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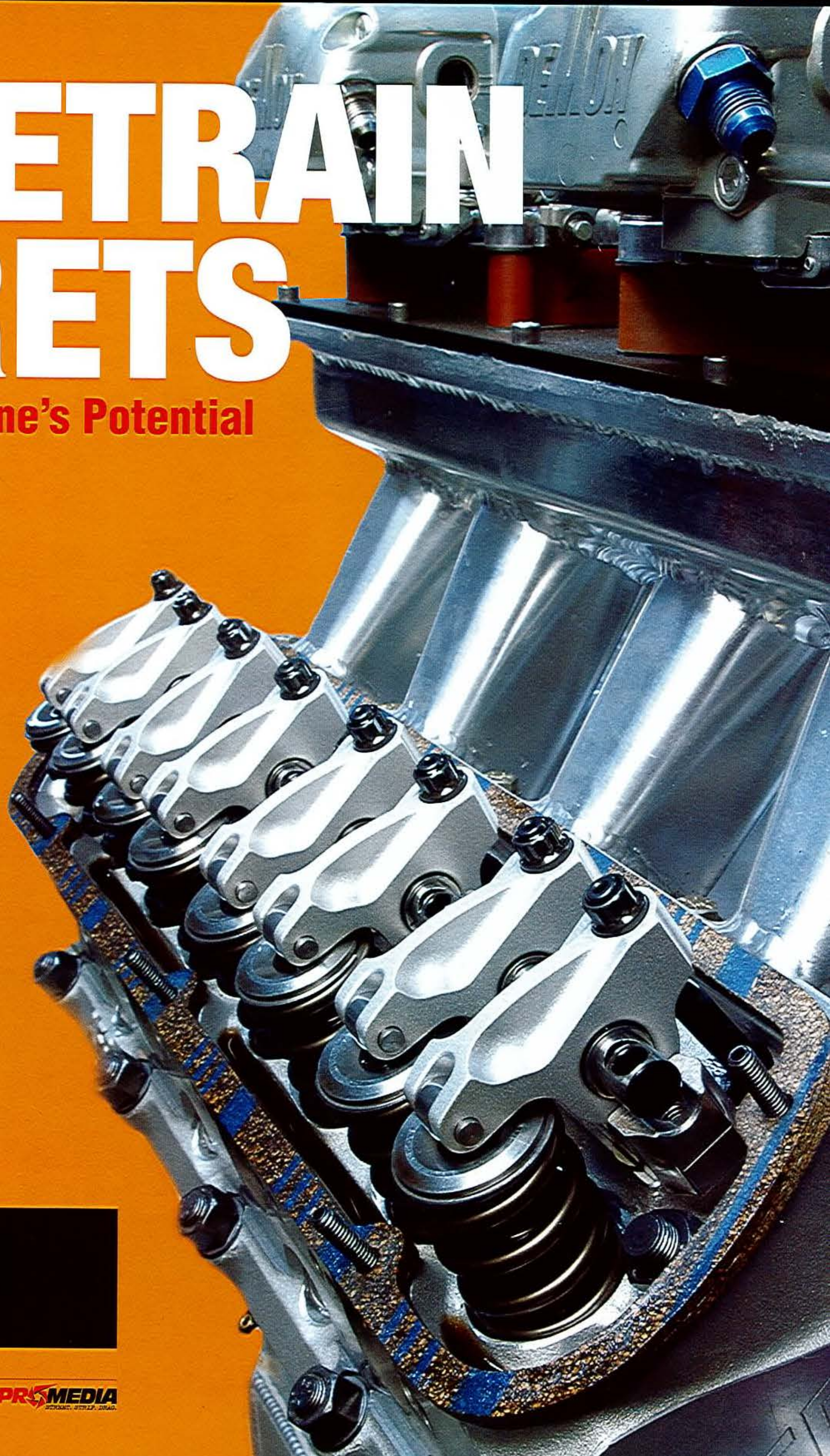
VALVETRAIN SECRETS

Unlocking Your Engine's Potential



Coverage INSIDE!

