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PERFORMANCE TECHNICIAN

ROLLER ROCKER SYSTEMS, 2

POSITIVE CRANKCASE VENTILATION

PISTON RINGS, PART 2

Vehicle Power & Performance Knowledge for Professionals

PERFORMANCE TECHNICIAN®

FEATURES

DEPARTMENTS

Christopher M. Ayers, Jr.
Publisher / Editorial Director
cayers@performancetechnician.com

Bob Freudenberger
Editor
bfreud@performancetechnician.com

Greg McConiga
Executive Technical Editor
gmcconiga@performancetechnician.com

Tom Nash
Managing Editor
tnash@performancetechnician.com

Christopher Ayers, III
Art Director, Webmaster
ayersc3@performancetechnician.com

Tamra Ayers
VP Business Development
tayers@performancetechnician.com

Contributors:
Ali Afshar, Steve Campbell, Henry Olsen, John Galt, Frank Walker, Glenn Quagmire, Adam Smith

Editorial, Circulation, Advertising Sales & Business Office:
134B River Rd.
Montague, NJ 07827
P.330.620.3929

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STARTING LINE

-Bob Freudenberger

RAT RODS RISING

When I first saw the phrase "rat rod" on craigslist.com some years ago, I knew intuitively what it meant, and it made me smile. I go to my local vintage/antique/hot rod shows, which are usually held in the shade of beautiful old live oaks at various venues in Florida, and I occasionally make it out to Las Vegas for SEMA. I always admire and marvel at the perfect craftsmanship the custom and restored cars exhibit. Lord, I sure would like to have the time, money, and storage space to create and keep, say, a '32 Ford Coupe with a spotless, chromed, and cammed 289 in it, or maybe a '40s flathead with its incredible, unmistakable sound. But I don't. Magazine editorial work hasn't been particularly lucrative for years and years, and I have a family to support. Plus, the shop space I have needs to be available for regular bread-and-butter automotive repairs and maintenance, not hobby pursuits.

The rat-rod concept, however, is approachable even to somebody like me. Googling the term produced almost 1.5M hits, so there must be plenty of people out there who are having fun fooling with automotive "works in progress." Another aspect of the appeal is the "Mad Max," steampunk kind of rebellious, distopian image rat rods evoke. I don't think I'd be decorating mine with skulls, spikes, and iron crosses, but I get the idea.

As is inevitible with any trend, there's a magazine devoted to this one both in print and online. ***Rat Rod*** states that the phenomenon is "the automotive world's fastest growing scene," and in its pages I found a good definition of it by Steve Thaemert: *"I used to spend a stupid amount of time trying to explain my stance on what a rat rod is and how I have formulated that opinion, but it all comes down to this: A rat rod is simply a blue-collar hot rod... the working-class answer to high-buck hot rods and street rods and all the pageantry and ego that seems to go along with them. Rat rods are about heart, history, and having a good time."*

Looks don't matter. They only "care if they tear."

PT's exec tech editor, Greg McConiga, is nothing if not a seasoned and precise craftsman. Even though he's one of my closest friends, I wonder what kind of reaction he's going to have to this column. Okay, Greg, I know somebody's got to be the perfectionist, but that's something I simply can't afford to be for all the reasons already mentioned. That doesn't mean I wouldn't thoroughly enjoy fooling around with my own automotive creation.

I can do all the work myself, and I'm not afraid of a little Bondo. I've painted lots of cars, but nobody would ever call me an *artiste*. I remember spraying a '65 Chevelle hardtop (after fixing substantial rust using a saber saw, Ospho, sheet galv, pop rivets, a spot welder, and polyester body filler) with Rust-O-Leum white gloss *outdoors* in the bugs, pollen, and dust. Not perfect, of course, but shiny and presentable. RRs are usually kept in primer anyway - you might even think of using a roller and some foam brushes to save masking time.

In my last ***PT*** column, I mentioned that my little grandsons, ages two and three, are car guys. They have an assortment of leg-propelled vehicles at our house, but the ones they love to race up and down the long hallway are two miniature plastic fire trucks with hollow wheels that are so noisy on the hardwood floor that I can barely have a conversation with my wife. They zoom toward a closed door, then skid sideways to stop, quite skillfully. One of the trucks is an old, sun-bleached rat of a hand-me-down toy, but the other is a recent Christmas present that's all shiny and even has sound effects. They swap them/ride them with no preference. It doesn't matter to them how they look. They only "care how they tear." ■


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POSITIVE CRANKCASE VENTILATION
MORE IMPORTANT THAN YOU THINK

-Henry Olsen

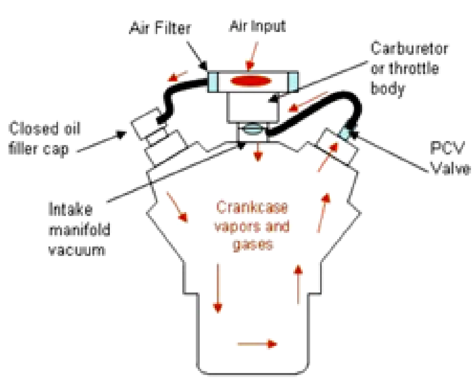
It's been around for over five decades, but do you ever take it into consideration? Ignore it at your peril.

A PCV valve is a very simple mechanical device, but if the system it's part of isn't right it can cause problems that range all the way up to serious engine damage.

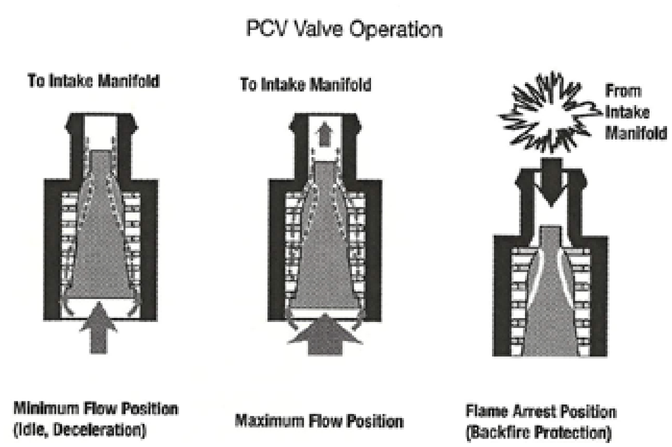
PCV (Positive Crankcase Ventilation, not "Pollution Control Valve," as some oil company ads of the 1960s would have had us believe) is one of the most ignored engine systems. When it's working properly, you won't even notice that it's present, but if it's not it can cause problems that range from poor idle quality and serious oil leaks to sludging and internal engine damage from oil contamination. Every piston engine no matter how well designed and assembled has a certain amount of blow-by past the rings, and if it can't get out of the crankcase pressure will build up and water vapor, excess gasoline, and combustion contaminants will collect in and dilute the motor oil.

Before automotive emissions control became a big issue, a road draft tube system was used to vent the crankcase gases straight into the atmosphere. This tube was a simple pipe that extended from the upper block to an area below the bottom of the engine, and its outlet was typically cut at an angle. When the vehicle was driven at highway speeds, the air passing by the end of the tube created enough vacuum to draw the blow-by out of the crankcase. Fresh air entered through a mesh-filled oil filler cap usually found on the valve cover. This kept pressure from building, but at slow speeds and idle no vacuum was present, so air flow was minimal and moisture and harmful acidic vapors tended to build up inside the engine.

In the 1950s, concerns over the heavy smog that hung like a shroud over Los Angeles and wasn't doing the health of the populace any good prompted research into the automobile's contribution to its formation. It was determined that up to 30% of vehicular air pollution was the unburned hydrocarbons and other gases and vapors that were emitted through the road draft tube. You could actually see (and smell) fumes escaping at both the road draft tube and the oil cap, especially if the engine was in bad shape. This visible air pollution was unacceptable in a society that was awakening to the damage our industrialized way of life was doing to our planet. So, PCV was mandated in California in 1961, and nationally in 1963. It wasn't a new idea even then. Long before emissions control became an issue, some military and commercial vehicles used it to cut internal engine



This diagram illustrates the flow of outside air through the crankcase to pick up blow-by and carry it to the PCV valve and into the engine to be burned during the combustion process.



These illustrations show the different flow positions of a PCV valve.

deposits. It's been an unmitigated success, eliminating a great deal of a vehicle's overall air pollution while keeping the inside of the engine much cleaner than it would be without it (it was a major factor in the adoption of the long oil-change intervals we have today).

LOCATION AND FRESH AIR

The PCV valve is commonly plugged into a grommet in a rocker or cam cover (an internal oil separator or baffle keeps liquid lubricant away from the inlet of the valve) and is connected to engine vacuum through a port into the intake, typically under the carburetor or throttle body. This vacuum draws a metered flow of blow-by, oil fumes, moisture, and fresh air from the crankcase into the intake stream so that they can be incinerated and evaporated in the combustion chambers. The source of the clean air that replaces the volume of vapors removed evolved somewhat since the inception of the original PCV system. Early on, it came through a mesh in the oil filler cap as it did with the road draft tube set-up. On a V8, this was usually found on the opposite-side valve cover from that in which the valve was installed. In 1968, the "closed" PCV was introduced. In this simple modification, the clean air was picked up through a plastic mesh filter inside the air cleaner housing. That way, if blow-by should ever exceed the capacity of the valve it would back up through the vent and still be taken into the intake stream.

