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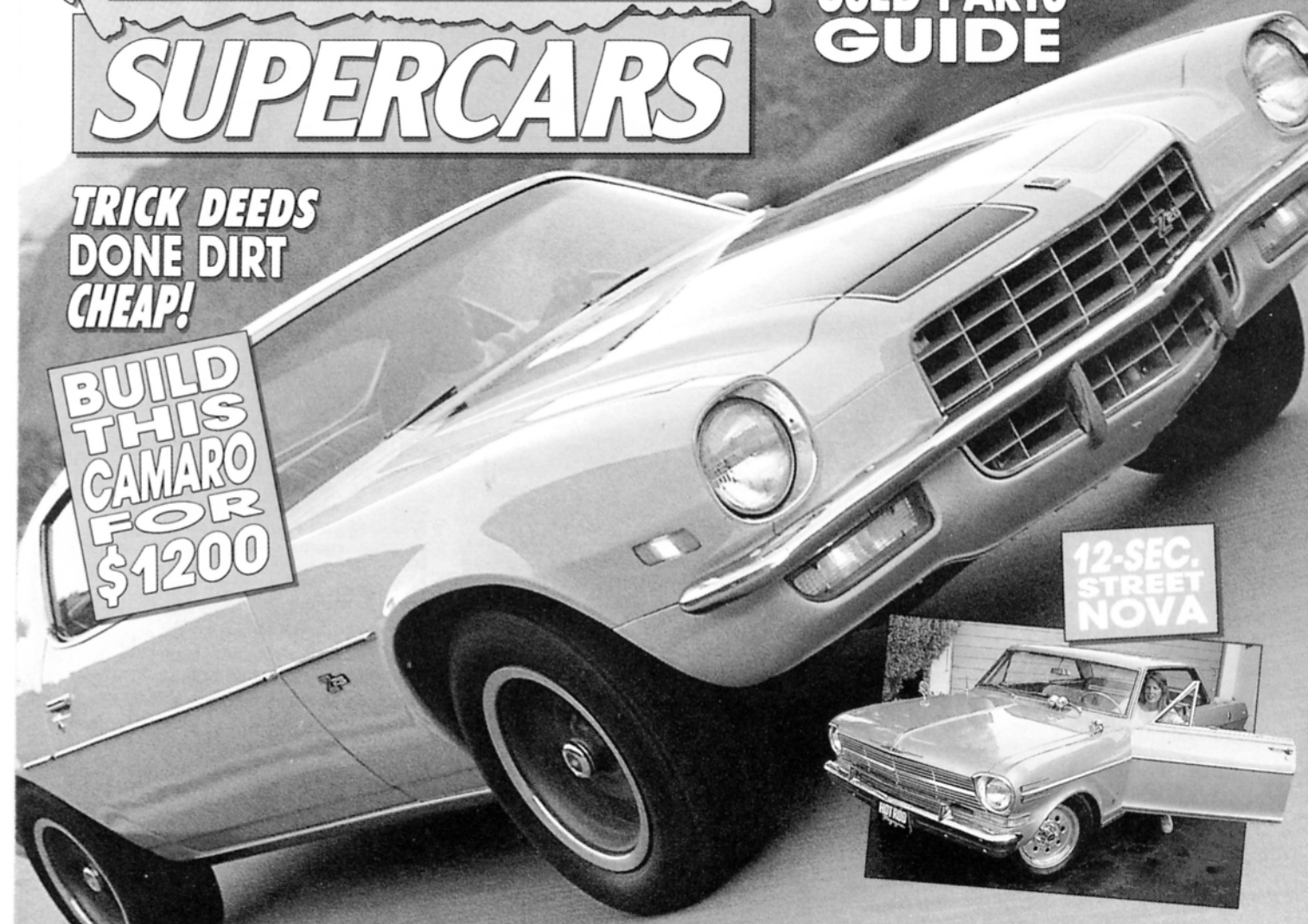

