adapter is a little fussier than the collets supplied with the P-45 and you might need a helping hand from time to time to use where space is limited. Once mounted, a quick spray with WD-40 on the diamond lapping face and a half dozen quick turns and the flare surface is smooth and polished. I can tell you this; it's a lot quicker and a lot better to do this before assemble as preventative medicine that afterwards when you're tempted to crank the fitting in tighter resulting in a split flare and a damaged seat in the female end of the assembly! Don't ask me how I know this….

My first exposure to the Koul product line up was the –AN braided stainless steel hose assembly tools. Like many, my first experience with these kinds of lines left my shop looking more like a murder scene than a garage and, being the quick study that I am, I decided that if I had any hope of surviving another go-around with these engineered terror devices I'd have to find a better way to put them together. Thankfully, my friends are smarter than I am and they gave me a heads up about Koul Tools. Dick Raczuk has applied his considerable talents to producing a line of tools and equipment that are purpose built to fix real world every day race and fabrication shop problems. If you're a fabricator, restoration shop, race engine builder or racing hobbyist you need to surf over to the Koul Tools website and do a little shopping. They are great people making a great product and they deserve your support.

RAE
Reliable Automotive Equipment, Inc.

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521-WW-MG-600V-MB

Applicable in all automobile workshops. Developed for repairing engines and transmissions, up to 1,102 lbs. / 500 kg (especially for 8 up to 12 cylinders). Easy to maneuver even with engine or transmission placed in the stand. 260-degree rotations with load. Compact space-saving design. Self-locking worn gear and lockable rear wheels allow safe positioning. Hydraulic adjustment of load holder height up to 180 mm. Ready to use with removable oil pan and handy tool reack. Engine and transmission support sold seperately.

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- Safe in all positions.
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- Max. Width: 31.1” (790 mm).
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- Total Height at Center: 35.43” (900 mm).
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- Load capacity: 1,322 lbs. (600 kg).

Universal Transmission Adaptor

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- Perfect accessibility for all types of transmissions. Suitable for common transmissions and axles.
- Quick and easy fixing possibilty.
- Also suitable for Mercedes-Benz OM651 & M271 EVO.
- Designed for the stands MG-250, MG-500 and MG-600V.

Universal Engine Adapter

521-WW-6/140MB

Designed for stands MG-150V, MG-250, MG-500 and MG-600V

Mobile Workshop Crane by Werner Weltner

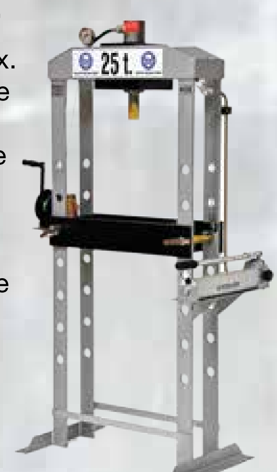
521-WW-W5K-1000

Applicable in all automobile and commercial vehicle workshops. Perfectly suitable for assembling and disassembling of engines, components and transmissions. Usable for 8 up to 12 cylinder engines. Boom can be adjusted to 5 positions (in increments of 125 mm) and can be applied in different kind of works. Equipped with high-performance hydraulic pump. Maneuverable in tilted position, easy and space-saving storage. Designed for parallel carriage in Euro-pallet width.

25 Ton Workshop Press

521-WW-HP-25T

- Capacity 25t max.
- Working pressure 700 bar.
- Maintenance free construction.
- Foot or hand pump operation.
- Quick press table adjustment.
- Spring return cylinder, 150mm stroke.
- Comes with air hydraulic pump.



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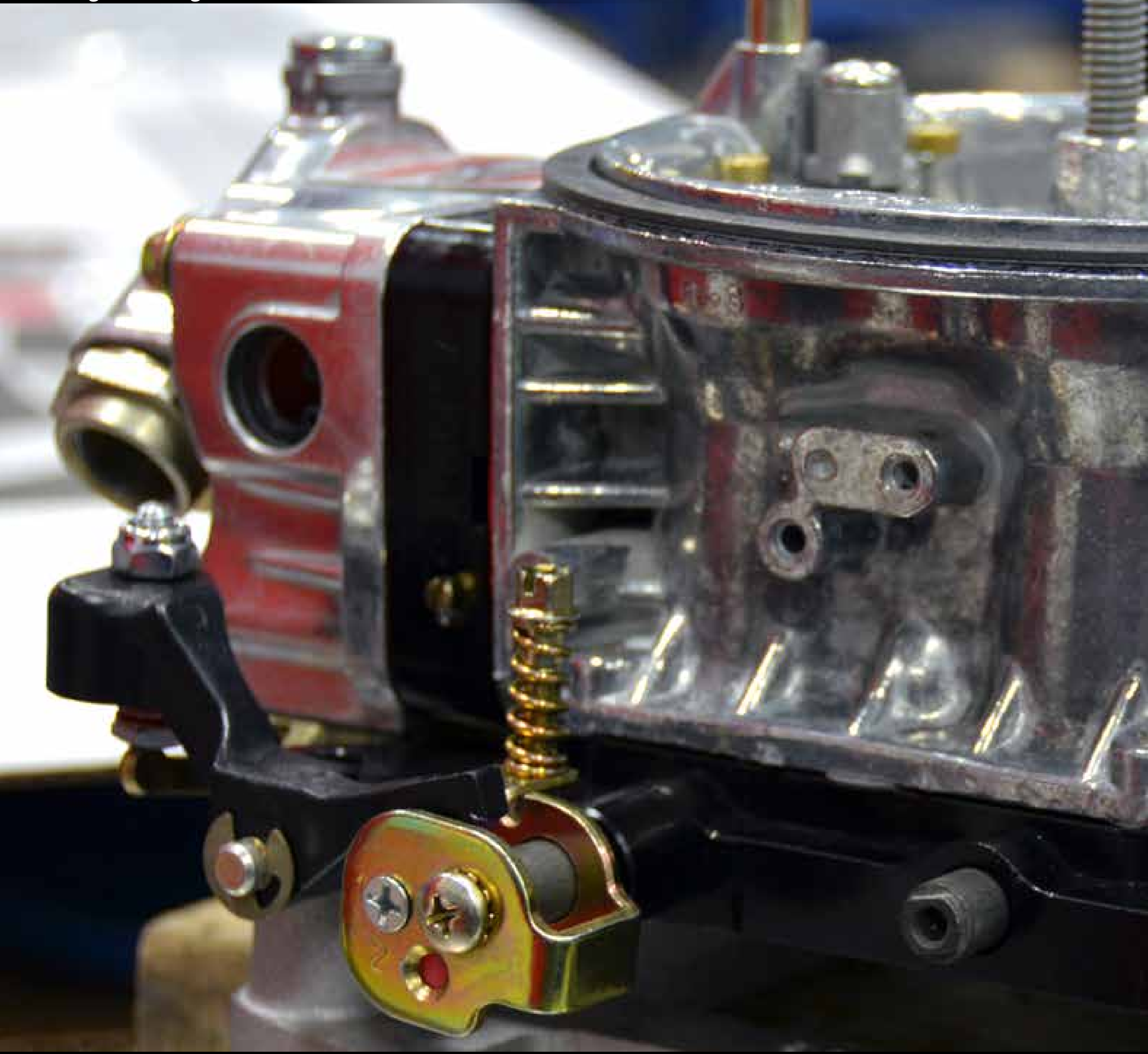
CARBURETION, PART 3:

