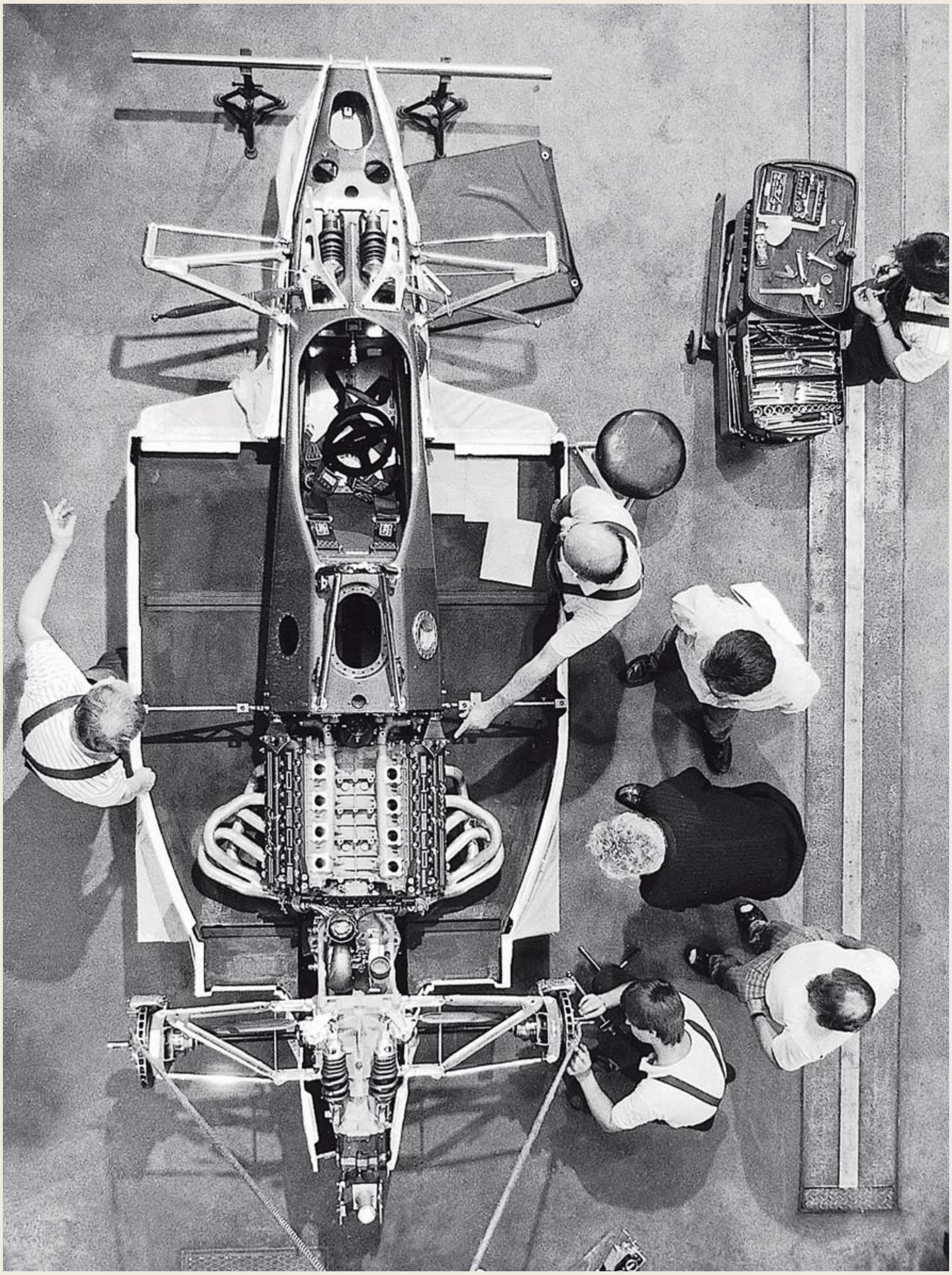
PORSCHE TURBO

RANDY LEFFINGWELL



First published in 2015 by Motorbooks, an imprint of Quarto Publishing Group USA Inc.,
400 First Avenue North, Suite 400, Minneapolis, MN 55401 USA

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ISBN: 978-0-7603-4758-4
Digital edition: 978-1-62788-792-2
Hardcover edition: 978-0-76034-758-4
Library of Congress Control Number: 2015935557

Senior Editor: Darwin Holmstrom
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On the front cover: The Typ 930 Turbo. *Porsche Archive*
On the back cover: Edgar Dören drove this 934/5 during the May 1, 1977, ADAC Eifelrennen at Nürburgring. *Porsche Archive*
On the frontis: In the racing shop, engineers and body assemblers began test fitting components to a full-scale wood model in late 1985. *Porsche Archive*

Printed in China

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PORSCHE TURBO

THE INSIDE STORY OF STUTTGART'S TURBOCHARGED ROAD AND RACE CARS

RANDY LEFFINGWELL

motorbooks

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ACKNOWLEDGMENTS

Several individuals took an early and enthusiastic interest in this project and their help and encouragement contributed enormously to what this book has become. I am most especially grateful to Doktor-Ingenieur Erhard Mössle, General Manager Product Line 911 Turbo/Carrera 4/ Targa 4; Diplom-Ingenieur Thomas Krickelberg, Director Powertrain Product Line 911; Grant Larson, STYLE Porsche; and to Dieter Landenberger, Manager Historical Archive.

Because of Weissach's well-justified pride in their turbocharging accomplishments, a significant population of Porsche engineers and designers opened their office, studio, or home doors to me and patiently answered every question. I wish to express deep gratitude to: August Achleitner, Herbert Ampferer, Jürgen Barth, the late Helmuth Bott, Wolfgang Dürheimer, Peter Falk, Helmut Flegl, the late Ernst Fuhrmann, Tony Hatter, Wolfgang Hatz, Hans-Jörg Hermann, Matthias Hofstetter, the late Jo Hoppen, Bernd Kahnau, Eugen Kolb, Matthias Kulla, Roland Kussmaul, Harm Lagaaij, the late Anatole Lapine, Horst Marchart, Michael Mauer, Hans Mezger, Ulrich Morbitzer, Stephen Murkett, Peter Reisinger, Valentin Schäffer, Peter Schutz, Harald Schwer, Norbert Singer, the late Dick Soderberg, Rolf Sprenger, Martin Stöfka, Johann-Georg Ulrich, Peter Varga, Thomas Wasserbäch, Christian Will, Hans-Jürgen Wöhler, and Klaus-Gerhard Wolpert.

A number of racers and those associated with racing also willingly recounted adventures and successes with Porsche's turbocharged competition cars. I want to thank: Jack Atkinson, Derek Bell, Tony Dron, Teo Fabi, George Follmer, the late Paul Frère, Hurley Haywood, Jacky Ickx, the late Vasek Polak, and Walter Röhrl.

As ever, it is impossible to do these kinds of histories without extraordinary cooperation from Porsche's Historical Archives. My thanks go to: Jens Torner, Dieter Gross, Yvonne Knotek, Tobias Mauler, and Maike Scheufele.

