Smokey Yunick's Hot Air Fiero

Many commonly accepted ways of doing things are based on tradition or opinion, rather than sound engineering, physics, and chemistry.

Pontiac Fiero Hot Air Engine
Now It's Ready.
April, 2010
By C.J. Baker

Editor's Note: This story was reprinted from the June 1984 issue of Hot Rod magazine.

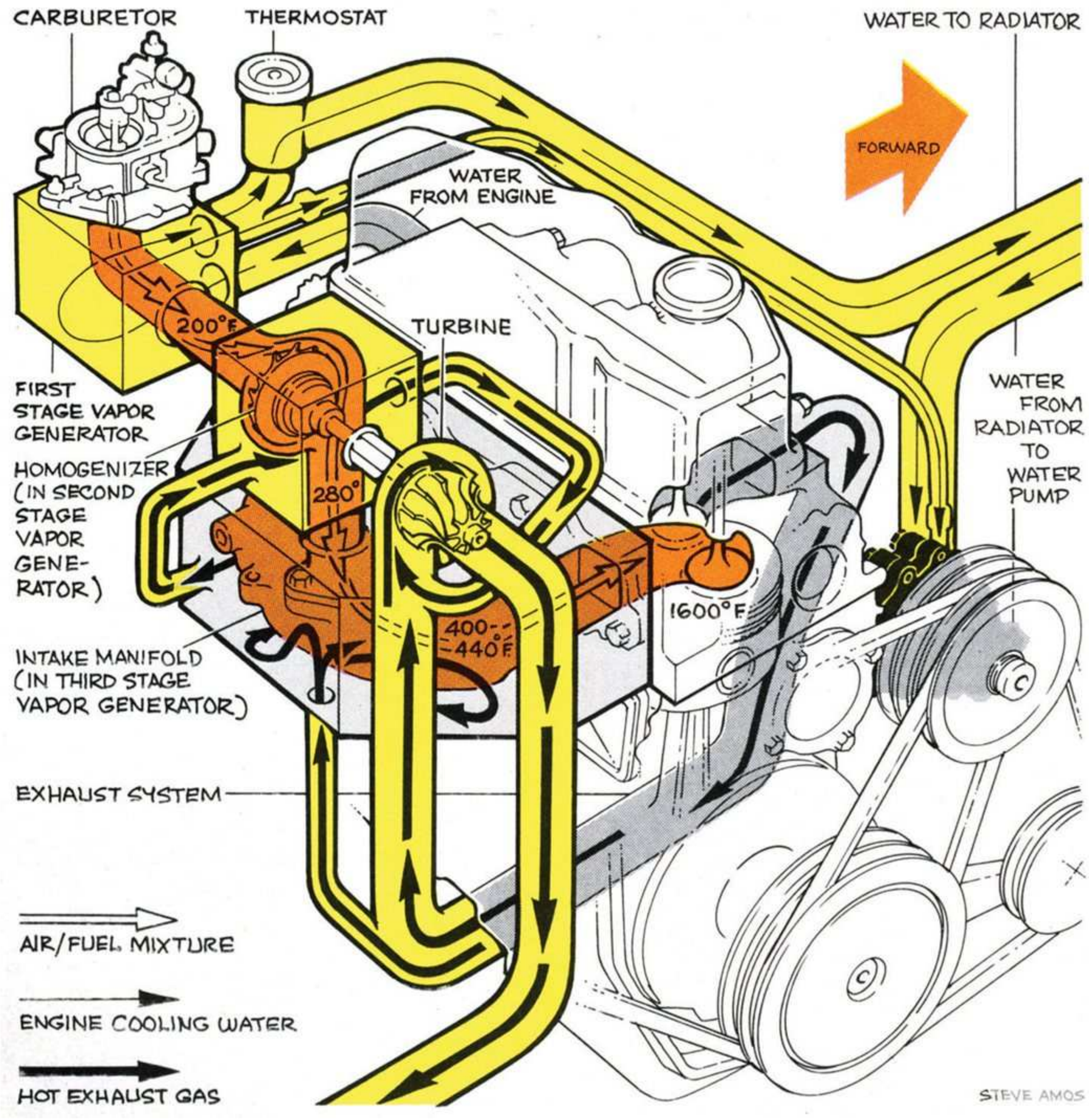
It showcases not only the spirit of innovation of the great Smokey Yunick but gives some insight into how non-conventional thinking can lead to significant technical innovation.