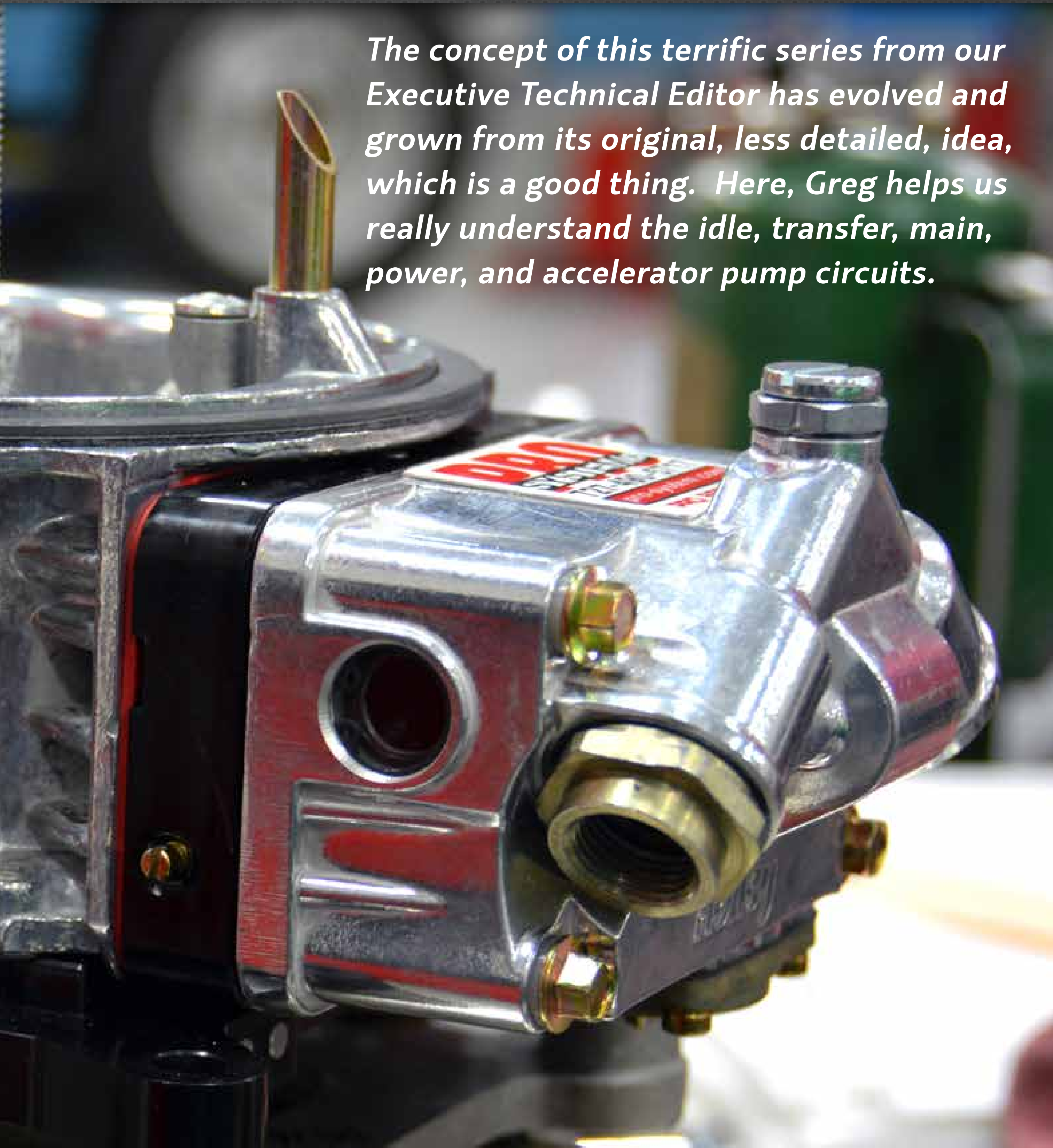
THE CONTINUING SAGA OF THE SEVEN CIRCUITS

-Greg McConiga



Shown here: Setting the float level can best be done with a bowl that has a built-in sight glass. Normally, the level is adjusted so that fuel is just at the lower edge of the glass to about a quarter of the way up. If there's no sight glass installed, the normal procedure is to set the level so that fuel just begins to spill out of the screw hole. There's also a temporary sight plug that can be installed, but I have

The concept of this terrific series from our Executive Technical Editor has evolved and grown from its original, less detailed, idea, which is a good thing. Here, Greg helps us really understand the idle, transfer, main, power, and accelerator pump circuits.



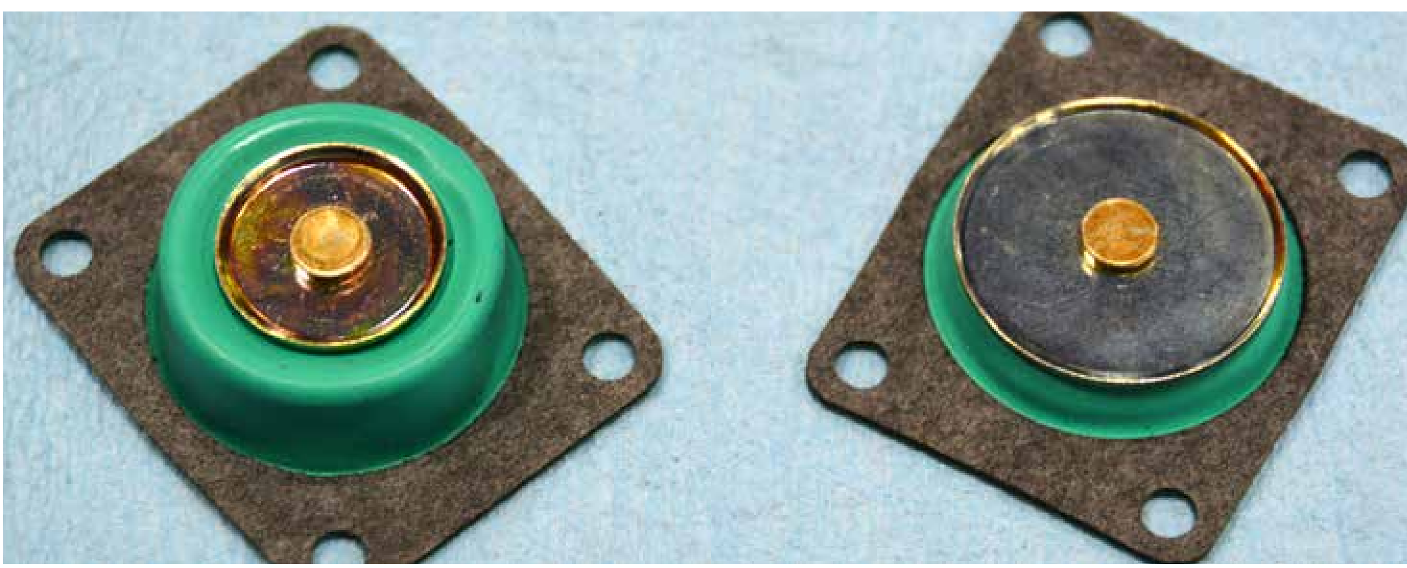
a hard time seeing through them and they're easily broken if you over tighten them. They seal with an O-ring, so very light pressure is all that's needed when you install them. Of course, fuel level on a Holley is always set with the engine running, so take all safety precautions to avoid a fuel spill and keep your hands away from moving parts.

A carburetor works because of differential pressures. In fact, the entire car works on differential pressure! The pressure of the fuel pump moves fuel into the bowl; the pressure of a spring closes a choke plate and air flow past the offset of the plate forces it open as air flow acts on larger and smaller areas producing a rotational "pressure" to open the choke. The lowered pressure inside the engine is used to actuate a choke pull-off. The low pressure created by piston pumping induces atmospheric pressure to force flow through the carb, and as air flows past the main and boost venturis that flow increases in speed as it decreases in pressure and creates a low-pressure signal causing atmospheric pressure to move fuel from the bowl into the main well, and from there into the engine air stream where it's drawn into the cylinders. Pressures can act in our favor or against it. For example, when they pulse or oppose the flows we're trying to increase or improve.

THE WET SIDE

The "big three" of fuel delivery are the idle, main, and transfer circuits, which are all fed from the main well. This well, in turn, is supplied by two incoming sources — the main jet and the power valve restrictor channels. The well then feeds two out-flow points, the main nozzle directly from the main well and the idle/transfer circuit through a cross-drilled channel that route fuel into an idle and transfer circuit well.

Once running, fuel demand on the main well causes its level to rise and fall slightly depending on total jet area feeding the well,



Once the nozzle is large enough, the total accelerator pump duration may suffer. 50 cc pump kits are available, which contain the pump arm, pump body, pump diaphragm or cup, return spring, and pump cam. Installation and adjustment only takes a few minutes with the carb on the bench. The only disadvantage to the larger pump cup is that each time you move the accelerator pedal, you pump more fuel into the engine, which dramatically impacts fuel economy. Not a consideration for drag racing, but if you're endurance racing or building a street/strip or touring car, it could be something to think about. If you don't need it, don't install it.

RPM, circuit activation, and air flow. This changing level provides a calibration point that is the result of and dependent on a properly-sized fuel pump and needle and seat, and a correctly-adjusted float system. This is a system — the pump pressure should be regulated if it rises over about 7-8 psi (your carb builder can tell you his or her preferred specification for pressure, and under what conditions that pressure should be measured). The needle size should be .110 inch up to about an 800 CFM carb, and .120 inch for a larger carb, and the float levels must be correctly set in order to calibrate fuel delivery. The whole fuel curve is set from bowl level.

A note about fuel pressure regulators: I'm not a fan if you can avoid them, particularly on street-driven, mechanical pump-equipped, pump gas cars. Pump gas volatility is all over the map these days and the typical non-return fuel pressure regulator is a great foam generator with its bouncing diaphragm and sharp edges. For race cars using an electric pump, a high-quality return-type pressure regulator is the only way to go since an electric pump has steady pressure and any foaming is confined to the return line back to the tank where it can settle down again. Watch your plumbing. Keep the return line at the other end of the tank from your suction line to avoid introducing vapor back into the suction of the pump.

The anti-siphon or anti-pullover nozzle has a cup or guard that surrounds the nozzle so that air flow won't cause fuel to be pulled out of the accelerator circuit. The check valves in the accelerator circuit both face in the same direction, so as the pump is relaxed fuel is drawn from the bowl, and as the pump is moved through its stroke fuel is shot through the nozzle. With enough air flow or pressure drop, it's possible to cause continuing flow through the pump circuit, or to have the circuit continue to flow after shut-down. Under the right circumstances, it's possible for fuel to keep flowing until the fuel bowl is siphoned dry, which can wash down cylinder walls, contaminate oil, or possibly lead to something as bad as a hydrostatic lock.