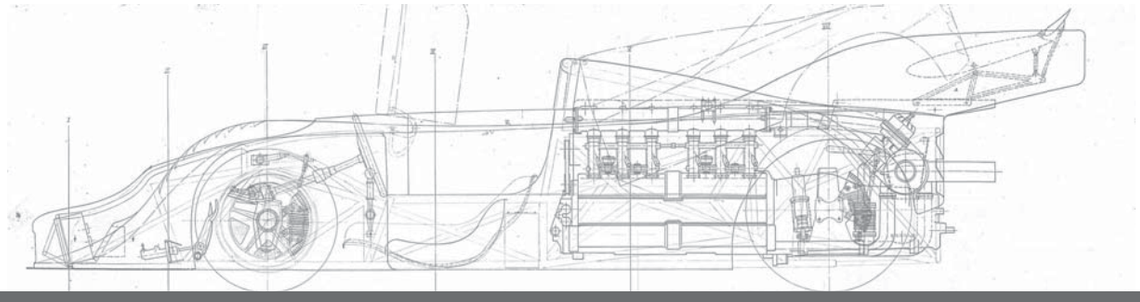
In addition, Porsche's Press Department, which for 25 years now, has been very supportive of my projects, was especially generous and helpful for this book. Among other things, they organized the intricate coordination of two dozen interviews over four weeks of work in Germany. I particularly want to thank: Thomas Becki, Elena Marciniak, and Hermann-Josef Stappen, as well as Eckard Eybl, Nicole Lay, and Tim Bravo.

I owe particular thanks to Andrew Cotton for his invaluable contribution to this book. For many years Porsche Motor Sport has trusted him with great access, and from his wisdom and experience, he authored Chapter Eighteen on Porsche's Typ 919 LMP1 hybrid/turbocharged prototype race car.

Once again I wish to thank Gill Campbell, CEO and General Manager; Barry Toepke, VP, Communications & Historic Racing; and Johanna Koch, Public Relations and Digital Media Manager, at Mazda Raceway Laguna Seca, for their continuing support of my book activities. Access is everything, and they have trusted me with everything.

Last but not least, I'm grateful to Dave Engelmann, Warner Hall, and Pete Stout, who answered my questions, asked me others, and who read the words, expressed their opinions, discussed the ideas, and suggested alternatives.

