• HOW A TURBO WORKS • KITS & GOODIES • '86 TURBO CAR TESTS •

GIANT **TURBO** SECTION

Canada $2.95 April 1986 $2.50

HOT ROD

MUSTANG MANIA!

- 351W ENGINE SWAP
- SALEEN TEST
- RARE GT 350 "R"
- WILD STREET 'STANGS

SHELBY GLHS WHIPS GT 350!

CARROLL'S BUILDING "REAL" SHELBYS AGAIN

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Starting Line

"**S**helby GLHS Whips GT350" . . . surely Emanuelson has gone over the edge, you think. Sensationalism? Maybe, but certainly no deception. This front-wheel-drive, four-door, 4-cylinder econobox has just blown off a legendary ponycar. I'll be honest and admit that I never thought I'd see the day when. . . . I'll also admit to telling some pretty important people in the auto industry that "the V6 engine might be okay for some applications, but just won't cut it in place of a V8—and forget four cylinders." Pass the mustard and ketchup as I choke down those words.

The point is that performance cars and engines are changing, and the turbocharger is the big equalizer. How can it be that the quickest and fastest production car from Detroit is a full-size Buick Regal with a V6 engine? Answer: Turbocharger. How can it be that a minuscule 2.2-liter 4-banger can whip a V8 that has been modified to produce over 1 horsepower-per-cubic-inch? Answer: Turbocharger. While engine builders throughout the country are trying to coax over 2 horsepower-per-cubic-inch out of their *race* engines, streetable production-based turbo engines do it with ease.

"HOW CAN IT BE THAT THE QUICKEST PRODUCTION CAR FROM DETROIT IS A FULL-SIZE BUICK REGAL WITH A V6 ENGINE?"

The '86 intercooled turbo Regal is capable of 14.30's at 96 mph, the GLHS intercooled turbo goes 14.7's at 94 mph, and the SVO Mustang intercooled turbo is right there at 14.7's at 94 mph. I think you'll find that these figures compare favorably with your favorite musclecar of the '60s. Just for your reference I looked up some test results from '69 and '70 issues of HOT ROD: '69 Z28 ran 14.3 seconds at 101 mph; '70 Boss 302 Mustang, 14.93 at 97; '70 GS Stage I Buick, 14.4 at 96; '69 400 Judge, 14.4 at 99; '69 Hemi Charger, 13.38 at 108; '70 LS-6 Chevelle, 13.44 at 108.17; L-88 Corvette, 13.38 at 108. The bulk of the cars ran mid 14's. The few exceptions ran mid 13's.

With a turbo bump-up kit, today's turbo 4-bangers are capable of 13-second performances at over 100 mph in a 3600-pound car. The difference is that a small-engine turbo car gets 25 mpg versus an LS-6 Chevelle that gets 8 mpg.

In this issue we provide just a glimpse of what turbocharging is all about and where it is headed in the future. Forty-five production turbo cars, turbo Top Fuelers, 6-cylinder Pro Stocks, and 13-second street sleepers are all leading indicators. **HR**

Leonard Emanuelson

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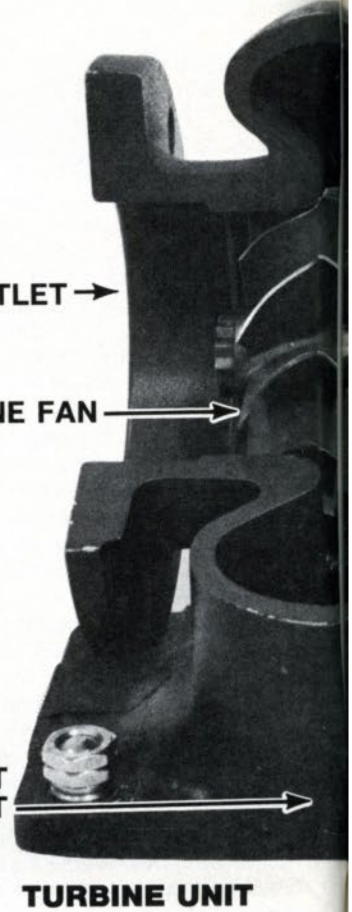
GIANT TURBO SECTION

TURBO TALK

Getting to Know One

By Pat Ganahl



A turbo is a *blower*, like a GMC, a B&M, or more similarly, a Paxton. It gives the engine more power by delivering a *supercharge* of air (to which you add proportionate extra fuel) on the intake stroke. The blower pumps more air into the motor than normal atmospheric pressure—about 14.5 psi—can push in.

Remember, an engine runs on *air*—the expansion of air. Air expands when it is heated. Combustion in the cylinder heats the air. The expanding air pushes (creates pressure) on the piston. This pressure is converted to work by the engine; we like to call it *power*.

The more air you get in each cylinder on the intake stroke, the more it will try to expand—that is, the more pressure it will exert on the piston—and, consequently, the more power the engine will make.

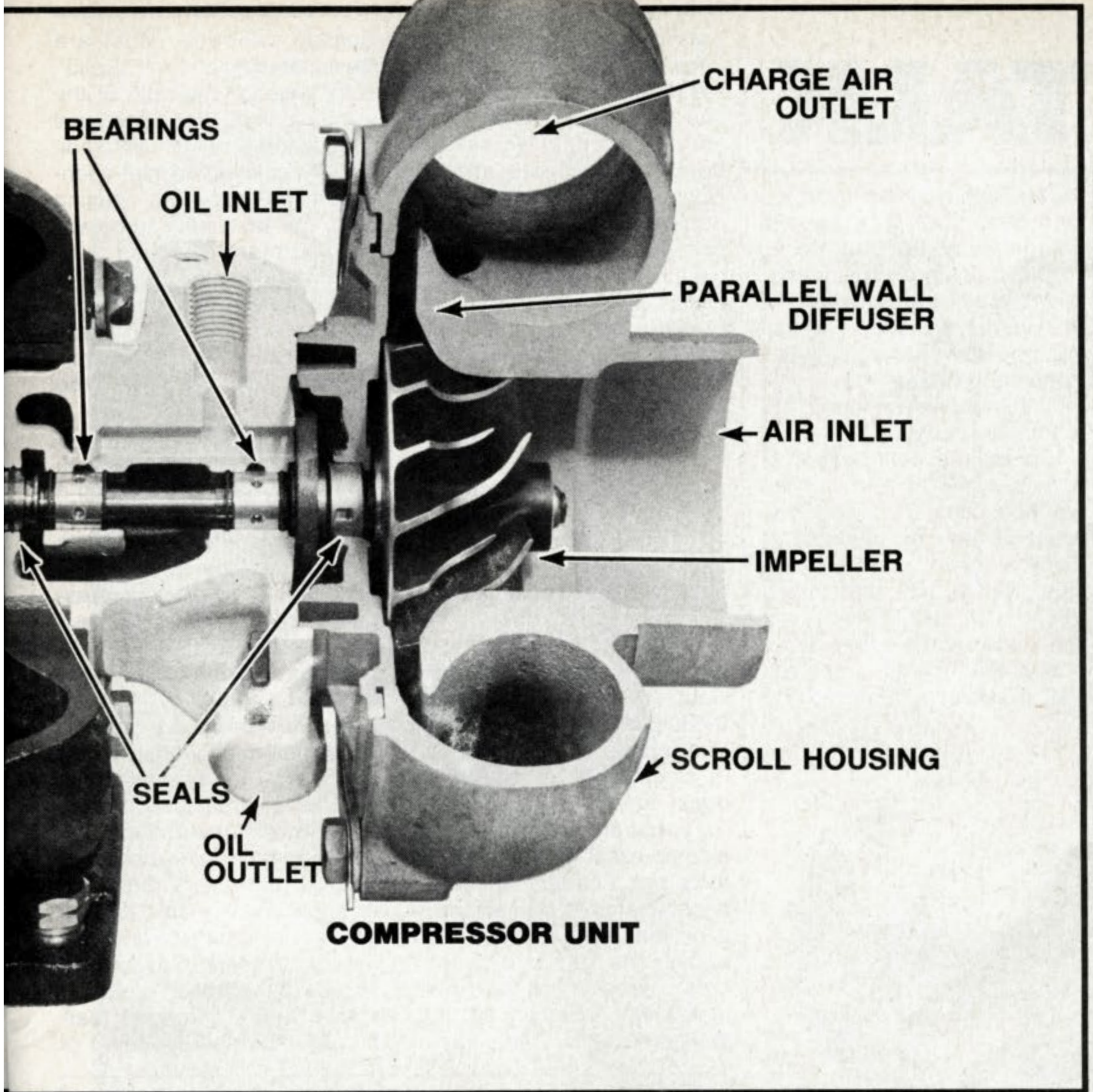
You all know that a supercharger's job is to blow more air into the engine. We're telling you *why* you want more air in the cylinders. It's simple physics.

