Cycle®

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Laverda Jota 1000 Triple

Yamaha IT250J

Kawasaki's GPz550

Single-Shock Speedster

Turbo Outrage! Suzuki 1100 Puffer

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February 1982 Volume XXXIII No. 2

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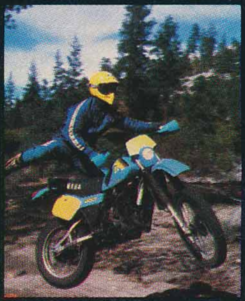

pg.47

This Month's Cover: Here you see the Kawasaki GPz550 at speed and at tilt; what you do not see is its single-shock rear suspension, tucked neatly away and hard at work thanks to Mark Homchick. Yes, he's paid to gas-it-up. The Dave Hawkins Magic Brownie catches the bend-it-over action and what's *not* there anymore—the twin shocks. The road test begins on page 28.

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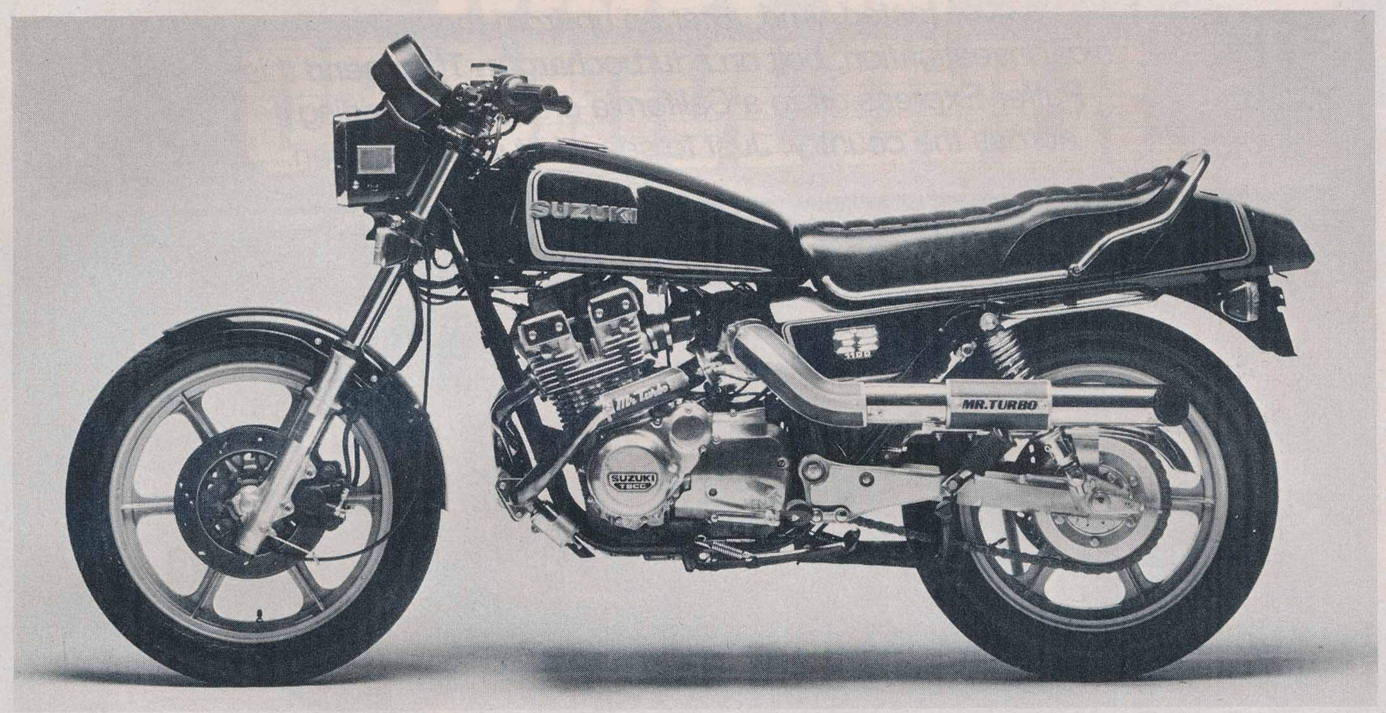
PROJECT EXPRESS

Some ideas are irresistible. Take the meanest, hardest-running street bike we've ever tested. And, after an up-from-the-crankcases technical investigation, bolt on a turbocharger. Then send this Puffer Express off to a California drag strip by riding it across the country. Just to see what would happen.

PROJECT EXPRESS

BOOST FROM THE GROUND UP

By Kevin Cameron



PHOTOGRAPHY: STEVE BROADDUS, JOHN OWENS

> *180 horsepower. Your casual, modest, unassuming 180-horsepower GS1100. This bike lets you twist the throttle and points you to the stars. The Good Plan means building an engine up to turbocharging rather than quickly slapping the puffer kit on.*

● EVERY WORKDAY EVENING WHEN THE sun is low, the crowded trains and buses glide up to their suburban stops to disgorge cargoes of people tired out from earning the money to live. An hour or two later the TVs light up the livingrooms and the smells of another dinner fade away. Soon Dad will be asleep in his chair.

Being frozen into a meaningless job, riding the bus in suspended animation—this static security can congeal the life and motion right out of you, like those dreams in which you desperately try to run but can hardly move a millimeter. Life is motion, and for the young particularly, velocity is a convenient metaphor of living fully. To leave the frozen dream behind there are those who will lay out all the money they have on machinery that can move them.

Ten years ago that was a big-block Chevy high-riser in a stripped Nova chassis. Today's shrunken dollar puts that 11-second street car out of reach and today's life puts it out of style. Far less money will buy a motorcycle that is worlds faster than any car.

How fast is fast enough? The old racer's expression holds that too much is just enough, but the average motorcycle buyer of the 1980s is pulling back from the 1000cc level. *Too much,* a lot of riders seem to say. *Give me a lighter, handier 750 or 550, something in reasonable human scale.*

Yet for a small and special group of enthusiasts too much is only the beginning. And what is the end? To have a big-inch, turbocharged, fire-on-warning missile that can pierce the gray barrier of ordinary experience. Zero on the turbo boost gauge is already too much, and there is a big, bright territory beyond. The 85-mph speedometer just tells the rider that the engine is running.

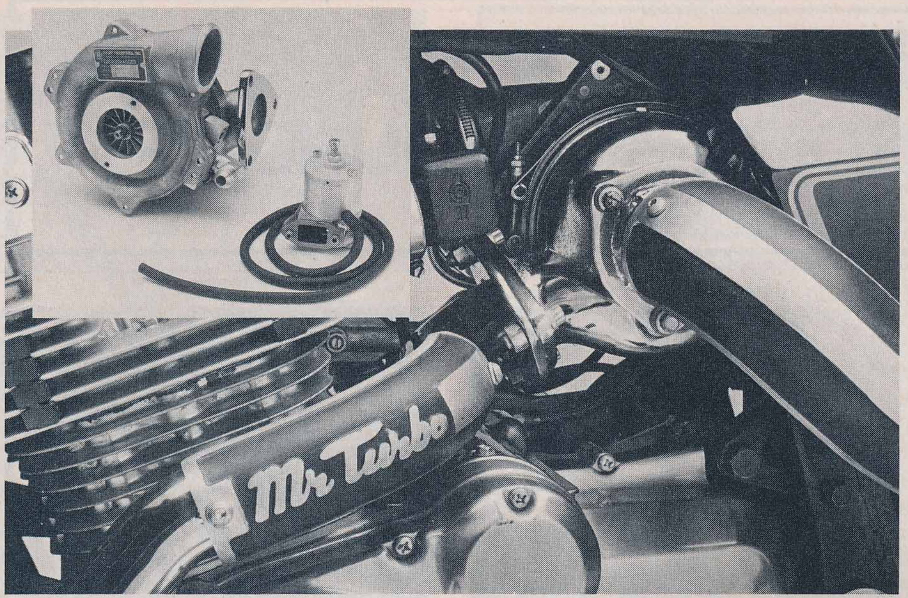
Who are these partisans of excess? Most are young; all have plenty of money to spend. One I know spends his weekdays in the financial canyons of Wall Street. On weekends, his turbo-CBX offers prompt, temporary relief from workday symptoms.

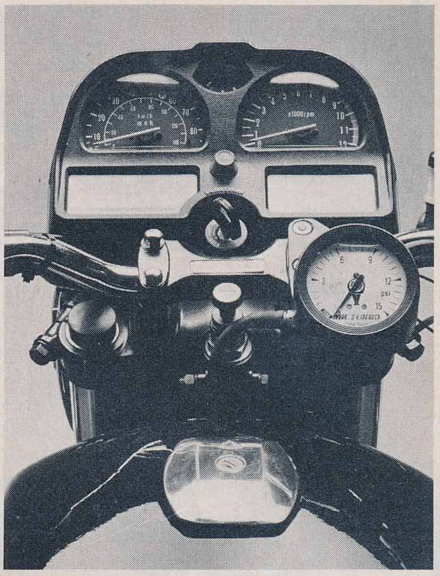
Woven deeper into the fabric of life is the night-world of the long, empty avenues and the 24-hour burger havens. Where the machines are parked, plinking quietly as they cool, there are small groups of men talking. Every owner has assumed a colorful title in this special knighthood, a name like Toolbox, Plugwrench, or Valvespring. Challenges are made and accepted, with serious money riding on the outcome. The place is agreed upon and there follows a quiet ride out and then the quick dash down the borrowed asphalt.