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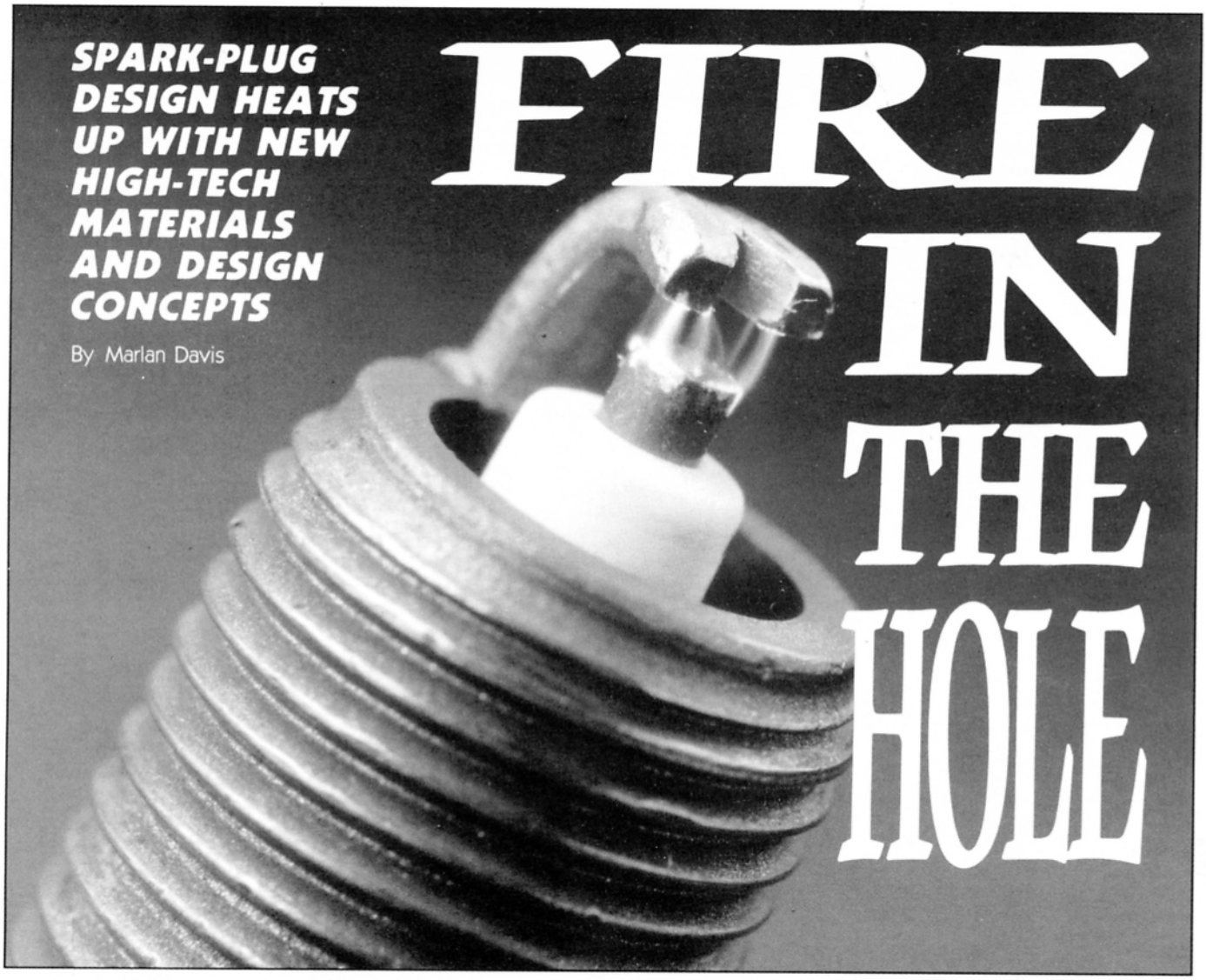
FIRE IN THE HOLE

SPARK-PLUG DESIGN HEATS UP WITH NEW HIGH-TECH MATERIALS AND DESIGN CONCEPTS

By Marlan Davis



If the '70s brought us the revolution in electronic ignitions and high-temp silicone spark-plug wire, and the '80s brought engine-management computers and electronic fuel injection, the '90s is shaping up to be a decade of innovation in spark-plug design. Ever since the late-'60s introduction of resistor and taper-seat "peanut" plug designs, spark plugs have remained essentially the same, even as the rest of the automobile and its engine-management system has gone through the electronics revolution.