VARYING THE FLOW RATE

Engine rpm, vacuum, and load all affect the amount of blow-by gases produced, so PCV valves are designed to vary their flow accordingly. Typically, there are two flow-rate modes for a valve. The first mode only allows a small amount of gases and vapors to pass at idle and low-load cruising when vacuum is highest and blow-by is lowest, while the second mode flows a larger amount when the engine is under load during acceleration and high speeds and vacuum is relatively low. The original equipment PCV valve works quite well with the specific engine package it was designed for, but due to part number consolidation many aftermarket replacement valves don't match the flow rates of the stock unit.

We cut this one open so you can see how the spring and pintle interact. This is the maximum flow position.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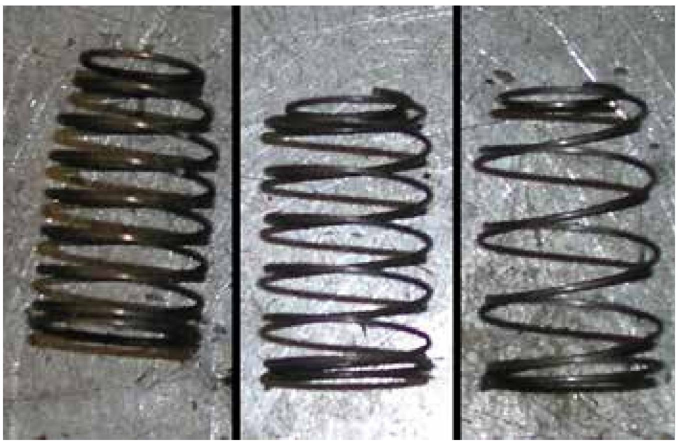
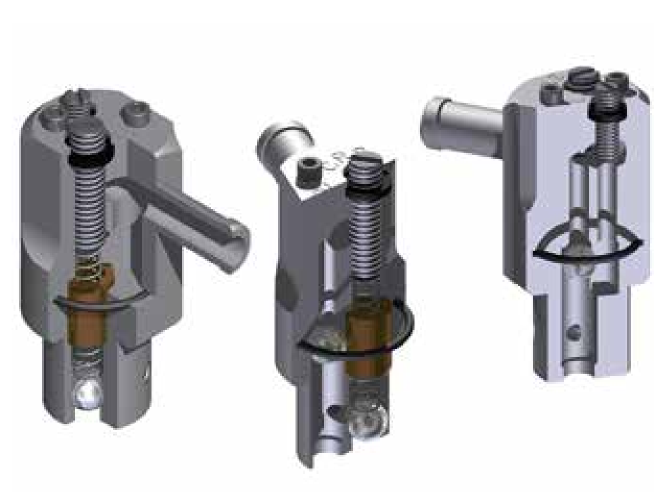
If any performance modifications have been made that change the vacuum characteristics of the engine, or even if the stall speed of the torque converter is causing low vacuum at idle in gear, the valve flow rate may not match the needs of the engine. We have been using PCV valves that were designed for engines with a “hot” cam, such as a Boss 302 Ford or a Chevrolet Z-28, in many tuning jobs. The brand of valve we’ve been using is AC Delco because the letter on the bottom of the valve’s pintle indicates the flow rate, while many others don’t. The letter “F” on a CV-769c indicates a medium-flow valve, and the letter “H” means it’s got low flow. The PCV valve should be in the low-flow position at idle including when the engine is in gear if it is equipped with an automatic transmission.



The PCV valve spring on the left is stiffer than the one on the right. The spring rate controls how much vacuum is needed to move the pintle to the low-flow position.



Here are the insides of the M/E Wagner adjustable PCV valve.

These pintles range from low-flow on the left to high-flow on the right.

If the PCV valve is pulsing from the low-flow to the high-flow position at idle, it'll cause rough, uneven running. If it's not functioning correctly and the flow rate is too high for the needs of the engine, it will in effect be an uncalibrated vacuum leak that can cause lean running at idle. The disadvantage of using a low-flow valve is that it may not have enough capacity for an engine that has a lot of blow-by. If you're working on a high-performance engine with a hot cam that needs a high flow rate, the answer may be to try an adjustable PCV valve.

This is a low-flow valve in the open position.

This is what a high-flow valve looks like.

The adjustable valve that we use is available from M/E Wagner Performance (http://mewagner.com) of Bear Creek, PA. It is adjustable for the idle mode (high vacuum), plus you can tune the cruise portion (medium vacuum) to come in when the valve transitions from idle to cruise based on the vacuum characteristics of the engine you're working on. This is a great idea. The valve comes with instructions for easy adjustment.

VAC SOURCE

The vacuum source for the PCV valve should be a place somewhere in the intake tract that will allow the incoming crankcase vapors to be equally distributed to all the cylinders. The most common vacuum source is a 3/8 in. tube located on the base plate of the carburetor or throttle body.

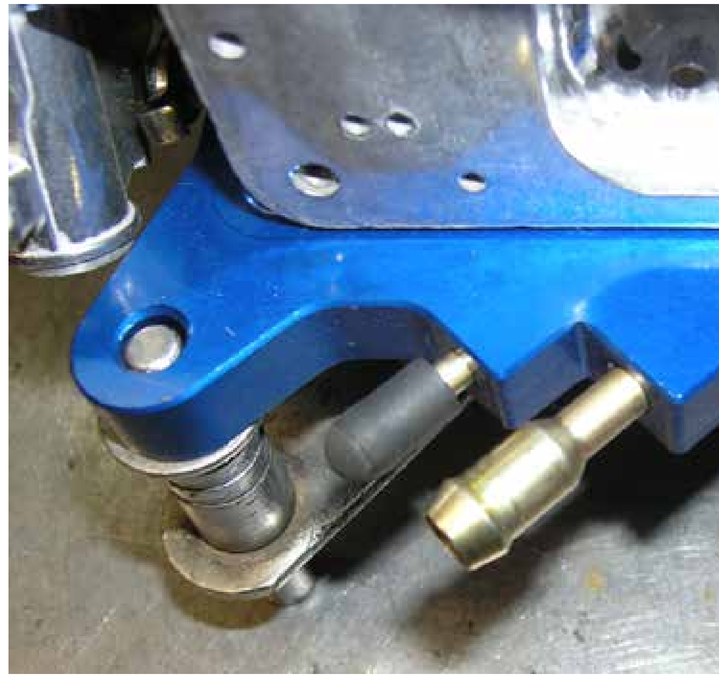
NOTE: Some newer aftermarket carburetors have a 3/8 in. tube under the primary fuel bowl that is intended for PCV vacuum, but that is necked down to 1/4 in. In our opinion, this may not allow enough volume to keep a high-flow PCV valve operating properly. If you're connecting the valve to the intake manifold itself, it should be in the plenum. If it's connected to a port on a runner that goes to one or two cylinders, it may cause those cylinders to not have the same air/fuel mixture as the others, resulting in unevenness.

VALVE COVERS AND OIL CONSUMPTION

The PCV valve should always be located in an area that allows it to draw the vapors from the crankcase without exposing its tip to liquid oil or oil spray. The most common location is in the valve cover of a V8 or V6 OHV engine, but there's a whole lot of engine oil floating around in there that's being thrown off from the rocker arms. Ford, General Motors, and Chrysler all use baffles or oil separators in their valve covers so that the PCV system won't pick up the liquid lubricant along with the blow-by. Some aftermarket valve covers have good baffles/separators, while others are marginal in this regard. If the engine you're working on has high oil consumption, or the spark plugs are getting oil fouled, the problem could be that the tip of the valve is being exposed to too much motor oil.

As already mentioned, the engine needs a vent system that allows clean air into the crankcase. The original-equipment hose connected to the clean side of the air cleaner usually works fine, but a K&N type crankcase vent filter can also do the job.

PCV systems continue to evolve. Some late-model engines, such as those from Volkswagen, get pretty much all the oil mist out of the stream of crankcase gases with convoluted passages and even cyclonic separators. That kind of sophistication isn't necessary with traditional OHV V8s. ■



This necked-down nipple on the base of a carburetor may not be the best vacuum source for a PCV valve because it may not allow enough flow for proper operation under load.

This separator/baffle does a very good job of keeping the oil that flings off the rocker arms from entering the PCV valve.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PISTON RINGS, PART 2
LORD OF THE CIRCULAR CYLINDER SEALS

-Greg McConiga

The second installment of our man Greg's magnum opus on rings talks about how they're all part of a system that includes various clearances, gas porting, and piston rockover, shape, and stabilization.

With an axial width of only 0.0236 in., this ring really is thinner than a dime. To an old mechanic like me, this is really amazing stuff.

This is all a much bigger system than you might suspect, as we will soon discuss. The rings' performance is wholly dependent on the piston, the piston ring groove accuracy and finish, the cylinder wall, the wall finish, ring sizing, preparation, and bore prep prior to installation. The ring can't do what it should if the parts it interfaces with aren't right. From the rings' point of view, the piston must present a stable platform for operation. Rockover should be minimized, the ring groove must be accurately cut and finely polished to allow sealing in the groove, the side clearance and back clearance must be correct, and piston overall dimensions must be appropriate for the application.

To check ring back clearance before grinding and installation, simply insert the ring into the groove backward and roll the ring around the piston's circumference. You should check all rings and all pistons because an error may be caused by either a ring improperly finished, or a piston improperly machined. Here you can clearly see that the ring is standing proud of the groove. This would have been a real problem had we not caught it during our mock-up and inspection process.