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BG Bruisers

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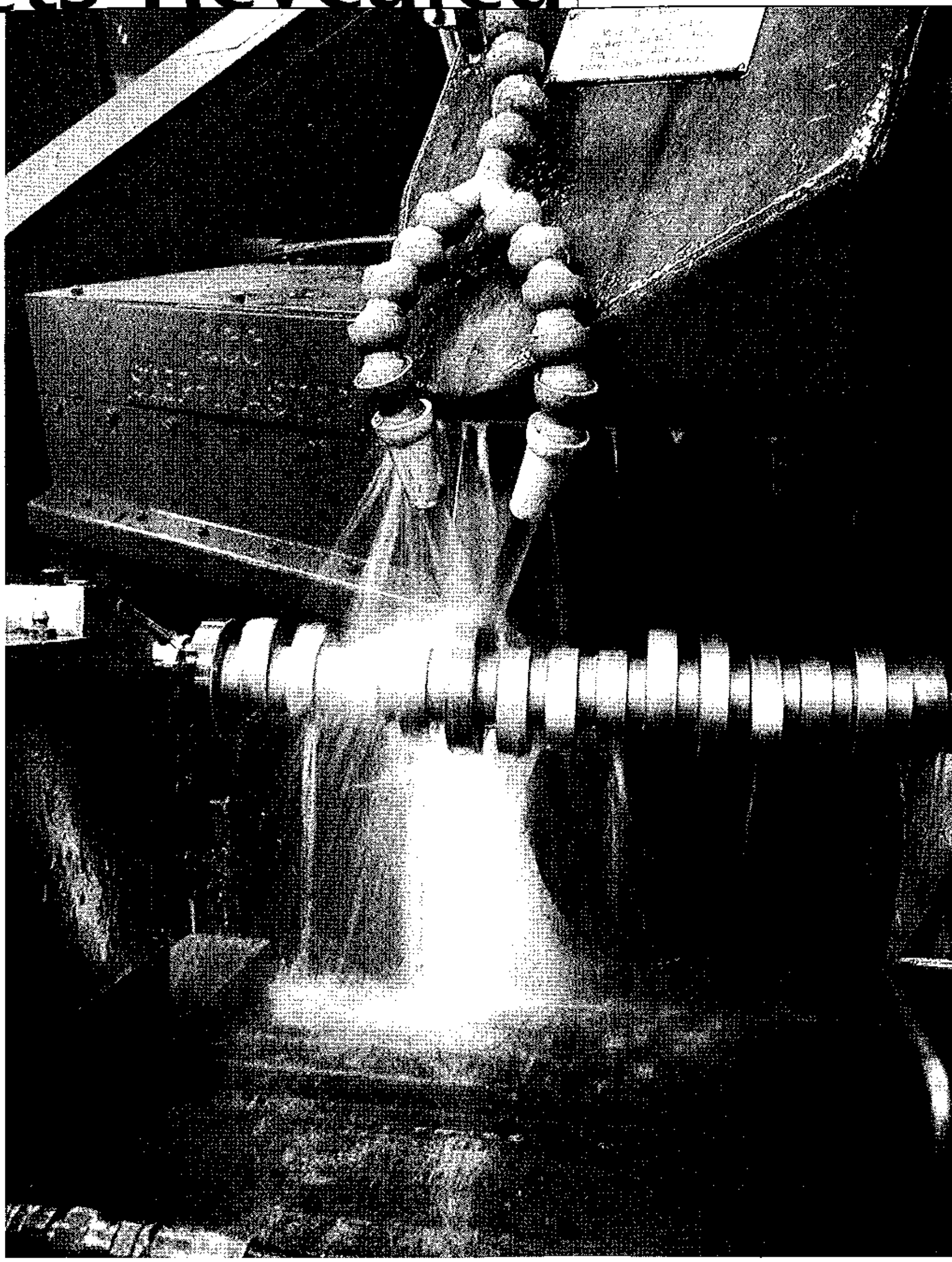
PLUS:

- Cam Development Revealed
- Is a Lightweight Valvetrain for You?
- Roots Blowers: A Powerful Punch

Secrets Revealed | COMP CAMS: INSIDE CAM DEVELOPMENT



Written by Chris Spies
Behind the Lens: The Manufacturer and *FSC*

The camshaft is the most controversial, misunderstood element of a racing engine. While most anyone who has ever picked up a car magazine with any regularity has some understanding of what a camshaft's lift and duration are, most have never spent much time pondering the complex dynamics that must be taken into consideration when developing one. A well-designed cam can be the difference between an ill-mannered underperformer and one, which delivers consistent, record-setting performances. That is not to say that the right camshaft is the cure-all, but few if any components in a racing engine carry the same weight that the camshaft does in the overall scheme of things. This month we called upon the collective expertise Chris Mays (Account Manager/Tech) and Billy Godbold (Camshaft R&D) two of the cam gurus at COMP Cams, and asked them to drop some cam knowledge our way and they were kind enough to oblige.