For decades, hot rodders and for that matter Detroit engineers have been locked into the idea that the only way to make more power in an engine was to cram more air and fuel into the cylinders. Traditional methods of doing that have included long camshaft event cycles, pressurizing the induction system, and cooling the incoming air/fuel charge. Those methods have produced success within limits but there has also been a heavy price to pay for power achieved with those methods in terms of efficiency. What has been consistently overlooked is the quality of the mixture that enters the cylinders in terms of its ability to react or oxidize. In everyday terms that means how well and how completely it will burn. When the reaction takes place, chemical energy is converted to heat energy. How much heat is generated and how well that heat energy is used to produce work is efficiency and quite frankly most internal combustion engines are pathetically inefficient, using only about 25 percent of the heat available. The rest is wasted-lost out the tailpipe, into the cooling system and into the air.

Now all of this business of efficiency is nothing new, but most people seem to have shrugged their shoulders and accepted it as a fact of life without really questioning if it has to be that way. Instead, in their quest for power they have been willing to accept even less efficiency if they could cram enough extra air and fuel into the cylinders to result in more net power at the wheels. Obviously, an approach that could improve efficiency has the potential of releasing even greater amounts of power from the same amount of fuel or equal power from a smaller amount of fuel. By the same token, extracting and using as much heat as possible from a given amount of fuel means better economy of operation. The bottom line is, if efficiency could be increased, we could have our cake and eat it too.

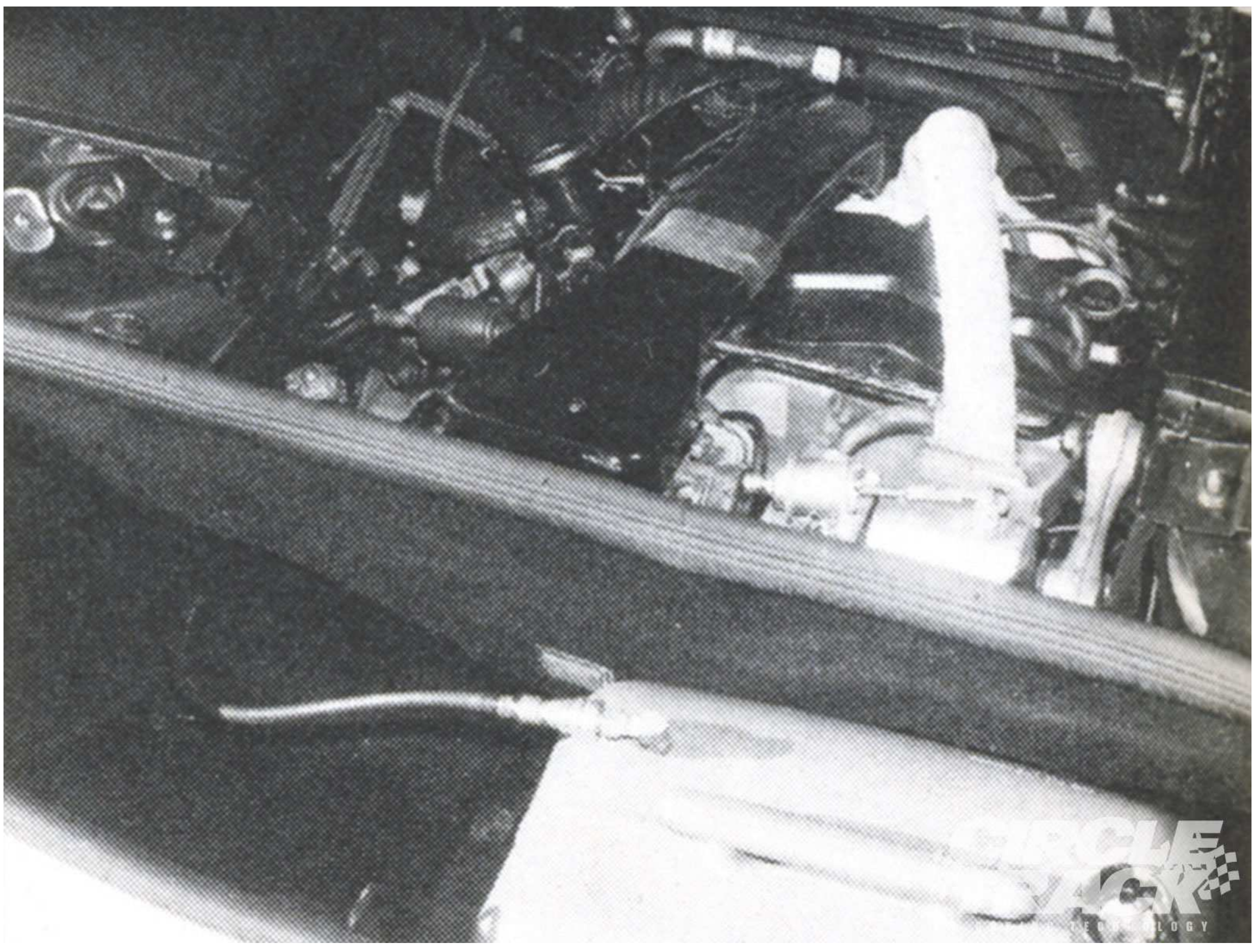
This is where Henry "Smokey" Yunick enters the picture. Smokey's mastery with racing and high-performance engines is legendary. Over the years many Hot Rod readers have learned a great deal from his insightful engine building procedures which have appeared in numerous articles and Smokey still writes a racing oriented questions and answer column in Hot Rod's sister publication, Petersen's Circle Track. Smokey has always been one to take the common sense approach to evaluating all aspects of engine operation, accepting nothing as fact until it was proven to be so, and applying the basic laws of physics and chemistry to problem solving. As he has often said, "It's all right there in any good high school physics and chemistry text books." What is less well known is that for the past 32 years, the same Smokey Yunick, who has become a recognized authority in racing and high performance has been developing and refining what may very well be the most significant advance in engine technology since the original concept of the Otto-cycle internal combustion engine.