For ring side clearance, we should see something on the order of .001-.0015 in. For back clearance - that is, the amount below the piston land that the ring sits on when viewed straight on - we should see something at or more than .005 in. recession, and this is a case where "less is more" until we get to the point that the ring grows enough to grab the bore with heat and load. We don't want the ring proud of the groove - and it should be intuitively obvious that if there is lower volume behind the ring, it will push out faster and be in more intimate contact with the bore sooner during the compression stroke if back volume is minimized.

A good friend of mine was once involved with another builder who failed to check the back clearance during the build and the ring was actually a little proud of the groove. On the dyno, the engine would start and begin to pull, then suddenly slow and stall. It would immediately restart and repeat the same behavior. Needless to say, there were a lot of ignition and fuel parts replaced before that one got figured out!

Nearly all racing applications make use of gas porting, either drilled down from the top or drilled radially in above the top ring. Gas porting just allows the ring to achieve a tighter gas seal earlier in the compression stroke. This is a good time to squelch the old wives' tale about gas porting. It doesn't increase bore wear. Never has and never will. The ports only cause the ring to actuate quicker as the piston comes up on compression. The end gap and the side clearances are such that compression and combustion pressure will always find a way behind the ring to press the ring into the bore - it just happens later without gas ports. We rely on cylinder pressure to apply the ring firmly to the bore, and always have. Gas porting just “applies” the ring sooner and more consistently.

Any time the ring stands proud or proceeds from the groove, you run the risk that the ring will grab the bore and stall the engine. How much back clearance is just right is dependent on the ring’s distance from the piston top (exposure to heat), its axial width (thickness), its radial width (distance from ring outer diameter to inner diameter), and its rate of growth with temperature. This is high-performance work (there is rarely “one right answer”), and sometimes you just have to cut and try to make it work.

ROCKIN’ AND ROLLIN’

Piston rockover causes ring control issues because the ring moves from a circle to an ellipse as the piston rocks over center, which is a function of changing rod geometry as the crank moves through top and bottom dead center. We don’t use piston pin offset in racing applications because doing so increases skirt friction as the piston rocks into the major thrust face sooner as it moves up the bore during compression. In fact, pin offset is rarely used any more at all - even in production engines. During rock, the ring end gap can vary slightly; the ring contact varies from top lower to bottom upper to face centered to top upper and bottom lower as the piston rocks over center. Rockover is caused or affected by stroke length, compression height, skirt length, skirt clearance, and piston head diameter cutback. Stroker engines can suffer from some of the worst cases of rockover as the piston is pulled farther out of the bore over bottom dead center, which explains some of the oil consumption issues often associated with stroker builds.

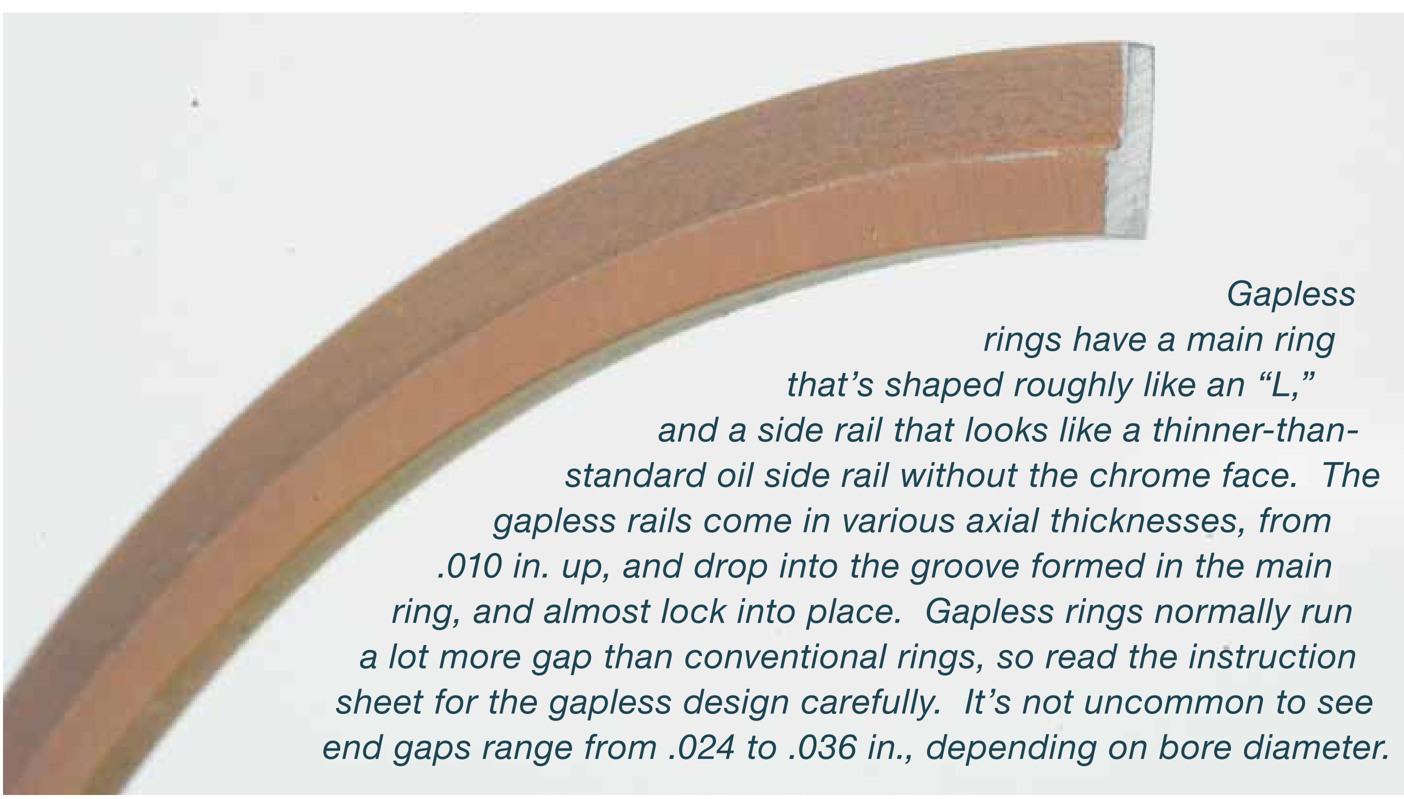
Thinner faces and less total square inches of contact with the cylinder wall equals less friction. You can see how thin this .043 in. two-piece gapless top ring has compared to the dime clamped next to it. It’s a long way from a 5/64th or a 1/16th in. ring, isn’t it? Grinding them is a pain in the hindparts, too.

The piston head is typically cut back between .030 to .090 in. less than the largest skirt dimension to allow for piston head expansion due to heat and carbon formation above the top ring, although that's not a hard-and-fast number anymore, either. The Pro Stock guys are always experimenting and rumor has it that they might run piston head diameters with less than .015 in. cutback. Of course, they're taking it apart every 20 runs, something most racers hopefully aren't doing.

SHAPELY

Piston shapes are more extreme now as racers and manufacturers look for any advantage. Let's face it, friction is a big problem in a racing engine and the more you reduce friction the more you reduce the parasitic power losses and the more power is available for moving the car down the track. Friction increase is linear with engine speed and increases rapidly with cylinder pressures and rpm, so any friction reduction you gain is increasingly beneficial at higher operating speeds. Rings and pistons make up roughly 50% of the frictional losses in an engine, another 25% is lost to the main and rod bearings, and the balance is lost to seals, other bearings, and the valve train. If you've got a choice between using up power to overcome friction and using up power to go faster, choose going faster.