Above: A conventional or straight pump nozzle lacks the tube extension of a tube nozzle and the protective cup of the anti-siphon. This is another part I used to drill, but now just buy the sizes I need because I discovered that if I drilled them to size sometimes the discharge stream pattern was thrown off. The other problem is once you drill them and then take them back out, you have no idea what size they really are unless you measure them.

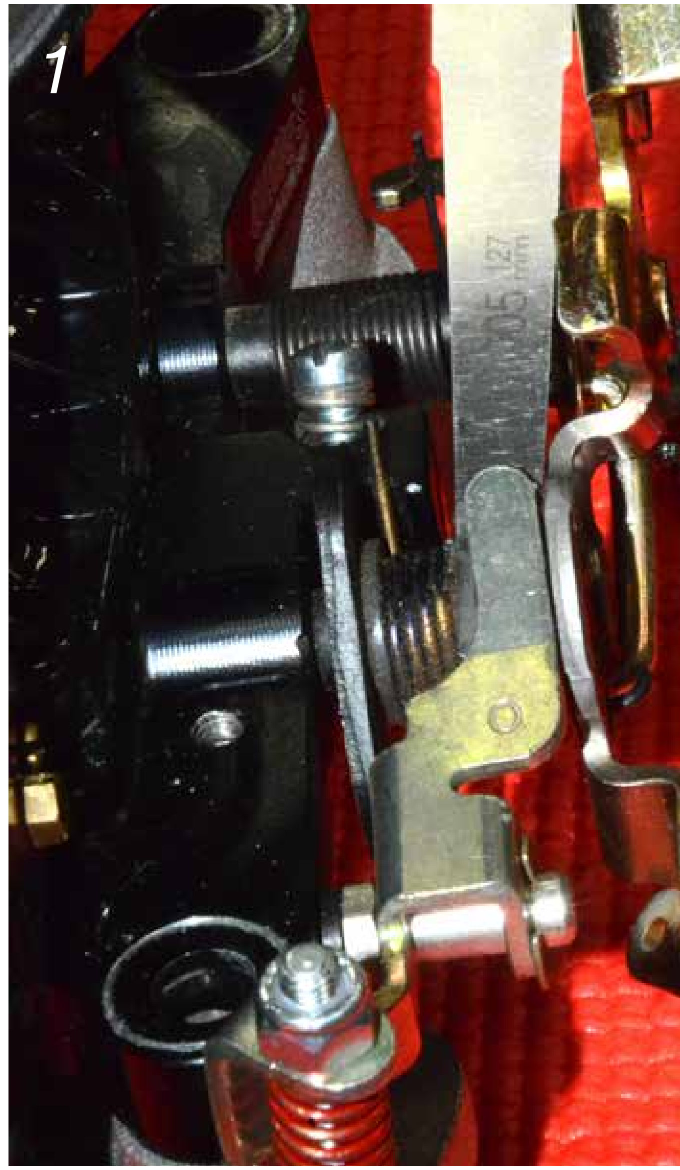
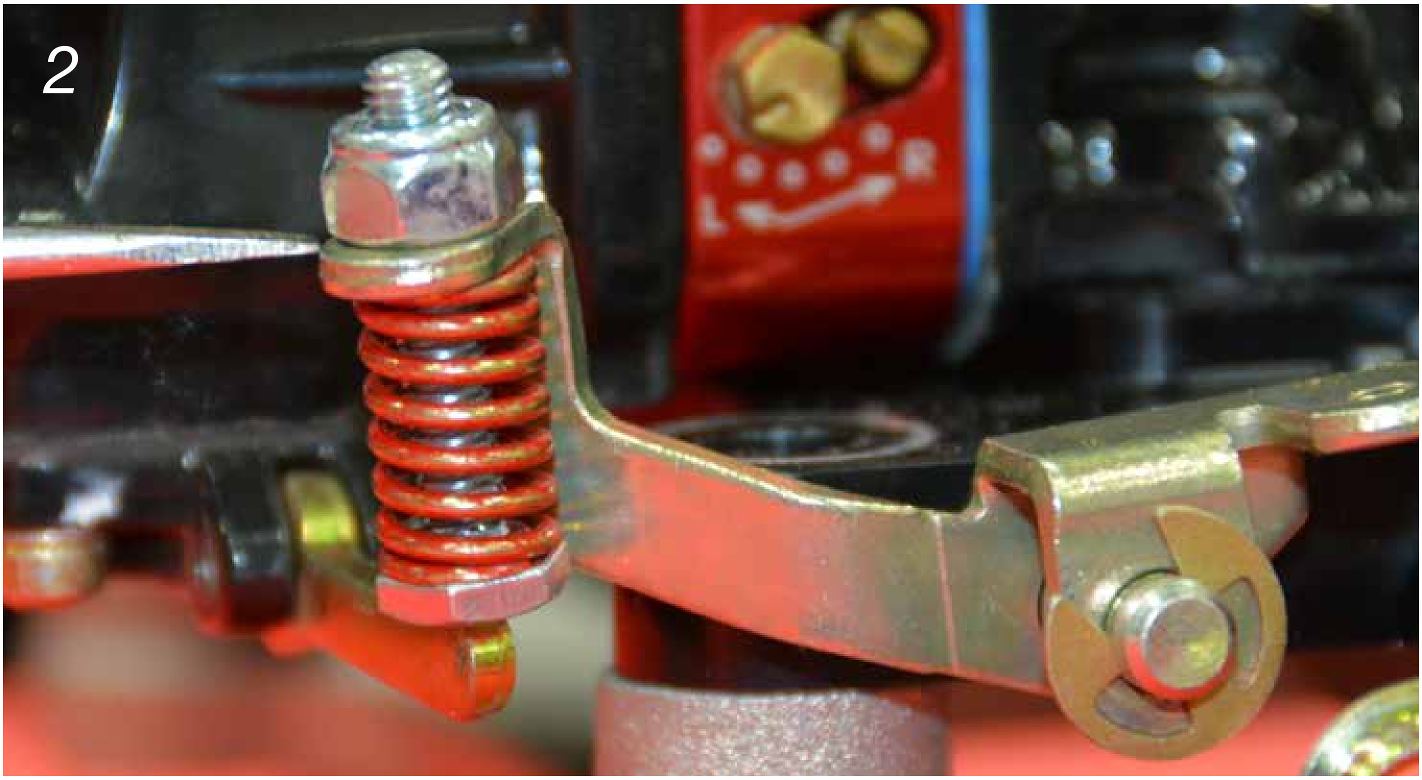


Figure 1-5, top right & opposite page: To adjust the pump duration spring, you simply hold the throttles wide open, confirm that the duration spring is strong enough to override the pump linkage, verify that the Nylock nut is fully seated against the pump arm, and adjust it until you've got something between .005 and .015 in. of clearance between the pump arm and the pump cam. The reason for the duration spring is to extend the length of time the fuel shot occurs by allowing the spring to override and apply pressure to the pump arm after the throttles have been moved to the wide-open position. It gives the non-compressible gasoline in the pump cup time to flow through the circuit and discharge out through the nozzles. Without it, we'd either just blow the diaphragm up or shoot the whole cup volume into the bore all at once going super rich for a second before falling off lean.

Holley makes several pump cams and each is color-coded and has two or three possible mounting positions. The number-one hole is typically earlier, and the number two and three holes are later. That's not all: in many cases, the later holes may increase total pump stroke and volume. Make sure to recheck duration spring adjustment if you move the cam from one position to another. All you really want to do is keep the pump from being over-extended and bottom out because stretching the pump will cause it to fail early.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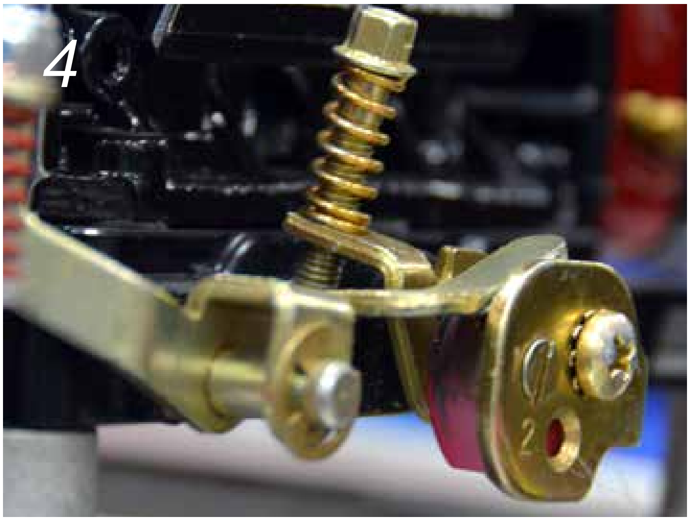
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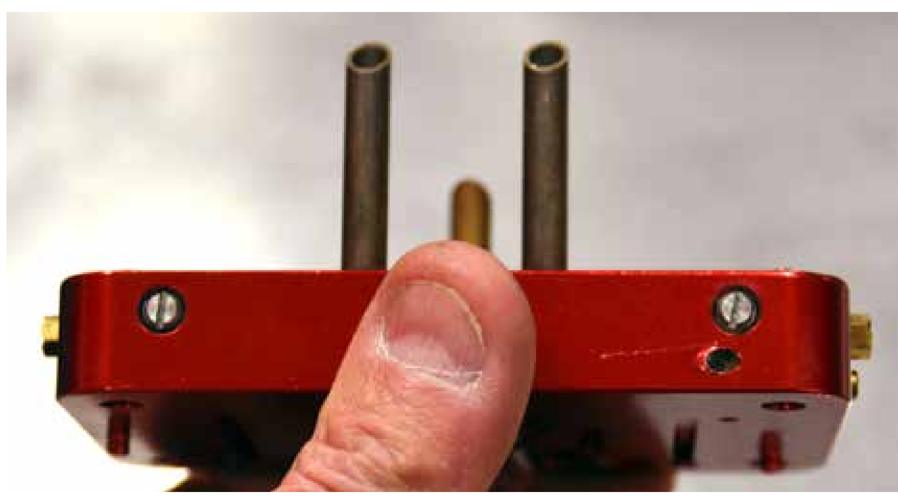
The main well level is designed to "auto-adjust" the spill height, which is the difference between the fuel level in the well and distance to the main nozzle feed port into the main body. As air flow increases with RPM, the flow through a fixed orifice isn't always linear with increased demand and increased pressure differential, and the carb signal or vacuum signal generated by the boost and main venturi is not linear at all. In fact, the boost signal curves upward with increased carb flow, with the signal difference gaining strength on the order of four times for a doubling of air flow through the barrel. This is why air bleeds, jet sizing, and the design of the emulsion system are so critical — they trim off the tendency of the carb to go rich at high RPM by dropping the main well level below successive emulsion side air feed holes, introducing more air into the mix which "bends" the increasingly rich fuel curve downward. The upper holes on the emulsion side trim low-speed operation and the lower holes trim high-speed mixture. A well-designed emulsion system and properly-sized air bleeds can produce an air/fuel mixture that is nearly perfect, particularly if you have access to a carb builder who wet flows his work and knows how to select the best booster design for your application.