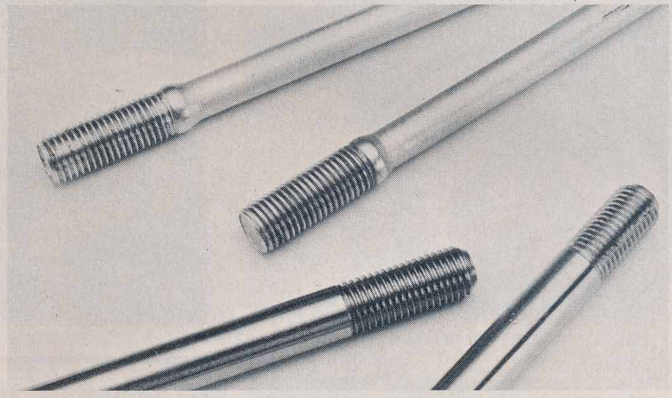
Stock machines lose their owners a lot of money in this kind of drag racing. If you are accepted into one of these circles you soon discover that although all the scooters are fast, some are faster than others. The owners of the less fast become uneasy. If life is motion, who wants to lag behind?

And so the telephone on the wall of the speedshop rings. The exact language of the call varies, but the substance is always the same.

"Look, I'm getting blown off all the time. Blown off bad. I've got two grand, maybe I can get up a little more. How







fast can I go for that much? I got to go real fast. Can I bring my bike down there right away?''

Performance shops can be found in every city, and many of them flower in spring, flourish through summer, and die at first frost. It's hard to combine the sheer enthusiasm of racing with the bottom-line seriousness of business. One shop that has succeeded is Orient Express, located a few miles from New York City out on Long Island. Owner Jack O'Malley and his several employees, all racers or ex-racers, build engines to order for customers all over the world. Their specialty is turbocharging for the street, and their reputation persuaded *Cycle* that it was time to investigate one of these too-much motorcycles—a turbo-kitted Suzuki GS1100.

The Orient shop is a rabbit-warren of tiny, brightly lit rooms, each devoted to a special function. Aside from Jack O'Malley's desk, the only furniture is machine tools. There is no fat on this business; it is as lean and densely packed as the interior of a submarine. Clearly, building a turbo-bike is not a hobby-time project to be completed in 45 minutes using only a pair of pliers and a screwdriver.

Jack's people began removing the engine from the Suzuki while he outlined what would be done. He noted that a supercharged engine gets its horsepower gain by raising combustion pressure, for it turns no more rpm than does a normally aspirated performance engine. Combustion pressure may be more than doubled by high turbo boost, so the first requirement of a successful conversion is containment of this pressure. The piston rings must not leak and the head gasket must not blow.

The 180-horsepower package includes, among other things, a Rajay unit and Mr. Turbo's plumbing and fixtures. Shown with their stock counterparts are a 7.8 to 1 Wiseco forged piston (right) and the Precision Machining cylinder head studs (bottom).

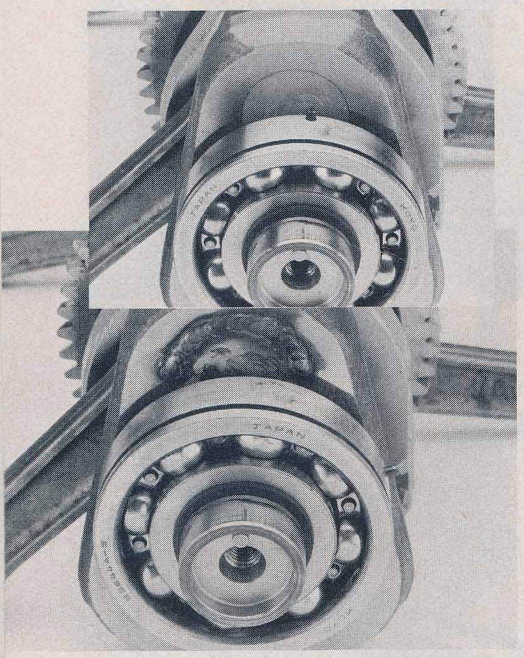
Every engine to be kitted receives a clean-up rebore and is fitted with oversize pistons that have compression ratios lower than stock. This reduction is needed because part of the compression will now occur inside the turbo's compressor. This, on top of a high stock compression ratio, would add up to destructive detonation.

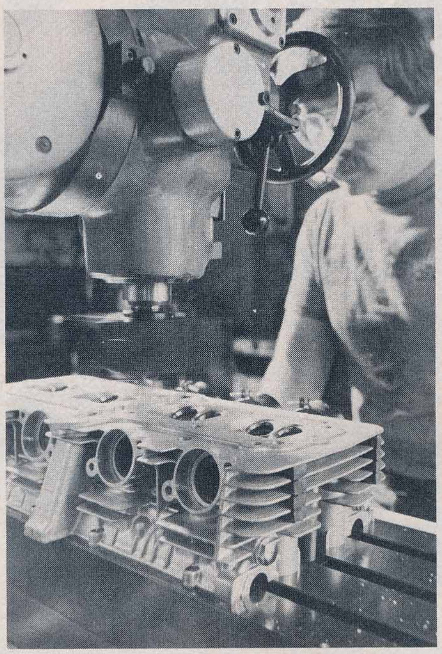
Orient has learned the lesson every shop trying to do good work at affordable prices has learned—only first-class equipment will do the job. It's true that an experienced craftsman, taking his (and the customer's) time, can extract good work from shaky equipment. It's also true that when that craftsman comes to work on Monday with a bad headache, you will see it in his work. Better to have the precision built into the machines.

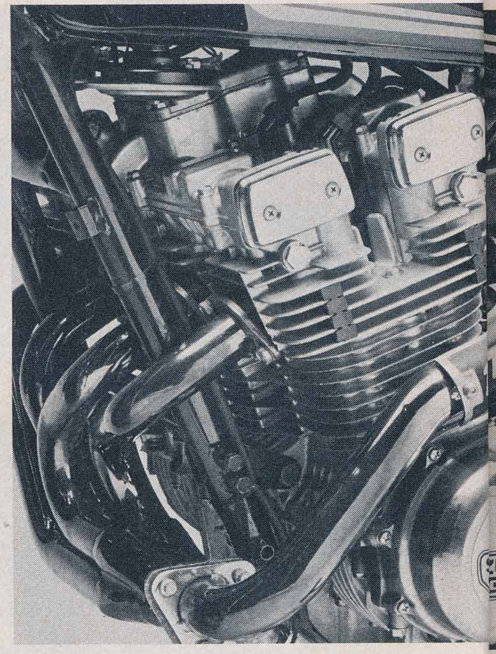
A lot of precision is required. A cylinder that's tapered or out-of-round by a half of a thousandth could destroy the ring seal in a turbo engine, showing up as an excessive leakage rate on a leakdown tester. Avoiding this requires working to a tenth of a thousandth on every cylinder—a tall order. It's filled by two solid Kwik-Way boring machines backed up by a horizontal-spindle Sunnen honing machine with a cabinet full of mandrels and stones. Final bore finish is cut with 550 stones, using a cross-hatch pattern flatter than the traditional 60 degrees.

Our Suzuki was to be overbored three millimeters, bringing it from

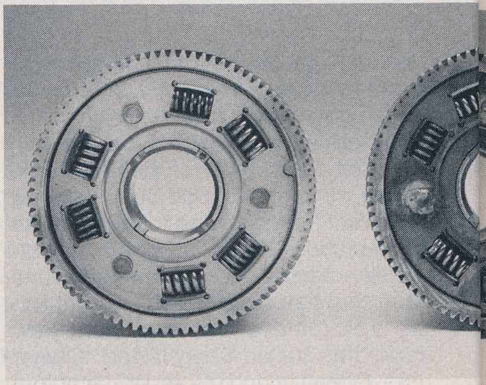
PROJECT EXPRESS
BOOST FROM THE GROUND UP







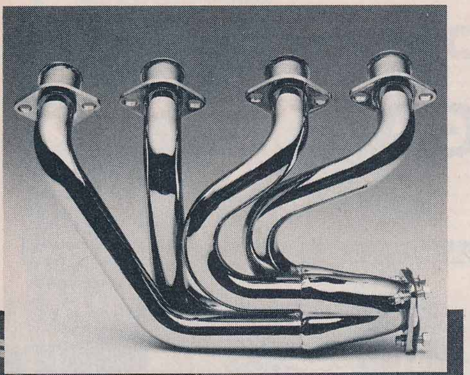
To prevent the crankshaft from twisting, crankpins are welded to the flywheels. Cylinder head gets a deck cleanup. Clutch baskets, left to right, are stock, modified, and a special construction model.