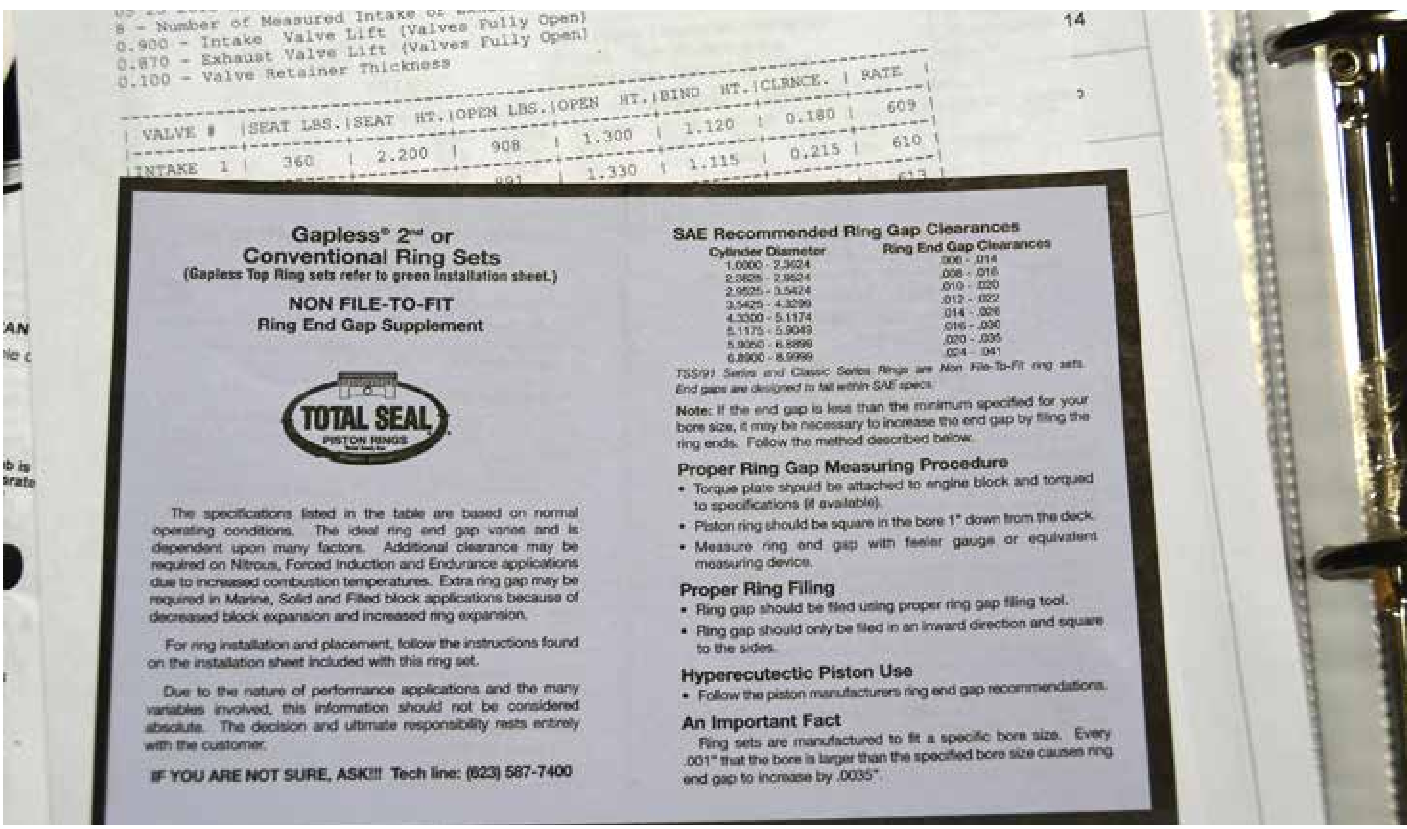
Shorter, lighter pistons with smaller overall contact patches above and below the rings naturally have less friction. The fewer square inches of material there is in contact with the bore, the lower the coefficient of friction; that's just common sense. BUT, it comes at a premium. Piston makers are utilizing reduced contact/anti-detonation grooves above the top ring, increasing the cam (oval shaped skirt, as seen from the top) and barrel (barrel shaped as viewed from the side), as well as reducing overall length from head to skirt bottom. They are also taking advantage of narrow ring



Gapless rings have a main ring that's shaped roughly like an "L," and a side rail that looks like a thinner-than-standard oil side rail without the chrome face. The gapless rails come in various axial thicknesses, from .010 in. up, and drop into the groove formed in the main ring, and almost lock into place. Gapless rings normally run a lot more gap than conventional rings, so read the instruction sheet for the gapless design carefully. It's not uncommon to see end gaps range from .024 to .036 in., depending on bore diameter.

options that eliminate the extra weight of pin buttons or oil control ring support rails by moving the overall ring pack up and out of the pin bore. Piston weight goes down, which reduces rod bolt load (particularly during overlap where the cushion of compression isn't there) along with a dramatic reduction in piston to bore friction. But the stability of the piston in the bore goes to hell; it's rocking over to the tune of .020-.075 in. Combine that with reduced ring axial and radial widths and lower ring tensions to further reduce friction and reduced ring mass to lessen the effect of inertia (a body in motion tends to remain in motion; a body at rest tends to remain at rest) as the ring pack reverses direction at the top and bottom of every stroke, and you've got yourself the very definition of a system on the edge of being dynamically out-of-control.

You NEED a light piston to keep rod bolt loads reasonable and your high rpm assembly alive, you need as little friction as possible, and you need thin, low-tension, low-friction ring packs that can provide oil control and compression and blow-by control. It can be done with the latest piston and ring designs, but anything you can do to stabilize the piston helps. A fairly new development is skirt-applied abradable powder coatings used to reduce skirt clearance and control rockover. This isn't just a spray lubricant or moly like you're used to seeing. This is a coating that has to be sanded away to fit the piston at



If you use Total Seal's rings, make damn sure you follow the correct set of directions. They make both conventional rings and gapless rings, and there's a purple instruction sheet and a green instruction sheet. Purple is for conventional sets or gapless second rings, which are popular with the alcohol-burning guys because they minimize crankcase contamination, and green is for gapless top ring sets.

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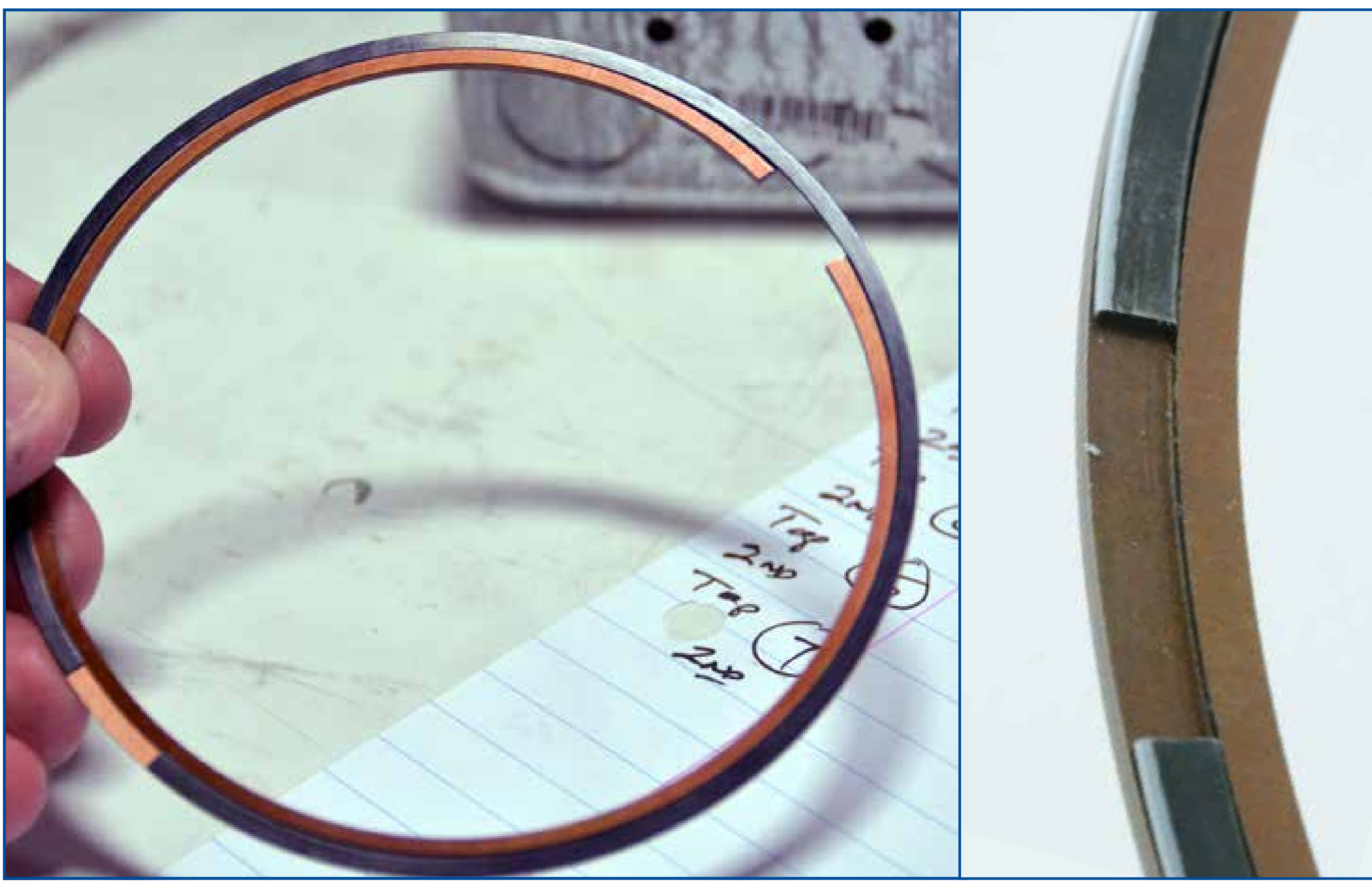
zero clearance to the bore and requires a very specific break-in cycle to make it work correctly. More information is available on this technology at the Line to Line Coatings website where you can see what they've been doing do stabilize the piston and what kind of results they are getting from that process.

Other considerations that will affect your rings' performance include crankcase capacity, windage control, oiling system type, and bearing clearances. If you increase stroke, a popular engine modification these days, you must also increase the pan or crankcase capacity by an amount similar to the displacement increase. Adding 50 cubic inches above the piston adds 50 cubic inches below the piston, and that means more pumping, and swinging a larger stroke can mean more windage in the pan. Oil clearances and throw-off on the low bore walls is an oil-control challenge with lower-tension oil rings. Putting a low-tension ring in the middle of a flood of oil will probably result in a consumption complaint, so drop the pan floor by going to a larger volume oil pan and add a well-designed windage tray or scraper or both and give the rings at least a fighting chance at functioning as designed. If it's an option, a dry sump oiling system helps to scavenge the oil, produces a partial vacuum in the crankcase, and de-aerates the oil, which



Here are a couple of examples of gapless top rings and how the rail sort of locks into the main ring. I say "sort of" because it really doesn't lock in in the traditional sense, but it does catch well enough that it will follow the ring compressor into the bore without a problem. The first time I loaded these into a block I thought for sure I was going to have a fight on my hands.

in theory can allow you to close up bearing clearances, thus reducing oil throw-off onto the cylinder walls from the rod bearings.

