KING OF THE BOOMERS

In a class dominated-at least on paper-
by four-cylinder bikes and six figure budgets,
the BMW of Udo Gietl and Todd Schuster
almost bagged the Superbike Championship
with a two-cylinder bike and hardly any budget at all.

By Kevin Cameron

The 1978 Daytona Superbike race was a promise fulfilled, at least in part. Modern 1000cc DOHC transverse four-cylinder machines finally finished first and second. Yet still spoiling their perfect win-place show finish was a lone BMW twin, matching its two venerable pushrod cylinders against the modern orthodoxy and beating all but two of the opposition.

BMW is the most remarkable and vigorous dinosaur in motorcycling, with fifty years of history behind its boxer twin layout and drive shaft. Precisely made, well-mannered and durable, the BMW has always been valued as the finest of touring machines, but might not be your first choice for the hard world of AMA Superbike racing. The jutting cylinders limit cornering clearance. The long valve train journeys tediously from the engine centerline to the heads. Two big cylinders cannot equal four smaller ones in the rpm derby. Shaft-drive is a heavy and complex method of connecting the gearbox and rear wheel.

What happened to these disadvantages, then, in the Superbike race? By rule, weight can be reduced 20 per cent from stock. This leaves the BMW 44 pounds lighter than the Suzuki 4, 60 pounds lighter than the Kawasaki 4. Brakes, tires, chassis and rider all benefit from this low weight. The flat engine's center of mass is below the crank, not above it as with the fours. All these things added up to quick Daytona infield times.

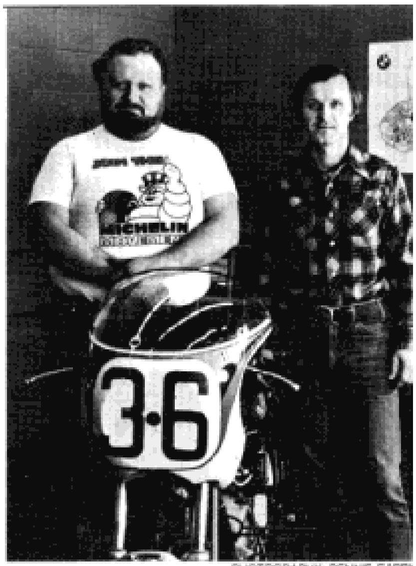
What else? Those big disadvantageous cylinders poking out at the sides were cool and comfortable in the direct air-stream, not hot and hidden behind the oil cooler, exhaust pipes, steering head and front wheel.

It's easy to tot up tables of pluses and minuses, but to squeeze more profit from those pluses than gets lost in the minuses takes real knowledge and work. What sort of machine was this BMW? What sort of people built it?

The story began ten years ago. While today BMW enjoys a reputation of sporting excellence, a decade ago that image was of excellence alone. I remember them well, purring down the streets of college towns, carrying their connoisseur owners to the lecture halls, in a picture of acceptable unconventionality.

This was not a real market. A wider sales appeal would need more than shiny black enamel, Earles forks, and sedate, if permanent, performance. BMW has worked with every sort of high-class technology in its long history; a sporting quality would not be technically troublesome. Away went the sidecar-inspired fork, down came the weight, up went the displacement and power. The US importers, Butler & Smith of New Jersey, launched a cautious road racing program.

The choice to head this program was Udo Gietl, German-born, US-educated, racing in the family and in the blood. In his hands the BMW ceased to be an unsuitable device in racing. His Formula 750 machine worked its way towards the top ten in AMA road racing, turning up to 10,500 rpm, making 100 bhp at the crank, and becoming faster than the once-dominant Harley V-twins. But F-750 was a two-stroke world, so BMW would best spend its money in some kind of production racing. The AMA Superbike event evolved from a West Coast production class that had attracted manufacturer attention. Udo Gietl was instrumental in bringing the AMA to accept the concept.



Superbike did provide a showcase for BMW, especially in 1976. Butler & Smith reasoned that the four-cylinder imports would soon become too strong to beat, so they must strike hard now to make their sales message effective, then get out. Their $150,000 was money well spent. The race shop lights burned twenty-four hours a day, the dyno engines fired every evening at five, and an unending stream of refinements poured forth into the three team bikes. BMW dominated Superbike racing in 1976.