One reason we're making this point is to help describe a turbocharger. There's an old saw about an internal combustion engine being basically an air pump. Not exactly. An engine doesn't pump air, it *gets pumped* by air. Our analogy isn't perfectly accurate, but it does relate to the two primary components—and the operating principle—of a turbocharger. A much better analogy is the contrast between a water wheel (as used to run an old grist mill or a modern hydroelectric generator) and a paddle wheel (as on an old-fashioned stern-wheeler steamboat, or like the prop on your ski boat). In one case we have a source of potential energy—running water—going to waste until we put the "water wheel" in it to convert that energy to work. In the other case we want to move a vehicle through the water; we can use basically the same method of power transformation (a "paddle wheel" of some sort), but this time we have to supply the energy to it to do the work. It's the same principle of energy transfer, but the opposite direction of power flow.

In fluid mechanics, the paddle wheel (or prop, fan, screw, etc.) that *does* work is usually called a pump. One that *gets worked on*, or driven, by the fluid is called a turbine. If air is the medium instead of water, since it's compressible, the pump is usually called a compressor. We might call it a blower; same thing. So, to make a long analogy short, a turbocharger is a blower that is driven by a turbine placed in the readily-available and usually-wasted exhaust stream, rather than by a belt or other mechanical means from the crankshaft. You can see where it gets its name.

In all turbocharger examples we know of, both the turbine and the compressor are similar in design—though opposite in direction of airflow—using a multi-vane "wheel" inside a snail-like housing. The two units are mounted next to each other, and the two "fans" are solidly attached to opposite ends of the same shaft. Thus the exhaust-driven turbine transmits its power immediately and directly to the compressor, and both "wheels" always turn at the same speed. Mechanically a turbocharger is utterly simple. It has only one moving part!

In terms of thermodynamic theory, the turbo sounds almost too good to be true. Remember, your small-block Chevy is a *heat* engine (combustion converts fuel energy to heat; heat makes the air in the cylinder expand; this pushes the piston). But what comes out the exhaust? Hot, pressurized air. Any heat and pressure above ambient that goes out the tailpipe is energy—horsepower and fuel economy—wasted. Thirty-five percent or more of your engine's potential power goes out the exhaust. The turbo



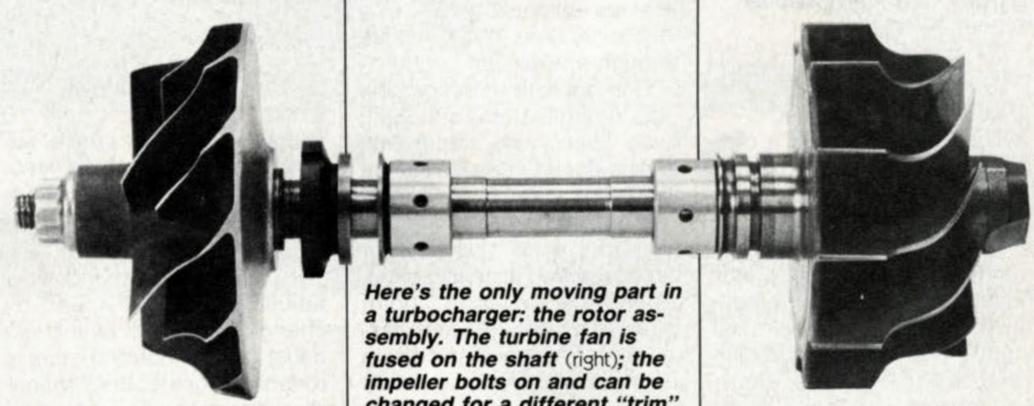
can't directly increase your engine's thermal efficiency (percentage of potential heat energy in the fuel converted to work at the crank), but it uses the wasted thermal power to greatly increase the engine's volumetric efficiency. A belt-driven blower, by contrast, not only lets exhaust energy escape, but it steals a further percentage of the engine's power directly from the crankshaft.

A turbo not only increases the efficiency of the engine as a system, but it is also much more efficient at compressing air than typical positive-displacement blowers. A Roots-type blower, such as a GMC, is lucky to achieve 50-percent overall efficiency at full boost. That means it takes a lot of energy (horsepower) to compress the air a given amount, and it transfers some of this energy to the air in the form of heat, which expands the air (see the following section on intercoolers for more discussion of this vicious cycle). A centrifugal blower, like all turbos, can run at 60 to 70-percent efficiency or more.

What's more, a centrifugal compressor will deliver increasingly more air the faster it's turned. A positive-displacement blower pumps the same volume of air with each revolution of its rotors: its output is directly proportional to its speed. The output of a centrifugal blower, however, increases *exponentially* (as the square) of its rotor speed. Turn the shaft three times faster and you get nine times more air; increase shaft speed 10 times and output increases a hundredfold.