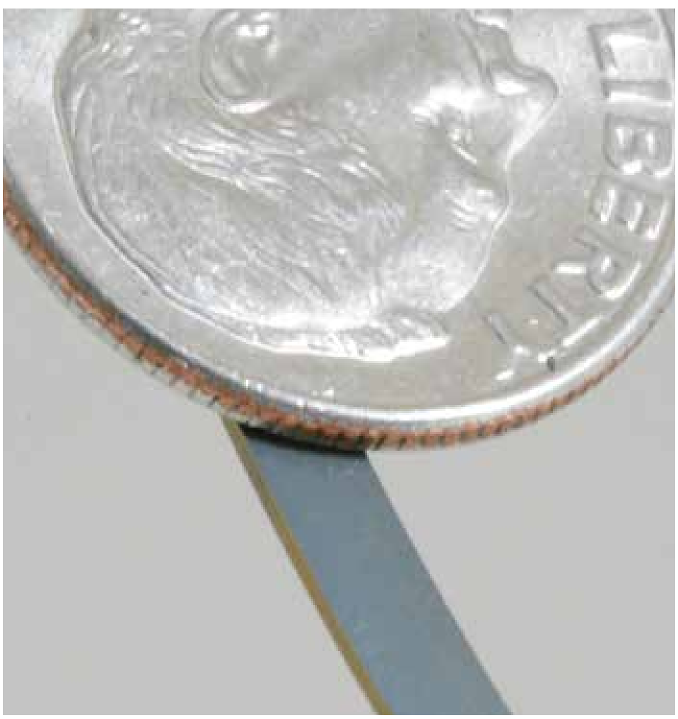
If that's not an option, you can investigate a vacuum pump to augment pan evacuation and entrained air removal. Just remember that on a wet sump engine the vacuum pump can affect the oil pump's ability to pick up liquid lube from the pan resulting in oil pressure fluctuation or oil starvation if you run too high a vacuum level. Well evacuated pans often show significant horsepower gains on the dyno, so it's worth investigating.

Lowering internal engine pressure is used to augment a well-designed system; it's not a fix for a poorly designed system. It's for removing air from the oil, thereby improving the oil wedge and reducing bearing wear.

RING SELECTION AND PREP

There are far too many options available to make a decision on which ring to use in your particular application on your own. Materials used in ring manufacturing include ductile iron, steel, tool steels, chrome, and moly. Profiles might be tapered, hooked, or barrel faced, and there are numerous special processes including coatings and high-tech polishing as well as an almost unlimited selection of axial and radial thicknesses, standard, gapless, and tension options, and special application options. You simply MUST consult with the technical service people to get the answers you need and the best recommendation for your application. If you are running special axial and radial thicknesses, or blown or nitrous applications, you will also need to consult with your piston supplier to make sure that the top ring is distanced correctly from the top and that the ring grooves are custom-cut to fit your ring selection. While most ring grooves are cut perpendicular to the bore wall, there are still some pistons made that have grooves that tip the ring slightly upward, so be aware of that possibility.

I have to admit I'm a fan of Total Seal gapless rings. The ones we've tried (circle track and drag engines) have worked well. The power improvements to be made with this design aren't just from compression gains, they also produce other benefits in terms of a stronger carb signal, cleaner engine oil, less bore corrosion between races, and improved exhaust scavenging. To get the maximum return from their use, however, you'll have to tune to their strengths. You might find that you need a different camshaft, carburetor or engine timing curve to get the most from the combination. ■



I used a dime to show you the scale of this conventional top compression ring, made by Total Seal. It's a .6 mm axial width, .102 radial width, Diamond-finished, C-72 face-coated, barrel-faced steel ring, and it's so pretty it makes me want to buy a gold chain and wear it around my neck. This is the kind of ring the Pro Stock guys were using three years ago. Wouldn't you just love to see what the cutting edge looks like now? Probably scare you to death...

Just to keep our perspective, here's a conventional top, ductile iron moly-filled 1/16th in. ring. Compared to the .043 and .0352 in. rings, it looks like a giant, and it should - it measured .062 in. axial width. Smaller, thinner, lighter - that's where it's all going.

ROLLER ROCKER SYSTEMS, 2
TRANSLATING THE CAMSHAFT

-Greg McConiga

Continuing the finest, most technical automotive writing you've probably ever seen, the second part of Greg's article on high-performance rocker arms covers angles, designs, materials, techniques, coatings and more. Plenty of great photos, too!

Here are the components removed from a T and D roller rocker body. The two needle bearings are pressed into the body leaving a common channel between them. The solid axle and nose wheel is pressed in and retained in the nose - I had to cut it out to remove it. It's not field-serviceable. The adjusting bolt and lock nut to secure it after valve adjustment are the last of the parts that make up this exhaust rocker. The center axle, retaining "C" clips, and stand are not shown.

Opposite Page: With aftermarket rocker systems and high-lift cams, you have to have enough clearance to allow the pushrod to articulate in the pushrod seat without side loading. Also, make sure to check the pushrod clearance where it nears heads and intake through at least two engine rotations. You don't need a lot of clearance here, but the pushrod cannot sustain any side loading without breaking or jumping out of the seat - 0.010 in. is more than enough.

Ask ten people for their opinions on correct valve train geometry and you'll likely get ten different answers. Here's the problem: The valve end of the roller rocker is moving in an arc and the valve is moving in a straight line, which means that the roller is going to move across the top of the valve to some small degree no matter what you do. Most agree that correctly adjusting rocker travel by raising or lowering the rocker shaft centerline relative to the top of the valve and changing the length of the pushrods until you get the minimum amount of transfer motion across the head of the valve is at or near the correct geometry for that application.

MORE MOVEMENT AT THE VALVE BY OPTIMIZING GEOMETRY

Without going into great detail about how to make this happen, let's just say this: You'll know when you've optimized your rocker stand heights and your pushrod lengths because when you get it right you will have the narrowest possible track across the top of the valve and greatest amount of valve lift as measured at the retainer. Ideally, you will also be exactly halfway through the net lift as measured at the valve when the centerline of the valve end wheel is centered on the valve stem and a line drawn through the pivot center and nose wheel center lies at 90 degrees to a line drawn up through the center of the valve. This also ensures that maximum valve acceleration is occurring at half lift. Of course, this means that your valve stem heights will all have to be the same if you're on a full shaft system.

NEED TO KNOW

In spite of the name, roller tips don't necessarily roll. Depending on spring load and cylinder pressure, they're more prone to skipping and skidding. In fact, it's not that it could roll that's most important; it's that the roller makes the valve end of the rocker closer to a fixed length by using a single line contact point on a wheel, like a roller lifter does on a cam. If you look at a typical production rocker, the face that rests against the valve stem is a long, slightly curved surface, like the sole of a clown's shoe. As this "shoe" moves to full open the effective length of the rocker arm actually gets a bit longer. It would be the same as going from standing flat-footed on the ball of your foot, located midway back on your sole to standing on tip-toes. Using this analogy, you can clearly see that the rocker gets longer by the distance from the ball of your foot to the end of your toes as it moves from closed to open. With a properly-adjusted roller rocker this effect is minimized.

The other benefit of a roller rocker is reduced friction (even if it doesn't roll, it's a lot less material in contact with the top of the valve stem), which translates into lower

This Comp Cams shaft rocker system is for a 440 Chrysler, and it's an affordable alternative to one that's fully-rollerized. The bushings ride on a chrome-moly shaft and the solid axle nose wheel reduces friction and valve guide loading.

The oil for the nose roller and valve spring is supplied by the shaft through the common channel in between the bushings, and discharges out of the top of the rocker body and out over the roller, retainer, and valve spring.

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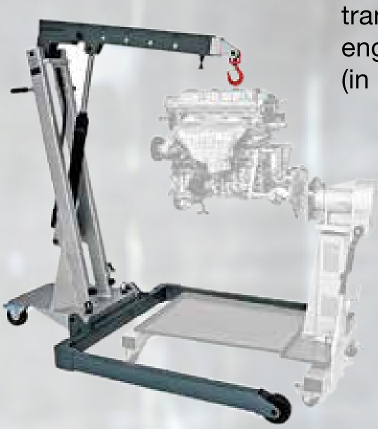

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I take everything apart and double-check it. I want to verify bolt torques, I want to see that the shaft is mounted correctly with the oil feed holes down, and I want to see that everything is clean and lubricated. The thing you don't check will be the thing causes you a problem.

The hole from the pushrod bolt passes through into the common channel, which is how oil moves up from the pushrod, between the pushrod and cup, into the common channel where it lubricates both trunnion needle bearings, and then out through the common channel to spray over the nose roller and valve spring.

While the stock set-up on an FE Ford and Dodge 440 feeds oil up from a passageway drilled though the head, you can reroute the oil depending on if the lifter galleries are bored end-to-end for oil feed and if you changed the pushrods to drilled pushrods in place of solids. If you divert the oil up the pushrod, you'll need to restrict the oil feed from the head to something around .040 to .060 in. to keep from flooding the top of the engine. You'll want a little oil in the shaft, but much less than the .095 in. or so that the head gasket hole restricts it to.