That was that. The company sold the dyno, the flow bench, and the bikes. They would not be tempted further. For them, the decision may have been a wise one. For Udo, however, the decision was a catastrophe he could not accept. After ten years' work he could not just stop his emotional commitment as the company had terminated its program. It was inevitable that he would continue. In his notes and in his head were all the tests, everything that had worked and why.

The no-race policy at Butler & Smith was firm, but they did offer Gietl two things: the use of their space and access to warranty parts. He walked to the dumpster and pulled out a damaged frame. Then he drove to the shop of Todd Schuster, a long-time friend and colleague in racing projects. Schuster is an enormous man of enormous talents, who has never let the difficulty of a job stand in the way of his pleasure in its completion. Between the two of them, they worked out a personal racing program. Udo would undertake engine and transmission, Todd would fabricate the rolling chassis. Floridian John Long would ride.

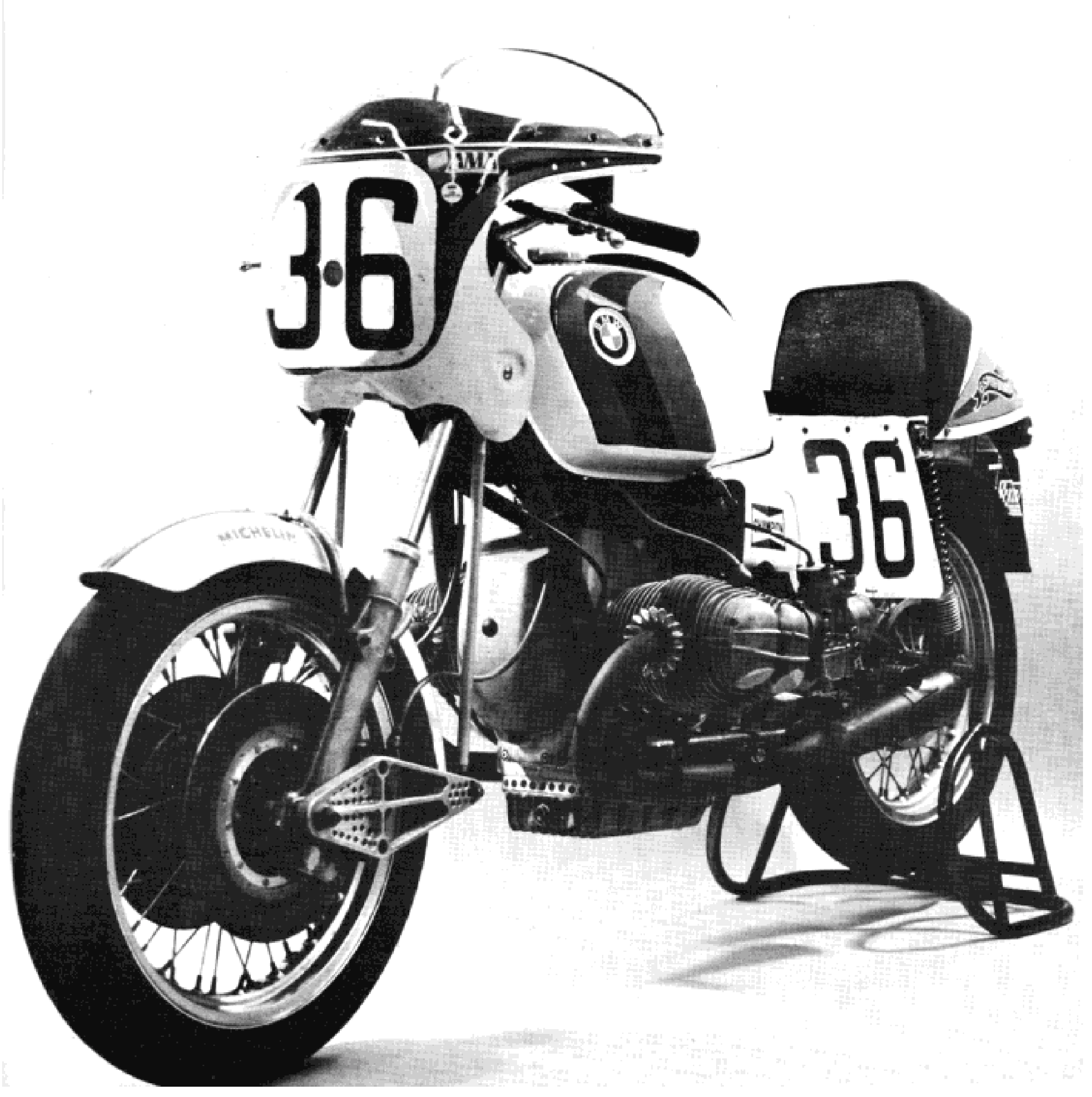
The 1976 Butler & Smith "works" BMWs had been the ultimate in rules-bending. Shock relocation had been legalized to oblige Kawasaki, so Gietl had relocated one shock right onto the parts shelf. The other had become a mono-shock. New rules subsequently prohibited this, so the dumpster chassis would have two shocks.