If the above statement seems a bit farfetched, consider the Pontiac Fiero shown here. Equipped with Smokey's "expander cycle" exhaust and induction system and requiring only a cam change inside the production 151 cubic inch (2.5-liter) Iron Duke four-cylinder, the car now gets more than 50 miles to the gallon, develops 250 hp and 230 lb-ft and cleanly, has no computer controls, passes federal emissions standards, and oh yes, it'll accelerate from 0-60 mph in as little as 6 seconds flat! Here's how it works.



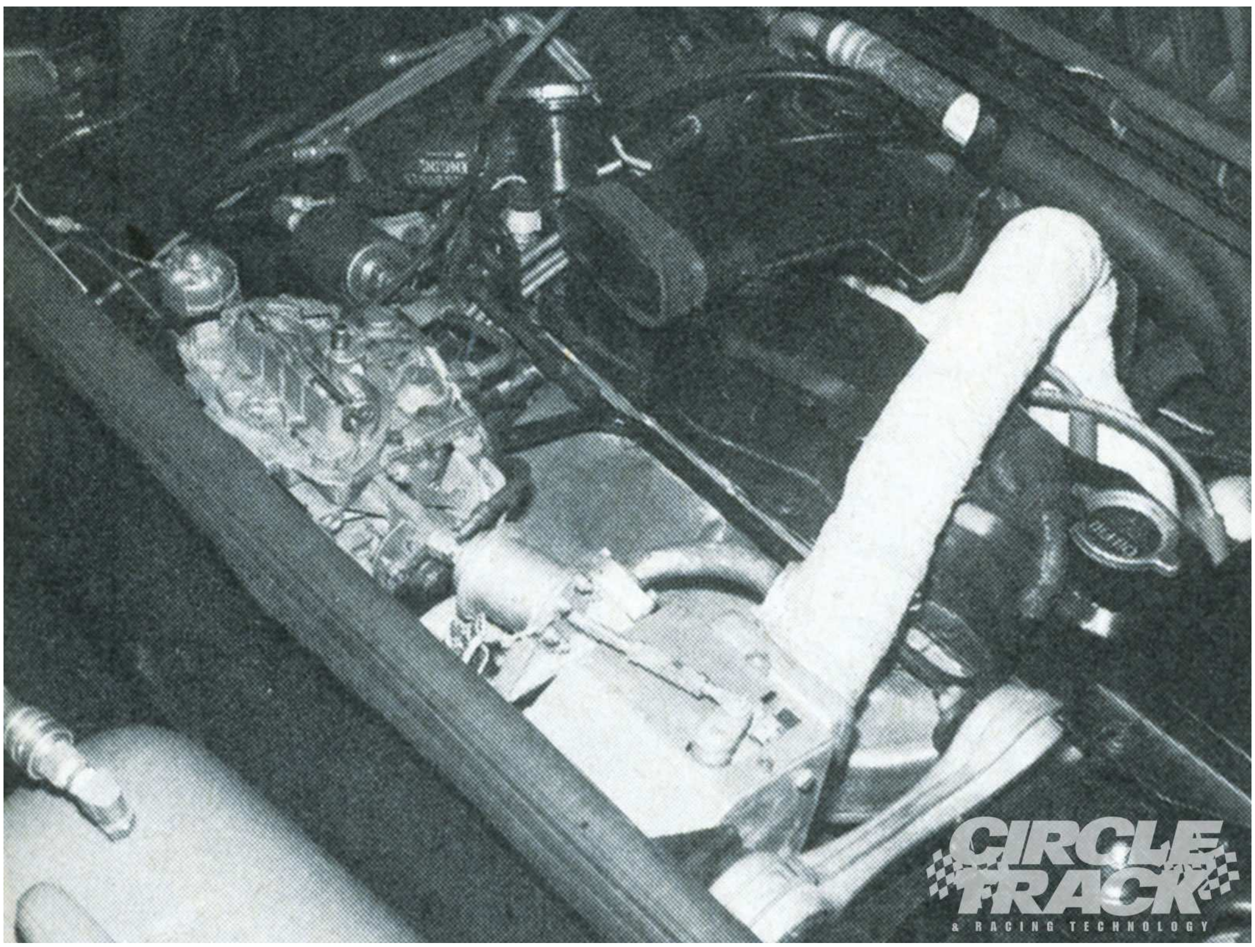
Essentially, Smokey's "expander cycle" design is an amplification of the Otto-cycle, spark ignited, internal combustion engine where heat released in the combustion process is used as efficiently as practically possible to fully vaporize the incoming fuel charge for complete combustion while simultaneously artificially aspirating the engine. That sounds complicated and involved so we'll take it one step at a time, and when we're finished you'll marvel at the common sense logic of it-and probably wonder why you didn't think of it yourself. But be forewarned, it requires a complete rethinking of how to handle air/fuel mixture.

We'll begin with the vaporization of the fuel. The most common automotive fuel, gasoline, is not composed of uniform hydrocarbon molecules. Gasoline is actually a mixture of many different compounds that are distilled from crude oil, and each distillate has a different vaporization temperature, or boiling point, at which the liquid changes to a vapor. Some parts of gasoline vaporize very easily at low temperatures to help get a cold engine to start. Other parts have a much higher boiling point to prevent the fuel from vaporizing in the fuel lines en route to the engine. What this all comes down to is that in today's typical engines, only part of the fuel entering the combustion chambers is in a combustible state. To fully vaporize pump gasoline, and to keep it vaporized for complete combustion, the incoming air/fuel mixture needs to be elevated to between 400-440 degrees F. Smokey uses heat from the water in the engine's cooling system and exhaust gas heat to progressively warm the induction flow on his system to the 400-440 degrees.



Although very little can be seen with the engine in the car, the system's simplicity contributes no extra hoses or lines under the hood. The tank in the foreground is a separate tank for precise fuel measurement.

