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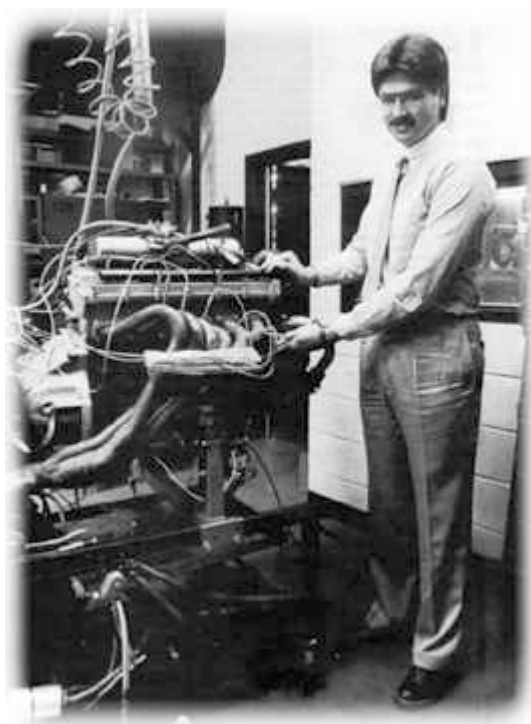
HOME

The Johnson Quadros

by Ellie MacDougall
Photos: Yale Rachlin

It's not often that an enthusiast has the opportunity to be witness to a serious, capital intensive R&D program whose objective is to create a new BMW engine.

But in researching this story, I did something a good journalist should never do. I lost my objectivity. I don't know whether it happened as I got to know the people involved and saw all the time, energy and brainpower they were investing in this project, or whether it happened the first time I test drove the prototype Quadros, unrefined as it was, and realized, "I want one." One thing's for sure. As I sit down to write this story, I know the facts I present to you will be totally accurate. But you should also be forewarned that I'm going to try to get you as excited about the Johnson Quadros as I am.



*Demands
of the
project
grew so
great that
Ted
Johnson
was forced
to choose
between
the
Quadros
or his job
at Loctite.
He chose
the
Quadros
and
created
Johnson,*

Inc. When asked how he got into all of this, he replied, "I don't know. I never really questioned it. It just happened."

Ted Johnson is a tall, soft spoken, deliberate man whose smile starts out shy and ends up overspreading his entire face. At first glance, he just doesn't look like the kind of guy who likes to slip through corners in a four-wheel drift.

His propensity for having fun behind the wheel brought him - and his 323i - to Callaway Turbosystems (see Bill Howard's story on Johnson's Callaway turbo conversion in an earlier issue of the Roundel). In time, he and Reeves Callaway became friends. And late one afternoon, they found themselves cruising the back roads of Old Lyme, CT on the way to dinner at the Bee & Thistle Inn, with engine designer Hans Hermann at the wheel.

Naturally, talk turned to cars - and Hans observed that what Ted's 323i really needed wasn't a turbo, but a 4-valve head.

That was in November of 1983.

Sometime the following spring, Ted was again at Callaway. There was an unusual blueprint up on the wall. "What's that?" he asked Reeves. "Oh, that," Reeves replied, "that's your 4-valve cylinder head."

They talked.
They
planned.
And that
night, they
shook hands
on an
arrangement
to begin
creating



what was to become the Johnson Quadros. Hans Hermann would perform the initial design. Callaway would undertake engineering, testing and development. The marketing, the financing, the overall vision of where the project was to go would be the sole responsibility of Ted Johnson.

Reeves Callaway set the initial design parameters for the project. The Quadros would be a "high rev, broad torque design with snappy response and natural aspiration." It would be a direct replacement for the stock cylinder head, fitting on any M-20 block, without requiring a change in the drive system or machining of the cylinder head. The package would include a specially tuned intake and exhaust manifold. No special training would be needed for proper installation.

Initially, the Quadros would be designed for the 2.3L 323i marketed in Europe. Shortly after completion of this phase, work would begin on modifications to make the Quadros compatible with the U.S. 2.7L 325 eta Motronics systems.