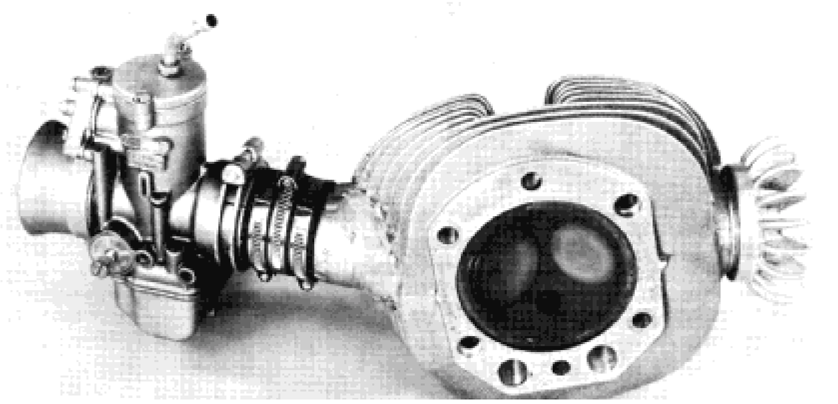
The engine was relocated ahead 15mm to counter wheel-standing. It was then captured in the frame by two welded-in struts that made a direct connection between steering head and swing-arm pivot. To set it free, the bottom frame rails were made removable by bolted conical joints.

The stock steering head is made limber to reduce perceived vibration, but such flexibility won't work with slick-tire traction. The entire steering head was plated in on all sides with gussets. Head angle was increased from the stock 28.5 by one degree, but wheelbase remained standard. The rear of the engine case was yoked transversely to the new steering head/swing-arm struts.

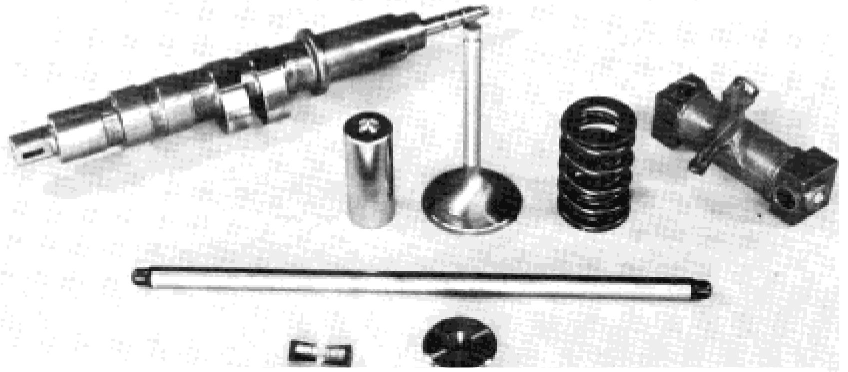
Shaft-drive exerts a torque on the swing arm as the pinion tries to walk up the face of the ring gear. When the throttle is closed for a turn, this torque reverses and the machine twitches. To brace this out of existence, monoshock-style reinforcement was welded to the underside of the arm. The cast aluminum final drive casing was pared of all possible excess material.