Heads up racers like to throw a wrench in the works through the judicious application of power adders.

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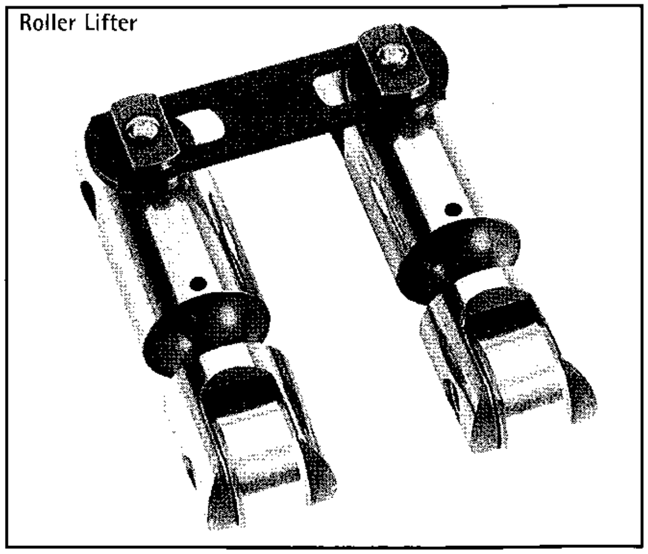
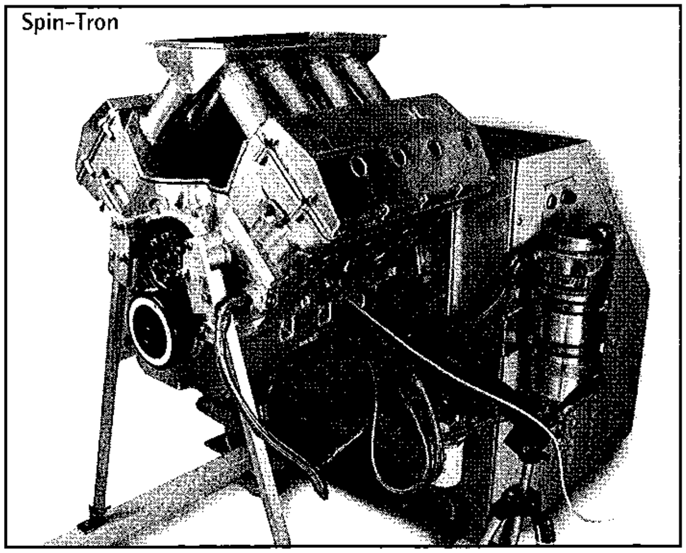
▶ With lifter reliability being a critical piece of the puzzle, COMP cams is proud to announce that every **roller lifter** wearing the COMP name is now equipped with premium INA needle bearings, a tool steel shaft and direct oiling to the rollers. With several different designs available, COMP is sure to have a lifter for every application.

▶ This Jon Kaase mountain motor has undergone hours of development in the COMP **spin-tron** facility. With huge valves approaching 1-1/4" of lift (no, that isn't a misprint), keeping things under control is more difficult than ever before.