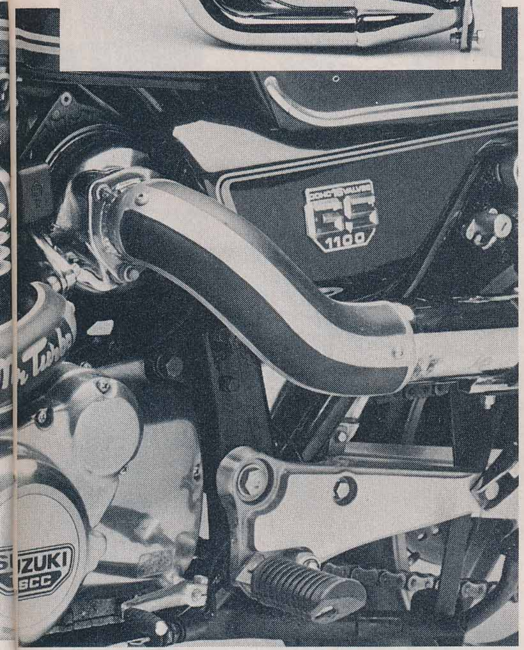


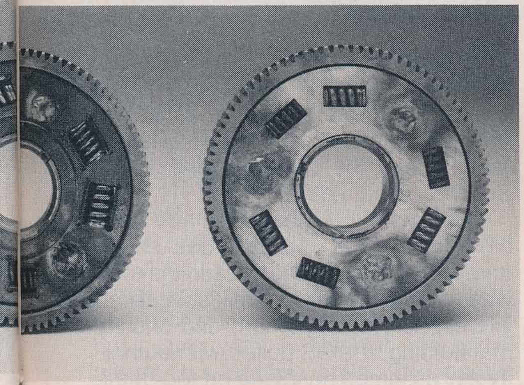
1083cc up to 1165cc, an eight percent increase. While the cylinder was being bored, the head went to the milling machine to receive a clean-up deck finish, removing slight production waviness that could produce uneven head gasket sealing. The cylinder, too, would receive the same treatment. While the cutter incised its bright path across the head, I looked over the pistons. These forged Wisecos would cut compression from the stock 9.5 to 7.8, less severe a drop than in most turbo conversions. The piston crowns were perfectly flat save for very slight valve cutouts. The 1.2mm second ring and 1.5mm oil ring were similar to stock, but the top ring was a special tool-steel, heat-resisting 1.0mm Pacific Piston Ring item.

There were the substantial Suzuki 1100 con-rods projecting from the crankcase, and their small-ends had neither bronze bushings nor copper plating to protect them from galling on the wristpin. How does this work? The pin is treated by the Parco-Lubrite process, and this is fine for stock wristpin loads. For turbo pressure, Wiseco supplies an extruded steel pin with a very fine interior finish (no stress-raisers here) and a bearing surface that is flash-chrome plated. The extreme hardness of the chrome makes a good friction surface for the tough but much softer steel of the rod's small-end.

Between the grip of the tire on the road and the turbo-multiplied pressure on the piston stands the crankshaft, a pressed-together ball- and roller-bearing unit. When the clutch bites, the crank can twist at its joints. Severe vibration warns the rider; proof comes when next he tries to set the ignition timing, and the pistons no longer come to top center in pairs. Although this problem is worst when sticky tires and strong clutches are used in hard drag-strip launches, it is not unknown on the street. Out came the Suzuki's crank to have its pressed joints welded. To preserve the bearings and seals from excess welding heat, Orient uses the TIG method to fuse crankpin material to the flywheels quickly and solidly. I was cautioned that it's best never to remove a factory-installed alternator rotor from its place on the crank end; despite pre-







cautions such as lapping and Loctite, a replaced rotor frequently loosens, galling the shaft.

While the cases were apart, O'Malley examined the transmission for correct dog engagement depth. A shift missed under turbo boost can send rpm instantly out of sight, so a sure-shifting gearbox is essential in the preparation. To prepare shims of special thickness when needed for repositioning gears on their shafts, Orient has a Harig surface grinder with a magnetic chuck.

Once the welded crank and inspected gearbox were ready, O'Malley assembled the crankcase. To my surprise, he used no gasket cement, explaining that cement squeezed from the

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THE DRAG-STRIP AUTOMATIC

Missed shifts are a special danger to high-performance engines because (a) there is more combustion pressure to spin up the crank when the load is accidentally disconnected and (b) the crank itself is often a special light racing part that accelerates more easily anyway.

Because of its ability to double or triple combustion pressure, supercharging makes the consequences of missed shifts far worse, for now rpm leaps into the destruct zone before human reflexes can stop it.

Drag-racing shifts are not made with the usual sequence (closing the throttle, pulling in the clutch, operating the shift lever, and so on); that would take too long, and the many steps involved would invite human error. Instead, the clutch is untouched and the throttle stays open as the rider simply jabs the shift lever. Internally, the sequence is as follows: First, the shift drum pulls the gear pair that is driving the machine out of engagement, releasing the engine from the load. Naturally engine rpm shoots up now if the throttle is not snapped back or the kill button thumbed. Next, continued rotation of the shift drum begins to push the engaging dogs of the next higher gear pair toward each other. As these dogs collide there is quite a bang, because the speeds of the two sets are not matched; the engine has been accelerating during its short period of being unloaded. Even if the dogs go straight together there is heavy shock, and if they crash past one another a few times on the way in, they sustain some damage. It is to prevent or limit this dog damage that racers may roll the throttle off slightly or use a kill button at the instant of shifting.

No matter how quickly this process is carried out, there is still a short time when the engine is not connected to the load; the machine is coasting down the strip while the gear dogs move out of engagement in one gear, then back into engagement in the next. Naturally this "dead time" was of great concern to racers. To shorten it up as much as possible, designers invented the air shifter. This is nothing but a mechanical foot driven by air pressure which executes the shift in a very short time and in a positive manner. When it's time to shift, the rider punches a button and air pressure does the rest.

This was fine because it eliminated drag-strip maladies such as slow foot and left-wrist paralysis. Its rapid action did a lot to prevent missed shifts, too.

There were still problems. The shift mechanism takes time to move, no matter how great the force driving it. Even though the air-shifter reduced engine dead-time, the stock gears were still stock. Despite frequent trips to the Magnaflux station, gears broke constantly under racing pressure.

How much engine dead-time is there? Even if it is less than a tenth of a

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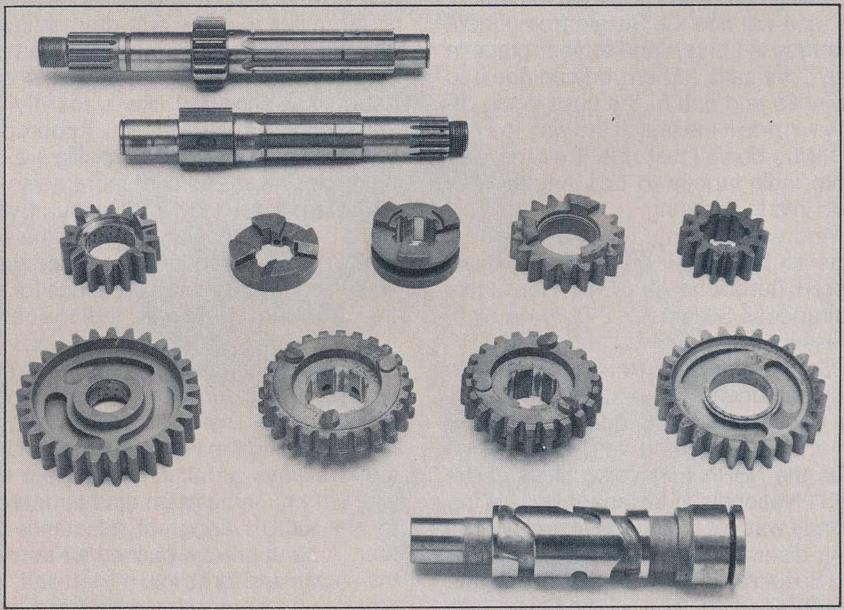
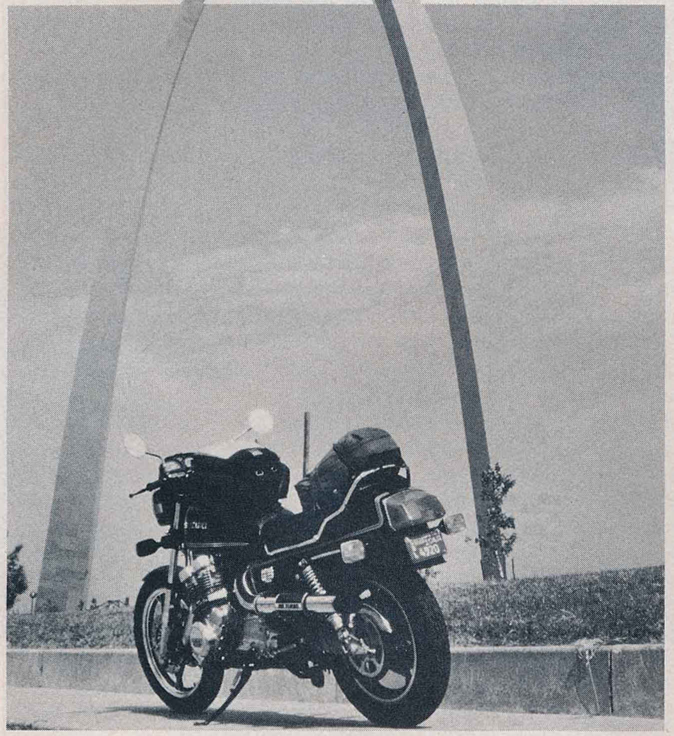
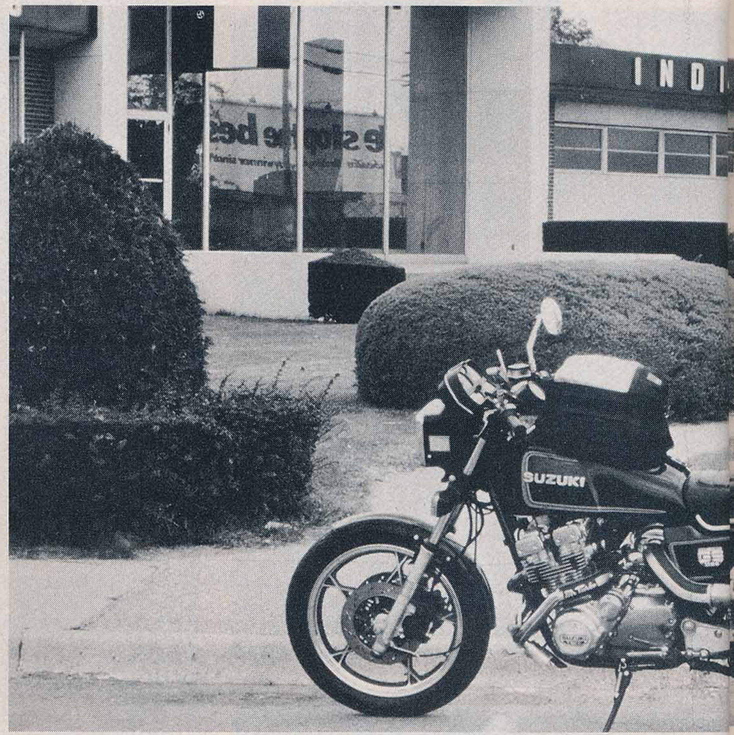