As I've said before, there's just no reason not to use the services of a carb professional these days. In many cases, the prices are nearly the same as an out-of-the-box carb and you get a wet-flowed custom-built carb designed to work for your application. The amount of time you spend testing and tuning will be cut down to minutes instead of hours. If you're buying all-out, custom-engineered, very high-flow racing carbs, the prices can get up into the $1,500-$3,500 range, and from the very few I've had access to they're real works of art and worth every penny if your application demands that kind of flow rate (I must have it bad — they're so pretty I just like looking at them).

Can you cut and try your way to success? Sure. Is that a worthwhile use of time, your most limited resource? Probably not. Do you need to track-tune all the time for air quality? Depends on the class you run and engine displacement. If you're running a class that's down to the thousandth, you'll be tuning more than if you're running any of the stopped ET classes like Super Comp,



This is an interesting innovation from Willy's Carb Shop. The main jets are externally adjustable on this metering block. Brass tubes are inserted where the jets would normally be and there's a 5.5 mm, click-type nut just above the idle mixture screws on the side of the metering block with five positions from rich to lean. Pretty darned handy if you have to track-tune the main jets!

Super Gas, or Super Street. If you've got a lot of displacement, you may not see a great deal of improvement by jetting for conditions as large engines seem to be more forgiving of air/fuel ratios that are less than perfect. This all assumes that you're running on a budget and lack full data-gathering packages — the pros all use high-end Race Paks to gather every bit of data they can from the car, which can add another $2,000-$10,000 (or more!) to a build, plus when you first install a data recorder you end up saturated in data that then has to be interpreted and applied correctly. More confusion!

POWER CIRCUIT

On aftermarket metering blocks, the power valve restrictors are replaceable and you can adjust the total area of the jetting (total main jet plus total power valve restrictor area) for best performance under load. The power valve restrictors on Holley stock metering blocks are pre-drilled, so if you want more fuel you'll need to break out the wire drills and carefully and incrementally increase the restrictor diameter. If it comes to that, there are some very affordable billet metering blocks out there with replaceable emulsion and power valve restrictors that you might want to buy instead. If I were doing it, I'd toss the stock units in a drawer somewhere and buy billet.

You can tune with main jetting only, but that only changes the no-load air/fuel ratio. Main jets don't affect all circuits equally since they control the level in the main well, which changes the spill height on the main nozzles while having little or no impact on the idle and transfer circuits. This is because they pull their fuel from the bottom of the main well and have their own restrictors between the main well and the delivery channel. If you can tune the power valve restrictors, then you'll only affect the mixture under power conditions and that will have less impact on part-throttle mixture and fuel economy. You may also have to tune the power valve vacuum setting for your application.

The power valve should be selected so that the opening set point is about 2 in. Hg above the idle vacuum reading, taken in gear on an automatic. If your high-overlap, long-duration cam reads 7 in. Hg of vacuum at idle in gear, then a 4.5 in. power valve should do the job for you. Keep in mind that if your carb is sized too small, a very low-vacuum-rated power valve can be a problem at high RPM. If the carb is undersized, engine vacuum can build up again and shut down the power circuit as intake manifold vacuum builds back up with RPM. It's not uncommon to use a large throttle plate with a smaller venturi main body to get good throttle response and drivability, so keep an eye on that and run a vacuum gauge on the car if you think it might be an issue. For racing applications, it's sometimes necessary to plug off either the secondary power valve or the primary and secondary if need be and increase main jet size as much as needed to replace the fuel lost from the power valve restrictor. Replacing the power valve with a plug eliminates high RPM lean off when you're running a small carb on a large-displacement high-RPM engine. The only downside is that the engine tends to be a

There used to be two Holley power valves that I knew of. There was one for stock or near stock applications, and instead of a large rectangular window in it, it had four small holes drilled into it for fuel delivery. I haven't seen one of those for a long time. The Holley large picture-window power valve is pretty much standard in everything that's stock or near stock, and the special high flow "four door" power valve is used in racing applications.

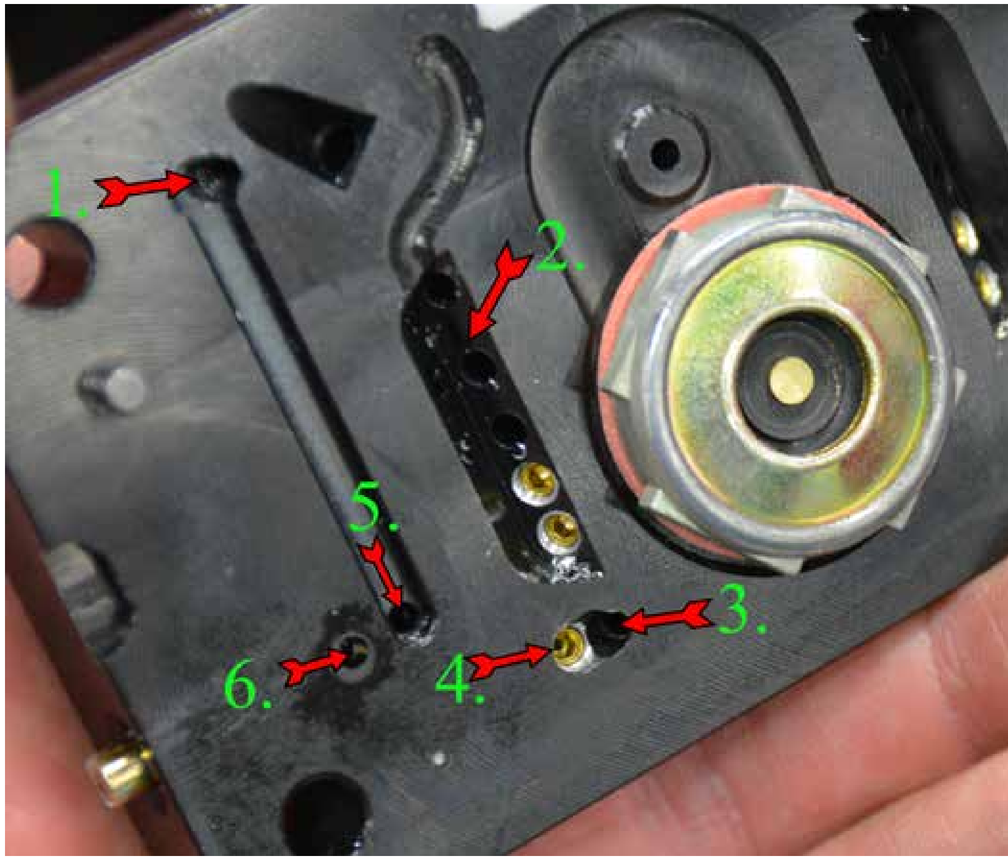
Holley power valves are stamped or inked with their opening set points, indicated in inches of vacuum Hg. They vary between 2.5 in. and 10.5 in. in one-inch increments and also are available as single-stage and two-stage, with two opening pressures on a single power valve to better trim the part-load mixture. The power valve installs into the metering block with a gasket or O-ring and seats into a deep chamfer so that fuel can flow into the channel the chamfer creates for 360 degrees so that the restrictors always see fuel.

little rich and blubbery at low- to mid-range operating speeds, and it's a little easier to foul spark plugs.