Nearby in New Jersey, Koni offered their shock dyno facility, and Gietl lived there, working out the damping curve he wanted. A progressive spring rate, soft at first, then stiffer under more compression, would offer best wheel compliance when upright yet still keep the cylinder heads off the ground under heavy cornering loads. Progressive springs exist, but their effect is too small. A better approach is used in formula car suspension: the compression bump rubber becomes more than just a soft washer on the shock rod. It becomes a long conical polyurethane molding that functions as a supplementary spring. The cone becomes broader the more it is compressed, so its spring rate goes up rapidly. Gietl hand-whittled his

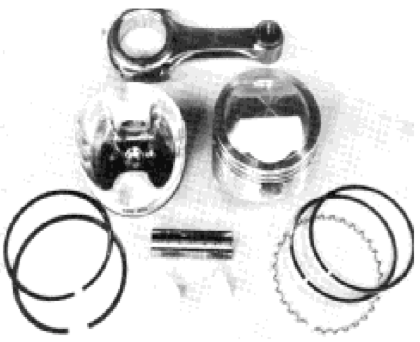




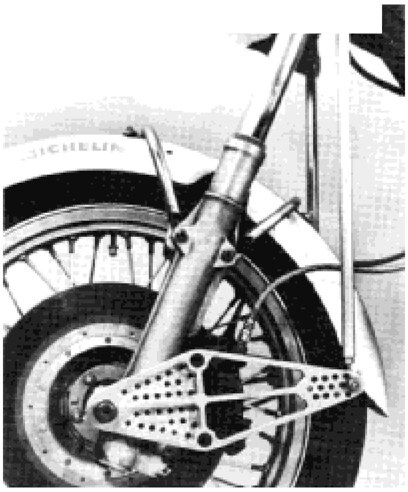
Top end uses relocated inlet runners, smooth-bore Dell'Orto carbs. Chrysler Hemi intake valves and 2 plugs.



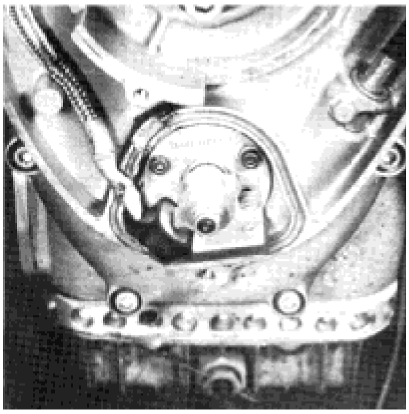
Valve action is controlled by Crane cam and springs, Smith pushrods, Wisemann tappets and stock rockers.



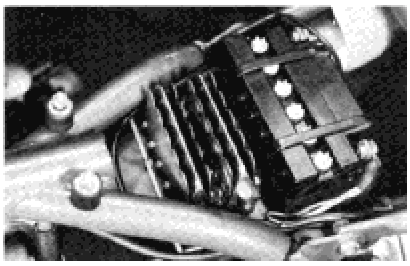
Thin-wall Venolia pistons, Amol Precision tool steel pins and Carillo rods have to be safe to 10,000 rpm.



Gietl's anti-dive, which keps the bike level during braking, did away with cornering clearance problems



Total loss Bosch CDI ignition is timed by camshaft-mounted ceramic magnetic trigger. There are four coils.



Crankcase volume control was finally taken care of by this large reed valve array, mounted under the seat.

from blanks, then matched them to the steel springs and damper units. The resulting shocks worked better than the former "works" monoshock had.

BMW's fork is a good unit. Its forward-axle construction allows increased over-lap of fork tube and slider, which makes the suspension work more smoothly under the side-loads of heavy braking. At first, Schuster restricted travel somewhat to prevent grounding of the heads when brakes were used at full lean. Later, a more radical measure was adopted. Anti-dive linkage was constructed, similar to that used occasionally in motocross. Each of the alloy Lockheed calipers was mounted on a rocker arm pivoted from extensions of the front axle. The trailing end of each rocker was linked by ball joint and pushrod (former Cummins Diesel parts!) to the underside of the lower fork crown. Brake torque tries to drag the calipers and their rockers around with the wheel, and this drives the pushrods up against the lower crown, producing a lift force that counters brake dive. The result is level braking at all angles of lean, with no chance of digging in a cylinder head.