You're looking at a full set of T and D rocker arms with stands, trunnion axles, and rockers. You can see that there are three distinct rocker forms here. One for exhaust and two for intake. For specialty heads, you'll need clearance to get the pushrod past either the intake port or the intake manifold, so running offsets like this is not uncommon. High-offset rockers and offset lifters if used present some side loading and geometry challenges.

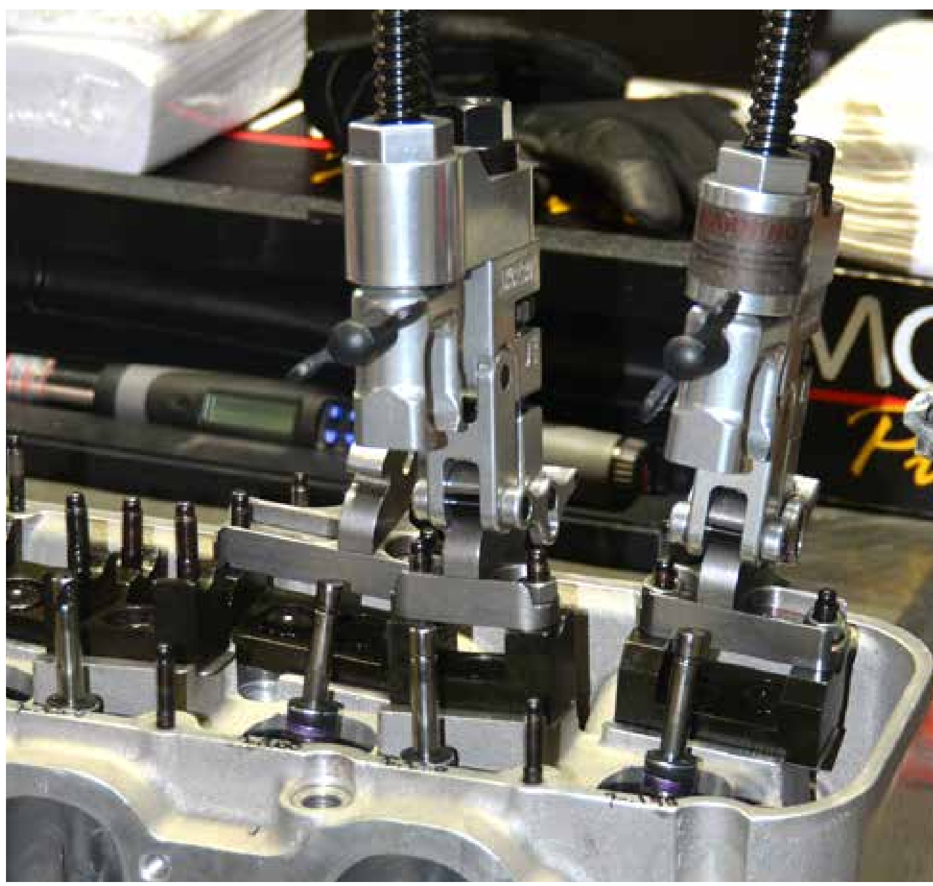
oil temperature, less shear, heat, galling, and guide wear since it doesn't exert as much side loading on the stem driving into the guide. A roller rocker can reduce wear materials from the rocker pivot, nose, and valve guide that ends up in the engine oil for the filter, or God forbid, bearings to gather up.

MATERIALS, CONSTRUCTION TECHNIQUES AND COATINGS

There are a number of options when it comes to roller rockers. You can find them bushed at the central shaft or trunnion, single-shaft systems or individual shafts and stands, a fully needle-rollerized shaft, a solid axle nose, or a fully needle-rollerized nose for use with high spring pressures in high-lift applications, or for smaller diameter valves. Valves measuring .312 in. (11/32ths) or smaller are more likely to need fully-rollerized nose wheels to prevent a single axle style roller from stalling and skidding over the valve stem tip.

Most rocker systems are steel or aluminum. The stands, shafts, central axles and adjuster bolts and nuts are steel or tool steel, while the bodies are steel or aluminum, heavily radiused and shot-peened in many applications. Low friction or long wearing coatings are also available. There are so many options available from so many firms that you'll just have to do your homework before selecting the system that you think will work best for you. I've used Comp, Crower, T and D and Jesel for many of the engines I've worked on but I would tell you that each has advantages in price, availability, or quality so you'll just have to shop. There are also some advantages in design as well, with some companies offering ratios that others don't and offering some rockers that have been constructed with the arms intersecting the main body at different angles that might make getting your rocker geometry correct a little easier.

A LITTLE BEARING SCIENCE...

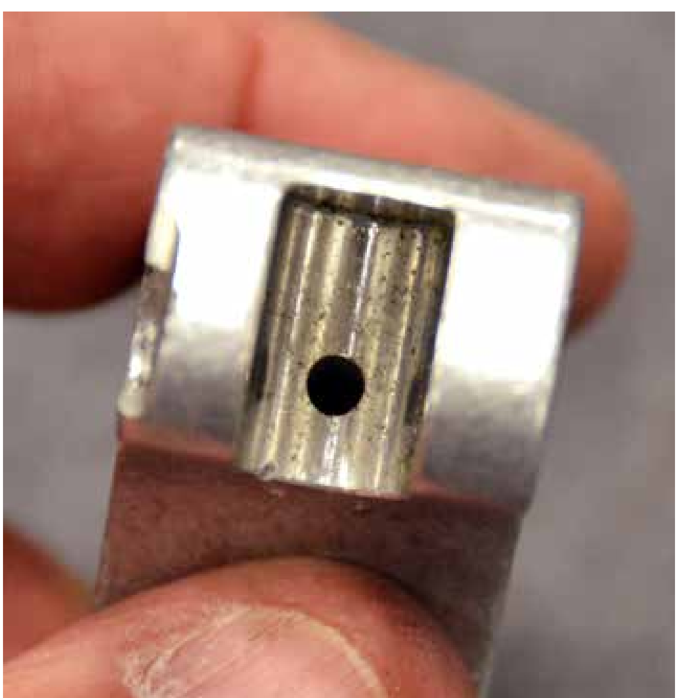


We're using a pair of Buxton valve spring compressors on this Profiler head, but what I wanted to show you was the stands with the axle mounting studs sticking up. Make sure you check that the studs are seated before installing the rocker, finger tight is good enough.

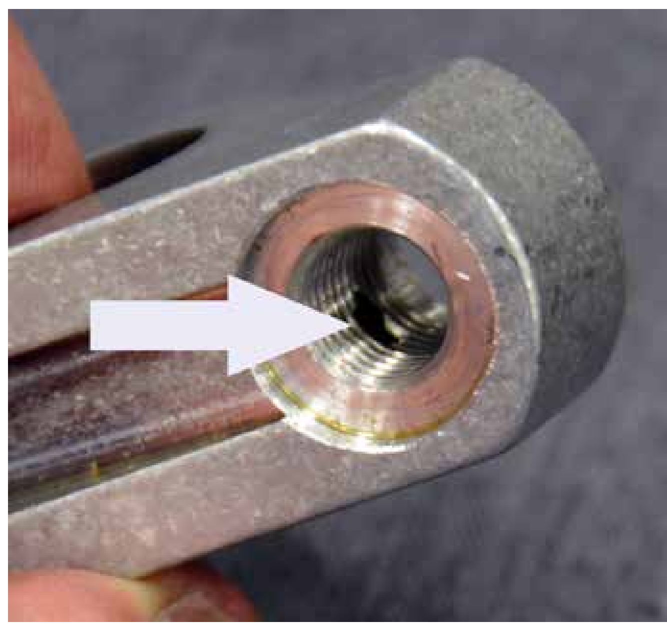
This preset torque wrench clicks over at 20 lb. ft., and the head has several replaceable bushings to support the T-headed Allen wrenches in various sizes. The tools accepts a 3/8-in. drive socket so you can switch between different lock nut sizes.

Bearings come in a number of varieties: plain, sliding, Babbitt, coated, and roller element. For the most part, we see roller element bearings in the transmissions, differentials, and transfer cases of most vehicles, but in racing applications we use roller element bearings in the form of needle bearings in a number of other places. Roller lifters, roller rocker systems, and in some cases we even substitute them for the plain Babbitt bearings used to support the camshaft.

Needle bearings are so called because they are a roller-element bearing with the highest roller length-to-diameter ratio of all roller-style



Here's the hole between the common channel and the nose wheel slot on the T and D rocker.



The adjuster bolt on a T and D will only move out about three threads before is shuts the oil flow off to the body. The Comp shuts off at about 2¼ turns, and some Jesels shut off at 1½ turns out. Make sure you read the directions, move the adjuster bolt in and out, and confirm for yourself where the oil gets shut off because without oil flow into the main body there's no lubrication for the bearings, nose wheel, or valve springs.

bearings. Roller bearings come in ball, straight roller or tapered roller, and each has certain advantages that dictate where and how they are used in an application. Other than very low frictional characteristics, the advantages of using needle bearings are that they have high load capacity (even higher than a single row ball or straight roller of similar outside diameter, which might surprise a lot of people) and come in caged designs that are well suited to high speeds and moderate loads with good tolerance for shaft alignment and deflection issues.