If you intend to change jets or power valve restrictors, your best result will be if you record all dimensions before you actually modify anything, and calculate the total area for all feeds into the well. If you take fuel out of the jet to lean off part throttle cruise, you can recover the needed fuel for full throttle enrichment by increasing the size of the power valve restrictor. The key is to know the total area of all jets and make any changes to that area in percent so you can roughly calculate what your changes will do. That said, knowing and recording the total area is just a baseline because jetting is more than just about area.

THE VAGARIES OF JETS

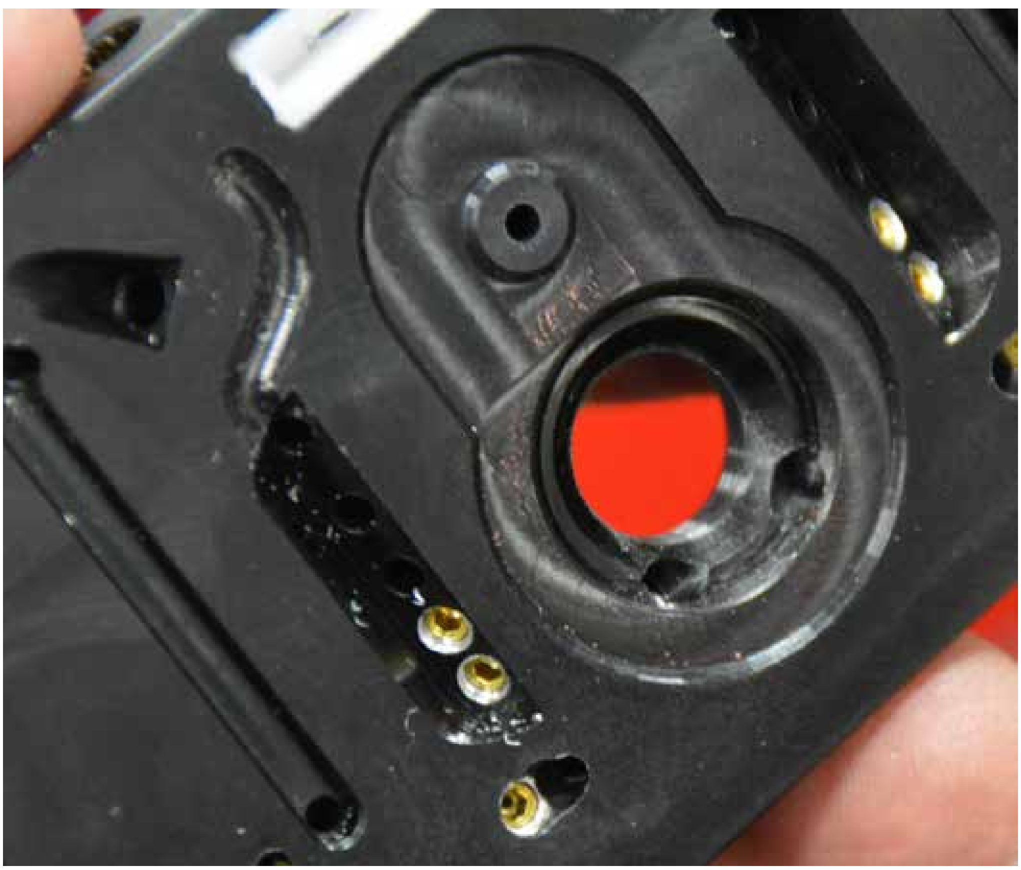
A word here about Holley jets. The number doesn't necessarily correlate to the jet size, and getting your mixture trimmed may take more than one try. Up to about a #70 jet, the number and the size of the hole in the jet are roughly the same, but above that they vary. Jet sizes are made to



This is an example of a billet metering block available from Pro Systems. The main well, the wet side, is on the other side of the block facing away from us in this photo, but this is the side that's most interesting. Older Holley's used a brass tube style emulsion system, but I haven't seen that for a long time. The wet side and the air side joined by the emulsion channel marked "2." In this case, the lower emulsion bleeds are plugged and the upper three emulsion bleeds are drilled in with no replaceable jets, much like a stock Holley metering block. Hole number three is drilled into the main well and forms the feed to the idle and transfer restrictor, labeled "4," which crosses over and upward to the idle air bleed feed point marked "1." The emulsion then drops down to the hole marked "5," which feeds the transfer slot, and behind that hole there's another cross drilling that feeds hole "6," which is the idle feed controlled by the idle needle with seats into the cross drilling between five and six. You can see how if flow increases through the transfer it will steal the fuel from the idle circuit.

yield about a 4.5-5.0% change in fuel flow per jet size, but they are far from precise. It's more accurate to state that jets increase by 3.5% with a plus or minus factor of about 1.5%, so it could be as little as 1% richer or it may be near 5% richer — it just depends on manufacturing that day — which explains why changing jetting is sometimes a little frustrating. If the jet you remove is on the rich end and the next size up you install is on the lean end, you may only see about one percent increase in fuel flow. There are close-limit jets available in sizes from 60 to 74, and these are indicated by a -1, -2, or -3 on the end of the jet number, meaning lean, mid-point, and rich end of the flow window for that jet number, which can help you tune in a bit better. You can check for main lean-off unloaded by running the engine up to 2,500-3,000 RPM and monitoring mixture, but to see what loaded operation is, you'll have to either drive it with wide bands in the pipes, or lash it down in a test cell with a gas analyzer.

Also know that the size of the orifice is only part of what determines the flow rate of the jet. The approach in and out of the bore and the bore finish are also part of the flow equation, which is why you should never drill jets, contrary to what the hot rodders of old commonly did. Buy what you need because drilling main jets doesn't yield a consistent result.



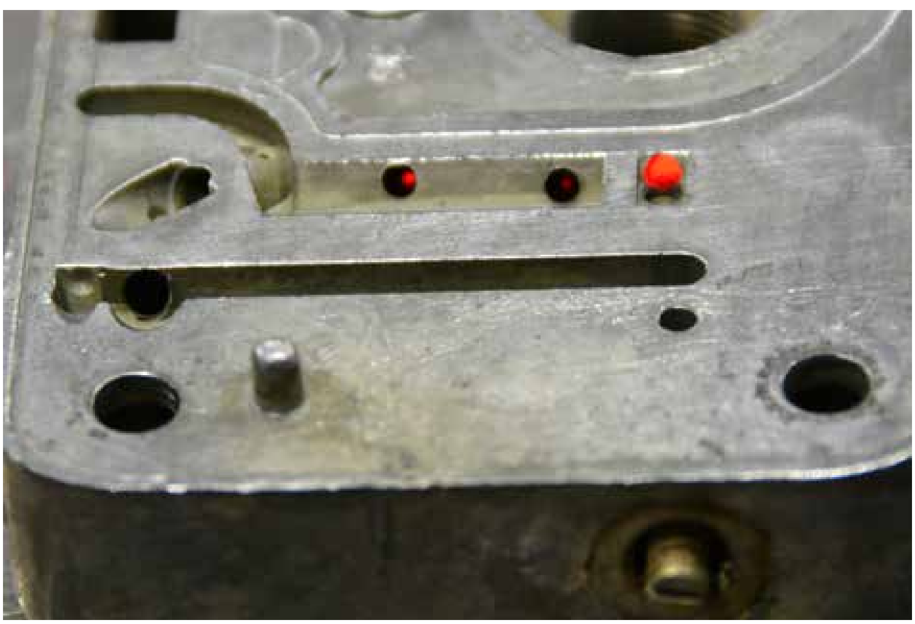
When you decant your new carb, take it apart and blow it all out. There's a lot of machining that goes into building a custom carb and you want to look it all over, baseline it, and make sure you get all the debris cleaned out of it. Sometimes they're cleaned up, sometimes they aren't. It only takes a few minutes to pop it apart and take a look. You can also see the chamfer and restrictor feed channel cut into the metering block for the power valve restrictors in this photo.