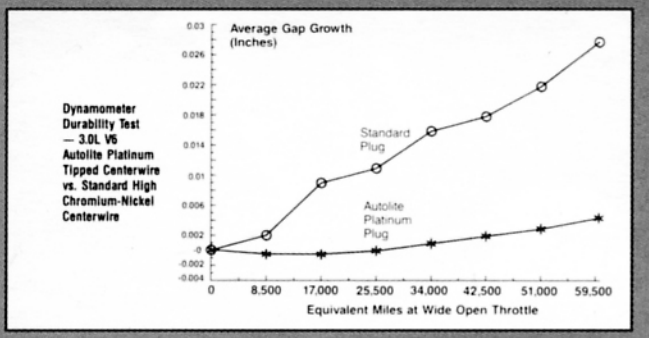
That's all about to change: On one hand, market saturation and declining consumer brand loyalty (the perception that "all spark plugs are the same") have driven plug prices ever lower. To reverse their profit squeeze, spark-plug manufacturers have elected to test the waters and see if there's a higher-end market for premium plugs featuring upgraded materials and design refinements that are said to offer longevity and/or performance benefits. On the other hand, tougher new governmental mandates—including dual-fuel vehicles, further fuel-mileage improvements, even greater emissions reductions, and the extension of emissions control-related component-parts warranties to 100,000 miles—are a distinct possibility. To merely hold the line on existing power levels and avoid a repeat of the dismal '70s, Detroit will use every trick in the book to stay ahead of the game. A breakthrough in spark-plug design could be crucial in helping to meet the projected future standards without driving customers to the poorhouse. Also driving the need for greater plug longevity are today's compact engine compartments, wherein plug changes are a "real pain in the behind."

Today, the major plug manufacturers are attempting to extend plug life by minimizing plug-gap growth. Just as the tip on a welder's electrode shrinks during the welding process, a spark-plug electrode is gradually worn away by the heat of the combustion process, which slowly widens the plug's gap until there is insufficient voltage to jump the void between the two electrodes, and the plug misfires. Increasing ignition voltage can overcome gap growth—but the higher voltage itself increases the gap-electrode-erosion rate. To help extend change intervals, many manufacturers once offered plugs with thicker electrodes, which, while not really preventing erosion, at least took longer to erode, thereby increasing change intervals.

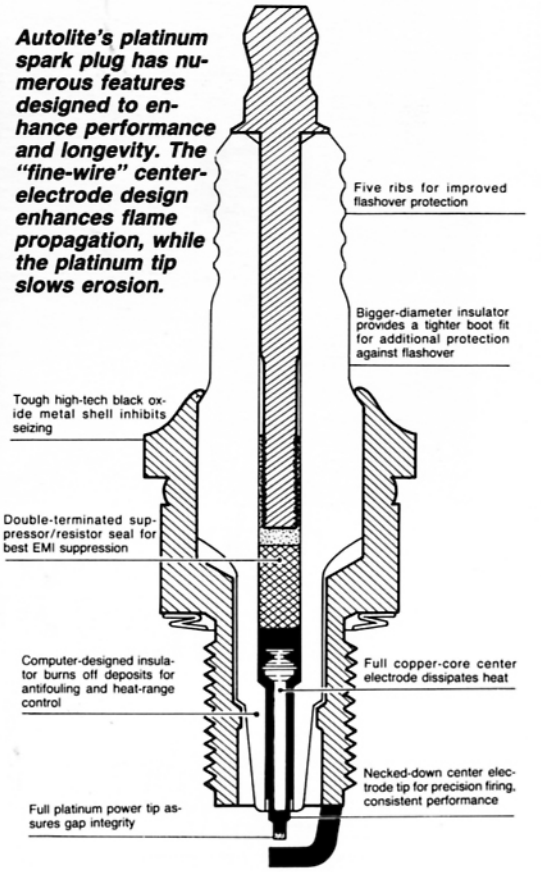
Unfortunately, such thicker electrodes hinder the ideal flame path and slow its spread through the chamber; the result is a performance loss that feels like retarded ignition timing. One

The new, patented Split-Fire spark plug's V-shaped ground electrode broadens the flame pattern without excessive erosion tendencies. The spark kernel is larger than those of a conventional plug, yielding more flame turbulence in the cylinder. Plug life exceeds 50,000 miles, according to the manufacturer.