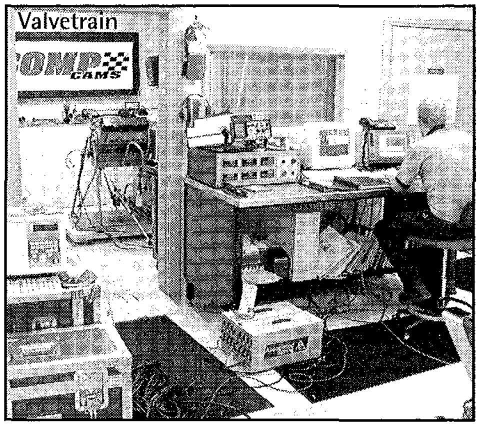
Roller Lifter



Spin-Tron



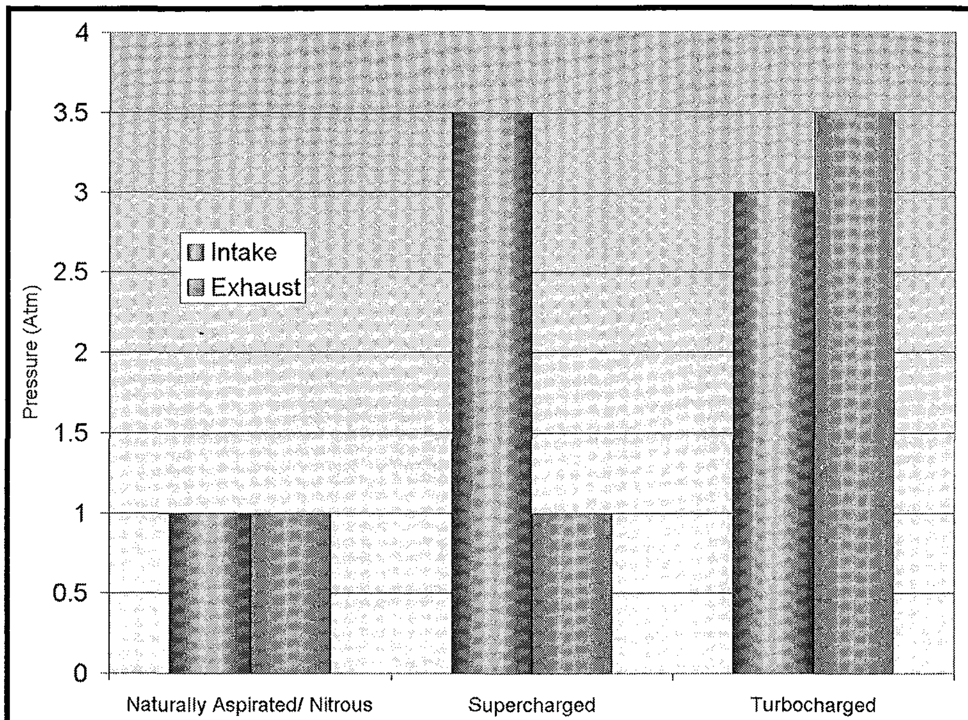
Engines often find their way into applications which cannot make use of the low-end torque such a combination generates.


Valvetrain

Cam Tech 101

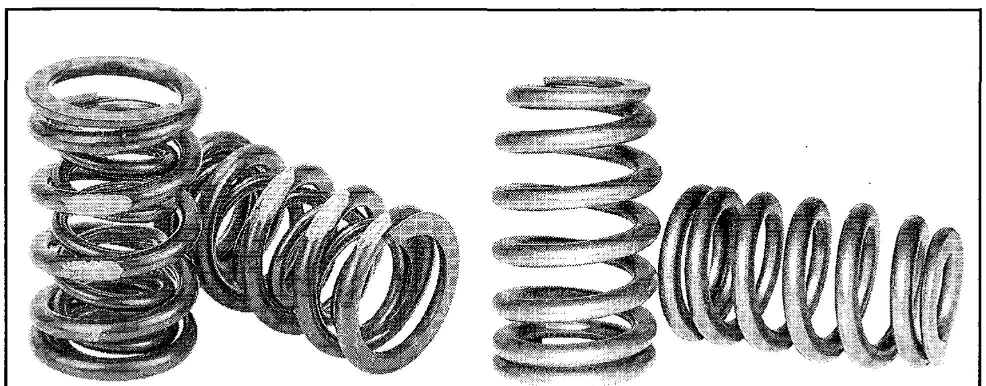
While lift and duration are the most commonly discussed dimensions of a camshaft, two camshafts having those in common can produce widely varying results in a racing engine as lobe separation angles, centerline values and intensities can vary greatly. We all know that increasing duration moves the power up higher and vise-versa, however taking the time to truly consider what is going on in the cylinder offers a deeper understanding of what the cam is actually managing. While it is more or less true that opening the valves for longer will allow more air/fuel mixture to enter the cylinder, when they open and close relative to the position of the piston (advance retard, lobe centerline) as well as one another (lobe separation) is an equally important part of the recipe. When it comes to advancing the camshaft, this is typically done to "shift" the power range downward. This is, for the most part due to the elevated cylinder pressures, which occur as a result of the intake valve closing sooner. In effect, you raise the engine's compression ratio when advancing the cam. Though compression is effectively increased at lower rpm's, power output often suffers at higher rpm's as the intake valve closes sooner, prematurely bringing the high velocity intake flow to a halt. When the engine is operating at a higher rpm the air/fuel mixture gains considerable kinetic energy (momentum) and does not begin to slow until the piston has traveled farther down (or even back up) the bore. By retarding the camshaft, this charge momentum is utilized to improve the engine's volumetric efficiency, more completely filling the cylinders and producing more power. On the other end of the combustion cycle, manipulating exhaust valve events is also a means for unleashing some additional ponies. Adding exhaust duration is a means of better evacuating the cylinder and making more room for the incoming air/fuel mixture, however opening the valve to soon will only serve to waste a lot of horsepower, make a lot of noise and barbeque your headers. Open it too late and you may "over-evacuate" the cylinder, sending raw air/fuel mixture into the exhaust before it can be converted into horsepower. A lot of time and effort is spent matching up the right parts to get a maximum amount of air and fuel into the cylinder, every bit which escapes during overlap is essentially subtracted from the effort.