So far, we have said nothing but great—nearly phenomenal—things about turbos. So why doesn't every internal combustion engine have one? Good question. An immediate answer might be "ignorance." You have undoubtedly noticed how diesel trucks, piston airplanes, and most industrial engines have fully accepted turbocharging in the last few years. Additional component cost and required owner maintenance (keeping engine oil fresh and clean) are two reasons that some auto manufacturers have been reluctant to install turbos on production cars. But for automobile engines in general, ignorance (and hence hesitance) about turbocharging is somewhat justified. How to apply this simple device to a high-revving automobile engine can become complicated in a hurry.

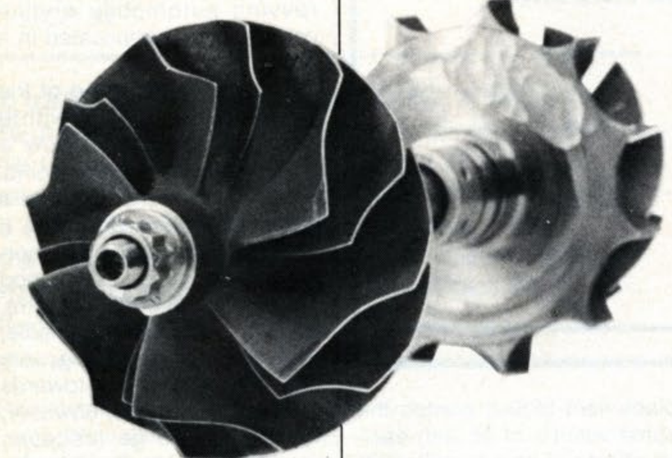
To help dispel some of the ignorance, let's start with a simple description of how a centrifugal compressor works. I like to use the analogy of a playground merry-go-round. If the kids are pushing the merry-go-round at a pretty good clip (a fast, but constant, rpm), but you're riding in the middle, you won't be travelling very fast. The farther out towards the edge you move, however, the faster you go (because you have to travel a greater distance to make one revolution). The game "Crack the Whip" is based on the same principle. Think of the turbo impeller wheel as the merry-go-round. Air molecules enter at the center, and move out to



Here's the only moving part in a turbocharger: the rotor assembly. The turbine fan is fused on the shaft (right)***; the impeller bolts on and can be changed for a different "trim."***

TALK

the edge of the spinning rotor, where they are flung off into the scroll housing at a higher velocity. Moreover, as the air molecules travel along the blades of the spinning rotor, they are flung outward by centrifugal force, which also increases their velocity. The centrifugal blower is thus an "energy multiplier." Using a minimum of input energy, it multiplies the velocity of the air two ways. In the scroll housing or "diffuser," the velocity energy is converted to pressure energy as the high-speed air molecules "stack up" like traffic—that is, pack together to form higher-density air. We call it "boost."



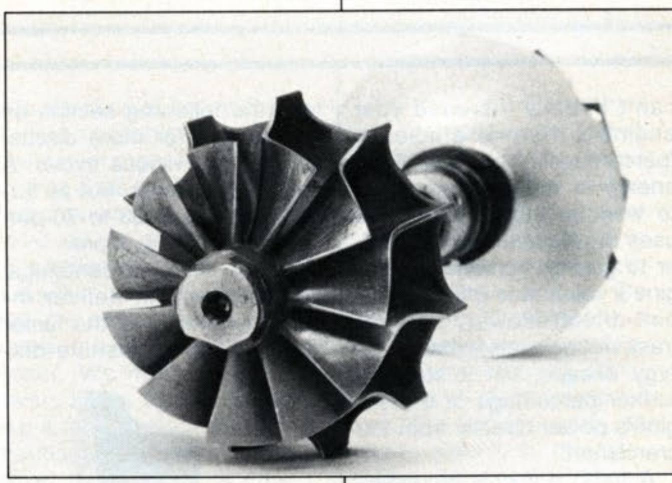
Most impellers have blade tips curved over where the air enters (called the inducer) near the center. This one also has "backward curved" blades which turn away from the direction of rotation at the outer edges of the wheel. This impeller turns clockwise as viewed here.

The problem is that a centrifugal compressor has to spin at a very high speed (around 100,000 rpm) to make a typical 10 to 15 pounds of boost. That's why it's so difficult to make a belt-driven centrifugal blower. Using the exhaust-driven turbine to drive the compressor solves most of those problems, although it does contribute to the annoyance of "turbo lag": since it is not directly driven, and since it must operate over such a wide rpm range (say 30,000 up to 100,000 or more), the turbine/shaft/impeller must overcome the inertia of its own weight (among other things) between the time you open the throttle and the turbine "spools up" to effective speed.

But the real complication of turbochargers is the non-linear boost curve. Let's say you want 15 pounds of boost at 5000 engine rpm. No problem. But at half that speed (2500 rpm), roughly speaking, the turbo will give only about 4 pounds of boost; and if you rev the engine up to 7500 rpm, the boost would skyrocket over 50 psi (bye bye motor). If the engine operates in a narrow rpm band (such as a diesel truck or an airplane), matching a turbo to it is relatively easy. But automobile engines—especially high performance ones—need power through a wide rpm band.

This is where turbocharging gets complicated—matching turbo speed and output with engine speed and size. There are *lots* of variables to juggle. Just considering the compressor side, each compressor has a certain efficiency range, as well as a "surge" point (since it's not a positive-displacement pump, at certain low-flow/high-pressure points the boost can begin to "back up" or "bleed back" through the rotor vanes). The efficiency range of a turbo compressor can be shown on a "map," which is a graph plotted from three variables: rotor speed, boost pressure (pressure differential across the compressor), and airflow. However, compressor speed depends directly on turbine speed, and this depends on exhaust gas flow and temperature. Turbine speed also increases exponentially compared to exhaust flow, and the turbine has a given efficiency range. Plus the compressor creates exhaust backpressure, which should be offset by increased intake manifold pressure. So you need to match the compressor output to the engine's parameters, and you need to match the turbine to the engine's exhaust output (compounded by the turbo's input on the intake side), and you need to match the turbine to the compressor. The turbo's complexity curve is beginning to match its boost curve.

Typical practice is to select a compressor (or pair of them) to deliver a certain amount of boost to a given size engine in a certain engine rpm range and in the turbo efficiency area. These numbers are estimates that hopefully get you in the ball park. Then you can adjust turbo rotor speed by changing the size of the exhaust turbine housing—this is roughly comparable to changing pulley ratios on a belt-driven blower. For all turbos a range of turbine housings is available, and they can be quickly swapped. Most are designated by an "A/R Ratio" size, which is the ratio of the exhaust inlet cross-sectional area to the scroll housing radius. The smaller the inlet opening, in proportion to housing size, the faster the turbo will spin. General practice is to start with a fairly large A/R housing, say a 1.2, and work down to a smaller size in safe increments of testing. Overboosting the engine can be fatal.



The exhaust-driven turbine fan looks a lot like a water wheel. This one turns counter-clockwise in this view.