PROJECT EXPRESS
HEAVEN'S WASTE GATE

By Riley Tharp

PHOTOGRAPHY: RILEY THARP





● "IF YOU PULL TOO MUCH BOOST WITH BAD gas it'll melt the pistons. And watch the oil; the turbo needs lots of oil."

As I listened to Jon Baugh's admonitions about the turbocharged GS1100, I wondered if it would ever make it to California. Indeed, I wondered how I had gotten involved in a turbo tour at all. Schilling had called a few days earlier.

"Jon will ride the Suzuki from Orient Express in Long Island to your place in Indy," he said. "Then you can ride it to Amarillo and one of the guys in the office will ride it the rest of the way to LA."

"Why don't I just ride it all the way from Indianapolis to Los Angeles?" I said in a fit of daring.

And with that, my fate was sealed. I was to ride a Manley-valved, overbored, turbocharged and thoroughly outrageous Suzuki GS1100 on a high-pressure cross-country tour.

Getting the bike from New York to Indy had been a real adventure for Jon. He usually rides one quarter-mile at a time, and he does it very well. Baugh won the NHRA Funnybike class at the 1981 Nationals in Indianapolis. This trip to Indy was his first by bike, and his first long-distance ride. Both racer Jon and the Suzuki arrived in one piece, and that encouraged me. The GS, however, was still suffering some shakedown pains. As Jon and I serviced the bike for the next leg, we fiddled with the Keihin carb in an attempt to better the 25-mpg performance Jon experienced on his ride.

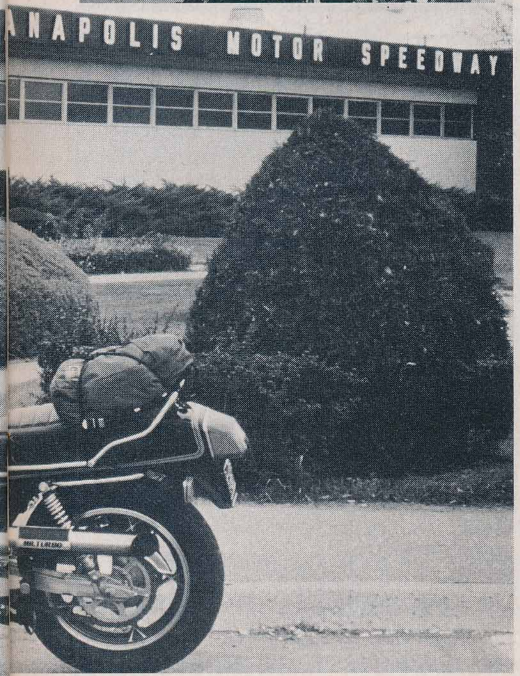
With the preparations finished, it was time to go separate directions. Jon headed for New York in a rent-a-racer, and I grabbed a fitful sleep wondering just how fast a motorcycle could be.

Ten miles into the first day I knew I wouldn't be alone; following me was a constant drone from the Suzuki's exhaust that sounded like a low-flying Cessna. This particular Mr. Turbo conversion was installed *sans* baffle—a little more power and a lot more noise—which ruled out a low-profile tour. Even good ear plugs couldn't provide the serenity I prefer for touring, and I certainly wasn't carrying enough ear plugs for all the troopers between Indiana and California.

Los Angeles seemed remote at my first gas stop in Terre Haute. My feelings about the ride were still a strange mixture. Crossing the vast middle of America is always an alluring prospect for me, yet my enthusiasm was tempered by the turbo's apparent reluctance to tour. A stout breeze pushed air across the engine and turbo into my left calf, so I baked in sympathy with the high-strung powerhouse. Our tinkering had only slightly improved gas mileage, coaxing it into the low 30s. All this seemed so unlike a GS1100, and I had yet to experience the turbo blammo that caused the compromises to the Suzuki's good nature.

Then, near Effingham, I made bubbles. Tall rows of corn past both shoulders seemed to still the air, and the road was flat and straight for miles. I gassed it. Despite the single carb and chunky manifolding, the GS pulled with authority as I assumed my place on top of the tank bag. The bike was still in top gear, so two or three seconds lapsed before the turbo could work. As the tach needle swept past 4300 rpm, I noticed a spritz of tiny bubbles in the damping oil inside the boost gauge—the result of pressure beginning to build in the intake manifold. No sooner had they appeared in my peripheral vision than the Suzuki tensed. The entire chassis seemed to tighten and strain as a frenzied rush of power clawed through the tire and thrust the bike forward. Since the speedometer was long pegged, my widened eyes watched the tach needle climb with awesome speed to 9300 rpm. Then I shut it down.

Instantly, my mind was flooded with new impressions. So that's what this bike is all about. Twist the throttle, wait



for the bubbles; and then hang on while your entire perspective of two-wheel performance is forever altered.

I was euphoric. As I slowed to semi-legal speeds, I wondered if humans are allowed to have so much fun. In spite of my new game of bubble-and-run, I quickly settled back into skepticism about the turbo as a cross-country ride. It was like listening to Eddie Van Halen play rock guitar. The energy is exciting, but I don't want to listen to the entire album. It's not my style. The gentle samba of a plush touring bike seems better suited to the continent beyond the Suzuki's instruments.

St. Louis is called the gateway to the West, and the Jefferson Memorial arch glistens by the Mississippi to welcome all travelers. While resting in the adjoining park, I imagined what the Wizard of Monticello would think of this engineering marvel. And what would he think of the turbo-Suzuki? A voice inside me whispered, "If you don't slow down you might get to ask him soon." But I decided that temperance and turbocharging do not travel the same road.

As the hollows of the Missouri hills turned deep blue with the fading sun, I was reminded how short the early fall days had become. Sunset, Joplin and the end of the first day all arrived to the

AUTOMATIC

second, with three or four shifts per run it adds up. One horsepower is 550 pounds-feet per second, and let's say that our turbocharged drag engine produces an average of 250 horsepower. That's 137,500 pounds-feet (550 x 250) of energy per second, or in an eight-second run, a total of 1,100,000 pounds-feet available to accelerate our machine if the engine is running and connected to the load all the way.

In fact it is not. Let's optimistically say that each shift has a dead-time of 0.05 second, and that we are making four shifts. That gives a total of 0.2 seconds (4 x 0.05) during which the engine is not driving the rear wheel, meaning that 27,500 pounds-feet (550 x 250 x 0.2) of engine energy never reaches the rear wheel. That's enough to throw machine and rider 50 feet into the air—quite a kick just to waste. Yes, it's silly, but what could be done about it?

A diligent student of the Honda 750 showed the way. While inspecting his engine one day he put the two gear shafts into the lower crankcase without the shift forks or drum. Idly he slid the first gear dogs into engagement and turned the front shaft. When he turned it forward, the dogs took up their backlash and began to drive on their driving faces (those that carry the load when the machine is under power). When he turned it backward, the driving faces parted, the dogs took up their backlash in the opposite direction, and then began to drive on their overrun faces (the faces that carry the load when the rear wheel drives the engine on the overrun).

Next he accidentally discovered something; he engaged the dogs for second gear as well as those for first (normally the shift drum and forks prevent such a double engagement). In a running engine, engaging two gears at once would try to turn the output shaft at two different speeds at once, which is impossible. The gearbox would either lock up immediately or break.

But our Honda racer was doing all this in slow motion. With first gear driving and second loosely engaged, he again turned the front shaft. As he did so, the second gear dog set took up its backlash and began to drive the output shaft at a speed faster than the first gear had just been turning it. The first gear was left behind, so its dogs backed up through their backlash until they made solid contact on their overrun races, locking the transmission solid; second's dogs were engaged on their drive faces, first's backed up against their overrun faces. Now our man had an idea. What if I cut a 45-degree chamfer on the overrun faces of those dogs? Instead of locking up the gearbox, they would automatically kick themselves out of engagement, just like a ratchet turned backward. Oh no, it wouldn't work because the gears are held in position by the shift fork's guide pin in its slot in the shifter drum. Oh well. But wait! What if I made the slot in the shifter drum wider just there—then I'd get just what I wanted. I could engage second while first was still driving, and first would kick itself out of engagement without any damage. And there would be zero engine dead-time.