First, all the hot water exiting the engine is channeled through a heat exchanger directly under the carburetor (or throttle body injection, TBI, unit). This plenum-like first stage vapor generator elevates the air/fuel mixture to approximately 200 degrees F. Next, the mixture flows through what looks like a small turbocharger, but this is not a turbocharged engine. The turbocharger-like device is actually a homogenizer and the second stage vapor generator. In the homogenizer an exhaust driven turbine drives what appears to be a rotary compressor totally wrapped with exhaust gas ducting. The homogenizer serves to mix the incoming air and fuel into one uniform, homogenous mixture while the surrounding exhaust gasses further elevate the mixture temperature to about 285 degrees F. From there the mixture flows through an intake manifold that is totally wrapped by exhaust gas ducting, elevating the mixture temperature to the desired 400-440 degrees F in this third and final stage. The fuel is now fully vaporized and distributed uniformly in a truly homogenous mixture that will burn cleanly and evenly in the combustion chambers without detonation or severe pressure spikes in the cylinders.



Partially visible is the wrapped exhaust crossover pipe leading to the homogenizer in the foreground. The arm attached to the top of the homogenizer controls maximum manifold pressure. Below the carburetor and homogenizer is the exhaust-enshrouded intake manifold.

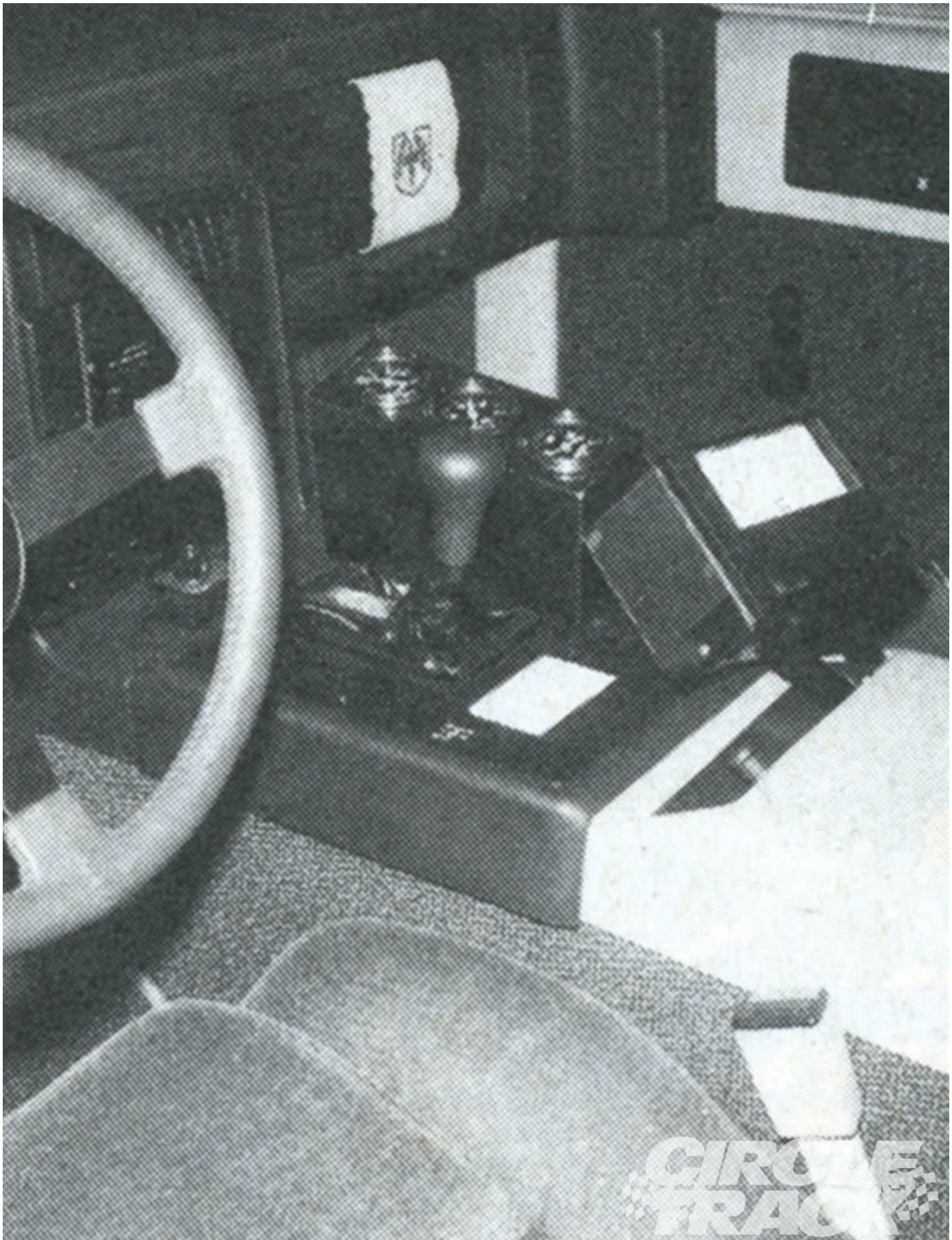
At this point, many of you are probably thinking that this is in total contradiction to everything you've been taught in the past, such as cooling the intake charge for greater density and to suppress detonation. We warned you that some rethinking would be required. Such cooling is necessary to suppress detonation when the fuel is not uniformly vaporized, since some parts of a non-homogenous mixture burn quickly and other parts slowly within the same cylinder, creating turbulence and colliding flame fronts and all traditional internal combustion engines are dealing with non-homogenous, incompletely vaporized mixtures today. It is also true that the heating of the incoming mixture reduces its density and causes it to expand. On a normally aspirated engine, such expansion would just push right back out through the carburetor, but on Smokey's system the expansion is trapped in the induction system because the small turbocharger (homogenizer) serves as a one way check valve. Consequently, with the expansion contained, the induction system becomes pressurized, providing high mixture density and artificially aspirating the engine. At anything above idle, the induction system on Smokey's design has positivpressure, but that pressure comes from heating the mixture, not from the turbocharger (homogenizer).