For most tracks, brake discs are Hunt coated aluminum, with meehanite iron rotors reserved for severe locations like Loudon. An extreme hydraulic leverage ratio is used between master cylinder and calipers, permitting hard pads to be used without excessive lever effort. The stock drum brake is used at the rear.

The front BMW hub is laced to a WM-4 (2.65inch) rim, the rear to a WM-5 (3.00- inch). Along with tires, Michelin has supplied advice and encouragement to the team all season long.

The lightweight, stiff chassis, excellent brakes, and developed suspension go a long way to explain the machine's performance, but it does need a little something to push it along. The engine would have to be largely summoned up from memory, unaided by such niceties as the vanished dyno. And memory would serve well.

Big-end seizure had plagued the early F-750 BMW, and dyno tests with transparent oil lines had shown the delivery turning to fizz above

9500 rpm. Cavitation in the stock Eaton-type oil pump was literally pulling the oil apart, while the pump drive required five horsepower at high speed. Although the Superbike engine would not peak much over 8200 rpm, Gietl wanted it to be mechanically safe to 10,000. This meant it had to have the special pump, smaller than the original in both size and power requirement.

Oil goes direct from the pump to the oil cooler, then to the two plain crank main bearings. These are grooved to carry oil to drillings in the crank leading to the rod journals. The crankpins are hollow, cored for lightness, and Gietl plugs them, turning them into emergency oil reservoirs by drilling additional feeds to the hollow pins, then from them to the journal surfaces.

Violent maneuvering can interrupt oil pickup in the wet sump, so a pan spacer has been added which increases capacity 50 per cent to three quarts. An oil temperature sender monitors the condition of the Klotz 20/50 synthetic, which accomplished something that other oils didn't: it eliminated gumming and ring sticking.

The finned sump is supplemented by an oil cooler located under the seat, supplied with oil through the familiar braided stainless hose and with cool air by ducts at the rider's knees. Gietl observes that plain shell bearings like those in BMW cranks and rods give up life by smearing at a surface temperature of some 360°F. The oil is usually 50° cooler than the surfaces it lubricates, so the oil temperature gauge is red-lined at 260° and is never permitted to get close. Gietl notes that a frequent cause of burst coolers and lines is excessive warm-up rpm with cold oil, whose high viscosity sends system pressure soaring despite relief valves.

Getting competitive power is clearly much more than just phoning up the local speed shop and ordering one of each. Every part of Gietl's engine is the most recent chapter in an entire book of development as yet unfinished. The pistons and their rings are fine examples, They are full-skirted Venolia/Alcoa forgings, machined to Gietl's drawings. The top ring is stainless, of Dykes L-section type. The second ring is rectangular in section, and of cast steel. The oil ring is a three-piece affair.

Why? He had noticed in dyno testing of newly completed engines that the weaker ones tended to blacken their oil far more than the good ones. Poor ring performance was allowing oil to pass into the chamber, carbonize on the wall, and then be swept back into the sump. The rings from such engines showed less than ideal contact with the cylinder wall. The rings hadn't seated and sealed very well at all.

Gietl examined the break-in process. He decided that the familiar cross-hatch hone pattern left by proper cylinder preparation is nothing but a one-time double-cut file to shave the rings into intimate contact with the wall. Once break-in was complete, the wide ring contact would be lubricated well enough to glide over the hone pattern, which would have worn down almost completely anyway. He reasoned that too good an oil film could stop the break-in prematurely.

He therefore adopted a dry break-in procedure. The pistons, rings and cylinder bores are solvent-cleaned and assembled dry save for a drop of oil on each piston skirt. The engine is started and run at half red-line for nearly a minute. Upon teardown, the rings will be seen to have seated very nicely.

Because they are air-cooled, the BMW's cylinders are subject to much distortion. The fins toward the front get cold air while those at the back get hot air. The tops of the cylinders are closer to the combustion chamber than are the bottoms. Therefore the rings must conform to a cylinder both bulged and tapered.