GAP GROWTH OF Autolite Platinum vs. Standard Plug



This graph charts the results of a dyno test that simulates a vehicle's engine working very hard for the equivalent of 60,000 miles—or like a Ford V6 Aerostar van towing a heavy trailer up a hill at 80-mph full throttle for a little more than 31 days without stopping!



Autolite's platinum spark plug has numerous features designed to enhance performance and longevity. The "fine-wire" center-electrode design enhances flame propagation, while the platinum tip slows erosion.

way to minimize erosion tendencies without hindering flame-front propagation is to improve the metal alloys used in the plug's electrodes. Copper-core center electrodes, which have improved heat dissipation and fouling resistance, were introduced commercially for this purpose in recent years by leading manufacturers.

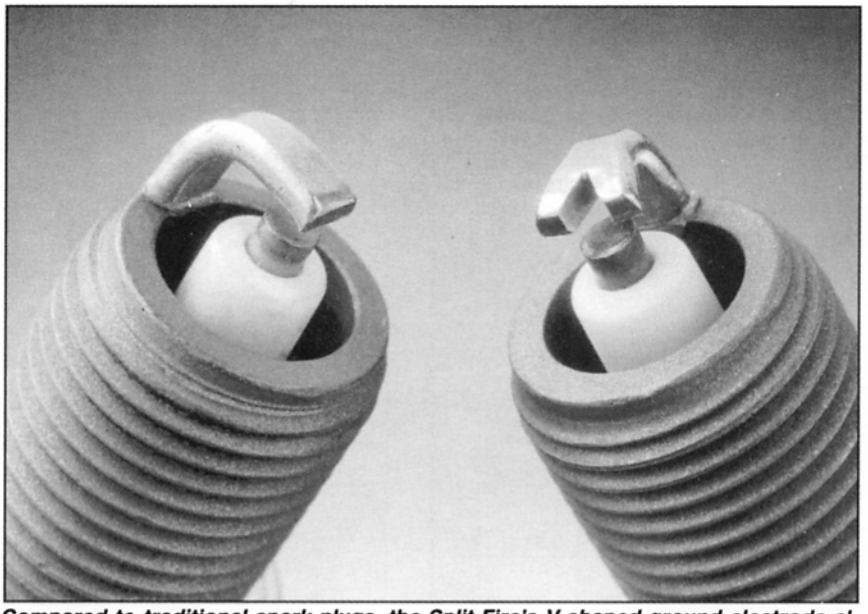
Decreasing the electrode diameter below the norm would allow even faster flame propagation. Of course, with conventional electrode materials, tip erosion increases. To get around this problem, several manufacturers—including Autolite, Bosch, Champion, and NGK—have introduced plugs incorporating exotic high-temp materials in an effort to further refine durability and increase performance. Looking first at Autolite's new platinum plug, its most visible feature is the shape of the plug's outer high chromium-nickel alloy center electrode sheath. The diameter is shrunken near the firing tip to about half that of a standard spark plug in order to concentrate the spark and hence reduce ignition-system voltage requirements and fouling tendencies. The smaller electrode provides less of a block to the spread of the combustion flame than standard-plug electrodes, resulting in better engine response. The platinum tip prevents erosion of the necked-down firing electrode.