One of the big advantages of the "expander cycle" engine is that it does not rely on high rpm to generate power. In fact, after being fitted with Smokey's system the Fiero developed the same performance at 1,700 rpm that used to require 2,200 rpm, so a lower numerical gear ratio was installed. Lower engine speeds also equate to less wear and less friction-hence better efficiency.

The beauty of Smokey's system is its simplicity, but simplicity is deceptive. Staged heating of the working liquid (air/fuel mixture), homogenization of the working fluid at the proper point in the heating process, and balanced heat management are the keys. Get one part of it wrong and the whole thing won't work. There's a lot of physics and chemistry involved, and a few of the details contained in the various patents on this design have been intentionally withheld by the Smoke, although the basic principle of operation has been explained here.

Now let's examine some of the numerous benefits offered by this high efficiency design, the most prominent benefits are performance and mileage. The design can be applied to any Otto-cycle engine, as long as the engine doesn't have direct port fuel injection. The fuel must be in the airstream for the preheating vaporization and homogenization to occur. On virtually any engine, whether it's a V-8, V-6, four-cylinder, or whatever, the system will produce roughly 1.8 horsepower per cubic inch. That would equate to 543 hp for a 302, 630 hp for a 350, 720 hp for a 400, and 817 for a 454, and in every case that power would be produced at a reasonable 5,200 rpm. Of course, nobody really needs those big horsepower numbers on the street, but 250 hp from a small, lightweight 151 cubic inch engine, such as in the Fiero, can make for a thrilling ride.

Such a reserve of power adds a margin of safety in passing or merging traffic situations, and it does it without any hint of roughness, bad idle, or poor economy. In fact, Smokey's Fiero was the smoothest four-cylinder we've ever been in



Added to the interior of the Fiero were manifold vacuum/boost, oil pressure, and water temperature gauges in addition to a tachometer. Not shown on the floor were exhaust temperature and fuel flow meters.

Essentially what Smokey's "expander cycle" does is give us the means to bring back cars that are comfortable to drive with a feeling of security only a reserve of performance can supply. It has acceleration acceptable to most drivers-something we haven't had since 1972 in most vehicles.Yes Smokey's setup may be too powerful for some of the motoring public but virtually every American car built up to 1972 was that way. Smokey's design is also fuel efficient and if someone doesn't want the power, they don't have to use it. Or for those who insist, an even smaller engine using the same principles could be installed that would be less powerful and even more fuel efficient.