Randy Leffingwell
Santa Barbara



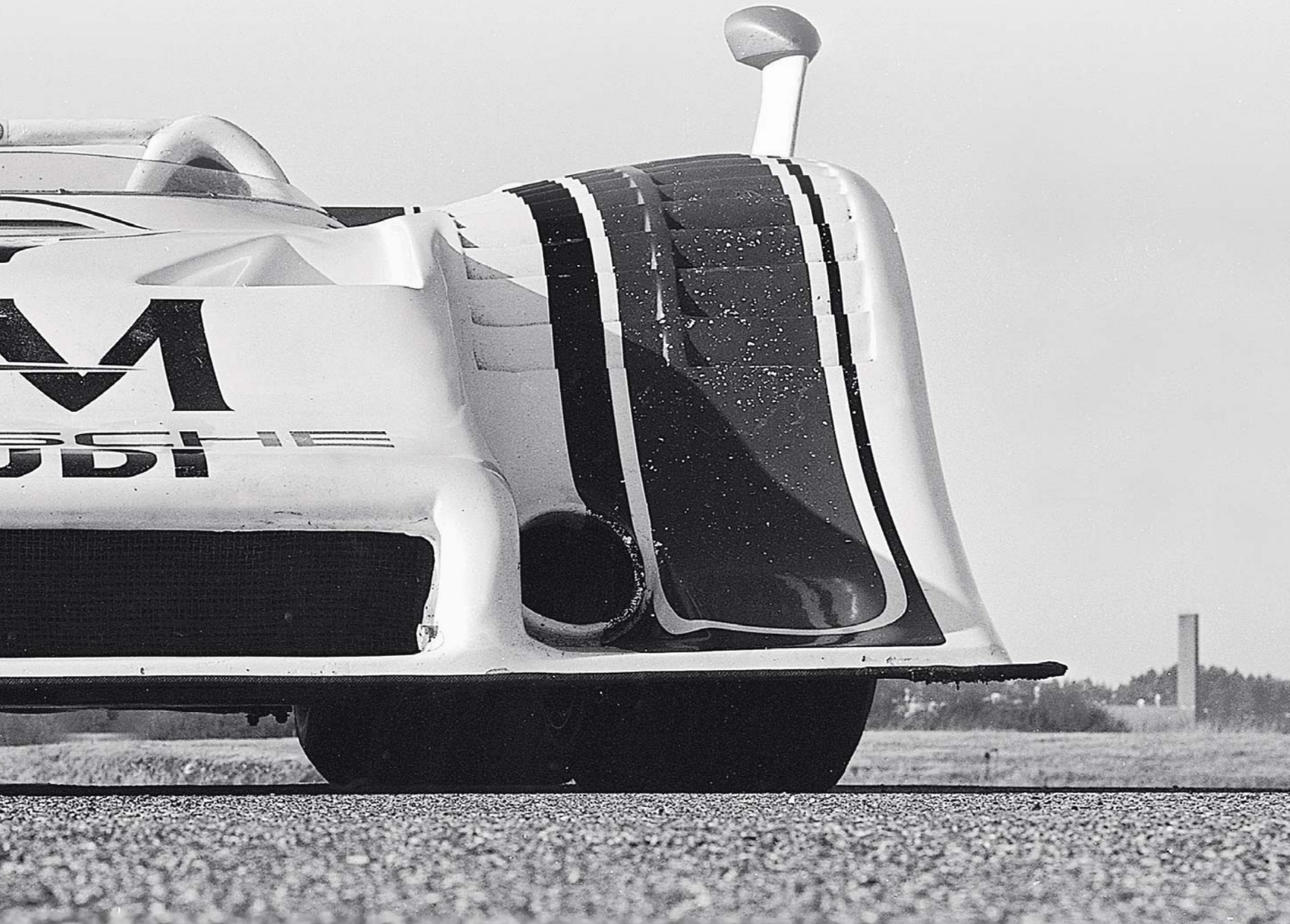
Chapter One

THE UNFAIR **ADVANTAGE**

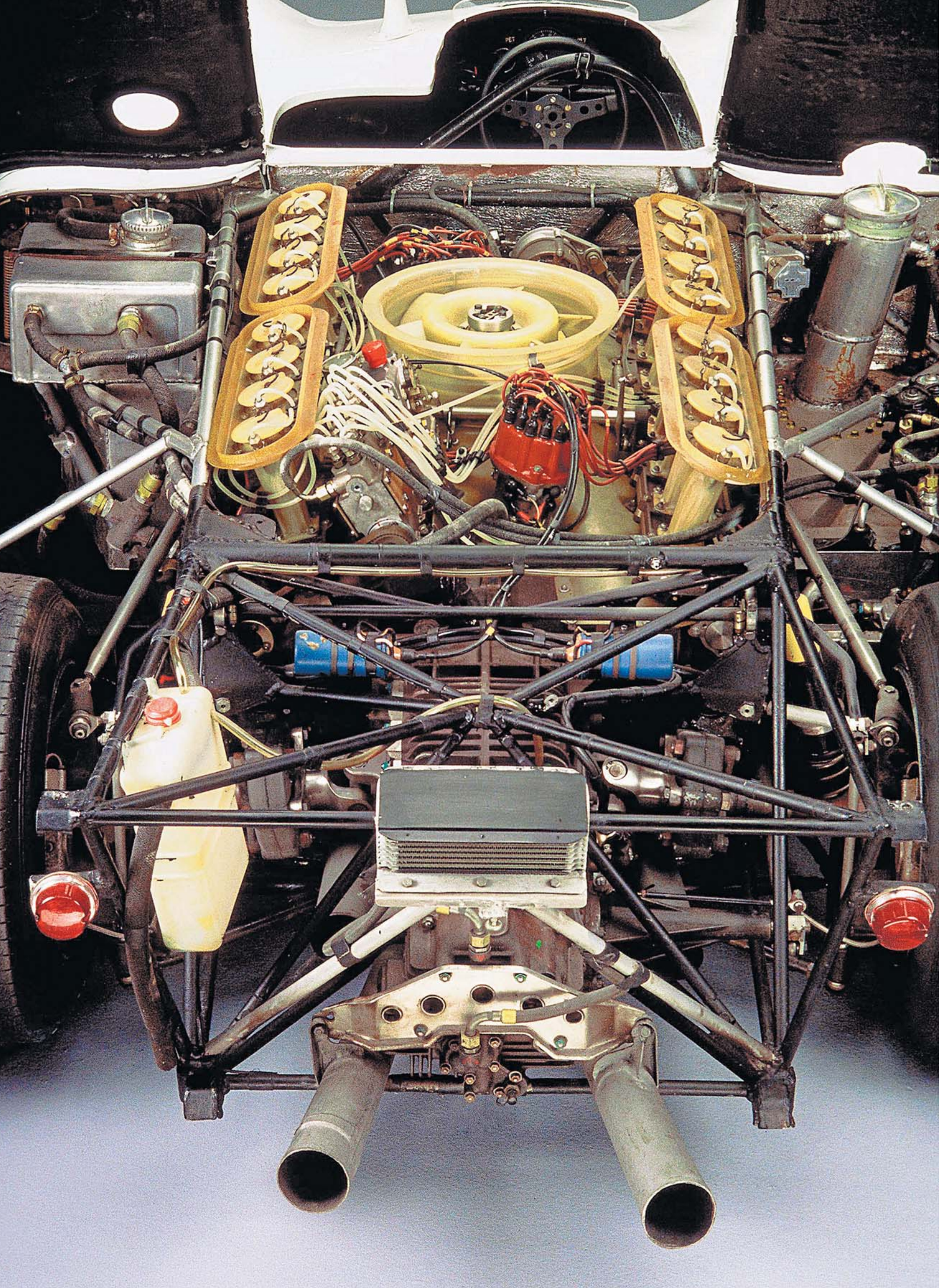
"You have to take care . . . this must be secret!" Porsche engineer Valentin Schäffer laughed at the old memory. "Mr. Piëch told me, 'Nobody should know that we are going to turbo charge the 917!'"

During an interview in 2011, Schäffer explained that beginning in June 1968, he and Hans Mezger, two of Porsche's most capable engine designers, had worked on another secret Piëch project, a 180-degree V-12 powerplant that Porsche intended for the World Championship of Makes (WCM). Racing's regulatory organization at the time, the Commission Sportive Internationale (CSI), had authorized a new Group 5 category for distance events that required a minimum of twenty-five identical cars weighing at least 1,760 pounds each with maximum engine displacement of 5 liters for the 1971 and 1972 seasons, and Piëch intended not only to enter the category but to win it.

Karl Rabe, Porsche's guardian of internal designations, labeled the engine as the Typ 912 to confuse suppliers and competitors into believing this project involved the company's series-production model. When the racer debuted at the Geneva International Motor Show in early March 1969, it broadcast Porsche's intentions: world endurance championship and outright victory at the 24 Hours of Le Mans. Mezger designed the Typ 912/00 engine with a target of 520 horsepower from its 4,494cc displacement, and



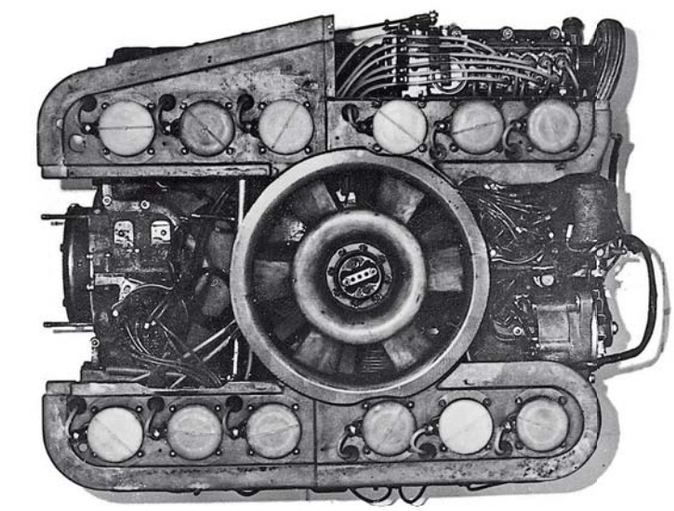
While the 917 coupes took several races and a few months to become all-conquering, the 917/10 Turbo Spyders achieved that performance from the start. Can-Am team owner Roger Penske brought L&M tobacco sponsorship and Mark Donohue to the series. *Porsche Archive*

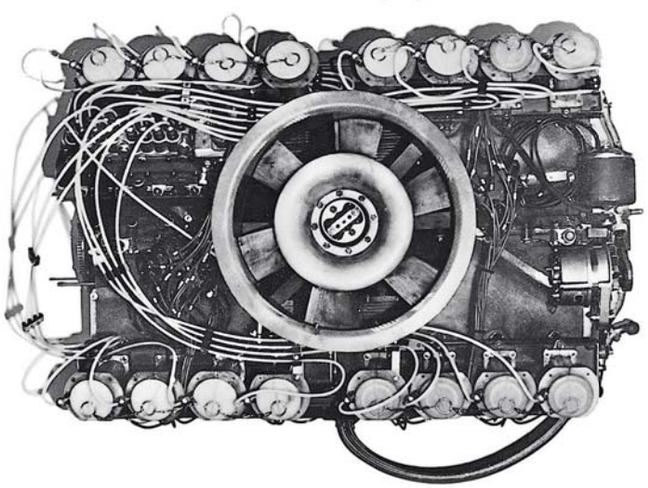


The 917-16, in chassis 917-027, fit within the typical 917 wheelbase of 2,300 millimeters shared by the coupes and the first-generation Spyders. However, the additional cylinders and their hardware added 30 kilograms (66.1 pounds) of weight to the car. *Porsche Archive*

