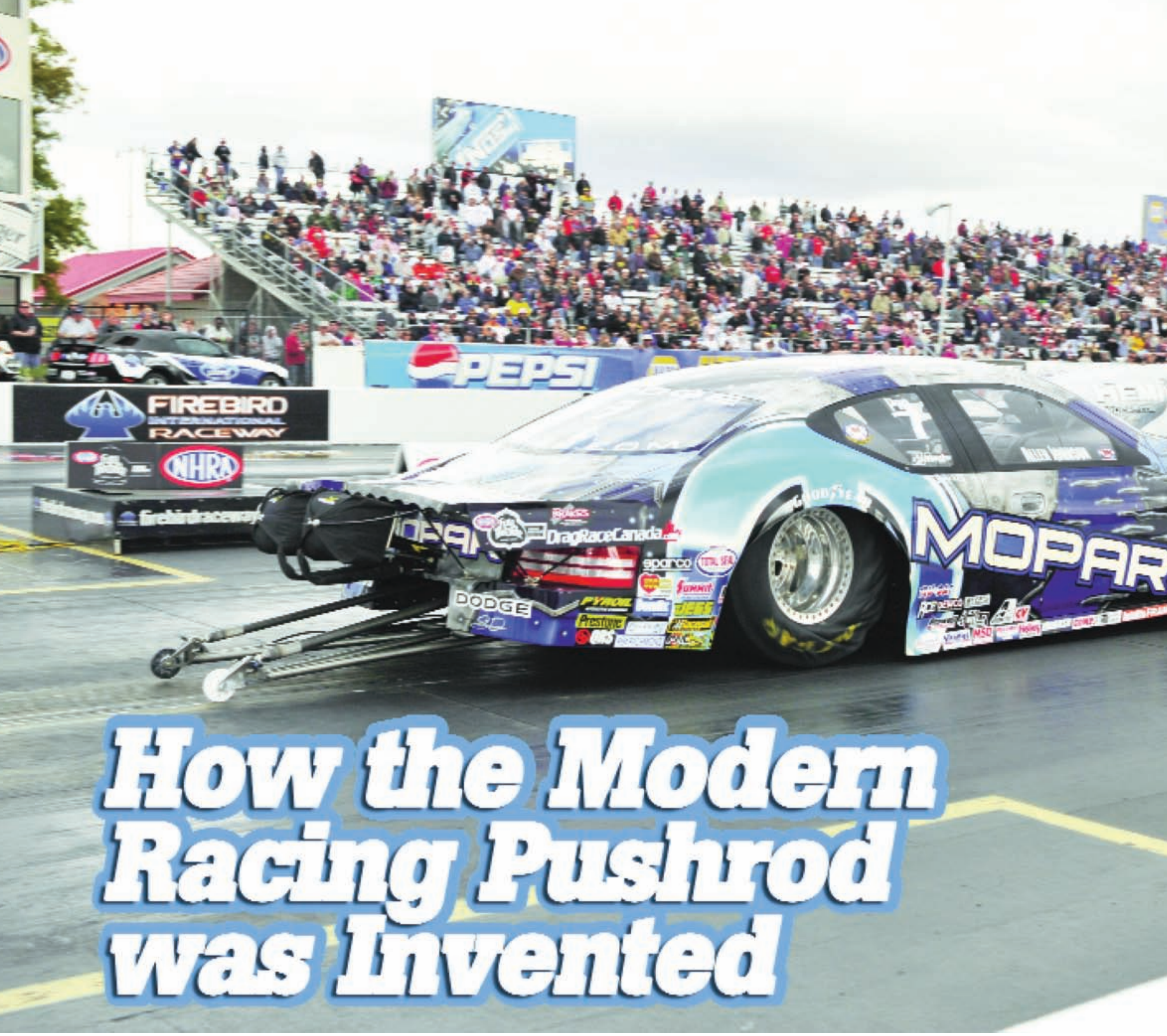


How the Modern Racing Pushrod was Invented

TREND PERFORMANCE PUSHING NEW BOUNDARIES

Text and Photos by Sam Logan

The most revealing sign of a pushrod's capability is its resistance to undue deflection—its column stiffness. Until 1993, meaningful research into valve train testing had not been possible. It was only when the Spintron emerged, a revolutionary, electrically powered valve train test machine, that profound inadequacies in pushrod design were first revealed.

The Spintron, which incorporates a substitute crankshaft that powers the internal engine components as fast or as long as desired, measures and records valve movement, among other things, by laser tracking. During the initial tests of 1993, the amount of column deflection of the conventional thin-wall 5/16-inch diameter pushrods and the lofting of the tappets as they became airborne while traveling over the nose of the camshaft lobes amazed Spintron creator Bob Fox and his collaborator, the late Randy Dorton, tuning wizard at Hendrick Motorsports. In other words, the actual movement of the valve was far removed from that suggested by the camshaft's lobe profile. As a consequence, pushrod design changed irrevocably.