Smokey's Fiero was also quiet, started quickly and was responsive. A manifold pressure gauge mounted in the car reacted as if it was mechanically tied to the accelerator pedal. As the throttle was depressed, the manifold pressure instantly responded in a proportionate manner. Maximum pressure was intentionally limited to 15 psi. Smokey pointed out that the system would easily produce 30 psi manifold pressure if unlimited, but that much power would probably blow the head gasket or break pistons, rods, or the transaxle in the stock Fiero.

When asked how the stock transaxle was coping with the increased torque and power which incidentally was capable of lighting the tires on the Fiero, Smokey replied, "The expander cycle setup provides such even and controlled combustion that the cylinder pressure curve is more rounded with no spikes so the drivetrain isn't subjected to that impact wrench effect that breaks things. However, if you abuse the power you can break the transaxle."

When queried about internal engine changes, Smokey stated that the only internal change was the camshaft to make maximum utilization of exhaust heat and to provide maximum cylinder scavenging. All else was left stock.

Other benefits include elimination of the fan and reducing the radiator to half the stock size. Heat from the cooling system is used so efficiently in the first stage vapor generator that there's very little heat left to dissipate through the radiator. Smokey claims you can overcool his system, but you can't make it overheat, and that there is absolutely no possibility for carburetor icing.

It is possible to improperly design the Smokey setup and overheat the incoming air/fuel mixture, however. If the mixture (working fluid) is heated above 440 degrees F, detonation can begin to occur and adequate cooling of the valves becomes a problem. Combustion temperatures typically run 100 degrees F higher than in a normally aspirated engine. However, on an engine built to withstand the stress, maximum manifold pressure could be allowed to exceed 15 psi for power outputs in excess of 1.8 hp per cubic inch.

Other points of interest about Smokey's Fiero are that it represents a return to relatively simple engines. There are no computer controls. The carb remains virtually stock. The ignition system, although fitted with an MSD amplifier, is otherwise stock, and the ignition remains stock, too. Because the engine is artificially aspirated, there is virtually no loss of performance at altitudes up to 5,500 feet, and above 5,500 feet, it is still better than a stock normally aspirated engine. The "expander cycle" engine is also not very fussy about fuel quality. All mileage testing was done on EPA-rated fuel, but utilization of low octane fuels or alcohol requires only a minor rebalancing of the intake system in terms of preheating, which is controlled by sizing of orifices in the heat loop. There is also a minimum of emissions equipment.

Most people assume Smokey's system uses a very lean mixture, which is not true. A lean-burn system doesn't get the maximum BTU content out of fuel. Lean-burn is a negative to thermal efficiency. Oxidation of gasoline must be at stoichiometric (optimum proportions) to get a full 17,500 BTU from each pound. Lean-burn won't give mileage and it doesn't make power.

Obviously, this breakthrough signals the beginning of a whole new plateau of engine development. As we said in the beginning, many consider this to be the most significant development applicable to the spark-ignited internal combustion engine in this century. Worldwide patents have been applied for and a well financed corporation has been formed to handle the marketing and licensing of the system to the major automotive, truck, aircraft, and equipment manufacturers. It's just possible that in a few short years many new car engines will be fitted with a form of Smokey's system.

So where does that leave the hot rodder? First, it means a return to high-performance engines that you can work on. It also means performance on a relatively poor grade fuel. Small, light, yet powerful engines will mean better handling and braking to match the acceleration potential. On a less happy note, it will probably hasten the emergence of four-cylinder engines and speed the demise of the big-inch engines that used to be required for performance.

In the immediate future, retro-fit kits for the Chrysler-built 2.2-liter and the Pontiac Iron Duke 2.5-liter will be offered through a division of Crane Cams in approximately one year and other retro-fit kits are bound to follow. Someone might even do kits for small V-8s.

And what about the long range future? What we've outlined here is only Smokey's first stage. Smokey is already developing stage five with exotic non metallic components, no cooling, and operating temperatures approaching 4,000 degrees F. Aren't you glad Smokey's one of us-and don't let anybody tell you hot rodding is dead!