THE PRACTICAL SIDE: INSTALLATION AND UPKEEP

When you first install your roller rockers, there are a few things I recommend. If your application uses individual rocker stands and those stands end up bolted into a bolt hole that intersects the intake port just stop and Helicoil those holes before you even assemble your heads. Helicoils by brand name or any other threaded

The common channel in the body between the bushings or bearings acts as an oil gallery to direct oil in and out of the body to lube the pushrod cup if the system lubrication is shaft-supplied and the pushrods aren't drilled, or into the body to lube the bearings or bushings if the pushrods are drilled. It also provides oil to the nose wheel and valve springs through drillings that join the channel and provide oil spray out over the wheel and spring. You want to be careful with restricting oil to the top of the engine. Valve spring temperatures rise very, very quickly and the oil supply is critical to spring life.

insert tooling is stronger than aluminum because its larger outside diameter spreads out the load. A lot of the stand mounting bolts will torque down to 60-85 lb. ft. and you'll just end up stripping the hole, usually when you're repairing something and really short on time. Trim your bolts so that they are just flush with the roof of the intake port because at speed that's where the air flow runs, up along the intake roof and you don't want anything protruding into the port.

Decant the parts, do your inventory and clean everything. Chase all the threads, or at least make sure the threads engage in the intended hole. Use a high pressure lubricant on the needle bearings and shaft and avoid washing the roller tips too much (if at all - you might just wipe them down) because

Depending on the oil map, you're either lubricating the ball of the pushrod or feeding oil to the shaft. Either way, you've only got 2¼ turns on this Comp rocker before it shuts this channel off.

Here we see just how deep the counterbore is that supports the pushrod cup. With a lot of lift, the pushrod angle drives the pushrod into the side of that shallow cup. Not only is oil shut off if you overextend the adjuster bolt, you'll lose the support of the body and risk a cup or pushrod failure.

Here's an example of an old-school Oldsmobile rocker and stand. It's metal-to-metal at the stand and on the nose where it wipes across the valve stem. I'm old enough to remember replacing a bunch of these due to wear.

If you have a nose wheel failure you'll have to send the rocker arm back for rebuilding because it's unlikely you'll find an elegant way to remove the axle from the body. There is a ring that engages a groove, but it sits way down in a counterbore and there was no way I could get it spread enough to get the axle free of the body. That's what nice about most roller rockers: They're rebuildable and it's not that expensive if you need to have it done. The main trunnion bearings are field-serviceable and, frankly, they fail far more often than the nose wheel does. I've replaced a lot of trunnion bearings - they usually make it three to six seasons before they need to be replaced on racing applications. On street applications with clean oil, I doubt that you'd ever have to service them.

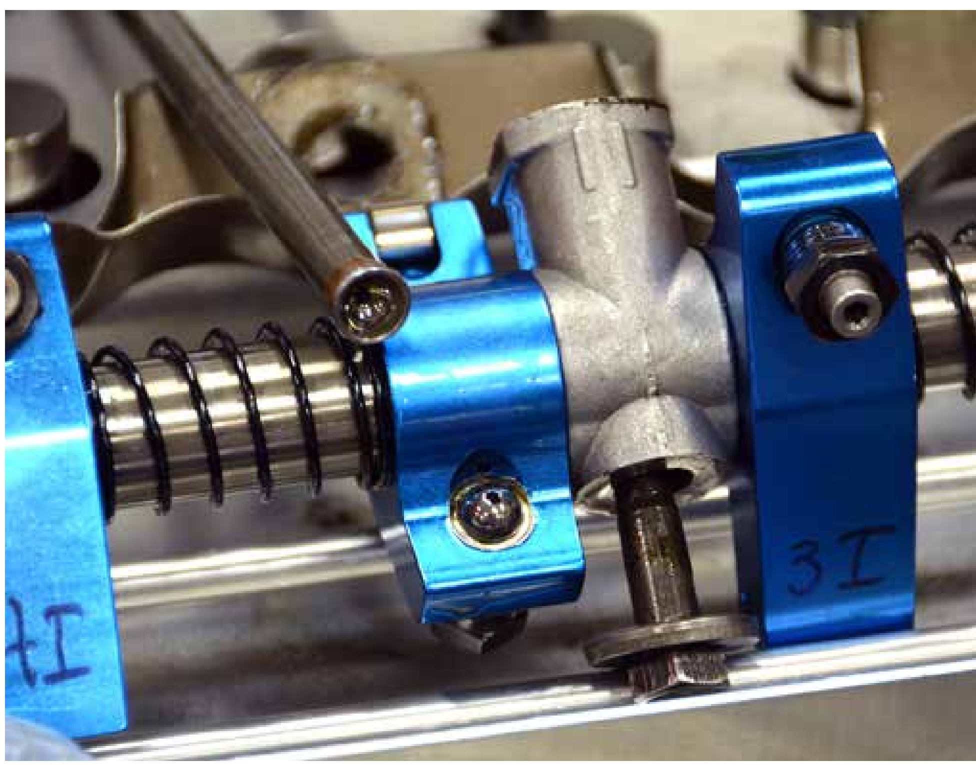
The T and D rocker uses a solid wheel and a solid axle, as do most rocker builders out there. Dan Jesel is the only company I've found that offers a fully-rollerized rocker arm with needle bearings at both the pivot and the nose wheel. I'm not saying that there are no other companies that offer them. There may be, and I just haven't run into them. Jesel is, in my opinion, the best there is and he probably supplies the majority of the professionals out there with rocker and timing belt systems. Beautiful workmanship, and, yes, you will pay for it. But it's like engine parts art - almost too pretty to run.

there's not a good way to reintroduce lube if you manage to wash it all out during cleaning.

If you have studs that mount anything, always check that the stud is completely seated into its hole so it won't pull the threads.

Take all precautions to get the pushrod length exactly right. Too long is an obvious problem, but too short is a problem as well. Every roller rocker I've worked with so far has a limit as to how far out you can screw the adjusting bolt that makes up the pushrod cup (or ball end if you're using a cup-type pushrod.) There are two issues with overextending the adjusting bolt. First, as it extends out it becomes unstable. Most rocker bodies have a counterbore that supports the pushrod cup and once the screw is overextended the sides of the cup can be overstressed without the support of the counterbore. You also need to be aware that on those rockers that oil from the pushrod up through the adjusting bolt and into the main body and then

On some shaft systems that are oil fed up from the head there will be a couple of special fasteners that are location specific because they are machined to reduced diameters to allow oil to flow up along them and into the shaft. Putting the wrong bolt or stud in the wrong hole will reduce or cut off the oil to the top end.



This is an example of what NOT to do. This cup-style pushrod was incorrectly sized and was too long for the application. The builder just backed off the adjuster bolt until the top of the cup bored into the aluminum rocker body. Good support I guess, just not what you want to see. Makes you wonder where all that aluminum ended up, doesn't it?

out onto the nose wheel, you've only got one and a half to three turns of total adjustment before the oil feel holes drilled in the adjuster are closed off by the rocker body! That's right, 1½ to 3 turns, that's it. At .040 in. per turn on a 24-pitch thread, you've got to hit the pushrod length on the nose. If you miss the length and over-adjust the cup screw, you won't oil the trunnion bearings or the nose wheel bearing and your rocker life expectancy will be nil.

During installation, roll the engine over as needed to assemble the axles to the stands without drawing them down against spring pressure. Watch the pushrod and make sure it's in the cup - if it snaps out of the cup it can damage the rocker. Adjust the valves using the "exhaust just cracked –intake half shut" method. Adjust the exhaust when the intake is half closed on the return trip to the seat and adjust the intake when the exhaust is just coming open off its seat. If you're running aluminum heads and the engine is cold, subtract .005-.006 in. from your hot specification and check it when it's hot to get your actual cold specification. Torque the nut on the adjusting screw to 20-22 lbs. ft. for most applications.

TITANIUM WARNING

If you're like a lot of racers, you've spent the money for copper beryllium seats and titanium valves. You can NEVER run steel on titanium or uncoated titanium against uncoated titanium! Titanium will gall up in a New York second if it runs on itself or on steel, I don't care if the valve end of the rocker is rollerized or not. If the valve doesn't have a steel insert in it you must run lash caps. I recently ran into a case where the lash caps were left off of an engine and within sixty miles the roller rocker ate its way through the valve end, through the titanium retainer and dropped the valve into the cylinder on a guy's hot street machine. All that metal in the oil? AND a dropped valve? That'll leave you broke.

YOU NEED THESE

There are too many advantages to roller rockers to not run them. While the initial outlay might be off-putting, they are all rebuildable and the power and reliability gains are well worth it. Just remember, read the instructions for your set and call the technical hot line if you have any questions at all when you first order them or set them up. If you're running a blower or nitrous or sky-high spring pressures, you might need the strength of heavy duty steel options, so talk to the tech people for advice. ■

What is really great is that several manufacturers are making direct bolt-on roller rocker systems for old-school hot rods. Here you see a T and D direct-fit for an early Ford 428 FE engine, and a Comp Cams direct-fit for a 440 Plymouth engine. There are some nice design features like restricted oil supply holes and chrome moly material. If you get a bolt-on system, make sure to verify that everything is clean and correctly assembled. I remember a customer years ago who installed brand new, fully-assembled rocker shafts on his FE engine and the shaft oil holes were facing up. He could not figure out the oil consumption problem until we found it for him. The valve covers were completely full when it was running! Makes you wonder if there was any oil left in the pan...