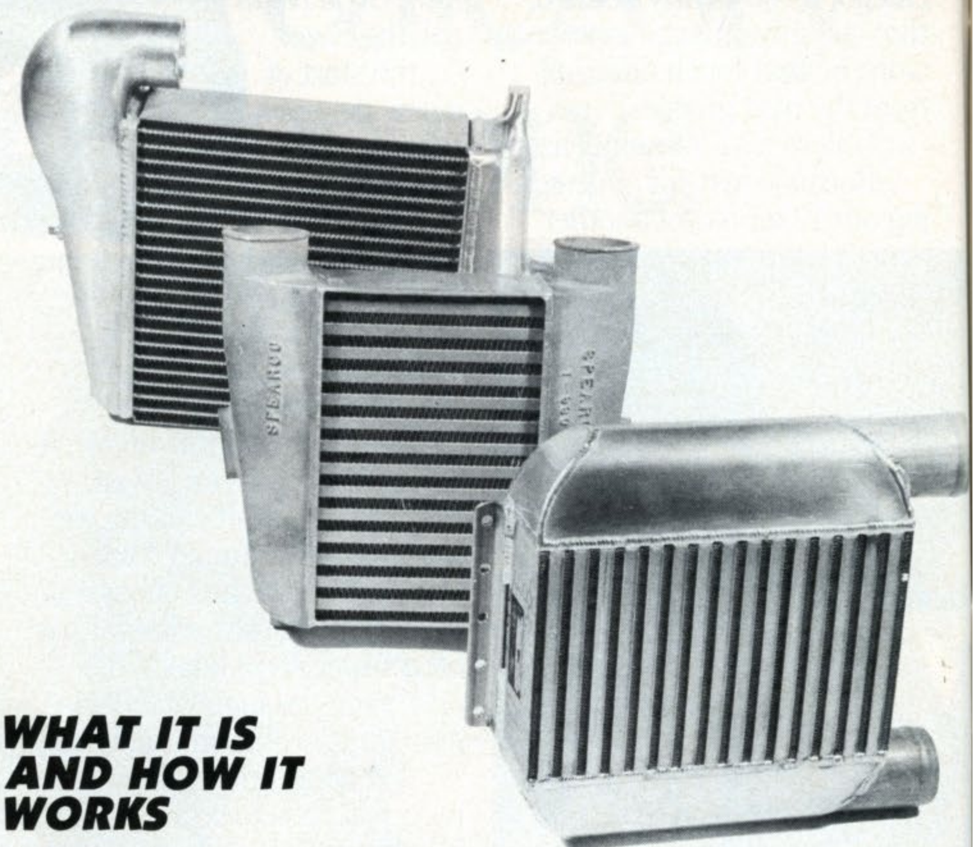
The common method for protecting against overboost, and at the same time giving a turbo a wider usable boost range, is to add a wastegate ahead of the turbine inlet. The wastegate is simply a pressure valve which diverts exhaust gases above a certain pressure around the turbo. Most wastegates are adjustable. Plus there are several other methods for adjusting or "trimming" the turbo itself, as well as controlling maximum boost by external means.

We haven't even begun to discuss particular turbocharger applications, such as dual versus single turbos, or "blow through" (the turbo pumps dry air into the carb or injectors) versus "draw through" (carburetor mounted upstream of the turbo, which pumps air/fuel mix into engine) installations. For further information, including examples of turbo maps and how to read and use them, we recommend the recently revised book *Turbochargers* by Hugh MacInnes (HP Books, P.O. Box 5367, Tucson, AZ 85703). More than that we can't say here, except that the more you learn about turbochargers, the more you'll like 'em. **HR**

TURBO

INTERCOOLING

A supercharger—such as a turbo—compresses air. Compressing air heats it. Heating air makes it expand. This is a Catch 22 inherent in supercharging.



WHAT IT IS AND HOW IT WORKS

By Pat Ganahl

Here's another approach. You put a blower on a motor to pump more air into it. But what is *more* air: more volume, more pressure, or what? Remember, air is elastic. You can measure it in cubic feet or cubic inches (volume), as we often do when playing with automotive engines. However, one cubic foot of air can have more air in it than another. This is basic physics. It's not simple, but it's basic. Consider a fixed volume of air, say a one-cubic-foot closed container with an inlet valve. There are two ways to increase the amount of air this container holds, above the amount that will fill it at room temperature and atmospheric pressure (called ambient conditons) when the valve is open. The first is to *pump* more air into it, thus increasing the pressure inside. This is what a supercharger does to get more air into the engine. The second way is to *cool* the air in the container. Cooling the air makes it contract (the molecules pack closer together); thus the air in the container shrinks, allowing more air to enter through the valve.

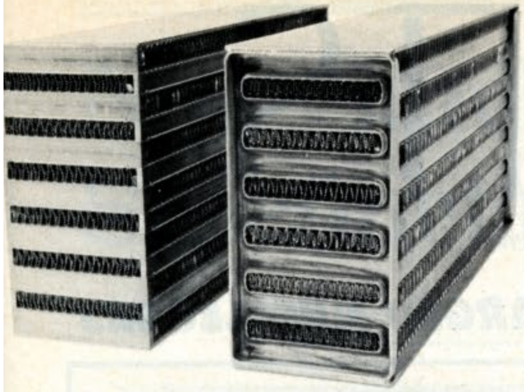
So rather than thinking of quantities of air in terms of volume (more cubic inches) or pressure (more boost), we should be trying to increase the *density* of the air going into the engine. Density is the amount of air per volume, in weight (mass); think of it as the number of molecules per cubic foot. You want the turbo or blower to increase the *density* of the intake charge.

Heating air tends to decrease its density. It can be manifest in two ways: it can increase the volume of the air at a given pressure, or it can increase the pressure of the air in a contained volume. All blowers heat the inlet charge as they create boost. Part of the heat is due to the mechanical energy consumed to pump the air (compression heats air); part is due to friction and leakage inside the blower; and in a turbo, part is transferred from the hot exhaust turbine, through the shaft, to the impeller, to the intake charge.

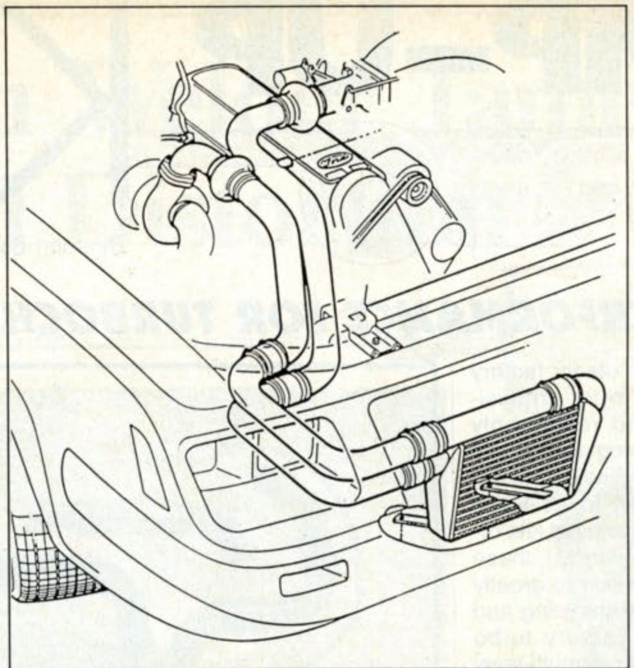
Heat is the bugaboo of supercharging. Consider our one-cubic-foot container again. At ambient pressure and temperature, the air inside will have a certain density. If we heat the air, it will try to expand. If the container is open, some of the air will escape; the pressure stays the same, but the density decreases. If the container is closed, the air cannot escape; the density stays the same, but the pressure increases. Put another way, you get "boost" in the container without any density increase in the air.