The initial design was critical to the success of the project. According to Callaway, "Hans Hermann was the only guy I knew outside of the factory who could do the job". Reeves yanked the engine out of his own 323i. The M-20 block was shipped to Hans. He parked it in his living room next to his drawing board. Six months later, the initial design was finished.

On October 1, 1984, at 2:27 am, the first Quadros 2.3L prototype roared into life on the dyno at Callaway Turbosystems. Preliminary tests employed a stock intake and exhaust manifold, medium cam and conservative compression ratio. Eight or ten initial castings were performed by Aeroalloys, Inc., a specialty foundry in Long Beach, CA with considerable experience in high quality aerospace and automotive castings. These were then machined on Callaway's own NC equipment, with the resultant jewel-like quality which characterizes their work.

It was at this stage of the program that I heard what was going on. I was developing promotional materials for Callaway's factory sponsored twin-turbo Alfa Romeo GTV-6 project. But since my avocation is Bimmers, I asked Ted and Reeves if they'd mind my becoming an unofficial observer to the Quadros' development. They not only agreed, but Ted took it upon himself to start me in what has become a year-long course in the fine points of automotive testing and design.

The first time I saw the Quadros intact it was on the dyno with specially adapted Hartge headers, two intake and exhaust valves, and the most astonishing "boy racer" stacks I've seen since the early days of Big Daddy Don Garlits. The project team had logged twenty hours of test data.

I watched as
the engine



was step-tested at 250 rpm increments. At 2750 rpm, it delivered 148 ft/lb of



torque - equivalent to stock output at 4500 rpm. The Quadros prototype, at 4500, put out 181 ft/lb. It ran all the way up to 7500 rpm with no effort whatsoever.

The sound was fantastic.

Fortunately, no fuel feed problems had been encountered. Three different cam lobe profiles were in the works to test horsepower versus driveability. Changing the cam angle significantly altered the characteristics. There was a general feeling that perhaps a compression ration of 10:1 or perhaps even 10.5:1 might make more sense. Optimum ignition was still under study.

At this point, the Quadros employed an external belt drive with internal gearing. This made for a narrower head which was not only more compact, but allowed a flatter combustion chamber. It was felt the noise from this arrangement would not be objectionable once the engine was actually dropped into a car.

But when this first prototype went into the mule, the clatter from under the hood was not in keeping with the silky character of the 323i. The design underwent the first of a long series of changes, refinements, more changes, more refinements.

By the end of 1984, the people at Callaway had customized a special intake design, coupled with the Hartge exhaust, and achieved 200 HP. They were getting closer.

Technical description

The Johnson Quadros is designed to take advantage of the latent power of the M-20 engine without a complete engine exchange or massive modifications. The four-valve cylinder head is designed for direct installation on the M-20 engine block. The result is 33% more torque and horsepower than the stock engine without compromising overall reliability. Two intake and exhaust valves increase volumetric efficiency, producing better performance and reduced fuel consumption. The pent-roof head design helps ensure complete and even combustion under all operating conditions, contributing to reduced emission levels. The head will also enhance turbo and mechanical supercharging.

Type	Dual overhead cam in-line six cylinder
Head material	Cast aluminum, 365 T6, stress relieved and annealed, solution aged and heat treated
Camshafts	Ground steel billet, hardened and ion nitrited. Supported in removable cam/bucket carriers. Cam timing through infinitely variable bushing adjustment. Oil pressure fed to each of seven cam bearings.
Cam drive	Three internally mounted nitralloy gears mounted in INA needle roller bearings. Stock cam drive gear mounted on steel halfshaft.
Valve actuation	Ground steel bucket-type cam followers, removable pad inserts for lash adjustment.
Valves	Nimonic stainless steel, 7mm chromed valve stems. Intake = 32mm, exhaust = 28mm for the 2.3 liter configuration.
Valve guides	Silicon bronze Valve seats High nickel alloy steel Valve springs Progressive wound flat wire springs
Spark plugs	12mm threads Computer generated patterns ensure all parts and combustion chambers are identical. All machining is done on the latest computer numerically controlled machine centers to maintain repeatability of parts.