The 912/00 engine, a 180-degree twelve-cylinder engine of 4,494cc displacement, produced 560 horsepower at 8,300 rpm for the 917PA Spyder. The experimental 917-16 delivered 755 at 8,200. *Porsche Archive*

In Weissach's shops, an intriguing lineup of 917s awaited attention. From bottom: the 917K "Weissach taxi," a coupe specially prepared to offer VIP visitors a thrilling lap of the test track; an early spyder prototype; the 1971 917K coupe for Le Mans; and, upper right, one of the 917/10 Can-Am cars. *Porsche Archive*

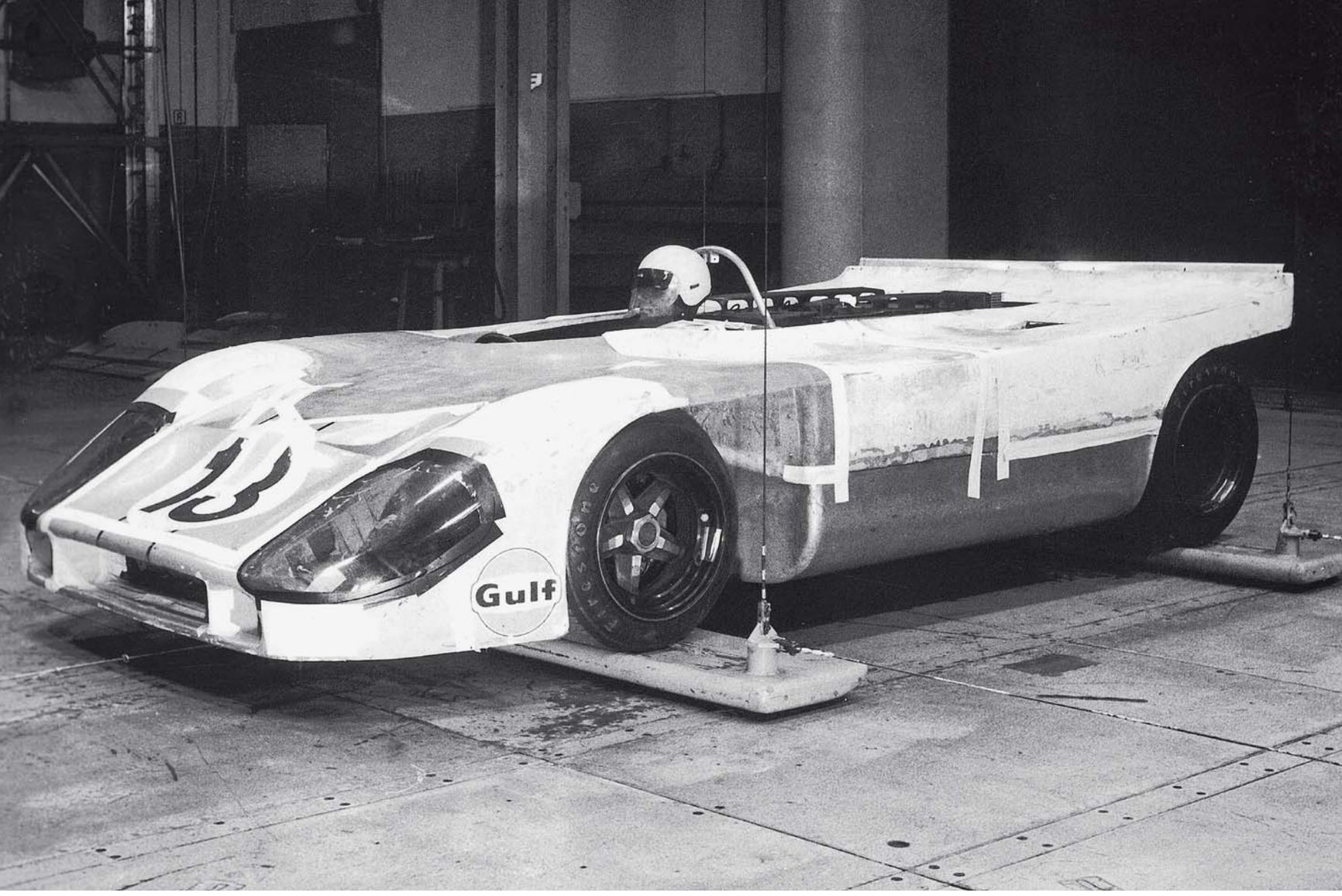




he was pleased when its first dynamometer test in December 1968 showed 542 on the gauges. Engine displacement grew to 4,907cc with the 912/10, delivering 600 horsepower at 8,300 rpm, and then settled at 4,999cc and 630 horsepower in the 912/11 for the 1970 and 1971 seasons.

The CSI, stunned by Porsche's brazen assault on the 5-liter rule for sports cars, reduced maximum displacement to 3 liters starting in 1972. Piëch and Porsche had no interest in retracing past efforts, having already been so successful in their 3-liter 908 racers. Instead, the company saw opportunities in the Canadian-American Challenge Cup, begun in 1966 in North America by the Sports Car Club of America (SCCA), and in Europe's comparable Interserie, launched in 1970. The rules were a kind of fantasy for Porsche's engineers and drivers: SCCA placed no limits on engine displacement and had no requirements concerning bodywork or aerodynamic aids; in fact, regulations seemed to specify little beyond two seats and enclosed-wheel bodywork for this new Group 7 category. Porsche works driver Jo Siffert especially loved this no-holds-barred type of competition, and Mezger and his staff developed the 912/12, a 5,374cc flat-twelve engine, developing 660 horsepower at 8,300 rpm, mounted in a 1,729-pound open car for their Swiss star. Everyone soon recognized that 660 horsepower was only a starting point.