The interrelationship of temperature, pressure, volume, and density for air—governed by an equation called the "gas law"—can get confusing in a hurry. For a complete discussion of the subject as it relates to blowers, including several equations and examples, I would refer you to my book, *Street Supercharging* (S-A Design Books, Brea, California) which devotes a chapter to it. Put very simply, the bottom line is that a blower increases inlet charge density by compressing it, but partially reduces the density of the charge by heating it; the power increase afforded to the engine is roughly equal to the *net* density increase it produces in the intake system. Here's an example. A blower making 15 pounds of boost could easily be raising inlet air temperature by 180 degrees (60 degrees ambient air temp into the blower, 240 degrees out). If so, 5 of the 15 pounds of boost is due to temperature increase alone—increase of pressure without increase of density. The net result, in terms of inlet density increase, is equivalent to only 10 pounds of boost (at an increased charge temperature). This is just one way of looking at it, but you get the idea.

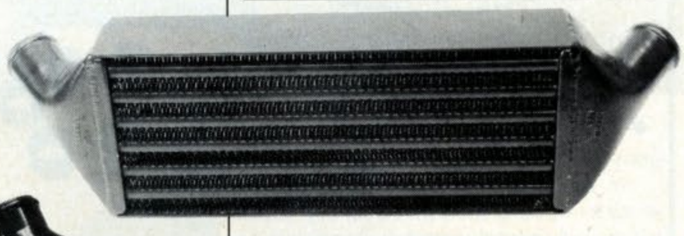
You can make the situation better in two ways. One is to use a more efficient compressor which will heat the air less in the first place. As described earlier in this section, a turbo is such a compressor. Second, why not cool the charge somehow to make it denser before it goes into the engine? With a belt-driven Roots blower mounted on the intake manifold, there's little practical way to do this. But with a turbocharger, mounting a cooling device in the ducting between the turbo and the intake manifold is not only possible, it can be very effective. Such a cooling device is commonly



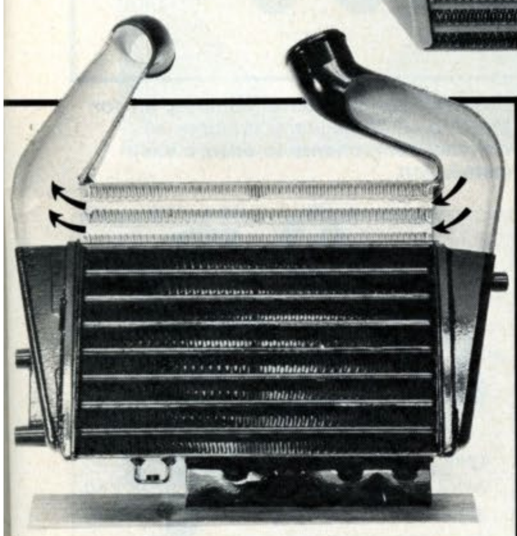
The two common types of air-to-air intercooler core construction are the "bar/plate" (left) made from flat aluminum plate, and the "flattened tube" (right), which is lighter and cheaper to make in quantity. Charge air enters the end facing the camera; cooling air flows left to right through the core. Note convection fins in tubes, and between them.



Where to mount the intercooler is the only problem. At the front of the car is best, even though it requires several feet of tubing.



This is the same AiResearch flattened tube cooler with end tanks welded in place. Fresh air flows front-to-back between the tubes; charge air flows in one tank, through the tubes, out the other tank. Installing one of these in the pipe between the turbo and the engine is really quite easy.



A cutaway of the Turbo Regal intercooler graphically shows path of charge airflow through the unit. This style of end tank, which does not rapidly increase in area, is the most efficient for compressed air flow.

called an intercooler (aftercooler or charge cooler is the same thing), and it can be any type of heat exchanger or heat-sink—any method of conducting heat out of the charge air by passing it over or through a cooler medium.

The colder the cooling medium the better, naturally. Short-distance race cars (drags, Bonneville) can use dry ice, cold water, alcohol, freon, or anything you can carry on board that will stay cold during the run. Boats have a ready source of cold water. But for most vehicles, the most practical coolant is outside air. Thus the typical intercooler is an air-to-air heat exchanger. It's similar in design and operation to the engine's radiator, except that you circulate the boost charge, rather than engine coolant, through it. Since inlet charge temperature under full boost can easily get up to 250 degrees or more, ambient air at 70 or even 100 degrees can cool it quite effectively.

The more contact (or convection) surface the cooler provides between the hot air inside and the cool air outside, the more heat transfer will take place. That is, the bigger the intercooler the better—as long as it has enough fins and/or tubes inside and out to make contact with flowing air. (Hot air flowing through an open tube or chamber is cooled only where it touches the chamber walls; adding fins is like adding more walls.) The closer the intercooler can drop the air temperature inside to that on the outside, the better its "effectiveness." For instance, if the turbo heats the air charge to 200 degrees, and the intercooler lowers it to 109 degrees, and the ambient air temperature passing over the cooler is 70 degrees, this intercooler is operating at 70-percent effectiveness. An intercooler's effectiveness depends on its size and design, and will vary with driving conditions; but under full boost, none is 100-percent effective. Typical air-to-air heat exchangers can be 70 to 80-percent effective, though.

An intercooler, as you might expect, also causes some restriction in the inlet tract. This is usually described as a pressure drop across the intercooler (between inlet and outlet). Some consider this as a loss of boost downstream from the cooler, but I prefer to think of it as a "false" increase of pressure ahead of the cooler. It's similar to backpressure caused by a muffler in an exhaust sys-

(text continued on page 147)

INTERCOOLER DO's & DON'T's

- Use the largest intercooler practical for maximum heat transfer and minimum pressure drop.
- Position the intercooler in a cool, fresh-air stream, preferably at the front of the vehicle, with unrestricted airflow ahead and behind it.
- Avoid sharp bends, especially right angles, in tubing to and from the intercooler.
- Do not mount the intercooler where it can absorb heat: in the engine compartment, above the engine, near exhaust, etc.
- An auxiliary fan behind the intercooler will ensure a steady supply of cool air, even when the car is not moving (at a stoplight; staging at drags).
- To minimize response lag on timed fuel-injection systems, preferably place throttle close to intake manifold.
- Intercoolers are not recommended for draw-through turbo systems. Not only is fuel condensation and separation a problem, but you also wouldn't want to backfire into a cooler and ducting filled with pressurized fuel and air.