STARTING POINT

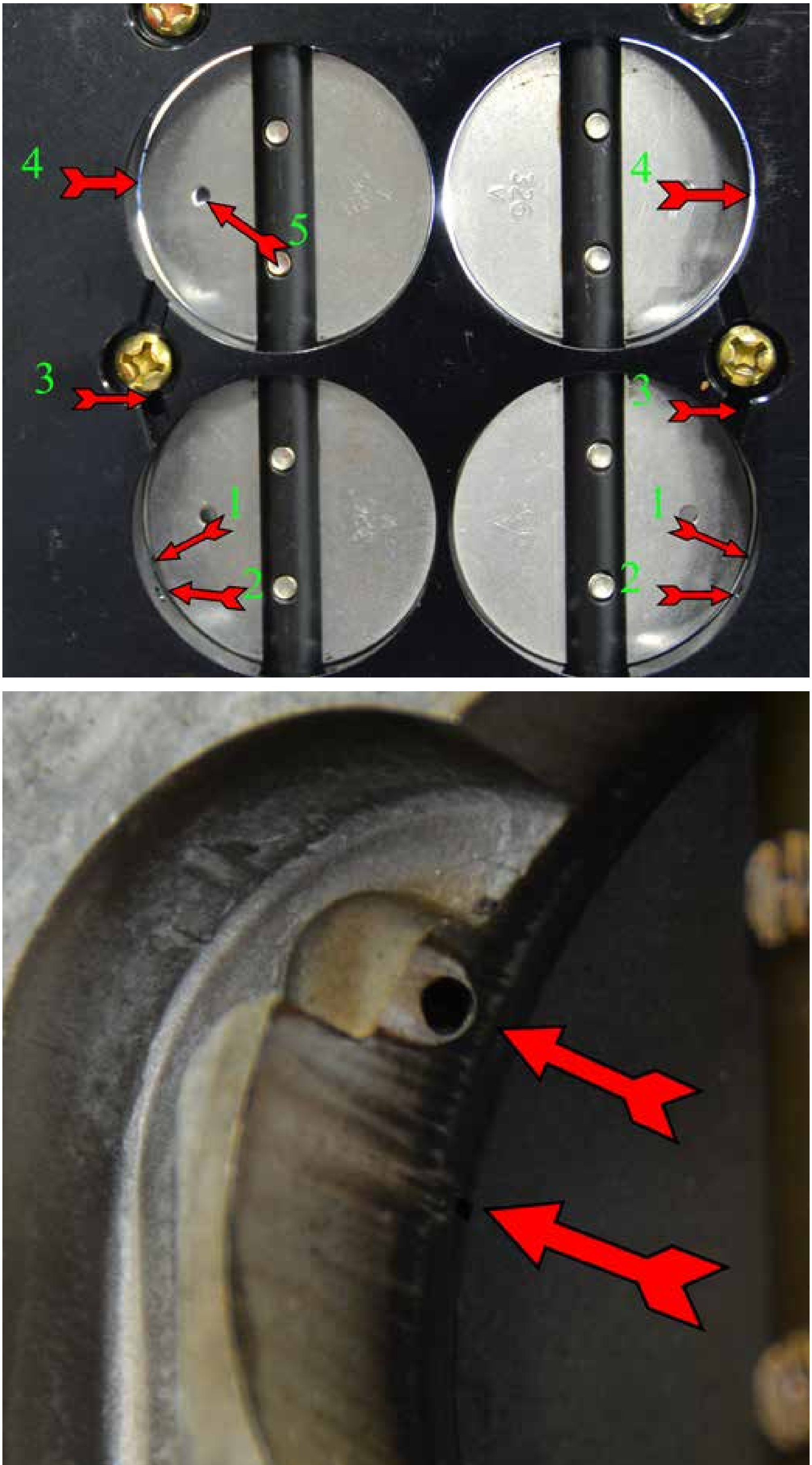
In my opinion, it's a good practice after you get your carb from your builder to tear it down, look it over, clean it all out, measure and record the transfer, idle, power valve restrictors, and jet sizes, along with the emulsion hole patterns and sizes. Baselining it means you can always refer back to the as-built data if you do any changes that later don't work out for you. I can't speak for all builders, but the carb man I use (Patrick James at Pro Systems) delivers his carbs with a spec sheet and a rich-lean jet window that I can reference. I've bought several of his carbs and I've never been disappointed with the cost, quality, or results he's given me.

I usually start out with the carb "squared" with all four throttles opened just enough to expose a square area of the transfer slot. In other words, the throttle blade exposes an amount of the slot equal to the slot's width. Is this an absolute rule? Not necessarily. I do it because it gives me a uniform starting point and on a four-corner idle carb I can't see what it hurts. I'm a simple guy — I like simple and repeatable processes. If I have to adjust RPM, I then adjust the primary and the secondary throttle screws equally. Ditto for idle mixture, I set them all the same and move them all the same amount so that they're equal. I count my turns on everything and write it all down so I can track changes, or bench-set it if I have to have it apart for any reason.

Remember that the transfer and idle circuits share the same fuel or wet side restrictor unless you're dealing with a three-



Here's a couple of photos of a stock Holley. I've fed a wire through the feed passage in the main body and through the nozzle. There are all manner of nozzles available for Holley carbs, some right from Holley, and several sources of custom-made pieces. They come in high shear, skirted, drop leg, straight and annular discharge design, with different amounts of gain or signal strength available. Changing nozzles is something your carb man does for you, and if you're buying custom-built carbs he'll make the decision for you based on the design and application criteria you give him when you order the carb. I pulled the plug out of this metering block and put a laser pointer in the passage so you could see the connection from the main well to the emulsion channel restrictors, and the feed channel from the main well to the transfer/idle fuel circuit.



Setting the throttle plates is done for timing. The stock throttle plate shown (natural aluminum) was pulled off a car, and at the upper arrow you can see the idle discharge port (the round hole). At the lower arrow, if you look carefully you can just make out the lower edge of the transfer port slot. The this runs vertically and is about a quarter-inch long. Its job is to provide fuel between the time idle fuel drops off and the main nozzles pull in. The black anodized throttle plate is from a custom-built carb, and it shows us a number of things. It's a four-corner idle since it has four idle discharge ports (marked at 2) and the shadow of the transfer slot shows up a bit better here as well (marked 1). The throttle openings are roughly equal (4), and the throttles have been drilled to help close up the plates at idle to avoid opening them so far that we start pulling in transfer fuel and robbing the idle circuit (5). The machined-in slots marked 3 are the feed to the vacuum side of the power valve circuit.

circuit carb, like some Dominators. If your camshaft requires opening the throttles too far to get a stable idle, you may find that you'll start shutting off the idle discharge flow below the throttle plate and render the idle mixture screws useless. The only reason to avoid excessive throttle opening is because the idle circuit and transfer circuit flow shifts between the lower discharge hole (idle) and the transfer slot depending on how much of the transfer slot is exposed to engine vacuum. Or, you may have to close the throttles down because you start to pull the main circuits in early, which can cause dripping from the boosters. As the throttles open, the flow through the transfer slot "steals" all the fuel previously delivered to, and controlled by, the idle mixture channel and the adjustment screw.

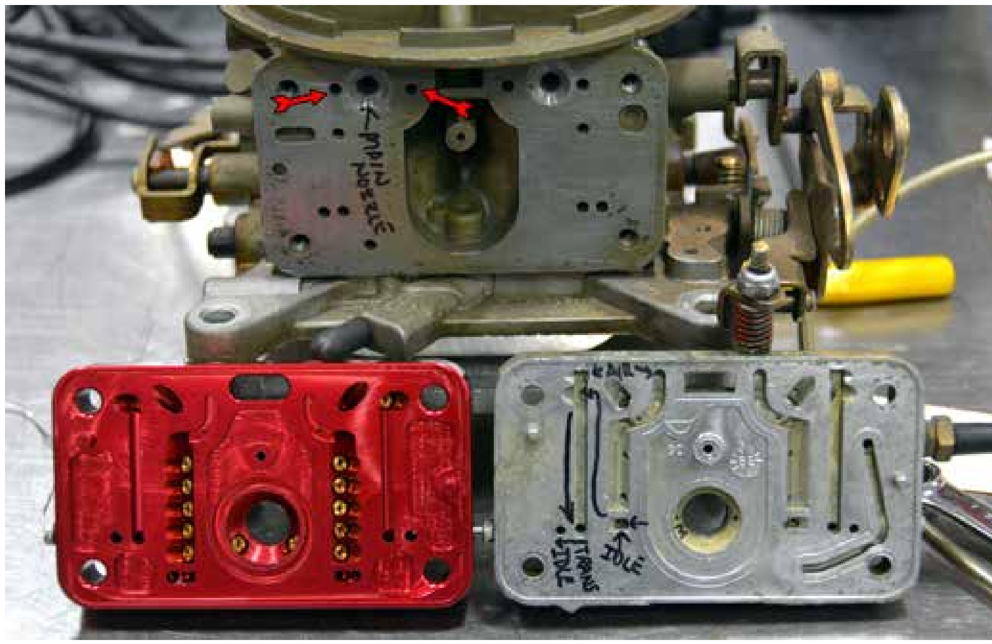
From there, I adjust the primary and secondary throttle plates equally to get the required idle speed. If you really have to jack the throttles open to get your idle speed right, you'll need to drill the throttle plates to allow enough of an air leak to close the throttles back down. You can always tell if you have to open the throttles too far when the idle mixture screws stop being effective as you wind them in and out, which tells you that you've got flow from the transfer circuit robbing the idle circuit. Normally, the idle mixture screws will be between 1-½ and 2 turns out for best idle, once the fuel restrictors and air bleeds are right sized and the carb throttle plates are evenly adjusted.

TOO MUCH IS JUST RIGHT

Can a carb be too big? Well, yes — and maybe. For the most part, it's hard to make a carb too big today given how many options there are for throttle bodies, main bodies, and booster designs unless you go full-on stupid with it. The "old school" answer is, "Yes, too big and you'll lose response because the venturi signal is too weak to pull fuel." It makes some sense — if the venturi is large and the displacement is small, then the air pump isn't big enough to cause adequate flow to pull a sufficient vacuum signal on the main nozzles to get flow early enough to make a smooth transition onto the mains. Given the design options that builders have today with booster nozzles, however, an outstanding carb man can custom build you a carb that is "too big" and still tire-shredding responsive. The good part is that bigger really is better for making top-end power, so if your carb guy can control the transitions and all-out top-end power is the name of your game, then make it big. Now, of course if you take it to the absolute extreme you can certainly make it too big, but you may be surprised at how big you can make it before it becomes undrivable.