By 1970/71, Formula One drivers, including Jackie Stewart, Peter Revson, Denny Hulme, and others, escaped from over-regulated F1 with its 1,200-pound open-wheelers powered by 3-liter V-8 or V-12 engines developing 450 horsepower. On alternate weekends, they piloted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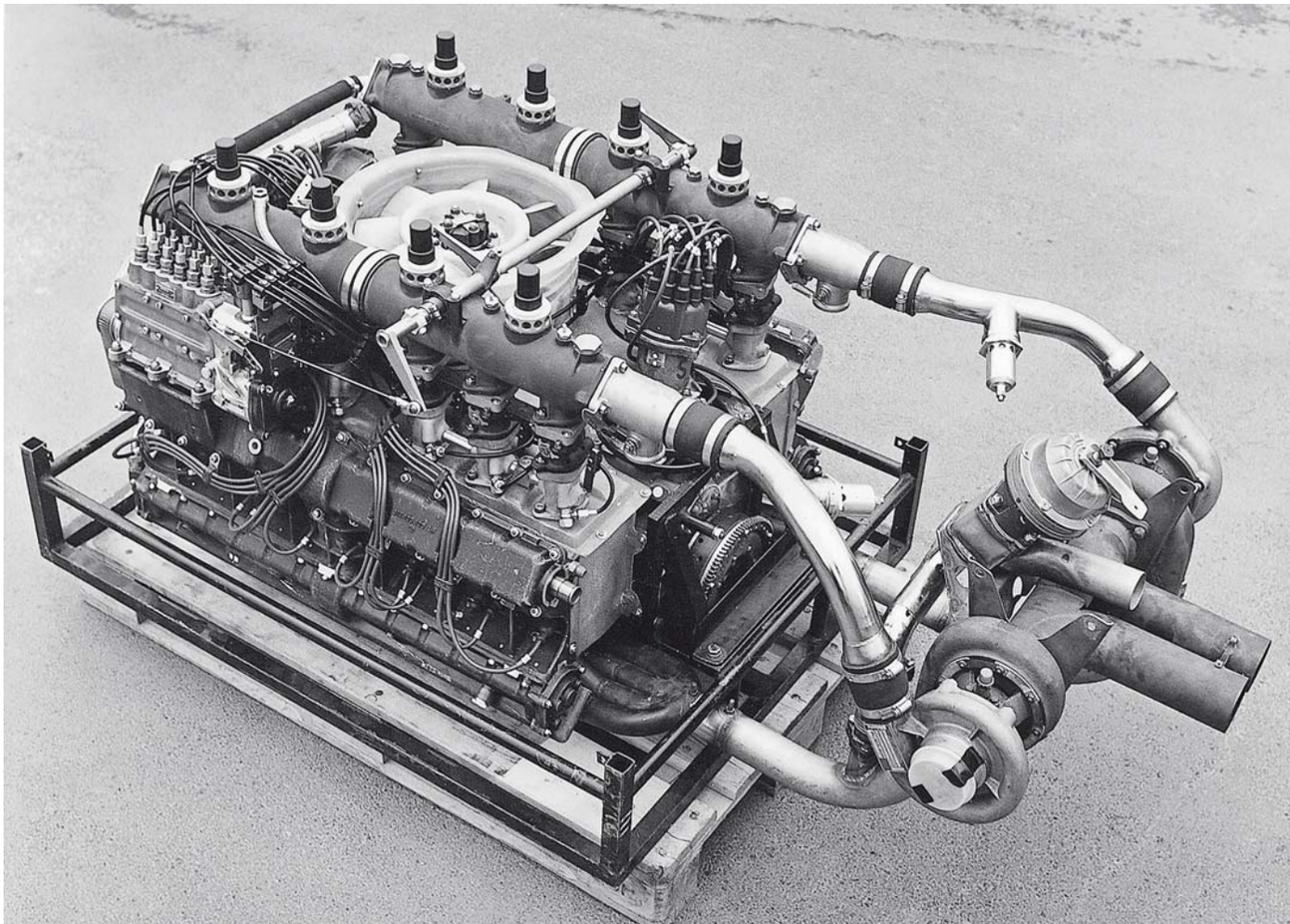
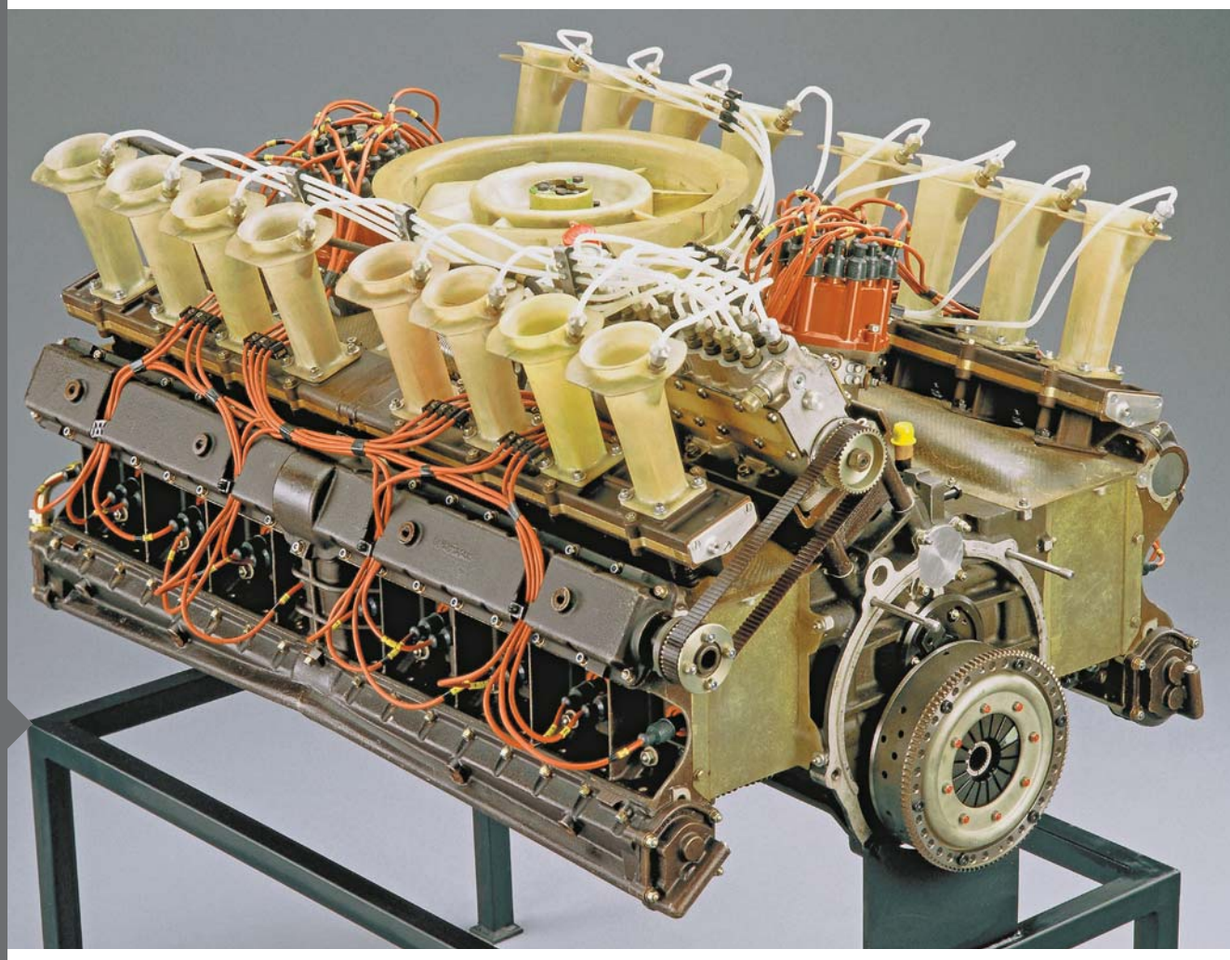




Early wind tunnel experiments grafted bits from various 917 coupe bodies onto Spyder tails to determine the combination with least drag but greatest front-end down force. *Porsche Archive*

Valentin Schäffer and Hans Mezger coaxed 755 horsepower at 8,200 rpm out of the 180-degree sixteen-cylinder engine. It displaced 6,543cc, with bore and stroke of 86 by 70.4 millimeters, and cylinder size matched the 912/10 engines used in Porsche's 1971 917 longtail racers with 4,907cc flat-twelve engines. *Porsche Archive*