Performance information for the 2.3L engine:	
Maximum rpm	7000
Horsepower (DIN)	205 PS at 6200 rpm
Torque	245 Nm at 5200 rpm
Note: the above is subject to change by the manufacturer.	

As impressed as I was with the tenacity, thoroughness and technical acumen employed in the creation of the Quadros, I knew there would be no substitute for getting behind the wheel of a car with one of these beasts under the hood.

My chance came early in the winter of 1984.

The stock 323i is smooth, refined and a genuine pleasure to drive. Ted Johnson's 323i was set up with plus-two BBS three-piece wheels, low profile European tread P-7's, a close ratio gearbox and the initially strange but eventually comforting ABS braking system. It was into

this mule that the project team installed the second 2.3L test Quadros.

" Don't be afraid to wind it up to 7000 before you shift," admonished Ted as I started to back out of the bay doors. Well, there was a certain inhibiting factor in that the tech only went up to a little over 7000. But, what the heck, this was a test car. They're supposed to be driven hard, right?

The idle was rough. But with a little feathering, I was out of the parking lot and heading toward that beautifully banked and winding access road to Callaway Turbosystems known as Reeves' Raceway.

The sound from under the hood was pure power. It was still unrefined, with a clatter that didn't quite match up with the sensuousness of the rest of the 323i, but there was something about it that said, "Are we going to be polite or are we going to go out and have fun?" It was an offer I couldn't refuse.

I came to a stop sign. A right. Then a left down a moderately short, tight ramp to the interstate. I looked down and saw the engine was still warm from Tony Vastola's last test run. So I tromped on it. An involuntary "Eee-haw!" came out as I realized the Quadros was pulling 150 kilometers. Then 160. 180.1 was barely onto the highway. And it still had a long way to go to hit 7000.

It was rush hour. Traffic was heavy. I pulled out behind a Camaro, then backed off the throttle without downshifting to see what interesting noises would develop under the hood. There was a satisfied little burble. The horses wanted to go for a gallop.

Naturally, I obliged.

The next exit came up all too soon but, rather than risk ending up in Rhode Island before I knew it, I got off and backtracked. That's when it happened - easily the most traumatic few seconds I've ever spent behind the wheel.

You know how you watch the races on ESPN and you hear Jackie Stewart all calm, cool and collected up in the climate controlled announcer's booth, saying things like, "Oh, that's a bit of bad luck. Looks as if the chap just lost his engine. "

Conditions under these circumstances are considerably less calm inside the car.

I was tooling along up I-95 at about 5500 rpm when, all of a sudden, there was no more road. Just white smoke fore and aft and the obscene sound of various engine parts trying to blast their way out through the hood. The truck next to me slowed down very quickly and I pulled over.

I got out. I locked the door - not that anyone could steal the car in its present condition. Smoke billowed out from under the hood and a puddle of oil was spreading onto the pavement. I felt like I wanted to throw up. Then I started to walk what was probably the longest mile of my life back to Callaway, trying all the while to figure out how I was going to tell Ted Johnson that his test engine was a dead carcass.

If I've ever said anything nasty about people who drive RX-7's, I take it all back. One flashed by, the driver quickly assessed the situation, pulled over and backed up. "You from Callaway?" He must have noticed the experimental test plates. "No, I was just out for a test drive." "Betcha won't buy that one." Sigh.

Ted took it well. First he got very pale. Then he got very quiet. Then he got Reeves and the tow cables. We got into my winter BMW (otherwise known as a Jeep Cherokee) and set off for the scene of the crime. We towed the Quadros in.

Back in the shop, everyone gathered around the engine compartment like good friends at a wake, all staring into the open coffin. Reeves was walking around muttering about cars blowing up when the press was there. Tim Good said I'd have to be a truly exceptional person to have driven the car any harder than the rest of them had. I still felt lousy.

About an hour later I was home, halfway into a bottle of wine and considering a switch to Jack Daniel's. The phone rang. It was Ted with the autopsy report. "It spun a connecting rod bearing. It wouldn't have made any difference who was in the car. You just got lucky." They discovered later that a connecting rod bolt had failed first, leading to the bearing failure.