Standard rectangular section rings usually have a good deal of spring tension. This is what presses them against the wall to form a seal at low speeds, below 3500 rpm. It was Paul Dykes who showed that combustion gas pressure, acting behind the ring, supplied the sealing force at higher speeds. A rectangular ring is too stiff radially to be flattened out onto the cylinder wall by gas pressure if that wall is the least bit wavy. Hence the Dykes, or L-section ring works better in such circumstances. Gietl has traced through all these developments in his own work. His present top ring is a stainless automotive L-ring.

There is a temptation to use only one top ring. After all, what can the second ring supply but drag? The G-50 Matchless used a two-ring piston and so do some of the Yoshimura kits. Gietl tried pistons machined for two rings and discovered that they needed much extra clearance to avoid seizure. Evidently, he reasoned, that second ring wasn't a gas ring at all, but a heat transfer ring. Shielded from combustion heat by the effective top ring, the second ring could pour out piston heat through its broad face to the much cooler cylinder wall. Very well then. With three rings, clearance could be reduced to a very small value. Gietl's second ring is a broad-faced rectangular steel ring.

The bottom ring is for oil control. Oil in the combustion chamber can lead to detonation, to plug fouling, to valve stem deposits and piston ring sticking. The stock BMW oil ring is one-piece, which Gietl finds works only in truly round cylinders. He uses a limber three-piece ring consisting of two thin rails separated by a spacer. There is the usual row of holes in the ring groove to drain oil scraped by the top rail, but where goes the oil scraped by the lower rail? In conventional designs, nowhere, but here there is another row of holes below the groove. Oil control is very good, and the piston crowns are a dry, creamy gray because of it.

A further impediment to the use of really tight piston clearances is excessive piston rigidity. Gietl removes a further 50-60 grams of weight from the pistons with handwork, concentrating on making the skirt as thin as possible. In his view, the piston is simply a guide for the rings and must hold their seal faces in strict parallelism with the cylinder wall. This is the compelling reason for tight clearance. A thin, springy piston can spread out on the wall a bit under load, relieving the oil film of concentrated pressure and placing more heat transfer area in the thermal circuit between piston and wall. With a close clearance, slight piston overheating causes an immediate increase in heat flow to the wall, cooling the piston and controlling the situation. His clearance is indeed tiny: .0015inch. The pistons run like this for several Nationals and are discarded when clearance reaches .0025inch.

Teflon buttons retain 2.5 mm-wall tool steel wristpins made by Amol Precision. The high ground finish used inside and out eliminates many surface defects and is part of the reason these pins survive where others have perished.

Although the 1976 works engine used special German-forged titanium connecting rods, Gietl's engine has steel ones. These are still food for hungry eyes for they are Carillo nickel steel items, machined on all surfaces and then shot-peened to put those surfaces in compression. Surface compression prevents crack-propagating tensile forces from appearing on the part's surface until that part has been bent far enough to completely relieve the initial compression.

The rods and cylinders are ten millimeters shorter than stock, and Gietl assures us that this is done solely to gain cornering clearance. Since the amount gained is less than two degrees of lean, I asked if the rod ratio selected had anything to do with the hot-rodders' discovery that shorter rods favor acceleration, longer ones top end power. He says no.

In a boxer motor like this one the crank-case volume changes radically every revolution. To eliminate as much as possible crankcase pressure losses, Gietl has run a large flexible line from the case breather to a foam-filled box under the seat. Atop this box is a row of reed valves. The case quickly pumps itself down through this array, and at high speeds, an exhaust aspirator adds its suction to the effect. There was power to be had here, and Gietl has helped himself.

The combustion chambers are designed for easy flow and rapid flame travel. The piston domes are featureless low pent-roof design, very like those of a four-valve engine. There are no valve cutouts. Because the R90S cylinder heads are castings adapted by BMW from earlier, smaller bore engines, the valve area is quite limited and surrounded by a wide 3/8-inch squish band. Combustion must be quite good because as little as 30° ignition lead is used on faster circuits. The heads are machined for dual ignition because Gietl found that with one plug, the valve seat inserts tended to warp towards the ignition source. With two, the problem has gone away, and spark lead can be reduced 2°. The sparks originate in a 9 ampere-hour battery which powers a Bosch total-loss CDI system, whose ceramic magnet trigger spins on the nose of the camshaft. Two coils are located under the tank, two under the seat. Gietl simply matched the impedance of his four coils to that of the two normally used with the system. There is an idle spark at TDC on overlap because the system fires all the plugs each time it is triggered.