Selecting the correct exhaust lobe duration is truly a balancing act. While these basic concepts are key to developing an efficient grind, modern camshaft design has risen to a new level. Though much of the craft is centered around generating valvetrain stability and producing a broad powerband, Mays reminded us that the best cam is not necessarily the one that makes the most peak power, but one that fully considers the context of the application. A cam optimized for a manual trans equipped Pro Streeter



Manifold pressures for different power adders

Though scenarios may vary somewhat from those indicated here, these graphs (courtesy of COMP cams) illustrate the different circumstances for which a camshaft must be optimized. As shown here, intake and exhaust pressures vary considerably greatly affecting the cylinder filling and emptying dynamics.


Springs

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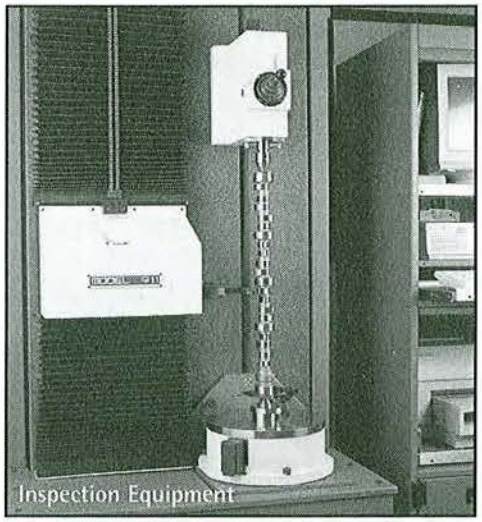
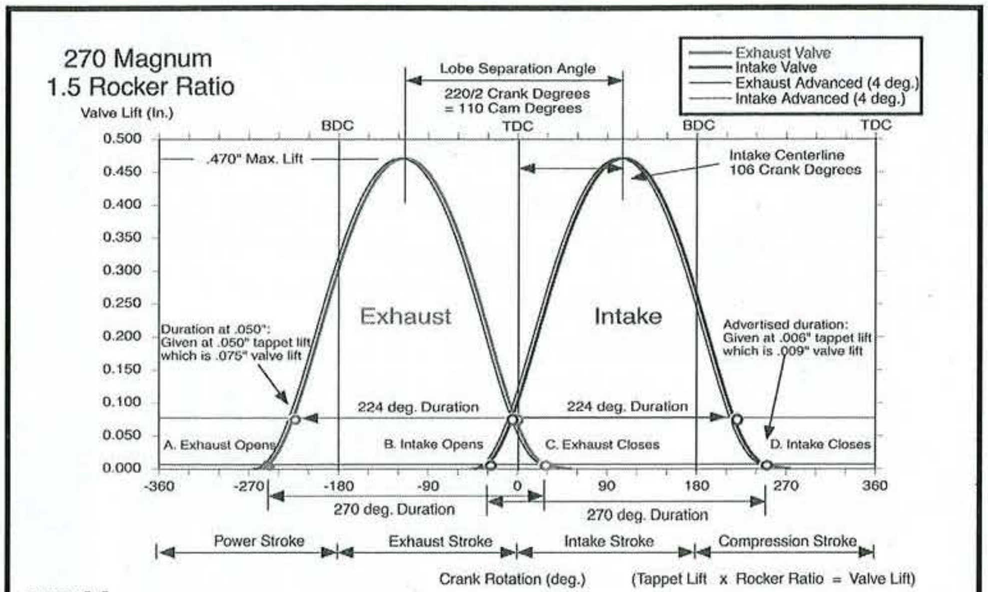
▸ Capable of operating the engine at speed up to 12,000rpm and capturing 2,000,0000 data points per second, this custom equipped Spin-Tron dynamic **valvetrain** analyzer enables COMP to test cam lobe designs and valvetrain components.