INTERCOOLING

(text continued from page 33)

tem. To reduce airflow restriction in the intercooler, once again bigger is generally better.

The point is that there are some tradeoffs with intercooling. Filling the cooler with fins to increase its effectiveness would increase its flow restriction, and vice versa. Since all coolers create some pressure drop, and none is 100-percent effective, there is some break-even point where the addition of an intercooler isn't worth the money, the extra weight and plumbing, or the installation hassle. For instance Indy cars, limited to approximately 9 pounds of boost, running on cool alcohol, and using highly efficient turbos, do not use intercoolers. Likewise, a street machine or a production model with a turbo set to make a maximum of 7 to 9 pounds of boost would see only about a 10-percent increase in full-boost performance with a good intercooler (if that). This is not worth the cost and installation of an add-on intercooler.

The true benefit of an intercooler, as is finally being realized on today's production cars, is to *allow an increase in usable boost* before incurring the detonation or ping limit of the engine. For any engine, regardless of size or modification, the horsepower curve stops climbing at the point where detonation begins. The detonation point is directly related to the octane rating of the fuel being used—and the octane rating of our available pump gas is you-know-what poor. As you probably know, the detonation and pre-ignition threshold of an engine is also lowered by an increase in cylinder pressure or charge temperature—and you get both with a turbocharger. Cooling the inlet charge, as we have shown, not only lowers the temperature of the air, but it lowers the pressure for a given volume of air at the same density. That is, an intercooler allows the turbo to pump in the same amount of air at a lower temperature and pressure, thereby raising the knock limit of the engine, and thus allowing you to increase turbo boost to pump even more air in. Turning up the boost on most turbo installations is easy to do. The intercooler allows you to take advantage of it.

For example: initial Buick turbo V6's (non-intercooled) were factory set at about 7 pounds of boost maximum. The new intercooled '86 model has been cranked up to nearly 15 pounds of boost—previously unheard of for a factory application. Look at it this way. At 14½ pounds of boost, or double atmospheric pressure, the 230-inch V6 is running on the same amount of air as a 460-cubic-inch, naturally aspirated big-block. That means, under full boost, it makes the same kind of power. That's what intercooling can do for you. **HR**

TURBO

BOOSTER CLUB

Turbo Parts & Accessories Buyer's Guide

By Marlan Davis

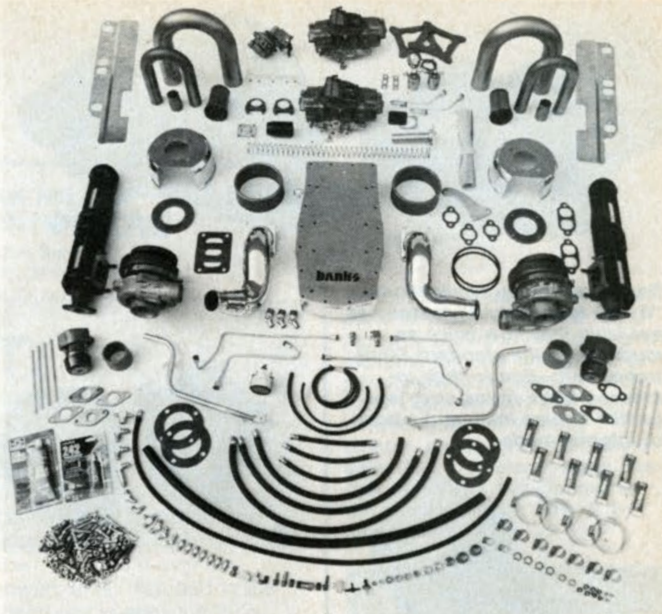
Research Assistance: Scott Dahlquist

Photography: Marlan Davis, Gray Baskerville & Pat Ganahl

Spurred by the numerous factory production turbo cars of recent years and the advent of sophisticated automotive electronic devices, the turbo industry has finally "grown up." And, as has been the case with virtually every other maturing industry, this actually means there are fewer turbocharger component businesses around today than just a few years ago. The weak sisters have fallen by the wayside, while those relatively few competent companies that gave customers their money's worth—by producing turbo parts that really work—have grown strong and prospered.

Today's kits run the gamut from diesel hop-up pieces to 2500-hp Top Fuel components. They incorporate all the hard-won accumulated knowledge of the pioneers, turbo durability advances developed to meet O.E.M. producers' reliability needs, and modern computer technology. Currently, industry leaders are gravitating towards blow-through (turbo ahead of carb) systems because of their superior throttle response and driveability. Recent advances in pressure switches and relief valves have worked the bugs out of the blow-through concept. Many augment their systems with intercoolers which, while being relatively expensive initially, have no additional moving parts to break down. Modern technology has also given us sophisticated boost retards, variable boost adjustment controls, new high-flow wastegates, and detonation-protection systems. Turbo efficiency has been improved by advances in compressor and turbine design; longevity by water cooled housings and modified lubrication systems.

For the future, expect to see the aftermarket follow the factory's lead and offer electronically controlled fuel-injected turbocharger systems. Once dialed-in, such systems eliminate all turbo lag and cold-start problems. Several aftermarket companies are already on the verge of debuting such systems. In the meantime, the following overview of major components and manufacturers presents a current look at the various state-of-the-art kits and components available for "boosting" your car's performance tenfold.



The ultimate street kit is this twin Holley blow-through system, which—depending on engine displacement and Holley carb cfm rating—can deliver up to 1100 hp on a 406-inch small-block or 1180 hp on a 454. Gale uses special annular discharge Holley carb list numbers built to his own specs by Holley, which are then further modified by GBE with an extra boost-actuated fuel enrichment circuit. The turbos are based on AiResearch TO4B's, with Banks-modified clearance tangential turbine housings.

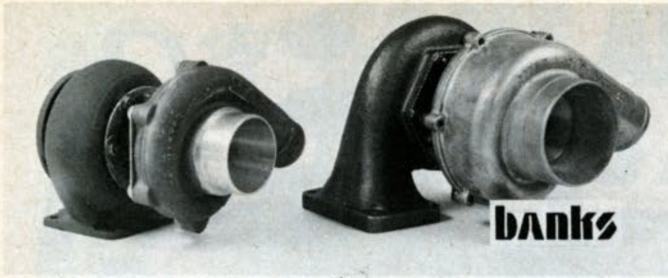
GALE BANKS ENGINEERING

546 Duggan Ave.
Azusa, CA 91702
(818) 969-9605

The premier home of turbocharged vehicles and engines of all types, Gale Banks Engineering has built everything from turbo diesels to nine-hour marine endurance engines to 2500-plus-hp Top Fuel motors. Gale's kits are designed for serious horsepower, and as such feature a number of innovative features to permit reliable street operation. "Bread and butter" kits fit the ever-popular 350 Chevrolet, and run the gamut from 500 hp all the way to 1100 hp. All are blow-through systems that deliver incredible off-the-line and top-end response. Complete turbocharged engines, as well as the turbo systems themselves, are available for purchase by the customer. The small-block engines/kits fit most Firebirds and Camaros, as well as '82 and earlier Corvettes. A 600-hp version has powered a street Firebird to over 200 mph.