Champion designed its "HOT" (or High Output Technology) plug to both operate as hot as possible at slow engine speeds and light load conditions in order to burn off the conductive carbon and oil deposits that result in low-temperature fouling, while also operating as cool as possible at wide-open throttle to prevent pre-ignition and minimize gap growth. A smaller-diameter center electrode enhances the slow-speed and idle regime, and is constructed via a patented tri-extruded process that yields a gold-palladium tip surrounded by a nickel-copper alloy. The HOT plug also features the world's first copper-cored ground (side) electrode; this material, when combined with a tapered tip and trapezoidal shape, is said to expose more fuel molecules to the spark than conventional nickel alloy-ground electrodes, thereby letting the plug run 200 degrees Fahrenheit cooler than normal. Heat is put back into the center electrode "where it belongs." Presently, HOT plugs are sold only through selected, certified tune-up shops in conjunction with an extended tune-up warranty. If you want to try them, call Champion for further information.

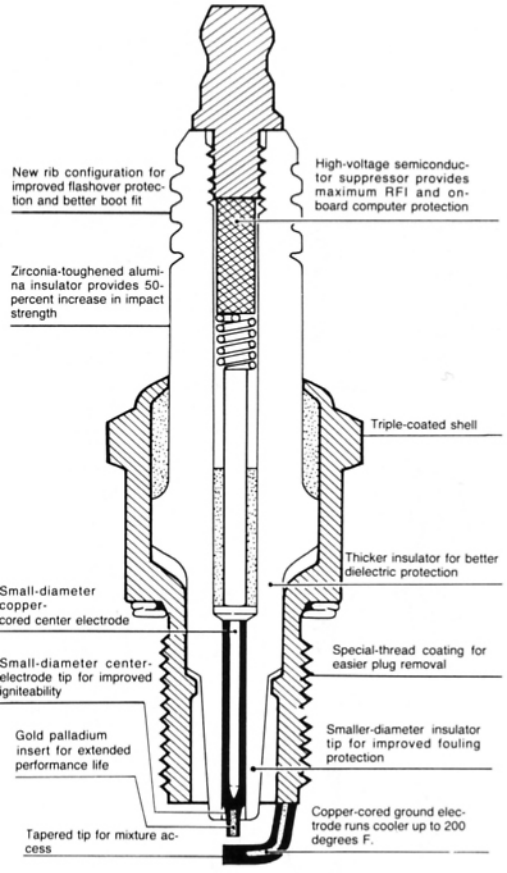
While these new exotic-material plugs are superior to their predecessors, they represent only an incremental improvement over the basic spark-plug configuration as it has existed for years. In the best American tradition, Split-Fire developer Earl Johnson, working in his small home garage, has refined a radical new V-shaped ground-electrode spark-plug design that represents a complete departure from traditional spark-plug technology. Known as the Split-Fire plug, the unique V-shaped electrode has shown reductions in vehicle pollution emissions on the order of 10 to 50 percent in certified lab tests. Interestingly, the plugs seem to clean up the combustion chamber in use, with the greatest emissions reductions often occurring several weeks after initial installation. The manufacturer also claims 5- to 20-percent gas mileage and horsepower improvements.

Chrysler, GM, and Ford tests have generally produced improved performance using Split-Fire plugs. One of the keys to improving flame propagation and achieving more complete combustion is to enhance turbulence or swirl in the cylinder. Detroit engineers have shown that the Split-Fire's modified electrode improves combustion-chamber turbulence, resulting in a better burn. According to Chrysler Engine Programs Manager Paul Sheridan, "Assuming an optimal amount of swirl in the chamber, further enhancement in burning can be obtained by superior ignition—either externally by a higher-output ignition system, or internally with devices such as the V-gap. This will increase the 'plasma' density within the chamber, which imparts an improved electrical reaction, and therefore a superior chemical reaction in the air/fuel charge. In fact, combining high-output ignitions with the Split-Fire enhances the operating characteristics of both."

Several showroom-stock endurance racers—among them 1989 IMSA Firehawk road-racing champion Paul Rossi and Mustang racer Chris Kaufmann—attribute much of their success during the past year to Split-Fire plugs. Rossi says the plugs make the engine run much smoother, and his engines look cleaner inside when torn down after a 24-hour marathon. Kaufmann has seen a consistent 5-hp improvement on the dyno simply by changing plugs. "If we changed the timing and fuel mixture



Compared to traditional spark plugs, the Split-Fire's V-shaped ground electrode allows energy and heat from the plug to dissipate into the combustion chamber more readily, thus inducing more complete combustion of the air/fuel mixture and thereby promoting idle stability and driveability.