▸ Continually raising the bar, COMP prides themselves for offering some of the industry's finest **springs**. These conventional pacalloy racing springs and beehive designs represent the current state-of-the-art.

Often times exhaust pressures upstream of the turbine exceed those observed in the intake manifold.





270 Magnum cams

This graph, reflects the valve motion of one of COMP's popular 270 Magnum cams and illustrates the relative positioning of the valve events with respect to the Intake, Compression, Power and exhaust strokes.

may not prove well suited for that same engine in a auto trans equipped Super Street ride and its requisite 10.5" tires. If building the right cam for an engine isn't complicated enough, heads up racers like to throw a wrench in the works through the judicious application of power adders that significantly alter combustion dynamics and operate according to a different set of rules. The folks at COMP were kind enough to share some of their insights regarding camshaft design for Nitrous, Turbochargers and Centrifugal Superchargers along with camshaft selection in general.

The guys at COMP raised the point that the cam should be the last thing you buy when building a race engine. The camshaft is the key component that ties everything together. We've all heard it a million times, bigger isn't always better. This is true of a cam than perhaps any other component. Godbold and Mays advised that an engine equipped with a weaker breathing cylinder head generally requires more duration to get the most from an engine, while one equipped with more modern, efficient cylinder heads may make the best power with a less aggressive, more parts friendly grind.

Nitrous Cams

While conventional wisdom tells us that you have to add exhaust duration to help evacuate the extra exhaust gases generated by the spray, developing a cam that allows a racer to fully leverage a healthy (500 hp+) shot of juice requires considerable scrutiny of the overall combination. In light of the fact that these engines behave much like their N/A counterparts, some engine builders subscribe to the theory that the cam, which works best N/A will also be the cam of choice for a motor built for spray. The engineers at COMP raised the point that these engines often find their way into applications, which cannot make use of the low-end torque such a combination generates. In an effort to produce a more usable torque curve, they often tack on some duration and go with a wider lobe separation to move the power back upstairs. This being the case, these grinds often wind up being the biggest, nastiest cams in a cam-grinders repertoire with duration at 0.050" exceeding the most radical N/A grinds by 6-10 degrees at 0.050" on the intake and 12-20 degrees on the exhaust side. With a mixture rich w/ N2O, combustion is completed rapidly in these engines. As such the exhaust valves may be hung open for a long time, giving the exhaust ample time to find its way out of the cylinder. Lobe separation also comes into play as these grinds utilize the wider lobe separations to reduce exhaust pumping losses by getting the exhaust valve open sooner.

Turbochargers

These cams seem to fall into a category all their own and have received a great deal of attention from the folks at COMP. With the legendary Ken Duttweiler continually putting their grinds to the test, they seem to have mastered the art of developing an effective turbo grind. While all of the other power adders behave similarly on the exhaust side, turbocharged engines operate with considerable exhaust pressure. Often times exhaust pressures upstream of the turbine exceed those observed in the intake manifold. This being the case, care is taken to avoid hanging the exhaust valve open too long as the exhaust flow may easily revert and contaminate the incoming charge. Another point Chris and Billy raised was the fact that the turbo has greatly evolved as more efficient exhaust turbines are being used and operating at lower exhaust side pressures than in years past. This freer breathing exhaust side has taken them away from the practice of running stingy exhaust durations and has them running equal to or greater than intake duration. Another point shared was how turbo (an centrifugal blower) cams favor "intake" lobes which get the valve off of the seat more quickly and bring it down more rapidly on the exhaust side. While rapidly closing a red hot exhaust valve can be catastrophic when using a longer duration, these shorter durations keep the valve on the seat longer allowing it

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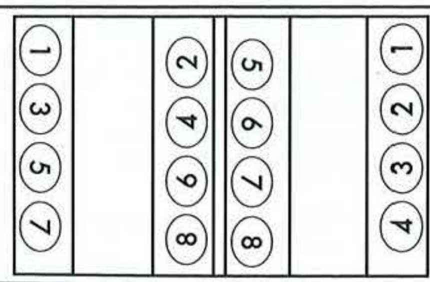
▶ Having a full arsenal of high-tech **inspection equipment** at their disposal, COMP cams is able to verify and sustain exacting standards.