Faced with the inviting wide squish band, an inexperienced person would be tempted to set squish clearances very close, as it is in some well-known race engines, to get extreme turbulence. In the BMW engine, the combination of crank whip and the panting of the crankcases just can't seem to define the piston's position very accurately. At anything less than .070-inch squish clearance, the pistons and the heads strive to achieve a more perfect union. Gietl has seen this flexing under the glare of strobe light; he has seen the cylinders walk on the case.

Valve ports are the traditional heart of the matter. After trying the work of the major commercial porting services, Gietl does all his own work, without a flow bench. By choice. Lest this seem odd, he points out that the commercial shops sell an abstraction that is very useful to some people: increased flow under conditions of fixed valve lift and continuous airflow. This is better than nothing, but ideally, each port change should be checked at least on the dyno, if not on the track itself. The airflow in a running engine does start and stop now and then, and the valves have been known to move. Gietl's long experience is the key; he has done the dyno work and the track testing.

The stock intake stubs turn inward toward the air cleaner atop the crankcase.

This means that intake air must make a sharp turn inside the head to come parallel with the valve stem. Gietl cuts off this stub and welds in a new one at a much more desirable angle. Of actual porting there is very little. The port is widened a millimeter on each side of the stem, and the excellent BMW bronze valve guide is cut back to the port wail. The junction of stub and head is faired and filled with Devcon F epoxy. The intake valve is recut from a blank intended for Schuster's favorite engine, the Chrysler Hemi (there is one lurking in his Ford van), and is of 45mm diameter. This is a small size for such a large bore engine, being in the ratio of 95.2/45 for area ratio of 4.5:1 Two-valve engines designed for operation at their limiting piston speed usually have an area ratio of at least 3.5:1 so this BMW is short in the intake area department. The 1976 "works" machines made slightly less than 100 bhp at 8200 rpm for a Brake Mean Effective Pressure of 155 psi. This pressure is low compared with the 200 psi seen in some all-out racing engines, but remember this machine is a clever compromise. If Udo could make power at the so-called limiting piston speed (these days perhaps 4500 piston feet per minute, or 9700 rpm on this engine's 70.6mm stroke) he would certainly do it. Power begins in earnest at 5500 rpm and it must be good because the machine accelerates very well. The small valve sizes give their best volumetric efficiency at rpm lower than the ragged edge. Bigger valves would be in danger of clashing on overlap. Even if the guides could conveniently be moved apart to permit bigger valves, there would be the problem of how to control them with push-rod actuation. There would also be the problem of how to make the engine finish races at the greatly increased level of stress in crank, rods and case. Engines that blow up can be packed with technical interest, but they never win races.

So where is all the trendy stuff? Where are the secret reversion barriers and short-side boundary layer suction devices? Nothing? Well, there is one nice little gadget. For the shorter tracks, Gietl slips a "restrictor" into the intake stub, a gentle 36mm I.D. venturi. It may act as a flow rectifier at low speeds, the extra velocity in its throat opposing the engine's natural tendency to pump back charge through the carburetor. However it works, it does improve low-end power.

Valve control is achieved through double coil Crane springs with 110 pounds of seat pressure, 280 pounds open at full .550-inch lift. They are tied to the stems by hard steel lash caps and automotive titanium retainers. Stock BMW rockers are used, unmodified. They never break unless someone tries to improve them.

The 1976 machines used lovely $60 titanium intake and exhaust valves. This material is less than 60 per cent the weight of steel, has excellent heat and oxidation resistance, and is a superior heat conductor. This keeps the valve head significantly cooler, which is nice if you are interested in avoiding detonation. It also keeps the sealing ability of the valve intact longer. Nice parts, but out of reach right now.