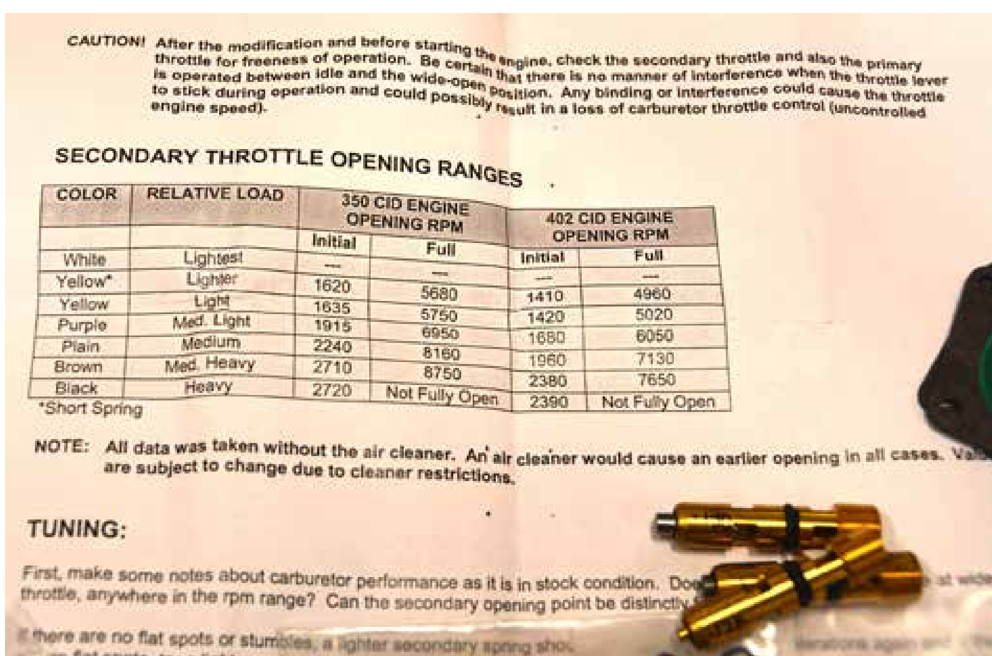
ACCELERATOR PUMP CIRCUIT

The accelerator pump is a simple circuit designed to overcome the difference in how fast air starts moving versus how fast fuel starts to move. Because fuel has more mass, it lags behind air and when the fuel lags the mixture leans out. The pump cup delivers fuel to the nozzle; the size of the nozzle determines the how much fuel is delivered (rate) and how long the shot of fuel lasts (duration). The duration is an accident of nozzle size — a larger nozzle dumps more fuel more quickly, so larger nozzle sizes increase rate, but decrease duration. If the 30 cc pump is too small to deliver the amount and duration in correct proportion, then a 50 cc pump kit is available for both primaries and secondaries. Those ratings are for 10 pump strokes, by the way, so it's 3 cc per stroke for the 30 cc pump and 5 cc for the 50 cc pump kit.



Metering blocks like the stock Holley on the right can be extensively modified and fixed, but the question is, Why would you do that? The Quick Fuel billet block shown has all screw-in jets, and if you don't need the vacuum port, indicated by the arrow, why go through all that work? The power valve restrictor on the stock block, pointed out by the screwdriver tip, is drilled into the block and can only be enlarged by more drilling, whereas the billet block uses a replaceable jet that you can tune more precisely and replace quickly if you miscalculate the fuel requirement. Drilling is fine, but if you go too far, putting material back in is kind of a trick. The arrows on the main body indicate the idle air bleed feed (to the left) and the main air bleed to the right, with the main nozzle feed centered between them. The idle restrictor on the stock block to the right is a drilled brass insert, located at the lower end of the transfer/idle crossover channel. On the billet block, there's a screw-in restrictor just visible at the top of the channel in the pocket at the left of the main nozzle feed port. Replaceable jets make tuning much easier and can be reversed if you make a mistake.

There are several tuning items in the accelerator circuit. Determining what you need to tweak or change in the pump circuit is accomplished with a test drive. Hesitations or backfires with rapid throttle movement indicate a lean condition and require one of several fixes. First of all, pump nozzles come in a number of sizes and in three configurations — tube, drilled, and anti-siphon. If you're lean, the first thing to do is change the pump nozzle, and each step should be an increase of .002-.003 in. If you find yourself with a nozzle size over about .040 in., you'll need to verify that you're using a hollow nozzle hold-down screw so that you're getting all the flow you should. If you get north of .037-.038 in., you might want to look at going to a 50 cc pump kit. The Holley accelerator pump also has a wide assortment of pump cams available, all with different delivery rates and delivery timing. Pump cams have at least two mounting holes in them. The #1 hole is typically used for cars idling at or under 950 RPM, while the #2 hole works well for cars with a higher idle. #1 hole tends to be earlier and less total lift, and #2 hole tends to be later with more total lift, but you have to check because that's not always true for all pump cams. They're easy to replace, so changing them and experimenting isn't too time-consuming.



CAUTION! After the modification and before starting the engine, check the secondary throttle and also the primary throttle for freeness of operation. Be certain that there is no manner of interference when the throttle lever is operated between idle and the wide-open position. Any binding or interference could cause the throttle to stick during operation and could possibly result in a loss of carburetor throttle control (uncontrolled engine speed).

SECONDARY THROTTLE OPENING RANGES

COLOR	RELATIVE LOAD	350 CID ENGINE OPENING RPM		402 CID ENGINE OPENING RPM	
		Initial	Full	Initial	Full
White	Lightest	---	---	---	---
Yellow*	Lighter	1620	5680	1410	4960
Yellow	Light	1635	5750	1420	5020
Purple	Med. Light	1915	6950	1680	6050
Plain	Medium	2240	8160	1960	7130
Brown	Med. Heavy	2710	8750	2380	7650
Black	Heavy	2720	Not Fully Open	2390	Not Fully Open

*Short Spring

NOTE: All data was taken without the air cleaner. An air cleaner would cause an earlier opening in all cases. Va are subject to change due to cleaner restrictions.

TUNING:

First, make some notes about carburetor performance as it is in stock condition. Do throttle, anywhere in the rpm range? Can the secondary opening point be distinctly

If you're running a vacuum secondary Holley, you may need to tune the opening rate of the secondary throttles. Holley makes a variety of color-coded secondary diaphragm springs to accomplish that. The chart will help get you in the ballpark, but if you notice, the spring opening RPM is displacement-dependent, so there's a little cut-and-try involved when you do your tuning.

Once you've landed on the nozzle, screw, and pump size and cam, the last thing to do is correctly adjust the duration spring by holding the throttle wide open and adjusting the clearance between the pump arm and the cam to .005-.015 in. to avoid forcing the pump cup past its limits and damaging it. Just make sure that the adjusting nut on the duration spring is seated against the pump arm (no daylight under it) before you adjust the arm to cam clearance. The duration spring overrides the pump arm and follows the pump lever down, increasing the length of time the pump shot is delivered.

THE ANSWERS ARE OUT THERE

I hope this quick primer will get you started out on the right foot. There are several good books written by some outstanding authors on the Holley series of carburetors and I'd suggest you buy several and read them all if you're looking for a more complete understanding of carb theory, operation, and tuning. Each author has his own approach, so there's something to be learned from each of them and they're all worth reading. ■

There is a multitude of ways to determine if your carb is rich or lean. You can read plugs, use a wide-band oxygen sensor in the pipes, a five-gas analyzer, or if you have time and room for removal, you can pull the headers off and look at pipe and port color. Instrumentation is the quickest and easiest, but sometimes for old guys like me we like to look for that very light mousey grey color in the pipe to confirm what we read on our equipment. This port is reading rich to me, and confirms what my wide-band said, which was that it was reading at 12 to 1 all the time with no high-speed lean out.

Tube nozzles are nice because they direct the fuel right at the booster, and they can be "aimed" a bit by carefully positioning them when you tighten up the mounting screw. They do extend out into the air stream, which can lead to pullover, so that's something to watch for if you are rich and can't find any other answer. Observing operation with loaded air flow may be the only way to catch a pullover problem.

TECHNICAL MINUTE: PRESSURE: LEARNING TO LOVE IT!

-Greg McConiga

Understanding the engine as both an air and vacuum pump.

When the engine is running with the throttles closed, the air coming in is restricted. Because the demand for air created by the falling piston exceeds the amount of incoming air available through the small opening around the throttle blade, a vacuum is created inside the intake manifold. The inlet pressure inside a running, idling engine is well below atmospheric, which is 14.696 pound per square inch at sea level, for standard conditions. Even this number, 14.696 PSI, isn't always a given and may be a corrected number because altitude, water content, and weather conditions will often raise or lower the number significantly. Next time a hurricane approaches, listen to the weather people as they explain the anticipated storm intensity based on the atmospheric pressure!