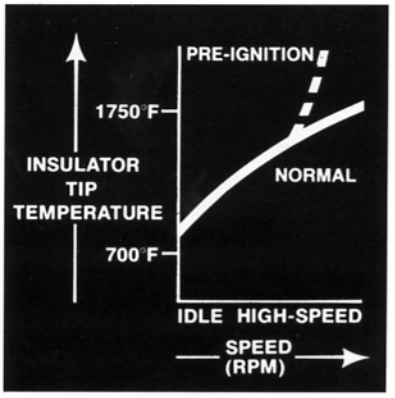
Champion's HOT plug features a gold palladium center-electrode insert for extended performance life. In use, the spark becomes even more concentrated (while firing voltage requirements drop) as the palladium tip is further exposed beyond the nickel surface.

slightly, we could get up to a 9-hp increase." Kaufmann's car consistently "ran 10 to 15 minutes longer on a tank of fuel" than his other Mustang competitors, "and in one case we ran 20 minutes longer."

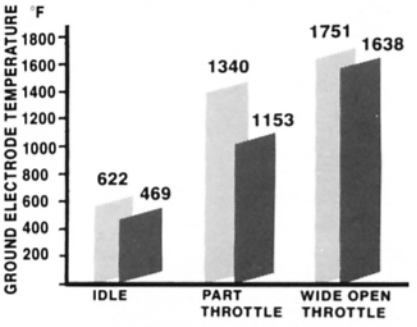
With such intriguing results, HOT ROD just had to try some V-gap plugs as well. On a Paul Rossi-built '72 Plymouth Duster powered by a 318 modified with fast-burn heads, an Edelbrock aluminum intake manifold, a Holley 4-barrel carb, a Mopar Performance cam and headers, quarter-mile times consistently improved by .03 second. As shown in the accompanying chart, the plugs reduced emissions when installed in a heavily modified '89 Camaro RS (a recent HRM project car) with a 305 throttle-body-injection motor. The Split-Fire plugs cleaned the car up to the point that it would nearly meet the stringent '89 standards, despite its advanced state of modification. Increasing the car's idle speed slightly brought the car fully into compliance. However, a brand-new set of standard plugs made slightly more horsepower than a month-old set of V-gap plugs (162 compared to 159) on Bob Jennings' chassis dyno, but it turned out that the No. 6 cylinder was going south and the used plug installed in that hole was heavily oil-fouled.

Split-Fire plugs were also installed in this author's personal '79 Trans Am equipped with a "real" Pontiac 400 motor with 80,000 miles on the clock. As a '79, the motor was chock-full of smog equipment but did not have the advantage of a computer to restore its driveability and mileage. The plugs

Typical Temperature Rise When Pre-ignition Starts



Ground Electrode Temperature Study



.062" X .100" SOLID NICKEL GROUND ELECTRODE

.062" X .100" COPPER-CORED NICKEL GROUND ELECTRODE

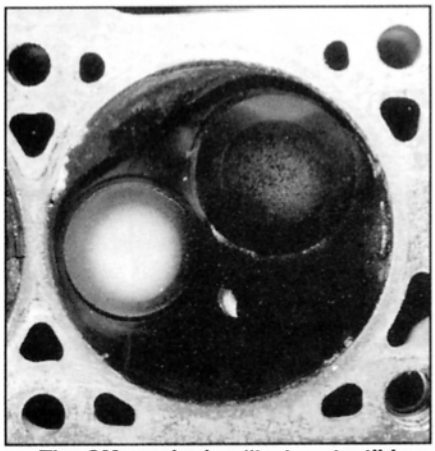
The HOT plug's copper-cored ground electrode runs 200 degrees F. cooler than typical nickel electrodes. As a result, acceleration and high-speed performance are enhanced—without the risk of pre-ignition that in extreme high-output, long-distance engines usually requires filing the conventional copper-side electrode shorter to combat heat-induced pre-ignition gremlins. Because these race engines had to file back the electrode, the heat range was effectively altered; but now the engine can operate at the correct plug-heat range with full gap coverage.