▶ **Firing orders** using a "4-7 swap" cam core has become a popular option for Chevy enthusiasts. By swapping the positions of the number 4 and 7 cylinders in the firing order (1-8-4-3-6-5-7-2 becomes 1-8-7-3-6-5-4-2) engine builders have found consistent power increases and in some cases improved durability. If you map it out, you will also find that the Ford Windsor firing order is identical to the LS1.

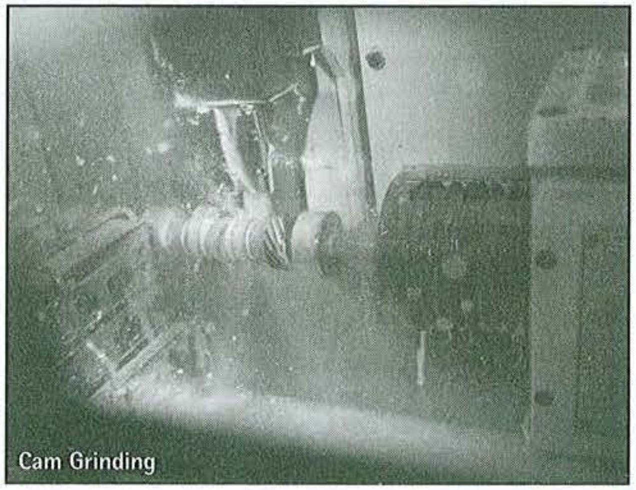


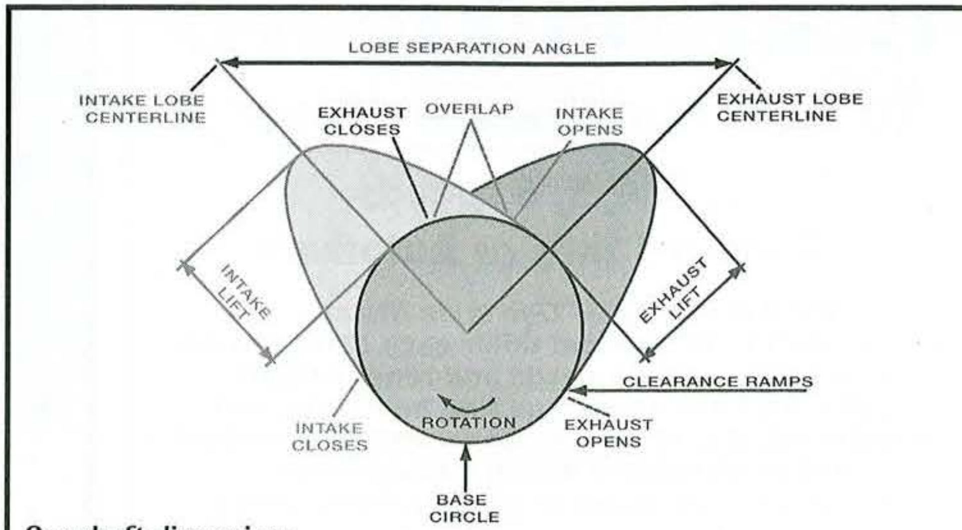
Chevy V-8 firing orders
1-8-4-3-6-5-7-2
1-8-7-3-6-5-4-2 (4-7 swap)
1-8-7-2-6-5-4-3-(LS-1)

Ford V-8 firing orders
1-5-4-2-6-3-7-8 (Early 289/302)
1-3-7-2-6-5-4-8 (Windsor)

Firing Orders

They respond well to grinds having less duration than a traditional "Roots" type blower


Cam Grinding



Camshaft dimensions

This illustration shows the various camshaft dimensions tweaked by cam designers. Taking a closer look, you can see how the dimensions interact with one another, particularly how increasing duration impacts valve overlap and how increasing the lobe separation angle can be used to offset those effects.