The 917-52 Can-Am engine developed 1,100 horsepower at 7,800 rpm from 5.4 liters displacement. It delivered 820 pounds-feet torque at 6,400 rpm. Bore and stroke measured 90 by 70.4 millimeters. The wastegate sat above and between the two large KKK turbochargers. *Porsche Archive*

7-liter American V-8-powered Lolas, McLarens, and Chaparrals. These engines started out at 500-plus horsepower in 1966, and by 1970, many—bored out to 8.2 liters—were pushing 675. At a mid-July 1970 weekend of a Can-Am and a six-hour WCM endurance race at Watkins Glen, New York, the wide-open regulations allowed John Wyer's Gulf Porsche team to run its 630-horsepower 917K coupes in the 200-mile Can-Am event. Siffert finished second in the 5-liter 917 spyder, 28 seconds behind winner Denny Hulme in his purpose-built McLaren. Richard Attwood and Vic Elford, each driving Porsche/Audi USA–entered 917Ks, took third and fourth, respectively. It whet Porsche's appetite for the series and raised questions about the best way to win it. At Ferdinand Piëch's insistence, Mezger and Schäffer enlarged the Typ 912 by adding two pairs of cylinders to each end.

"I had made a sixteen-cylinder," Schäffer explained, "and I had 760 horsepower and that was all I had. They said I must have more and I had no more." The resulting 6,543cc engine added weight without commensurate gain in output. When engineers installed the first engine in a prototype spyder, Willi Kauhsen established a new Weissach track record, but he suggested the chassis needed work because of the extra weight and length. "So Mr. Bott and Mr. Piëch decided we [would] make a 917 engine—the Typ 912—with turbochargers," Schäffer explained. "They said I had to go find

out about them." Barely 10 miles from Zuffenhausen, a company called Eberspächer had begun developing turbos in 1947.

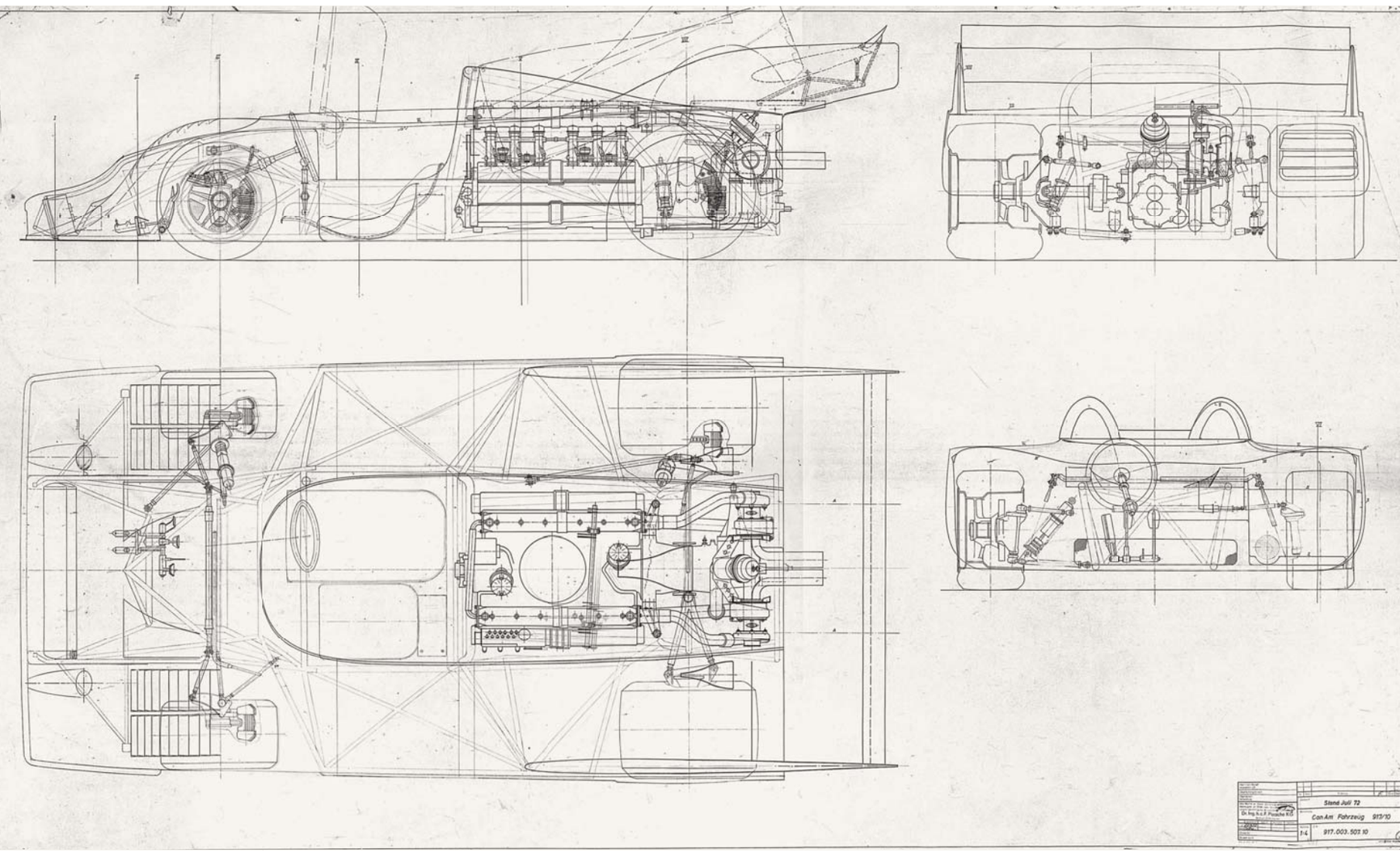
"I came to them, and their people were sitting at a table waiting for me. They asked me, 'What kind of turbocharger do you like?' What kind? . . . I didn't know. Mr. Piëch had said this is a secret, nobody can know! And I didn't ask him, 'Well, what *am* I allowed to say?'"

"I need about 800 horsepower," Schäffer said he told them. "And they looked relieved. 'Okay! That's a boat. That's a thing we can start with. But you will have to use two of the biggest that we have.'" He returned from Esslingen with the two turbines, and he and a mechanic concentrated on intakes and the exhaust. Piëch's requirement for secrecy meant Schäffer and his engine-designer colleague Hans Mezger could ask no one for information or advice. (Ferry Porsche had watched his father, Ferdinand, supervise design of an air-cooled, sixteen-cylinder diesel engine for tanks using turbochargers, but that was decades earlier.) "We had these huge turbos," Mezger recalled recently. "Response was bad. We only could control boost through blowoff. We thought *all* gases had to pass through the turbine."

The twelve-hour WCM race at Sebring interrupted Schäffer's work, and he flew to Florida for testing with Wyer's Gulf 917 team. Gulf officials invited Schäffer to see the new dynamometer lab at their Pittsburg headquarters. The Gulf cars finished fourth and fifth at Sebring, and Schäffer promised he'd visit prior to his next US race. He returned to Germany and resumed turbo engine setup.