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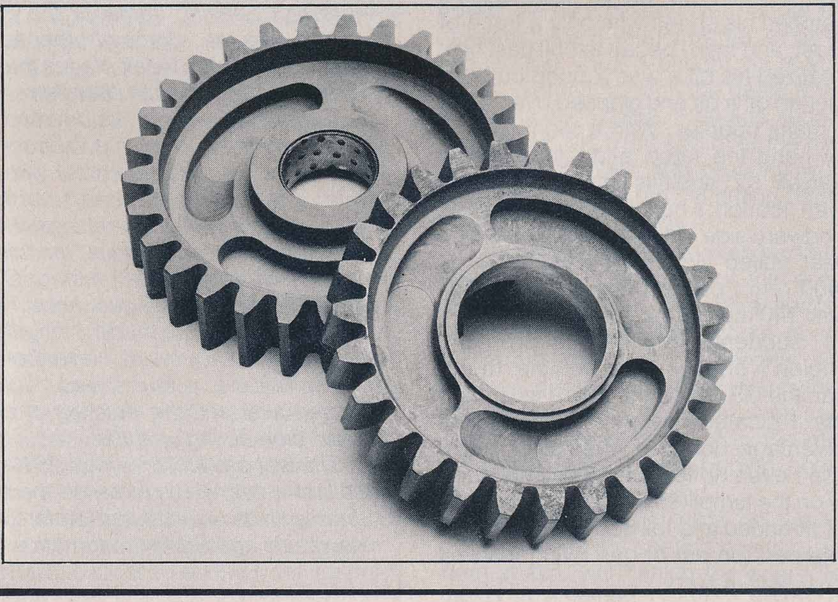


piping of crickets. I wondered, were they answering the shrill note of the turbo, or was their vibrant song in lament of an imminent, frosty demise?

Ambivalence still prevailed at the start of the second day. The thrills the GS could produce made the call of the road more inviting, yet its harsh side was the price for the powerful ride. Starting required numerous throttle twists to the pumper carb since no choke was provided, and I was sure the gasping, barking warm-up had awakened everyone in the little motel. I hastily left the parking lot and entered the chill of the open road. The turbo-Suzuki was a very demanding companion. Cold and sleepy, I wanted two easy hours of riding while the sun warmed the air, but the turbo growled at me in protest of being ridden slowly. Between 55 and 65 mph, the Suzuki's exhaust note became an angry blat. Above these speeds the engine quieted down a bit, and lower speeds softened the blat to a deep rumble. Compromises. Definitely compromises. And with that I stopped for breakfast.

While the sun came up in the east, a strong wind came up from the west. By the time I was on the Will Rogers Turnpike in Oklahoma, I realized the turbo and I were in for a rough day.

Soon, however, I was challenged by something other than distance and wind. As I pulled out from a gas stop, a traveler on a KZ1000 flashed by in the fast lane. When I caught up and matched his speed we exchanged glances. As his eyes scanned the turbo, I felt my cheeks push against the inside of my helmet—the result of a wide grin. We played roll-on tag a few times and then he stayed on it. The Suzuki matched his speed with only a trace of boost, and then I began to pull past him. I realized his bike was topped out, so I backed off a bit and glanced over. Time to make bubbles. With a slight twist of my hand the turbo and I leapt away from Mr. KZ, and this time I stayed on it. Even though I hunched down on the windward side of the tank bag, the wind blast pulled violently on the bike. At 9400 rpm I backed down. That's well over 140 mph into a strong wind.

I suddenly realized I probably wouldn't encounter a vehicle faster than the GS during the entire westward ride. I gloated heavily on this tactical advantage during a brief stop, and I didn't even notice the other rider pass by on the turnpike. A bit later I found Mr. KZ stranded at a toll booth, claiming his bike had run out of gas trying to keep up. Gee, I'm sorry.

After Tulsa it was time to leave the highway for a hundred-mile stretch of old Route 66 into Oklahoma City. This road bobs and weaves through the last woodlands I would see until Flagstaff. The chassis behaved with typical GS aplomb, but I saved the turbo's power until the bike was completely vertical. I motored out of turns just below boost range because I feared the consequences of a sudden power surge; my overall approach to the twisties was slower than my attack speed on a normally aspirated machine.But the turbo's ability to make the front wheel dance in any gear made the ride every bit as exciting.

Halfway to Oklahoma City I slowed down. Café riding isn't what a turbo does best, and Los Angeles was still a long way off.

Throttling back gave me more time to notice the dated and abandoned

(Continued on page 91)

AUTOMATIC

Our hero did just this, and he was rewarded with the fastest-shifting drag transmission ever seen. Unfortunately, the Honda transmission has some gears with dogs for one ratio on one face, and those for the next ratio on the other face. In these cases, there is no way to use this idea; such a gear has to disengage before it can begin to engage the next ratio. This modification of course made the transmission useless for any but drag-strip use; closing the throttle in any gear but top instantly shifted the gearbox into neutral when the driving dogs backed up against their chamfered overrun faces.

There were other small problems. With the shift-drum slots made wider to permit automatic disengagement, what would hold the gears in the right position for transmitting power? The answer was ball-and-spring detents in the shafts, locking into dimples on the I.D. (inside diameter) of each sliding gear. These detents were strong enough to resist accidental disengagement, weak enough to offer no resistance to the automatic disengagement.

Jack O'Malley of Orient Express decided that gearbox failures and the waste of engine dead-time had irritated him long enough. He would, he decided, build himself a special transmission that would solve all these problems, not just reduce them a little. No more exploded second gears. No more mollycoddling weak transmissions to eke out a few more runs. No more big pieces on the drainplug magnet.

First, it would have four speeds, not five. That would allow each gear to be 25 percent wider than before, a valuable gain in strength. Second, it would have the automatic disengagement feature on all three shifts, so the engine would be connected to the load 100 percent of the time. Away with that 0.2 second of dead-time. Third, the gears and shafts would be made from the best available material for the job. He chose double-vacuum remelted 9310, a gear steel toughened by a high nickel content and fortified against fatigue by the purity resulting from vacuum remelting.

The high carbon content of iron is oxidized out in the steelmaking process to a level low enough for toughness and strength, but high enough for hardenability. Leaving some of the carbon in the steel also leaves many other atomic species, atoms of other substances that don't fit into the crystal structure. This creates weak places that act as nuclei for crack growth. The fewer of these crack nucleation sites there are, the longer the material can endure stress before dangerous cracks develop.

Remelting the steel in a vacuum allows these impurity atoms to volatilize out of the melt, leaving the steel with its valuable carbon and alloy content. This refining process is not cheap, but it is essential for parts you can't afford to have fail ahead of schedule—things like landing gear struts of heavy aircraft. Such "pedigreed" steel was just the thing for the Orient Automatic.

Material is only the first step. O'Malley would have to pay for metric spline broaches and special gear hobs. He would also have to pay just as much for the inevitable mistakes made during the setup process as for the perfect parts that would eventually result. Nevertheless he decided to go ahead.

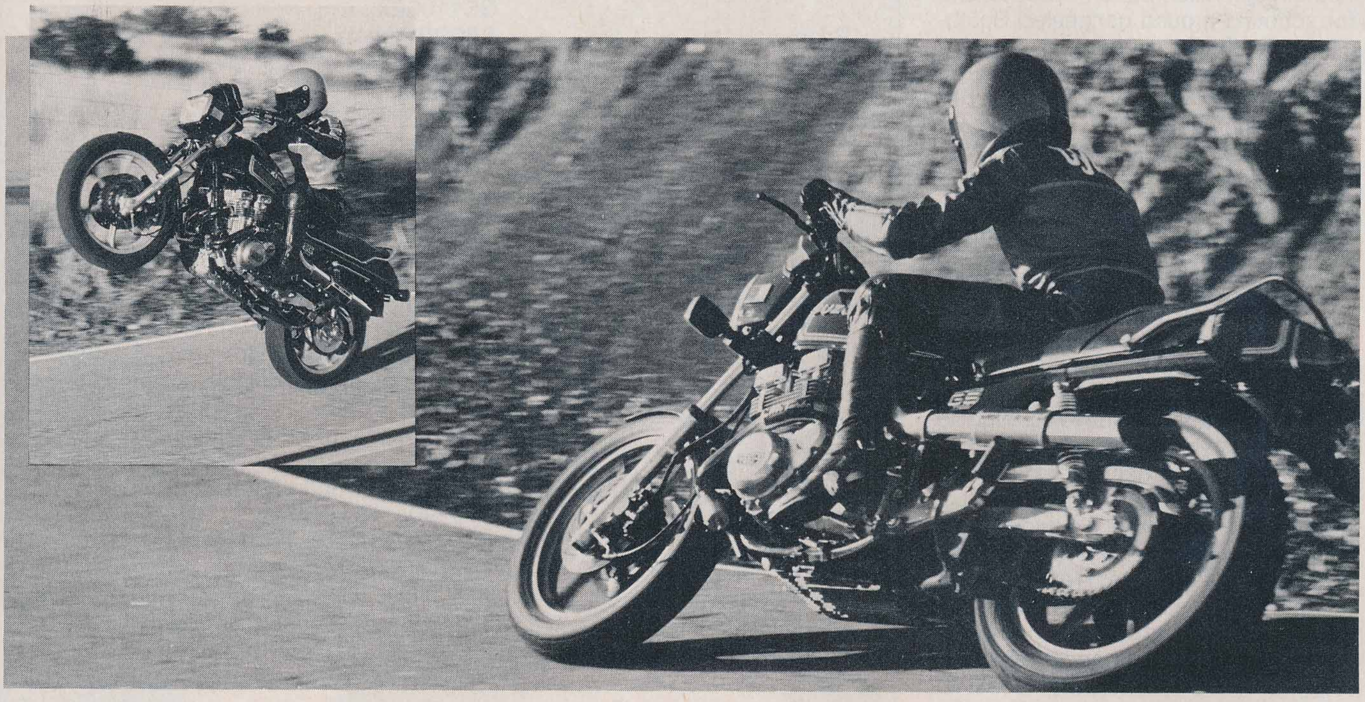
The result is a four-speed "automatic" that can stand up to turbocharged horsepower and the violence of clutchless shifting while eliminating all engine dead-time during upshifts.