A lot has happened in the past few months to change the character of the evolution of the Quadros. For one thing, it is becoming apparent that the concept is highly do-able. For another, considerable interest has been expressed by outside sources in marketing the Quadros both here and across the pond.

The result has been a change in attitude within the project team. According to Johnson, "This has gotten serious."

For example, Callaway alone has the capacity to produce 7001000 cylinder heads per year in their own shop, and secondary sources are under investigation. Sources of supply for camshafts, valves, timing chains and other essential components are also being lined up.

The plan is to continue the current R&D phase through September 1st. Right now, in addition to developing the

2.3L engine cylinder head, Callaway is testing the design on a non-Motronics 2.7L motor.

I was invited for two test drives in the 2.7L mule. In the first, it sported a rev limiter at 4000 rpm.

In the second, the engine was allowed up to 6000 rpm - with the driver as rev limiter.

The 2.7L feels much different than the 2.4L. It is smoother and stronger, partly because of further refinements in the system and partly because it is a different - and larger - engine. Estimates are that this configuration will put out about 230 horses once it is properly tuned. Keeping in mind that what I drove was still an untuned set-up with the capacity for a possible 20% increase in torque and horsepower, here is what I observed.

No feathering was needed to prevent stalling at idle. Low-end torque was sufficient to enable the 2.7L Quadros mule to start from a standstill in second gear on a flat road. There was noticeably more torque on the low end than in the 2.3L, but still not enough for Ted. ("It should snap you to attention right from the bottom," he said.

The power began to kick in at about 1750-2000 rpm. There was a slight flat spot around 3200 rpm. With a foot on the throttle, I felt as if I should consider a neck brace by 4500 rpm, and was thinking how I was looking forward to seeing the 0-60 figures once this baby got out on the test track.

5500 rpm produced such an abrupt change in the sound of the engine that I looked down at the instruments to make sure I hadn't broken something else. It seems the drive gear had reached a new harmonic, changing its sound. This change continued until about 6000 rpm - about 130 rpm at the top of fifth gear. The car felt as if it could have easily accommodated a sixth gear. Also, a few more aerodynamic modifications.

Obviously, this will not be a car for the meek.

Much of the noise had been quieted by a specially designed chain. Instead of anything remotely resembling a clatter, all I heard was the sound of those 24 little valves up under the hood, breathing away, happy as clams.

Other refinements are under consideration, such as the incorporation of a truly handsome valve design which eliminates the shoulder in the current 2.7L prototype, providing greater airflow. These valves are made to Quadros specifications by the same company manufacturing valves for Cosworth.

All of this has not come about without difficulties. Ted managed to crisp up and bend some valves when yet another OEM part failed. Also, some interesting things have been discovered about the normal production engine which will make a significant difference in the highly tuned, high performance Quadros. For instance, TDC in the 2.7L production engine has been found to be off as much as 3 degrees. With the Quadros, this can mean a loss of approximately 5%.

It has become apparent that header design is a critical factor. Variations in length appear to rob the Quadros of as much as 10 HP. Design optimization has become a priority within the current R&D program.

Even with problems still to be solved, the 2.7L in its untuned state could meet nearly all emissions requirements outside of California. Obviously, it is an efficient design. Johnson projects there will be no problem in producing a street car which will meet emissions in all 50 states.

Johnson fully realizes the kind of interest a design like this is bound to stir up among enthusiasts. But the fact is, the Quadros is nowhere near being finalized. Intensive R&D lies ahead. Only then will come the decision as to who will market and distribute the Quadros, and in what form.

None of this will be determined until September, when the current program ends. Which means no further information about availability, price or final specs will be available until after September 1.

Sometime this fall, when decisions have been made, another story will appear in the Roundel. It will give you final technical and performance specs on the Quadros in its various engine configurations. There will be further test drive impressions, including a detailed evaluation of the final product. You'll get to know a little

more about each member of the project team and how they've contributed to the creation of the Quadros. You'll find out precisely when and where you can buy a Quadros of your very own. How much it will cost you. And about Ted Johnson's plans for a stage 2 Quadros.

I can hardly wait.

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