"Nobody knew how turbochargers worked," he recalled. "You have so much exhaust it blows up the engine. We had a pipe about 2 meters high. Normally you measure with mercury. You can read it on the pipe and say, 'Aha, 70 or 60 millimeters,' whatever. But we measured only on the intake, on a small pipe. And when we started the engine, the pressure blew all the mercury out of the tube and onto the ceiling. It rained down on our heads."

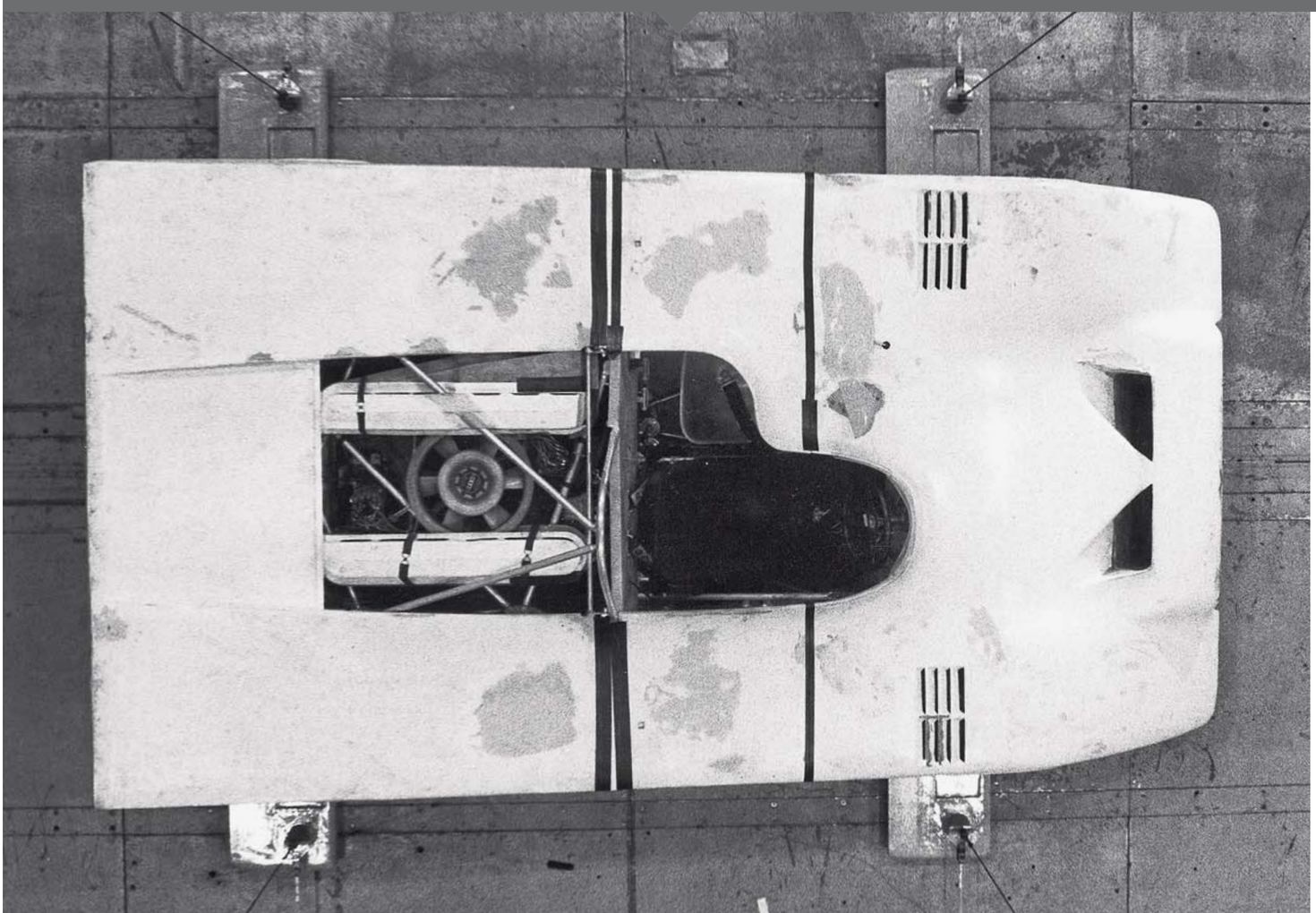
Schäffer concluded they should measure exhaust-side pressure. They began drilling holes in the pipes and making step-by-step tests, easing open the throttle, measuring and recording each increment. After several weeks' effort, "we decided that it works," Schäffer said. "But it is *not* okay!" He returned to the United States and stopped at Gulf. By this time, they had