The first production run of 25 Kawasaki transmissions sold out at a thousand dollars a set, which included the two shafts, eight gears, and the special shift drum with its unusual cam slots. O'Malley is taking orders for the next batch of Kawasaki and Suzuki automatics.

—Kevin Cameron

PROJECT EXPRESS
BLOWN AWAY

By Mark Homchick



● THE TURBO-GS1100 IS AN OUTRAGEOUS toy. Outrageous because the Orient Express-Mr. Turbo-Suzuki GS1100 is excessive, extravagant, fanciful, violent and unrestrained. Catch my drift? Outrageous is the best word, because outrageous implies that the limits of what's bearable and endurable have been exceeded. This turbo-GS1100 is a toy because it appeals to a childish nature; it's a plaything, an entertaining object. There's a catch in all this, a contradiction. This blown toy is not frivolous, not lacking in seriousness. The turbo-GS is like discovering your Roy Rogers cap pistol will shoot .357 ammo. Bang, bang; surprise. Bang, bang; you're blown away.

Some riders may get giddy over big-inch street turbos. Not me. I don't like one-liter turbos—the concept, the result. I do *Cycle*'s quarter-mile testing, and much of the earnest-sweat canyon scratching. That's fair for someone with neither wife, nor child nor mortgage, exactly those things that make the most aimless souls responsible. Since my idea of weekend entertainment includes getting an AMA Formula One bike around race circuits, you'd think I'd be a natural for this bike. That's what I thought. But having spent all the time I wanted aboard the turbo-GS—which included all modes of pavement riding—I've concluded that the only way for me to have fun with the turbo is to be *around* it, not *on* it.

Most street bikes are well-behaved, civilized creations. They produce what you demand along a response curve most riders can handle. You want to concentrate hard and go fast. Dial up your speed to the desired amount, where your personal skill and terror come into equilibrium. Want to cruise and enjoy the scenery? Turn your rheostat down and putt to your heart's content. Whatever your concentration level, you can fine-tune the machine to match.

A standard GS1100 tickles my fancy. For me, a low-11-second quarter-miler is plenty fast for the street. The big Suzuki builds power in a predictable way that good riders can handle and modulate. The power overtaxes neither frame nor tires. The noise level is very low, and the seating position good.

This turbocharged GS1100 takes the tickle right out of my fancy. Its response curve is all out of proportion to my demand curve. Twelve pounds of boost tosses smooth power delivery aside like a battered rag doll. There's lag, but the strength of the engine off boost tends to mask lag. This puffer will lift the front wheel right up in second gear, *and* it will loft the front through fourth gear. It's hard to steer when the front tire only occasionally contacts the ground.

In an effort—more obligatory than real—to cope with the engine's power, we fitted the latest Dunlop high-performance tires, K291 Elites, front and rear, on EPM mag wheels, WM4 x 19 front and WM6 x 18 rear.

Cosmetically, it may look just wonderful; it does not work that way. The WM6 spreads the rear tire out a bit too far for the carcass; in corners with dips the bike picks up, and the tires have so much traction and the engine so much power the bike misbehaves. Under acceleration the Suzuki's frame winds up and the fork wags—almost out of your hands. Getting through the gears at full throttle is impossible. First and second gears bring the front end over the horizon. Third through fifth provoke wobbles. Where's the fun? In letting off the throttle, that's where.

The standard tires on standard rims don't grip like Dunlops, but that's not all bad. They kept the bike upright. However, the rear tire would go up in smoke any time the throttle was wacked open in first gear. Hard shifts brought wheelspin if the tire was cold. The front coped better than the rear, but needed additional stopping power in light of the extra speed.

The high exhaust pipe on the left compromises the seating position. The heat shield, with which the rider's left leg is in constant contact, wards off

BLOWN AWAY

heat in all but the hottest weather. More annoying was the ineffective muffling; the bike relied solely on the turbine in the exhaust for quieting. Mr. Turbo offers a real muffler; our unit needed one for scooting around congested Southern California. Teenagers might be blind to the looks and gestures created by noisy motorcycles; we're not. Other motorists noticed the turbo-Suzuki, and if their looks could have killed . . .

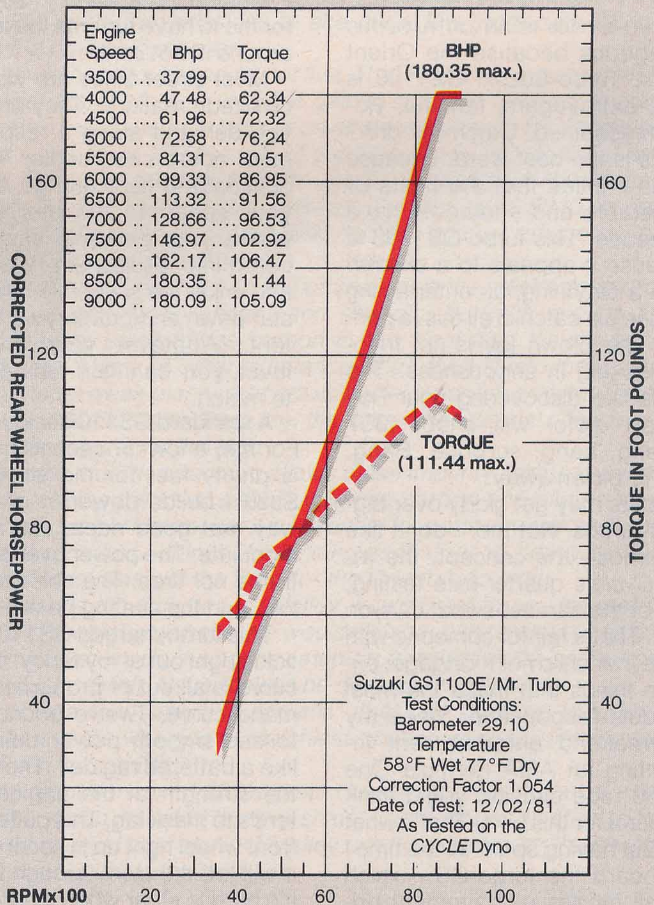
For the record, the Orient Express-Mr. Turbo-GS1100 is nothing like a Formula One race bike, though it has more horsepower than almost any Superbike or Formula One racer you're likely to find. Good race bikes are complete, balanced machines. Hurtling around a track at a competitive pace under complete control is a challenge to master, something that's attractive enough to keep riders trying to do better. Riding a racer on the track has nothing in common with riding a fully energized big-bore turbo on the street. I couldn't master the turbo, and I quit trying. This turbo operates on a level that I refuse to pursue on the street. Sure, you could turn down the boost and cool out this hyperkinetic 1100 to some acceptable velocity. It wouldn't take much boost to have the hardest-running engine you and the rolling chassis could stand. But considering the cost/benefit ratio, why would anybody do a turbo 1100? Because it's a powerful, intriguing idea.

Turbocharging one-liter engines for real street bikes is an idea that has greater interest and richness and merit in the abstract than it does in reality. It's like some beginner deciding he's going racing: it's a great and glamorous idea when you're five months, 2000 miles and 10,000 dollars away from doing it. At closer range, many riders find the idea a lot less appealing. To some riders maybe a 180-horsepower street bike sounds fantastic, because 180 is a much, much bigger number than 90. That kind of stuff makes the best daydreams. An outrageous toy is heady stuff, especially from the security of a wintertime rocking chair. So a one-liter street turbo may well tell you more about a guy's daydreams than his motorcycling.