Atmospheric pressure can be expressed as Bar (as in "Barometric" — 1 Bar = 14.503 psi), or in Millibar (1/1000th of a Bar, the typical unit used when reporting tropical storm intensity), in inches or millimeters of mercury (29.92 in. Hg, or 760 mm Hg), in feet of water (33.8 feet of water), or inches of water (406.78 inches of water column, abbreviated WC). The scale you choose is determined by how low the pressure or pressure differential you're looking at is and what kind of resolution you need for your measurements. For small measurements or differentials, a large scale reveals small changes, which is why inches of water are often used when referring to the tests we conduct on carburetion and cylinder head flows.

Daniel Bernoulli, 1700-1782

You may also run into readings listed as PSIG or PSIA, which stand for pounds per square inch gauge and pounds per square inch absolute. Absolute pressure is zero-referenced against a perfect vacuum, so it is equal to gauge pressure plus atmospheric pressure. Gauge pressure is zero-referenced against ambient air pressure, so it is equal to absolute pressure minus atmospheric pressure. You may also run into a compound gauge that shows a scale registering PSI above zero and readings in inches of mercury below zero. There are also absolute pressure gauges that indicate 14.7 PSI at rest. The scale and gauge function is normally written on the gauge face, particularly if the gauge has a scale other than PSI, or if it's a very sensitive gauge with a limited range.

Pressure is a key design consideration on virtually every part of the modern automobile. We use it to move pistons, actuate or activate transmission, power steering, and brake components and we measure the amount of pressure and flow over the skin of the car, both top and bottom, to help build slippery shapes that reduce drag and achieve better fuel economy. Differential pressures induce flow or movement and movement of air across specifically-shaped surfaces can create differential pressures. In a corollary to the law of conservation of energy, Swiss mathematician and physicist Daniel Bernoulli (1700-1782) proved that if you increase the speed of the fluid that there must be an accompanying decrease in pressure in the fluid, authoring what we now call the Bernoulli Principle. Airplanes, for example, fly because the curved upper airfoil shape forces air to move faster over the upper surface of the wing than across the flat bottom, and if you force air to increase in velocity over the top of the wing you get a corresponding drop in pressure that the wing then moves up into, creating lift. It's why you see light airplanes tied down at the airport — you don't have to start the engine to fly. If there is sufficient wind speed at ground level, the airplane will lift off the ground on its own. Whether you move the plane through the air, or the air over the airplane doesn't matter. It only takes movement over the wing to make the pressure drop on the top side of the wing, thus creating lift.

The Bernoulli Principle is what makes our carburetor work. If you look at a cross section of the main venturi, you'll see an airplane wing. If you consider it in the whole, you have a "wing in the round," if you will. We boost this low pressure area by locating a boost venturi, basically another, smaller venturi, so that its lower end rests exactly at the point of lowest pressure in the main venturi. Doing so amplifies the effect and creates a stronger "venturi signal" that is then used to draw fuel from the main well through a jet and into the engine air stream. Taking it one step further, it's actually differential pressure at work. Atmospheric pressure, acting through the bowl vent, pushes the fuel into the lowered pressure created by the main and boost venturi.

See? What's not to love about pressure? ■

FINISH LINE

-Greg McConiga, Executive Technical Editor

WANDERING FULMINATIONS ON HIGH-PERFORMANCE

THESE CARS RUN ON CODE

"The only reason we put tires on cars is to keep the computers from dragging on the ground."

Attributed to a Toyota Engineer

1969. Apollo 11. The Lunar Module Descent-and-Landing Computer took control of the space craft several thousand feet above the lunar surface, and this single computer controlled the main engine, thrusters, and navigation inputs bringing the ship to a safe landing at Tranquility Base. This computer operated on roughly 100,000 lines of code and it performed flawlessly over several missions doing a critical job with a tiny fraction of the hardware and software found on a typical modern car.

Fast forward to 2016, and the average car, negotiating in a far less challenging environment, contains as many as 100 microcontrollers, 50 onboard computers or modules, two and half to five miles of wire, and as many as 100,000,000 lines of code (that's one hundred million there, boys and girls...). Brave new world, indeed.

The Next-Gen cars will make what we drive today seem like dinosaurs as the increased pressure to produce zero-emissions vehicles mounts. Variable-compression engines, high-compression Atkinson, modified Atkinson, and Miller cycle engines are all on the market, or coming out in the next few model years. Dry sump systems, too. This will apply undue pressure on the system that produces the service techs of tomorrow, and, frankly, we can't meet the demand today. Just as we have paramedics and paralegals, we are past the point of needing para-engineers to work on our modern automobiles.

In a classic example of putting Band-Aids on bullet holes, we have allowed the car makers to sell us all on the idea of the "directed repair process," which has resulted in an entire generation of techs with no real working knowledge of the underlying engineering that makes our cars hum. We

Apollo 11 Lunar Module, circa 1969.

have been made into bakers — add this much flour, this much sugar, a bit of butter, and suddenly we have cake! Unless it turns out to be biscuits. Then we're just confused because we don't have access to the design and operation parameters that would let us perform a more traditional style of diagnosis and at least figure out how our cake turned into biscuits!

Here's what I'm seeing from my vantage point: The manufacturers are throwing in the figurative towel. Even their own tech lines can't help anymore past telling us to bolt this part on or overlay this harness. The only real good they do is that they authorize the "guess" so that at least we can recover all or part of the time we spend trying a half dozen different things to get the customer on the road again. Sadly, the power to authorize repair "attempts" is being eroded as in many cases they advise us to "try this," but then tell us to first call the district manager to get an authorization code before proceeding. That's if you can get him or her to answer the phone (good luck with that!).

Practical vehicle life cycle is shortening as repair parts disappear in six or seven years (hard parts), and no one really knows what the anticipated life cycle will look like for those 100,000,000 lines of code. We all own computers, and we all have bought software packages. What happens every few years? You get roped into buying an update package. So what happens if the software on a ten-year-old car is corrupted? Will there be legacy support for these vehicles? Your guess is as good as mine, but I'd bet you lunch that manufacturers aren't going to expend resources to keep an old car or truck alive when they can force you to buy the update package — surrounded by a new car or truck, of course. But, hey! What's $30,000 to $80,000 between friends?

Everyone is going to win except the consumer if it gets to the point where the life cycle shortens to four or five years. The car makers lock in increased demand for new product, the vendors have parts to make, the environmentalists are delighted because each new generation of automobiles is cleaner. The consumers get hammered with a new and ever-increasing car payment to service, and the used car customer buys a pig in a poke, not knowing that the three-year-old car only has a realistic service life of a couple of years left in it.

The technician can't get access to the training and information needed to fix any of them because the manufacturers themselves don't know how they work, and the hardware and software guys are all compartmentalized, and the guy who used to have the big picture isn't working there anymore.

The whole repair process becomes a "try this and see" with parts that cost thousands of dollars; parts that once programmed can't be taken off the car and reprogrammed to fit another vehicle should it be determined that the part didn't fix the problem. What this eventually becomes is a consumer chained to the equivalent of another mortgage payment for as long as he or she needs to own a car or truck. It's either that, or we will all end up Ubering or renting a car when we need it.

Attracting a Next Gen technician is going to be a real challenge given the way the commercial side of our trade operates. We make our techs buy the means of production (tools) and then pay them based on piece work. If a tech faces a challenging problem, one that's "off the flow chart," the factories will not pay straight time unless you raise a mountain of hell with them, and even at that they are always poised to swoop in and take back money previously paid (after the fact and long after the vehicle has left your care) under the guise of an "audit" — basically a guilty verdict rendered after the fact and after all your defense proof (the fixed car) is long gone.

The traditional methods of drafting youngsters into automotive programs aren't capable of attracting the kind of heads-on and hands-on guys we need to start on a career in what will become the auto service field of tomorrow. The kind of folks we need just also happen to make pretty damned good engineers, and while the engineering field isn't a great deal more challenging from an academic point of view, it's far more lucrative and is perceived to be a more productive and professional career path.

Let's be honest, the physical demands of the field mean that the real time from competent to worn-out is only about 35 years, and how do you incentivize what is a de facto forced early retirement at today's wage, or under any iteration of the flat rate system? Fact is, we can't compete!

What does this mean to racers? Mechanics used to be the guys who loved the work, loved making and fixing things, and they were where a lot of racers came from. Now mechanics spend most of their days with a laptop updating the programs rather than learning engine fundamentals. Racing laptops doesn't have quite the same thrill, and the results of your work aren't quickly visible, which kills most of the passion. Your day is spent trying to make a paycheck for the family.

Fuel economy and clean air regulations will put pressure on large displacement "V" engines, slowly reducing their numbers, which means that all of our racing products will come from bespoke designs and aftermarket companies at an increased cost. No matter how you slice it, our racing industry will track the commercial side of our industry and fewer and fewer will be drawn into the performance field. Once that takes root, the law of supply and demand will drive prices and wait times for parts and services through the roof.

The repair trades and the racing associations need to start joining forces and work to encourage high-quality, passionate people to join our ranks. Running on code may be the order of the day for our daily drivers and it will be a growing part of the tuning trade, but I'm not sure that it's enough to keep us all profitable and growing. ■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