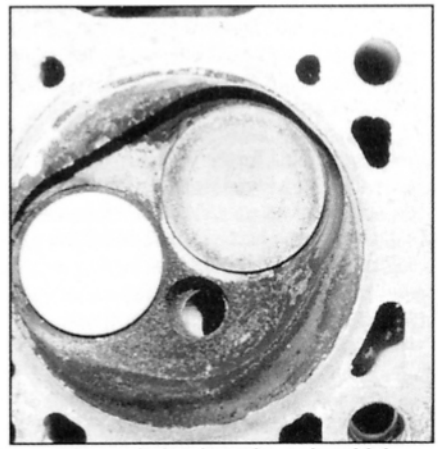
smoothed out and slightly increased the idle speed. For the first time in 10 years, he could run the full factory 18 degrees BTDC initial timing spec without detonation. Overall gas mileage over a 4000-mile test period improved from the previous standard-design plugs' 8.99 to 9.42 mpg with the V-gap plugs, a 4.78-percent gain. We hope to be able to report engine-dyno results in the near future. In all these tests, the plugs were the only thing changed on the vehicle. Other testers have achieved greater gains by optimizing the engine's state of tune to take full advantage of the Split-Fire's greater flame kernel.

SPLIT-FIRE SMOG-TEST RESULTS

Using both standard and Split-Fire plugs, Kaufmann Products tested our former '89 Camaro RS V8 305-TBI project car using the California Emissions Test Procedure. The car was heavily modified with a high-lift cam, Corvette aluminum heads, richer injectors, free-flowing exhaust, and aftermarket intake. After two weeks of use, the Split-Fire plugs cleaned up the car to the point where it would nearly pass the stringent '89 specs without turning up the idle. It should be noted that the Camaro had been heavily abused during previous drag testing, and its No. 6 cylinder was oiling heavily due to what later turned out to be a broken ring land.

	IDLE TEST		CRUISE TEST	
	HC	CO	HC	CO
CA STANDARD	100 ppm	1.00%	220 ppm	1.20%
TEST—USED STD. PLUGS (2000 miles)	477 ppm	0.68%	88 ppm	0.75%
TEST—NEW SPLIT-FIRE PLUGS (766 rpm during idle test)	231 ppm	0.39%	60 ppm	0.31%
TEST—NEW SPLIT-FIRE PLUGS (950 rpm during idle test)	83 ppm	0.20%	N/A	N/A
TEST—USED SPLIT-FIRE PLUGS (450 miles city driving, 800 rpm during idle test)	160 ppm	0.35%	46 ppm	0.64%





The GM spark plug "torture test" is a 335 hour thermal-shock regimen in which the engine is operated essentially under continuous cold-start, rich-mixture, "open-loop" conditions, never being allowed to warm up to the point that the computer would place the engine on the closed-loop program. Standard plugs usually require replacement every 100 to 200 hours; the Split-Fire plugs lasted 1400 hours without a misfire. The Split-Fire plugs also kept the combustion chamber cleaner (right***, compared to standard plugs,*** left***).***

Split-Fire plugs are presently available through mail order by calling the number listed in the source list at the end of this article. In the future, the plugs will be marketed at the retail level by Peak Antifreeze. If nothing else, the emissions reduction alone warrants using Split-Fire plugs in those cars having trouble passing local emissions checks. Assuming that further tests substantiate the plugs' benefits, don't be surprised to see them specified for future O.E.M. usage as mileage and emissions standards continue to tighten. Split-Fire plugs may just be able to prevent another future performance gap—and that's a real spark of hope! **HR**

SOURCES

Allied-Signal, Inc.
Allied Aftermarket Div.
Dept. HR
105 Pawtucket Ave.
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Autolite Platinum Plugs

Champion Spark Plug Co.
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Champion HOT Plugs

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Split-Fire Spark Plugs

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