New kits scheduled for mid-1986 introduction include a single turbo system for '85-'86 Camaros/Firebirds with 305 Tuned Port Injection engines, a twin-turbo TPI system for '85-'86 'Vettes, and a single turbo kit for fuel-injected S-10 Chevy/S-15 GMC pickup truck, 60-degree V6 engines. Farther down the road will be kits for the Ford Ranger/Bronco V6, and the Pontiac V6 Fiero. Besides these streetable systems, Banks continues to offer a full line of marine pleasure and racing small and big-block Chevy turbo engines and kits, and is currently involved in extended development of drag racing and endurance racing turbo technology (see Top Fuel dragster article, "Quiet Revolution," page 91). Banks is heavily into gas and diesel kits for popular trucks and RV's. Also available is on-premises engine building, kit installation, prototype work, and complete dyno testing. All Banks components may be purchased individually.

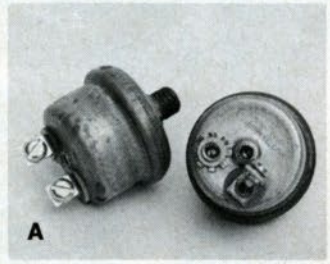
Gale is now developing kits for GM Tuned Port Injection Camaros, Firebirds, and Corvettes.

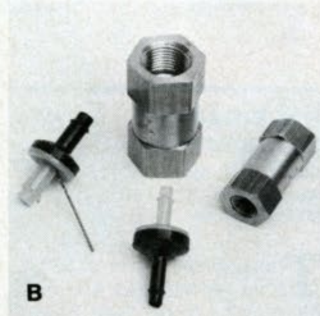


For all-out racing applications, "Banks High Output" turbos are available that flow twice as much air as the standard TO4B turbos (left)—due to their increased turbo frame size, tangential turbine inlet, and a host of internal mods.

GBE produces a large variety of wastegates, including the largest automotive wastegate in the world, shown here. Designed for all-out racing applications, up to 3-inch diameter stainless steel valves are available. Drag racing version (pictured) is all-aluminum except for stainless steel valve, offering a drastic weight reduction. Similar endurance version has ductile iron valve-guide casting.

Bank's unique water injection system does away with a separate electric motor; instead it is modulated by boost pressure after initial activation by a pre-set boost pressure switch. Various nozzle sizes and pressure switch settings are offered.





Banks carries a full line of heavy-duty pressure switches (A) useful in actuating accessories like water injection under boost pressure. Vacuum check valves (B) protect vacuum-actuated accessories under boost pressure. Valve with extra bleed hole (shown by drill bit) allows normal auto trans full-throttle vacuum-modulated shifts even under boost, since trans sees only atmospheric pressure.

One problem with streetable pressurized blow-through systems is excessive pressure buildup in the air plenum after throttle back-off or during gear changes. This can cause bucking, surging, and turbo lag when full-throttle operation is resumed. Gale uses a shuttle valve installed in the air plenum that, unlike a simple pop-off valve, actually opens before the pressure spike develops. It senses the pressure difference between the air on top of the carb butterflies and vacuum in the intake. With this system, the turbo does not have to strain against the restriction of dead air in the plenum.

Unequal-length split wishbones, anti-sway bar, and Spax coil-overs keep narrowed Ford rearend in place. Note how alternator is driven.

Solid aluminum hood sides have been "window'ed" to clear turbo snails and cause comment. Hood side's inner face has been covered with heat-resistant foil panels to keep exhaust temp from burning Indian Red paint job.

Beautiful Al Cooper-stitched interior makes passenger feel quite at home. Maris built the aluminum dash panel and fitted it with VDO, Auto Meter gauges.

WHEN MIKE MARIS REBUILT HIS DEUCE HE CHANGED EVERYTHNG—INCLUDING SWAPPING A HUFFER FOR A PAIR OF HAIR DRYERS

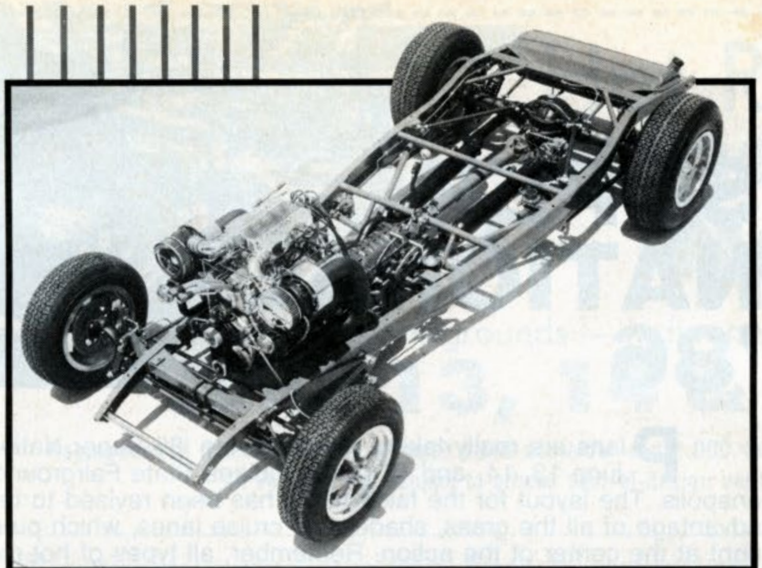
SWITCH HITTER

By Gray Baskerville

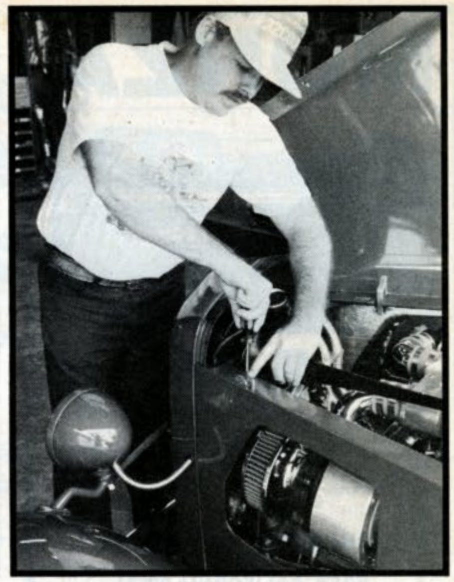
Gale Banks Engineering-built twin-turbo package was augmented by Mike's love of detail, including his hard lines and aluminum housings.

Since HOT ROD Magazine became involved with rod evaluation tests throughout the years, there appears to be a common string which ties them all together. It happens to be the fact that no self-respecting hot rod is ever finished: rodneys are constantly being rebuilt, reworked, refinished, and refinanced. So it shouldn't come as a real surprise that Mike Maris' "hot-tech" hauler bares little resemblance to what it was the instant before the front end fell off on his way to work. *(continued)*

Conventional chassis under Mike's Deuce coupe allows you to see how the rod's inner workings are laid out. Everything is new, including the repop frame, front and rear crossmembers, driveline components, and tires. The oldies are the wheels and gas tank.