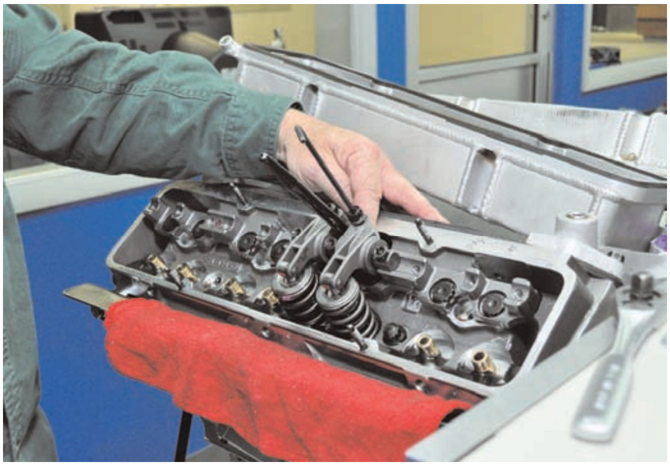
Fox had established his pushrod company, Trend Performance, in Warren, Michigan, in 1988, after having

worked as a tech representative on the phones at nearby Diamond Racing. While at Diamond he became aware of troubling quality issues in pushrod manufacture: Pushrod lengths varied and their ends failed—both ends. Manufacturers would reduce the material thickness of the cup ends in order to form them, and as a consequence, they would crack. Further, their lengths were so inconsistent that each pushrod had to be inspected and graded accordingly. It was this encounter that caused Fox to contemplate life as a pushrod maker.

By the end of his first year in business he had developed two new products, a 5/16-inch pushrod for small-block Chevrolets and a 3/8-inch for big-block Chevrolets. Though they possessed consistency in length and in material thickness at the ends, Fox was unsettled as to what he would do next. Without conclusive data on pushrod operating behavior, his future course was unclear.

But by 1993, and aided by extensive data gathered by Spintron testing, he had vastly improved his product line. Today, Trend's crown jewel is its one-piece 7/16-inch double taper creation. Available from 6.000 to 13.000 inches long, and in increments of 0.025-inch, these 4130 chrome molybdenum pushrods are case-hardened to a value of Rockwell Rc60 and used extensively

The Spintron uses a substitute crankshaft that powers the internal engine components as fast or as long as desired. It measures and records valve movement via laser tracking. Previously, it was assumed that valve timing was controlled by the shape of the camshaft lobe, but at higher engine speeds the Spintron quickly contradicted this theory as it had the ability to calculate the deflection of a pushrod and measure the loss of contact between the camshaft and the valve train.



One common test conducted with the Spintron is the step test, which involves recording a base profile, a trace of the valve movement at low engine speeds followed by a sequence of step tests where engine speed is increased, and tracings are taken at each step until the maximum desired rpm is reached.

in drag and oval track racing at all levels. Moreover, they're affordable for all pockets because they're made in production quantities and available as shelf-stock items.

To comprehend the advancements made by Trend, it is helpful to recognize and review some fundamentals.

Back to Basics

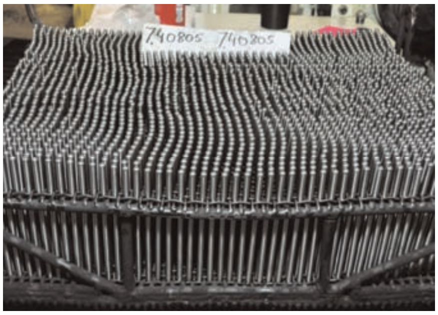
Pushrods transmit the reciprocating motion of the valve lifters to the rocker arms. Both ends of the pushrod (some have ball-ball ends, some have ball-cup ends) form a connection that accommodates the angular movements of the pushrod from the linear motion of the lifter on one end to the arc motion of the rocker arm on the other.

While transferring the motion created by the cam profile, pushrods are exposed to extreme vibration and shock from the opening and closing of the valve against extreme spring pressure. Certainly, these forces are present in a stock engine, but when the camshaft profile becomes more aggressive, valve spring pressure must also increase if higher peak engine speeds are to be realized. Thus, the strain endured by the pushrod is exponential to the aggressiveness of the cam grind, the weight of the valve, the pressure of the valve spring, and the engine speeds, among other factors.

Inventing a new Pushrod

Trend was the first to recognize that column deflection, harmonics and compression of the pushrod would cause the net valve action to be significantly different from the travel created by the tappet. But these discoveries paled in comparison to tappet lofting. Until 1993 no one had ever heard of lofting, except in golfing circles. No wonder the efforts of so many professional race teams were failing in terms of power production.

Cylinder head designs were improving and advanced machining technologies were paving the way for new, improved cam lobe profiles—profiles that could not have been produced in earlier days. Yet power output was not responding in like fashion. Engine simulation software would show that potential BMEP (brake mean effective



Pushrods are straight before they are subjected to heat treatment, but they emerge as warped parts. The problem is they are not *consistently* warped. Therefore, every single pushrod has to be assessed and straightened. Some are straightened by hand and some by machines that calculate the process via computer analysis.