Pushrods right out of the Smith automotive catalog make the jump from the rockers down to Wiesmann steel tappets. Aftermarket cams frequently are not what they are supposed to be. From lobe to lobe, and from timing card to cam, the figures may not agree, yet they are critical for power. Gietl has found that Crane cams are accurate any way he measures them, and the one he is using now gives a long 330° duration at the running clearance and 286° at the .050-inch checking height, with 112° lobe centers. This long cam timing is a virtual necessity with a heavy valve train, which takes a long time to start and stop. Smaller valves also require longer timings.

Air is invited to enter through Dell'Orto carburetors which have been bored from 38 to 40mm. These are the pumper type, with that feature deleted. To take advantage of "creative rules interpretation" often seen in the tech lines at the races, Schuster has spent incalculable time in converting another set of these carburetors to smooth-bores, making up the necessary hollow slides from brass tubing, filling the bore enlargement with a suitable machined plug, and then making it all work. And they do, providing another small advantage.

The burned gases leave through a stock exhaust port and 39mm valve. The exhaust pipe is another of those curiosities that might just never be noticed if you didn't stare. It is made in steps, smaller at first, then bigger and bigger. I asked about it. My hosts smiled ruefully and explained. Udo had tried many different pipes, including sets with a crossover tube. This tube, he reasoned, is there to provide extra expansion area for the exhaust pulse. Therefore he installed a second crossover tube ahead of the first. The torque spread improved again. Interesting. If provision of increasing expansion area within the pipe was the requirement, how about a pipe that tapered from small to large, like the header of a two-stroke? He made up a set of those. A small, but measurable gain in overall torque spread. That is Gietl's business: to add up many small gains.

The stock BMW flywheel is of incredible thickness and mass to guarantee the traditional clock-like idle. The stock pressure plate of the automotive single-disc clutch transmits its share of torque through a silent, lash-free sheet-metal diaphragm. Racing stress is just too much for this civilized part; it rips. To fix it, Gietl mills away almost all the flywheel's thickness, leaving six integral, cylindrical posts projecting axially at the edge. The pressure plate receives welded-on ears which are pierced to slip down over these posts, making a bulletproof slipper-clutch-style drive. Cross out clutch trouble.

The bare engine weighs 115 pounds without gearbox, and the two men might have liked to leave it that way. The gearbox, made as it is from used parts, has been the largest single cause of failure. Overrewing from accidental disengagement has destroyed more than one set of cases. Finally a major financial effort put new gears between the engine and its load, BMW's fine $600 close-ratio set. First gear is a bit tall for clutch starts, turning them into a series of awkward hops as the rider feels for the right amount of slip. The stock first, or a special intermediate ratio made up by Amol Precision, gives better results.

Gietl's brow furrows a bit, looking at his machine.

"It needs a lot of money, really."

He has many more ideas for improvement than he has any prospect of being able to implement. There is only so much work two men can do, and they have done a lot. Limited resources are always a big problem, yet I don't see these people quitting and putting the money into season passes to the opera. Running on empty is racing's natural state. This machine is being sold, but plans go on.

When Gietl and Schuster first met their 1978 rider, John Long, they looked questioningly at each other. This man couldn't be a racer. He wasn't tense enough, didn't make proper unreasonable demands, didn't complain or carp. Before the start at Daytona, the race which was to justify all their work, Long sat on the pit wall, eating grapes unconcernedly until the last possible moment. The last numbers were coming up on the board, machines were running, people milling. He got to his feet, yawning and stretching, and shambled happily over to his machine. When the flag dropped, he showed them. He rode brilliantly into third place.

The third at Daytona was followed by a second at Loudon, both outstanding in view of the technically advanced opposition and the private status of the little team. Mechanical troubles prevented finishes at Sears Point and Pocono, and at the second Loudon a technicality lowered their third place to an eleventh. The season finished with a fourth at Laguna Seca, a first at Mosport, and a points tie for the Superbike Championship.

Udo, in his most matter-of-fact manner, urges that there is nothing trick about his machine. In any small detail, this may be arguably so. What is trick beyond any doubt is that the machine exists at all- that this many finely conceived details have been brought together into one functioning whole. And certainly any twin that had so many fours laboring in its wake is by definition trick in the extreme.