Turbocharging may have a place in the real world of motorcycling, in the middle-displacement range. These bikes can withstand the additional power without becoming caricatures of themselves; so too can the riders. The true measure of a motorcycle's success here at *Cycle* is how often it's ridden home by the staff. The turbo-GS1100 spent many a lonely night out in the *Cycle* shop. ◉

PROJECT EXPRESS SPECIFICATIONS

Make and model	Suzuki / Orient-Express / Mr. Turbo GS1100EX
Price	$8000 approx.
Engine type	Four-stroke in-line four, air-cooled, DOHC with roller chain cam-drive; four valves per cylinder with Rajay turbo forced induction
Bore and stroke	75.0 x 66.0mm (2.95 x 2.60 in.)
Piston displacement	1165cc (71.07 cu. in)
Compression ratio	7.8:1
Bhp @ rpm	180.35 @ 8500
Torque @ rpm	111.44 @ 8500
Carburetion	(1) Keihin butterfly-valve with accelerator pump
Air filtration	K&N oiled paper element
Ignition	Battery-powered, inductive, magnetically switched
Wheel, front	EPM cast magnesium, WM4 x 19
rear	EPM cast magnesium, WM6 x 18
Tire, front	Dunlop K291 Sport Elite, R compound, 110/90 x 19, V-rated
rear	Dunlop K291 Sport Elite, R compound, 140/80 x 18, V-rated
Curb weight	548.5 lbs.
Standing start 1/4-mile	10.32 @ 138.67 mph
Average fuel consumption	29.6 mpg



Engine Speed	Bhp	Torque
3500	37.99	57.00
4000	47.48	62.34
4500	61.96	72.32
5000	72.58	76.24
5500	84.31	80.51
6000	99.33	86.95
6500	113.32	91.56
7000	128.66	96.53
7500	146.97	102.92
8000	162.17	106.47
8500	180.35	111.44
9000	180.09	105.09

The Ground Up *Continued from page 69*

joints gets into the engine oil and can block the oil feeds to the turbocharger. The result? Instant seizure of the special floating bearings for the turbine shaft. The production finish on the case mating surfaces is good enough to prevent leakage, and in any case, a well-prepared engine should have little piston-ring leakage to pressurize the case and cause leaks. If it does, it will have to come apart anyway.

Before installing the pistons and cylinder, the Orient men removed the stock cylinder-head studs and set in their place a stronger set of Precision Machining studs. This is done simply to prevent loss of bolt tension in operation, not to allow use of more installation torque. At 28–32 pounds-feet head sealing is adequate and distortion is at a minimum. Up at 35 pounds the bores start to distort inward at the stud locations, defeating all the good work of boring and honing. These engines are not diesels; there is only enough metal to do the job, and without excess weight. They cannot stand a heavy hand on the torque wrench.

When they finally slid the cylinder over this package, I got another surprise—I could easily turn the crank with my fingers. The low-pressure piston rings slide easily over the smooth, round and straight cylinders. Such a combination will break in quickly and uneventfully, and maintain its seal for a long period of use.

With the case halves together, the clutch was next. Four-cylinder engines aren't famous for their smooth torque delivery, so there has to be a torsional shock absorber between the crank and gearbox. This takes the form of six compression springs fitted into the sheet-metal back of the clutch basket/drive gear. The springs are fine for stock horsepower, but under the double torque of turbo boost and drag-strip shifting these springs bottom, bulge and wallow gradually out of their slots. Presently, they begin to hit nearby components, beginning with the shift drum. The onset of the disease is signaled by the motorcycle's beginning to shift its own transmission. Should the owner ignore this warning, there is worse to come. The escaping springs then batter off the oil-pump drive gear, which quickly wedges itself into the whirling parts, producing in some cases total catastrophe; the crankcase breaks apart, the crank bends, and even the cylinder may be smashed. All this is worth preventing, and even if you like that sort of thing, it happens much too fast to appreciate.

"How're those magazine guys going to ride this bike? Are they going anywhere near a drag strip?" asked Jack. Would they resist the temptation nobly?

(Continued on page 86)

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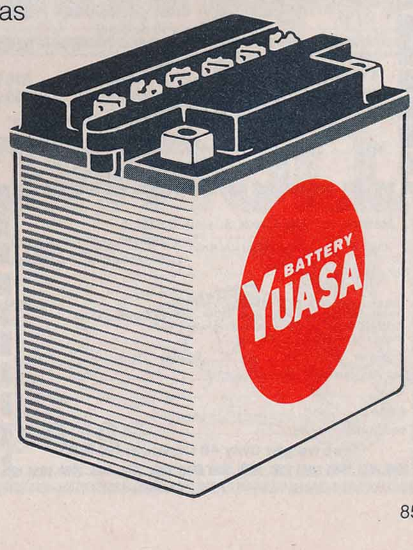

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The Ground Up *Continued from page 85*

Or would they indulge themselves swinishly? Jack recommended a special clutch basket whose backplate is machined from solid stock and is fitted with heavier springs. A little engine life insurance.

To seal the head to the cylinder, a stock-type composition gasket is satisfactory for non-racing use, but a competition engine like the one in Orient's seven-second Funnybike would require a solid-metal gasket and wire O-rings.

A competition head would receive stronger valve springs, some port work and one-piece valves; our engine would get only the set of PM racing springs, as protection against the rpm of possible missed shifts.

With the head on the bench I looked at Suzuki's Twin Swirl Combustion Chamber, one of many rapid-combustion schemes now being used in new engine designs.

"Does this really work?" I asked.

"Well," replied Jack, "if something like this really did work, I'd expect it to require less spark advance than usual, I'd expect it to be more efficient—burn less fuel—and I'd think it should tolerate more compression. In fact, it does all three. First, the stock Suzuki fires at 32 degrees BTDC, which is nearly 10 degrees less than two-valve engines. Second, with the same set of carburetors, the Suzuki will give best power two or three sizes leaner than other thousands. Third, we're able to run more compression with turbo 1100s than we can with other engines."

The chambers are remarkably smooth and free from angles. In fact, they are machined—a method too expensive to use without good reason. Machining gives the production engineer very good control over compression ratio, which is extremely important when maximum performance must be squeezed from poor-octane fuel. The smooth shape of the four-valve chamber allows the motion of the entering intake charge to persist during compression instead of being dissipated into random turbulence by angles, edges and bumps in the chamber.

We have been educated to believe that combustion chamber turbulence is a good thing. Isn't it? When flame is spread by random turbulence of the kind generated by old-fashioned squishbands there are several compromises. First, flame spread by random motion spreads at random speed; effective ignition timing varies widely. Second, increasing turbulence ultimately leads to excessive heat loss to the chamber walls by a kind of scrubbing action; too much turbulence causes power to fall. Third, the squish areas that have been so useful in the past actually cool the charge trapped in them to the point that not all of it can burn—hydrocarbon emissions and EPA eyebrows go right up.

If random motion in the chamber is replaced by steady uniform rotary motion, the actual gas velocity past the wall can be cut down to prevent heat loss while rapid flame travel still keeps detonation at bay. During compression, the dual rotary charge motion in the Suzuki not only persists but speeds up as the charge is confined to a smaller and smaller space. At the moment of ignition there is a more or less definite ratio between the rotation rate of the charge and the rpm of the crank. By adjusting this "rpm ratio," the designer can control flame speed and thereby prevent detonation.

Even in turbocharged form, O'Malley said, the Suzuki can still use the stock setting of 32 degrees BTDC—testimony to the rapid flame speed of this combustion chamber.

As the Suzuki was being assembled with stock cams, O'Malley described some of the difficulties cam grinders have had with the new four-valve designs. When any new model arrives there is a mad rush to hit the market first with everything from cams to chrome racks; the first 1100 aftermarket cams were based on timing figures that had worked well on Kawasaki 1000cc two-valve engines. In the Suzuki they were a disaster — with no low-end, no midrange, then everything at once all up on top. How could this be? The four-valve, with its two 27mm intake valves has really no more flow area than does the two-valve with its single 37mm intake (1150 sq. mm versus 1074 sq. mm). They should flow the same, right? Yet this direct approach wasn't working.

They had to reconsider the way in which flow area develops as the valves open. At full lift, the valve will be open a distance equal to 0.25 to 0.33 times its head diameter, and with a well-designed port, the valve at full lift may act as though it's not even there; the flow restriction is not at the valve head, but at the port throat, where diameter for best flow is something like 0.8 times the valve-head diameter.

But what about at the beginning and end of the intake event? How is flow area figured then? Obviously, with the valve open only a small distance, the smallest flow area is between the valve and its seat. The area is calculated by multiplying the distance around the valve(s) times the distance the valve has lifted from its seat. This, because the seat is cut at 45 degrees, is not quite the same as the lift, but is closely related. With this idea, we get a very different calculation. The perimeter, or distance around, of the Suzuki's two 27mm intakes is 170mm, while for the single 37mm intake of the two-valve it is a mere 116mm. This means that for

(Continued on page 89)

HOW THE POLICE PROTECT ONE OF THEIR OWN.

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The Ground Up *Continued from page 87*
equal lift, the four-valve will give 1.46 (170/116) times as much flow area as the two-valve.

Wait a minute! Won't the two-valve have proportionately more lift and thus give the same total flow area, timing for timing? It's true that the two small intakes of a four-valve need only lift 70 percent as far as the single larger one of the two-valve; but using the same valve acceleration during opening, the two small valves will reach full lift much sooner because they don't have as far to go. Thus two-valve cam timings will provide more flow area when used on a four-valve. The time-area, or result of multiplying the average flow area exposed times the total open duration, will be far too much. Now add to this the fact that the smaller a valve is, the higher the cam acceleration it can safely tolerate without stretching, dishing or breaking. When the cam designer exploits this fact, the four-valve's intakes reach full-open even sooner, providing an even more overwhelming intake flow time-area.

Those first-try cams, based on two-valve timing, were providing so much extra flow area that at low and medium speeds mixture was being pumped back out of the engine. The intake velocity needed to buck out this blowback (through ram effect) wasn't occurring until much higher up the rpm scale, resulting in the light-switch power characteristic. As soon as shorter duration cams were ground to take advantage of the low-lift flow advantage and high potential valve acceleration of the four-valve, the aftermarket cams began to work well in the Suzuki.