SWITCH HITTER



Although three-piece aluminum hoods are a part of today's high-tech look, they remain a pain to raise and lower. Here, Mike Maris replaces the side panel after showing us how the heat-resistant inner panels were attached to the hood sides.

SPEC SHEET/'32 FORD THREE-WINDOW COUPE

ENGINE:

Engine Type	'70 Chevy V8
Displacement	302 cubic inches
Bore & Stroke	4.00 x 3.00 inches
Carburetion	Holley 800 DP modified by Gale Banks Enterprises
Compression Ratio	8.0:1
Fuel Type	Pump gas

DRIVELINE:

Transmission	Doug Nash 5-speed
Rearend	'70 Ford 9-inch narrowed 10 inches and equipped with 3.08 ring-and-pinion

CHASSIS:

Frame	'32 reproduction built by Deuce Frame Co.
Front Suspension	Vintage Axle forged I-beam (dropped 4 inches) with Deuce Factory four-link split wishbones, leaf spring, tube shocks
Rear Suspension	Solid axle with coil-over shocks, four-link rear radius rods, anti-sway bar
Brakes	Front: Edco disc Rear: Edco disc
Shocks	Front: Spax Rear: Spax coil-over
Steering	1974 Vega cross steering
Wheels	Front: American Racing (6x15 spoke) Rear: American Racing (8½x15 spoke)
Tires	Front: Goodyear Arriva (165x15) Rear: Goodyear Arriva (235x15)

MEASUREMENTS:

Overall Length	12 feet, 4 inches
Overall Width	5 feet, 7 inches
Overall Height	5 feet, 1 inch
Wheelbase	106 inches

GENERAL:

Weight	2600 pounds
Mileage	17 mpg
Color	Ditzler Indian Red
Cost	$35,000

For Maris, the changes really began about 10 years ago when he initially bought the Deuce three-window coupe from a guy in nearby La Habra, California. "The previous owner had never driven the coupe in the five years he had owned it," said Mike, "so you can imagine how I felt when a cop pulled me over while I was driving it home. I thought for sure I was going to be busted. But instead of getting a ticket, the cop just wanted to tell me that it was he who had originally rebuilt the car back in the '60s."

So for the last 10 years, Maris drove his three-window to work on a daily basis, first as a normally aspirated (carbureted) "beater," then later as a Jimmy-blown/4-speed breather. "Unfortunately, on the way to work [Maris is the plant manager for Zwick Energy Research in Huntington Beach, California] a couple of years ago, the entire front suspension broke. So I decided first to put a new frame under the same old body. Then one thing led to another and I ended up changing everything except the wheels."

To Mike, changes aren't simple-minded things like adding blue dots to your taillight lenses or having someone engrave your wind wings. Mike made a series of really big moves, like chopping the top, buying one of Deuce Roy's chassis, and best of all, a real, run-of-the-mill switcheroo: Mike replaced the 6-71 Jimmy-jammed 350/4-speed combo with a twin-turbocharged 302/Doug Nash 5-speed package resulting in some thought-provoking contrasts that might be of interest to our readers.

"I had gotten to know Gale Banks through my association with Bruce Geisler [Banks and Geisler have been close friends since the dawn of time] because it was Bruce who helped me put together my blown 350. While we were up at Bonneville crewing for Bruce, Banks talked me into turbocharging my coupe. I had always wanted a trick engine; you know, Carrillo rods, good crank . . . but I couldn't afford to do it again."

So Mike assembled his trick engine—a 302-inch Chevy V8 based on a '70 cylinder block—and filled it with all those things he'd always wanted: Carrillo rods, a full-on Hank the Crank stock stroker, and naturally, one of Banks' complete kits including the cam, pistons, modified carburetor, a brace of hair dryers, and all the support elements one would need to complete the conversion, with the exception of the exhaust system. Mike did those twice. "I screwed up the first set when I didn't leave enough room to get at the spark plugs."

So now it was time to do our thing, and although I love three-windows, they scare the bejeezus out of me. Three-windows have front-opening doors, and front-opening doors have a nasty habit of coming unlatched with berserko results . . . like have you ever seen a door wrapped around a rear tire? So has Mike. In fact, the door on the driver's side unglued itself on the rod's maiden voyage, and only a valiant save by Maris kept the thing from bouncing off the rear fender and ending up on the San Diego Freeway. So Maris installed a pair of auxiliary latches, which one must contend with as soon as the shotgun position has been assumed. Then it was time

(continued on page 148)

SWITCH HITTER

(continued from page 111)

to launch into Beach Boulevard for some serious cruising. Your first impression is that Maris hasn't totally forgotten the whine of his Jimmy blower. You see, he's installed one of Pete Jackson's gear drives, which gives off that distinctive square-cut gear yowl. Aside from the gear drive, the cockpit noise level is quite low, even to the extent of being luxury-car quiet. You can actually hear the mellow tones of the turbo-type exhaust system, which continue to remind the passenger that he's still in a hot rod, not a wimpy stocker.

Then it's a quick right on Slater for a little "hot-power" demonstration. Again Mike shakes it easy. The McLeod "twin-disc" street clutch ("These double-disc clutches are such a nice, soft unit," says Maris) is one of these in-or-out models which, according to Mike, "Takes some getting used to." If the driver hits the throttle too hard and pops the clutch, it's instant smoke. If, on the other hand, the driver eases it out, then the engine wants to bog. So, finding the middle ground between go and no-go requires a certain amount of "pedal dexterity." But does this lil' red sucker pull in second, third, fourth, and fifth! I mean, this motor builds off-idle torque in an ever-increasing curve, and when the engine comes down off of boost, there's that incredible whistle which sounds like a tire going flat.

But freeway driving is what Mike had in mind when he emptied his exchequer and totally rebuilt, reworked, refined, and refinanced his coupe. The worst thing about freeway driving is the 55-mph speed limit. At 55, Mike's tach is reading below 2000 rpm, and this thing doesn't want to run until the needle swings past 2200—which computes to 70-plus on the dream wheel. So Mike keeps 'er in fourth, remains happy with its 17 mpg, and heads for another rod run "over there."

When asked about the differences between the two powerplants, Mike doesn't hesitate to state his opinion. "Even though the coupe was easier to drive with the blown 350 because it made more low-speed torque, the turbo motor is far more deadly. So I've really got to watch the rpm's because when it gets into boost, especially in the higher gears, things begin to happen too quickly . . . and I know I can't afford to buy any more parts."

Because Mike has seen fit to stick the twin "snails" through the hood sides, people have a hard time dealing with what they don't understand. In fact, one guy asked Mike why his car needed two alternators. Maybe Mike should have taken him for a *ride* in his Deuce to show the unsuspecting numbskull what happens when you get turbo'ed on! **HR**

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