Photo by Michael Furman

INFORMATION STATION

LED OFF ROAD LIGHTS

KC Lites offers the Daylighter for Jeep, Truck and SUV off road lighting needs. The 6" Gravity model features two powerful Cree XML2-T6 10w LEDs mounted on a flexible base with a hard-coated polycarbonate lens, along with protectiv ABS stone guards. They are available in two-packs in Spot or Driving patterns finished in black or stainless steel housings. For more information, log onto www.kchilites.com.

REMAN STARTERS & ALTERNATORS

Bosch is releasing 13 new remanufactured starter and alternators. The new releases include reman alternators for 2012-2014 Mazda 5 L4Cyl. 2.5L; 2010 Chrysler Town & Country V6 Cyl. 3.3L and 3.8L; 2007-2008 Jeep Wrangler V6 Cyl. 3.8L; 2008-2010 Dodge Ram 3500, 4500 and 5500, L6 Cyl. 6.7L Diesel and more. Reman starters are available for 2006 Honda Civic L4 Cyl. 1.8 (M/T only); 2008-2013 Nissan Rogue L4 Cyl. 2.5L; 2010-2013 Lexus RX350 V6 Cyl. 3.5 L; 2009-2011 Toyota RAV4 L4 Cyl. 2.5L and V6 Cyl. 3.5L; 2011-2012 Toyota Sienna L4 Cyl. 2.7L and V6Cyl. 3.5L; 2004-2008 Dodge Dakota V6 Cyl. 3.7L and V8 Cyl. 4.7L; 2007-2010 Volvo S80 V8 Cyl. 4.4L; 2011 Volvo XC90, V8 Cyl. 4.4L and more. For information, visit www.boschautoparts.com.

AIR SUSPENSION KITS FOR 2015 FORD F-450

Air Lift's LoadLifter 5000TM air spring kit for the F-450 provides a cushion of air and works with the existing suspension to deliver up to 5,000 pounds of load-leveling capacity and eliminate sagging and bottoming out. These fully adjustable air springs keep the F-450 stable, level and comfortable whether loaded or unloaded. It can be easily installed in approximately two hours with no drilling into the vehicle's frame required and is backed by a lifetime warranty. For more information, visit www.airliftcompany.com or call 800-248-0892.

NEW SPARK PLUG CATALOG

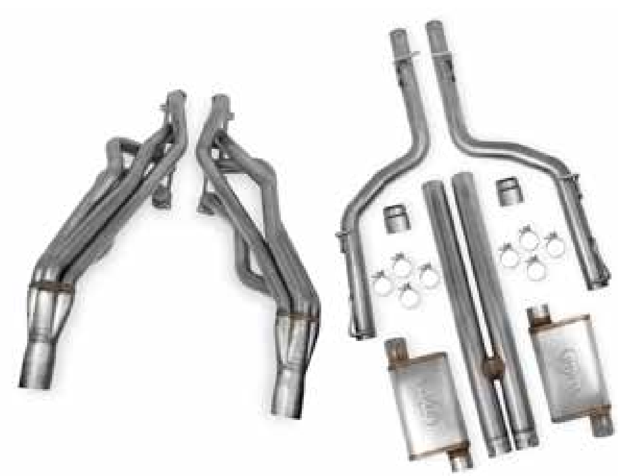
DENSO has released its 2015 Spark Plug Catalog, which features more than 634 part numbers covering more than 250 million cars and trucks in operation. The catalog includes the newest product line, the Iridium TT "Twin-Tip" Technology spark plugs, designed to perform for more than 100,000 miles. Available online and in print, the expanded catalog features seven new OE-type spark plugs that provide additional coverage for many brand new vehicles, as well as older models. For more information, contact your supplier or go to www.densoautoparts.com.

FUEL INJECTOR REFLECTIVE HEAT COVERS

DEI offers a solution for vapor lock or heat soak caused by heat, introducing Fuel Injector Reflective Heat Covers available in packs of two, four, six or eight, that reflect direct and radiant heat away from the injectors. Constructed of high-temperature rated glass fiber material bonded to a heat reflective aluminized material, the covers can be used on most any engine configuration utilizing stock or aftermarket fuel injectors. The company says cooler fuel injectors will perform more efficiently, offering a more consistent throttle response. For more information, visit www.DesignEngineering.com or call 800-264-9472.

PERFORMANCE EXHAUST FOR 2009-2014 HEMI MOPARS

Holley announces additions to the Hooker Blackheart exhaust line for 2009-2014 Challenger, Charger and 300 with HEMI engines. The components are constructed of lightweight 18-gauge 304 stainless steel to maximize strength and durability. Cat-back and axle-back exhausts are available with either a straight-through muffler or no muffler design that exits into a variety of dual wall polished stainless steel tips laser-etched with the Hooker logo. Tube geometry is optimized for maximum clearance and retains the use of factory mounting points for a hassle-free installation. These exhausts are also engineered to use the factory exhaust tips for a stealthy look. For details, log onto www.holley.com.



FINISH LINE

-Greg McConiga, Executive Technical Editor

WANDERING FULMINATIONS ON HIGH-PERFORMANCE

EVERY EXPERT WAS ONCE A BEGINNER...

Life has certain trajectories, and many run concurrently through our days; in some cases they are overlapping, in some cases complimentary, and in some cases these arcs run opposite to one another. For example, you may be at some high or low spot in your career while simultaneously being a parent or a student. You may be engaged in the excesses of youth while attending college - learning both what to do and think and what NOT to do or think all at the same time (hopefully while avoiding jail and not killing too many brain cells.)

> "I have not failed. I've just found 10,000 ways that won't work."
>
> *-Thomas A. Edison*

At some point you realize that nothing is stagnant - everything is changing - and that the rate of change is driven by the number and diversity of the people engaged in finding solutions and optimizing the increased power of all the new technology that appears. It's as if life and all that it is is a raging river and your only options are to run downstream as fast as you can to try to keep up with what's rushing by, or to stand still and become obsolete by proxy.

Just a few computer generations ago, we wrote Fortran IV and ran punch cards. Now, we carry a computer on our belt or in our pocket. Amazingly, this sea-change has occurred in about forty years. Can you imagine what the next generation of technology will look like?

At nearly 64, I'm in the early part of my seventh decade among the living and at twenty-five I was running punch cards; this morning I picked up my iPhone to look up a website, answer a text, and make a phone call. At twenty-five I was energetic, possessing an insatiable wanderlust, and thought I knew every-damn-thing, but lacked wisdom, patience, and knowledge. At 64, week-long car trips are just a hassle and I refuse to get on an airplane as a matter of principle; the Navy gave me a top-secret clearance and charged me with operating our most powerful nuclear weapons delivery platform, and now I have to submit to being X-rayed or fondled to get on an airplane in my own country? I'm just enough of a grouchy old cur that I'm not letting that happen.

Today, I'm a lot more focused, patient, and more comfortable with vertical learning curves and not knowing what I don't know. The distractions of youth - wine, tobacco. and young women - have been revealed with passing time and increased wisdom to be more dangerous to health, wealth, and sanity than the pleasures they afford are worth.

At the risk of sounding like "an old man," I've also discovered that there are certain immutable rules that apply, in spite of what the politically-correct and muddy, non-critical thinkers believe. Over 4,000 years of recorded human history shows us that we are remarkably adept at self-deception and stubborn in our refusal to plot a new course for humanity. The fact is that human nature barely changes at all, even as our mastery of technology and innovation should dictate that it would.

As John Maxwell once famously observed, people only change when they know enough to recognize the need for change (education), have enough to be able to afford to change (wealth), or are in so much pain that they have to change to emotionally or physically survive (self-awareness and personal growth). So, while our body of knowledge increases exponentially and our access to information is made easier, we don't seem capable of using that information to make any permanent changes in our basic natures that would allow us to forego the tragedies of starvation, war, and human cruelty. Instead, it appears that what we've done is maximize our ability to commit atrocities - we're simply more efficient in our efforts to eradicate one another.

A cynic might say it would seem that computers have only helped us make more mistakes, of greater magnitude, more quickly and efficiently. Perhaps if we had more mechanics in power, we'd see a greater emphasis on fixing mistakes instead of defending or hiding them.

Those of us with simpler, less complicated interests than the state of humanity are reaping the rewards of technology in our pursuit of horsepower. There are literally hundreds of new options appearing almost daily. Blocks, cylinder heads, cam technology, metallurgy, manufacturing processes, parts selection, and availability are all coming to market every day. The result is that we're all becoming beginners again. Parts, processes, tools, and techniques are, by necessity, under constant review and revision and this forces us to try, try, and try again to perfect our craft. Our results get better, but only as long as we embrace change and the constant need to re-learn everything over and over. You might not be a beginner in terms of your years spent in the mechanical arts, but you will be a beginner again in terms of what you do each day in the shop because that river of knowledge is wide and rapid.

"Our greatest weakness lies in giving up. The most certain way to succeed is always to try just one more time."

-Thomas A. Edison

Embrace change, celebrate it, and enjoy being a beginner again. Change drives learning, so learn to love learning and the fresh perspective it brings to what you do each day. Learn that there's no such thing as bad knowledge. Learn all that you can and hold onto it because you never know when or where in life you'll be able to plug it in and use it. Knowledge, like interest, compounds, and if you remain focused on new knowledge there'll be no time left for frustration. ■

PERFORMANCE TECHNICIAN

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