ample time to cool between combustion events. Another consideration with turbochargers is the extremely cool, dense air/fuel charges which must be burned. These charges (particularly on intercooled applications) burn slowly, further reinforcing the need for an exhaust lobe, which keeps the valve shut a bit longer. Were it practical to get the valves open to the .900" plus valve lifts required of some of today's high flowing cylinder head designs, Chris advised that most turbo cams would wind up with 0.050" duration figures in the vicinity of 240 degrees. This being impractical, duration figures are still conservative, often coming in at 250-260 degrees at 0.050". These modest duration figures afford the turbo engine the bottom end steam needed to get the turbo spooled while the free breathing heads and boost can stretch the upper end of the powerband to 9000 Rpm and beyond. Another common thread among turbo (and blower) grinds is the wide lobe separation angles and retarded intake lobe positions. Since the cylinders fill rapidly, opening the intake lobe later (by retarding the cam) minimizes pumping losses incurred by raising cylinder pressures before the piston finds its way past TDC. Widening the lobe separation angle minimizes overlap and over scavenging of the cylinder. If some of the mixture finds its way into the exhaust, it isn't as great a loss as it is with other power-adders as the energy will give the turbo an extra push when spooling.

Centrifugal Superchargers

With no exhaust restrictions, these engines scavenge the cylinders very well. This being the case, cam grinders are very mindful of the amount of time both valves spend open as the pressurized intake charge will quickly find its way into the exhaust side during extended overlap events. While widening the lobe separation does effectively advance the exhaust event and reduce overlap, care must be taken not to open the valve too soon. With the gargantuan intercoolers that have become commonplace in centrifugally supercharged (and turbocharged) rides, the mixture is very cold (sometimes as low as 40 degrees F) and very dense (20-40psi). This being the case, the mixture often needs to spend an extended amount of time in the cylinder to fully vaporize and burn. If not given sufficient burn time, the mixture will burn in the headers, quickly fatiguing header tubes, scalding ceramic coatings and wasting considerable amounts of power. Centrifugal blowers, particularly some of the earlier designs, bring a car off of the line with a modest amount of boost (8-14psi) and climb steadily with rpm, sometimes making 20-30 psi more at the top of the gear than at the starting line and drop some boost on the gear change when coupled with the stiff torque converters sometimes needed to get the power to the wheels. This being the case they respond well to grinds having less duration than a traditional "Roots" type blower grind and often wind up with intake durations similar to turbo grinds and exhaust lobes 14-20 degrees beyond the intake. ■

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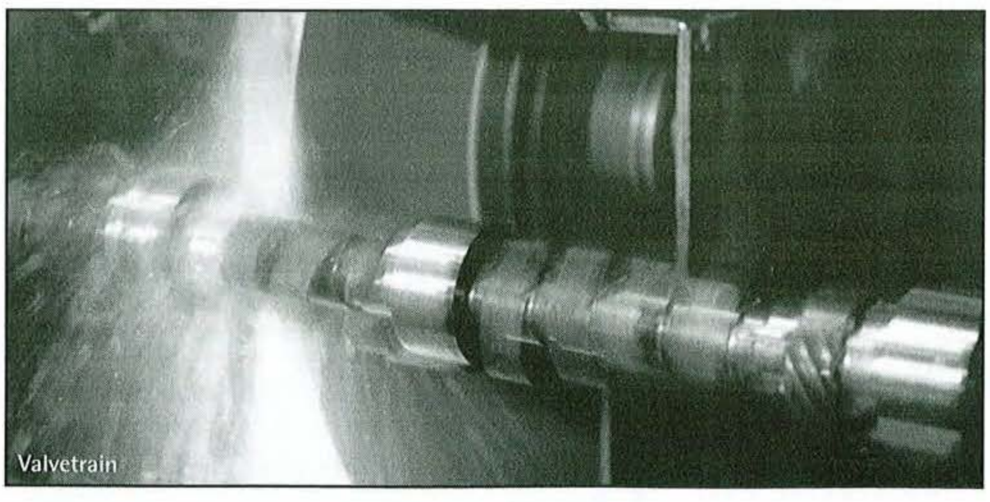
▸ To a degree **cam grinding** is still a black art. Although many racers have custom grinds, chances are it was their engine builder or "cam guy" who came up with the numbers on the card and the racer may not be able to explain why those numbers are the way they are.

▸ Getting the most out of your **valvetrain** begins with a custom ground cam that's developed with your complete combination in mind.


Valvetrain

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