O'Malley drew a further contrast between the cam requirements of a normally aspirated performance engine and those of a turbo engine. To get the most from an unsupercharged engine we have to exploit the ram effect and the resonances in the intake and exhaust, and this requires keeping the valves open long enough to let these effects do their work. Generous timing and long overlap characterize the unsupercharged performance engine, giving it a steep powerband and a rough, *rumpa-rumpa* idle.

A turbo puts positive pressure on the intake valve all the time, not just when sound waves bounce in. There's no need to wheedle and coax the mixture into motion; the compressor forces it in the moment the valve begins to lift. There is no need for long timing and large valve overlap. Overlap just allows the compressor to blow mixture into the intake and right out the exhaust. A late intake closure is unnecessary because force-feeding from the compressor accomplishes cylinder filling on the downstroke. The exhaust does have to open

(Continued on page 96)

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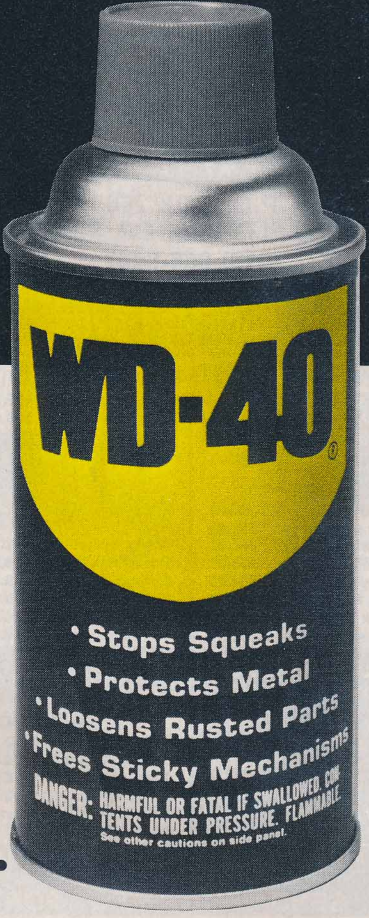

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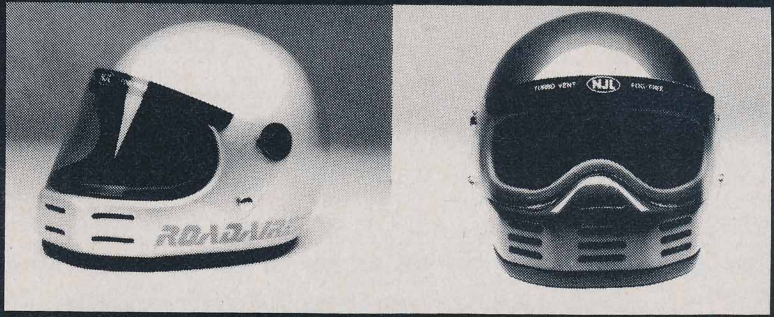

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The Ground Up *Continued from page 89*
early enough to allow exhaust energy to empty the cylinder so it doesn't have to be laboriously pumped out by the piston on the upstroke, producing a power loss. The major requirement for a good turbo cam is that it get the valve up and out of the way quickly so the high pressures in the intake and exhaust can get on with their work. This means a high-lift cam with rapid valve acceleration—exactly what a four-valve engine thrives on anyway.

The drag-strip tuner uses exhaust closing timing to cool the inside of the combustion chamber with wasted mixture, thus controlling detonation. This is the "fifth cycle" made famous in 1960s hot-rod cam advertising—simply closing the exhaust valve(s) later when you need to pull down the temperature of that greatest of detonation-inducers, the exhaust valve.

Naturally making the exhaust close later makes it open earlier, shortening the power stroke and dumping the extra energy into the turbine. This pushes the powerband higher up the rpm range, just as does a higher exhaust port in a two-stroke engine.

Jack O'Malley is fascinated by the many similarities between a turbo four-stroke and a two-stroke. Both engines load up at low speeds because fuel tends to puddle in low-velocity areas of their intake tracts. Both have sudden powerbands because they depend on pumping devices with strongly non-linear output curves (the centrifugal compressor of the turbo has an rpm-squared output and the two-stroke has its resonant exhaust duct). Both depend on the tuner's skill in balancing his need for power against the threat of assured destruction by detonation.

The turbo hardware on the Suzuki comes from Chicago's Mr. Turbo. The engine's exhaust ports fire into equal-length, small-diameter manifold tubes that join at the turbine inlet in rotary pattern (looking up the collector you would see the engine's firing impulses arrive in circular rather than diagonal sequence). The pressure and velocity energy in the exhaust is conserved by the small tube size, which limits pre-expansion of the gases. Once inside the Rajay turbine the high-speed gases give up their momentum to the turbine wheel, which in turn spins the compressor impeller on the intake side. The compressor draws mixture from a Keihin

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The Ground Up *Continued from page 96*

butterfly-throttle carburetor, compresses it, and sends it to the intake ports through a small-volume cast-aluminum manifold. No matter how good the combustion chamber, when boost reaches a certain level, the engine will begin to detonate. To prevent this, intake pressure is linked to a valve that vents off exhaust pressure before it reaches the turbine. By adjusting a preload spring holding this valve shut, the tuner can set the maximum boost the engine is allowed to reach at a safe value for the fuel being used.

If this were a drag engine, far more boost would have to be used—enough to require further controls to prevent detonation. Our street Suzuki with its central spark plug and swirl combustion chamber can get away with the stock 32-degree ignition timing and no retard; a drag engine would have a pressure-operated retarder to make ignition timing inversely proportional to boost.

The drag engine would also require a self-contained oil system for the turbo, for the drag engine is shut down after passing through the lights and its oil pressure would drop to zero. To keep the turbo lubed during coast-down, a little battery-operated pump circulates oil at 60 psi through the turbo unit.

Carburetion remains a problem for turbo bikes, racing or street, because the technology is new. O'Malley has to rework the emulsion tubes of the carburetors he uses to tailor their mixture curves to his needs, but there are still inherent problems. Between carburetor and intake valves is a lot of plumbing—all full of whatever mixture the engine is using at the moment. When the throttle is snapped open to accelerate, all that mix has to be eaten by the engine before it can get anything new. A large amount of liquid fuel creeps along the large wall area or lies in lakes on the floor and in the compressor's scroll housing. When the throttle opens and that fresh gust of mixture whistles in, it gathers up all this extra fuel and carries it into the engine, producing a rich transient and engine stumble. At the same time, the compressor cannot increase its delivery until the engine makes the exhaust volume needed to spin up the turbine, so the turbo engine is trying to pull itself up by its bootstraps. When the components don't work well with one another this is called turbo lag. When they do work well, it's called a very fast motorcycle. Experience with the variables has allowed veteran turbo tuners like O'Malley to build more of the latter and fewer of the former.

The usual street turbo kit uses a very low compression ratio to prevent high-boost detonation. This low compression, especially when combined with turbo lag and the carburetion transient,

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The Ground Up *Continued from page 99*

drastically reduces the engine's low-speed torque, making it, in fact, slower than stock up to about 6000 rpm. This turns the motorcycle into a pie-in-the-sky machine, giving up real-world street performance in favor of mind-blowing fifth-gear wheelies on top-end. Is that what we want?

Therefore, the Orient Turbo Suzuki carries only a moderately lowered compression ratio, but it is overbored enough to make up for the torque loss down low. The result is a machine that is faster everywhere than a stock motorcycle; the pie is right there on the plate all the time.

Finally, there it was: a fearfully fast wolf in wolf's clothing, a motorcycle that many people already consider too fast made much faster yet. What is too much, then? Who decides? Any of today's performance machines, even the 550s, are much faster than the road-ruling Brough Superior of the pre-war era. Today's stock machines would have been thought insanity then. Technology is ungovernable as long as there are people interested in what it can do. When a thing becomes possible and someone wants it, it will happen. Sometimes, as with the zeppelin and the autogyro, the results are disappointing; but often they are an arrow into the future. Brough Superior, anyone?

The 130-mph wheelie, though thrilling, is of little practical significance or use. Do we therefore need laws to protect us from the possibility? Remember that we already have laws to deal with speeding and other forms of anti-social motoring. Will some government bureau of the future say, "Sorry fellows, you've had enough fun now. From now on it's a 250cc 25 bhp limit"?

Consider the car world. There is a wide range of extremely fast and expensive cars that enjoy steady popularity with the orthopedic surgeons and corporation lawyers who can afford them. Do these men need to drive at 180 mph?

Certainly not, but that isn't the point. Such cars are built, and they are very different from the humdrum 50-horsepower econo-box most of us drive. These cars may cost $100,000 and there may be a six-month wait for a set of pistons, but people want them. As they tool along the expressway at legal speeds, they are getting there no sooner than the rest of us, but inside those people know that the potential exists in the machine to leap over the normal into another world. They are paying happily for that knowledge and for that freedom from normal constraint *even if it is never used.* When the door is closed and you can't open it from the inside, we call that prison. If the door is unlocked, even if you never step outside, you still know you are free. ◉

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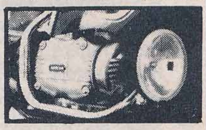

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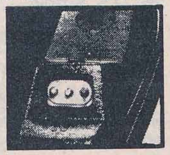

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