When race engine builders began experimenting with new lubricating oils in their quest for more horsepower, they succeeded in reducing frictional losses and gaining power, but as a consequence the oil lost some of its vital lubricating qualities. To combat this deficiency, Trend introduced pushrods that contained bronze inserts. These immediately overcame the problem.

cylinder pressure) should have been created, but instead it was being lost.

Prior to the Spintron there was no verifiable method to confirm what design elements of the pushrod were actually required. For proper pushrod design, it is imperative to see in real time what is happening as it is forced to open the valve via all of the intermediate components. To accomplish this, the Spintron employs a high-powered AC electric motor that spins a substitute crankshaft in a test engine. This, in turn, spins the camshaft, which powers the valve train, while an advanced laser camera tracks valve motion and pushrod behavior.

Analyzing the Results

Once Fox and his team understood the effect that cam motion had on the conventional 5/16 x 0.080-inch wall pushrod, they knew a stiffer one would be necessary to stabilize the valve train. But it took years before engine builders accepted the heavier pushrod. Upon reflection, the typical race engine that operated with 5/16 x 0.080-inch wall (55 grams) in 1993 has switched to 7/16-inch double taper with 0.165-inch wall (112 grams) or even 9/16-inch with 0.188-inch wall (160 grams). Quite a switch! The chief threat is no longer weight, but stiffness.

But this isn't the complete story. After years of exhaustive testing, Fox told *Drag Racer* magazine that, "The process to create a better pushrod begins not in the machining centers, but at the receiving door at the rear of the plant." He revealed that the key to the success of Trend's pushrod line is

In the '90s, Bob Fox pioneered the one-piece chrome molybdenum pushrod that permitted V-8 engines to rev higher. During its development, he and his team created the Spintron.

multi-faceted. Every minute detail is critical and includes but is not limited to:

- Tool steel bars and chrome molybdenum tubing custom-made to Trend's specifications
- Materials ordered in large batches of 50,000 to 100,000 feet and each batch checked for specification compliance before pushrod production begins
- Strict procedures imposed for cutting, forming and machining the steel tubes and bars
- Heat treatment processes carefully followed

What Happens to the Pushrod When it's in the Furnace?

Over the years, Trend has acquired an abundance of tribal knowledge, not least in the science of heat-treating. On these issues they remain tight-lipped. However, the tooling and fixtures they have devised for heat-treating are clearly visible and intriguing. They have introduced special racks that are made of round bar stainless steel to endure many heating cycles in the furnace without degradation, and the grids of the racks are precisely laid out to position the pushrods a vertically to within 3 degrees.

Before the pushrods are subjected to the heat treatment process they are straight, but as their stresses are relieved during the process, they emerge from heat treatment as warped parts. The problem is that they are not *consistently* warped. Therefore, every single pushrod straightened. Some are straightened by hand and some by sophisticated machines that calculate the process by computer analysis.

Probably the most common material used by Trend today for the manufacture of racing pushrods is 4130 chrome molybdenum tubes. Obviously, these allow the pressurized oil in the lifter bores to be transferred up through the pushrods to the rockers. But for Top Fuel drag cars, Funny Cars and most Alcohol engines, Trend uses solid bar formed from H13 tool steel because the rocker assemblies of those engines are not lubricated via the internals of the pushrods. Trend switched to this type of tool steel three years ago because it's tough and responds well to nitriding.

After heat treatment the pushrods are taken to the vibratory tumblers and from there to the inspection room, where the ball ends and clearance angles and other vital statistics are inspected. Most of the production pushrods are finished in black oxide, while Trend's custom creations have a polished natural finish. Finally, the pushrods are laser-etched to identify the part and then shipped to the customer.

During Trend's 20-plus-year history, much advancement in pushrod technology has been brought to market. A recent notable example of the firm's mastery of the racing pushrod is its chrom-moly creation fit with a bronze insert on the cup end. Designed for 500- and 825-ci Pro Stock engines and also large displacement nitrous engines, the bronze insert eliminated damage to the rocker ball that was caused by changes in the constituents of some racing lubricants.

Pushrods are often the last part ordered, but they are the part most urgently needed. To overcome this concern, Trend introduced a new quick-ship program called QSP that decrees custom-length pushrods will be shipped within 24 to 48 hours. The service can be applied to any combination of machined tips, tapers or double tapers. Just select the length (from 6.00 to 13.00 inches), the diameter (3/8, 7/16, 9/16-wall thickness) and either a double or single taper, ball-end or radius-cup. This program is further strengthened by an inventory in excess of 100,000 pushrods.

As Bob Fox says, "Telling a racer he can have the part in two weeks is small consolation if he needs it in two days!" ***DR***

SOURCE

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