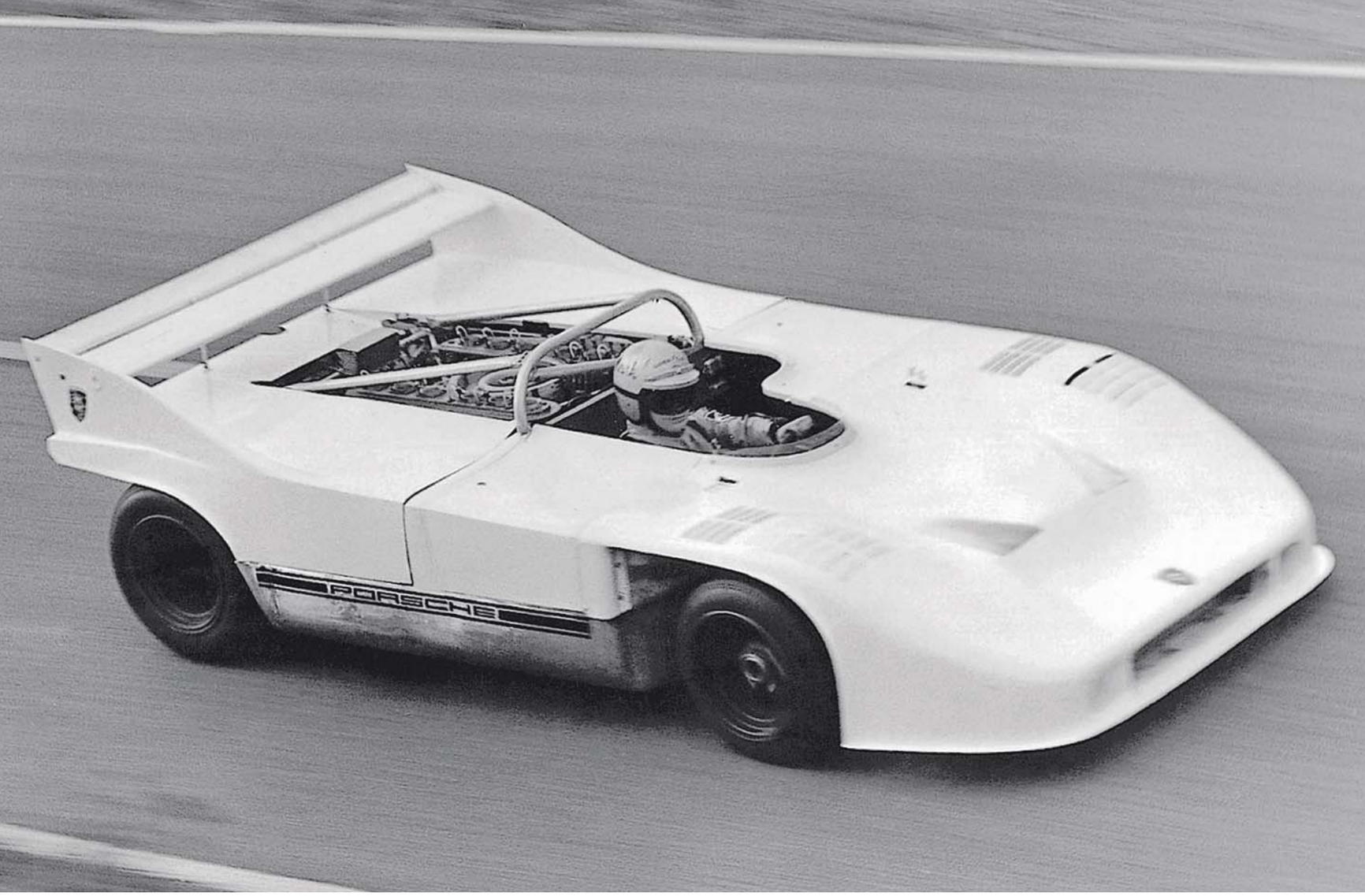


In this first of two successive Can-Am chassis drawings labeled "status July '72," the illustration revealed the profile of bodywork on the 917/10 models. The tube frame chassis was hinted at inside the car. *Porsche Archive*

It's not quite the vacuum-cleaner-nozzle nose everyone came to recognize as 917 Can-Am front ends. But Flegl's wind-tunnel tests did develop the low oil-cooler intake as well as intakes for front brake cooling. *Porsche Archive*

With 917 coupe noses long gone, Helmut Flegl and his team of wind-tunnel aerodynamics engineers began looking at improving airflow with louvered vents on the bodywork. *Porsche Archive*

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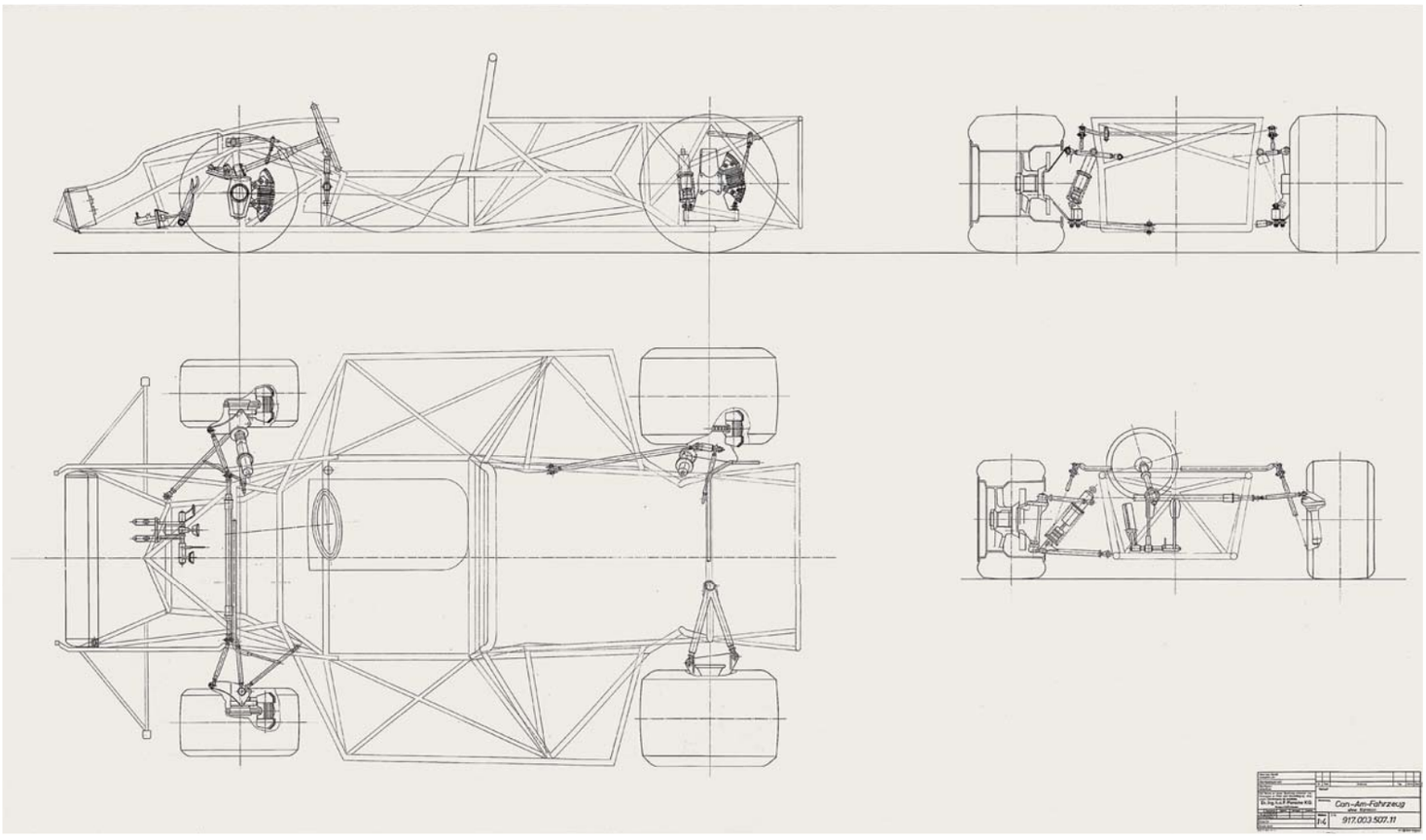
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twenty-five active dynos, and on one, engineers ran a turbocharged four-cylinder Offenhauser through its paces.

"They had a wastegate on it," Schäffer recalled. "I asked what it was, and their engineer explained what it did."

"Oh! Can I buy one?" he asked. He flew home with it in his hand luggage. It went on the test engine, and turbo boost became manageable. "I could turn the screw on the butterfly. And we started our testing. Then we started making our own [wastegates]. We made them lightweight, and they worked very nicely." The 4,494cc turbo engine, designated 912/50, produced 850 horsepower at 8,000 rpm. It went into the radical spyder known as the 917/10 that Roger Penske planned to run for Porsche/Audi USA, sponsored by L&M, the Liggett & Myers Tobacco Company.

In October 1971, Penske and his driver Mark Donohue flew to Weissach to test the car. They planned to be there for three days, but Donohue stayed three weeks, working with Schäffer on engine development and Helmut Flegl on chassis, suspension, and body adjustments. Solving these teething problems produced steady improvement. When the 1972 season began in mid-June at Mosport International Raceway outside Toronto, they felt confident.

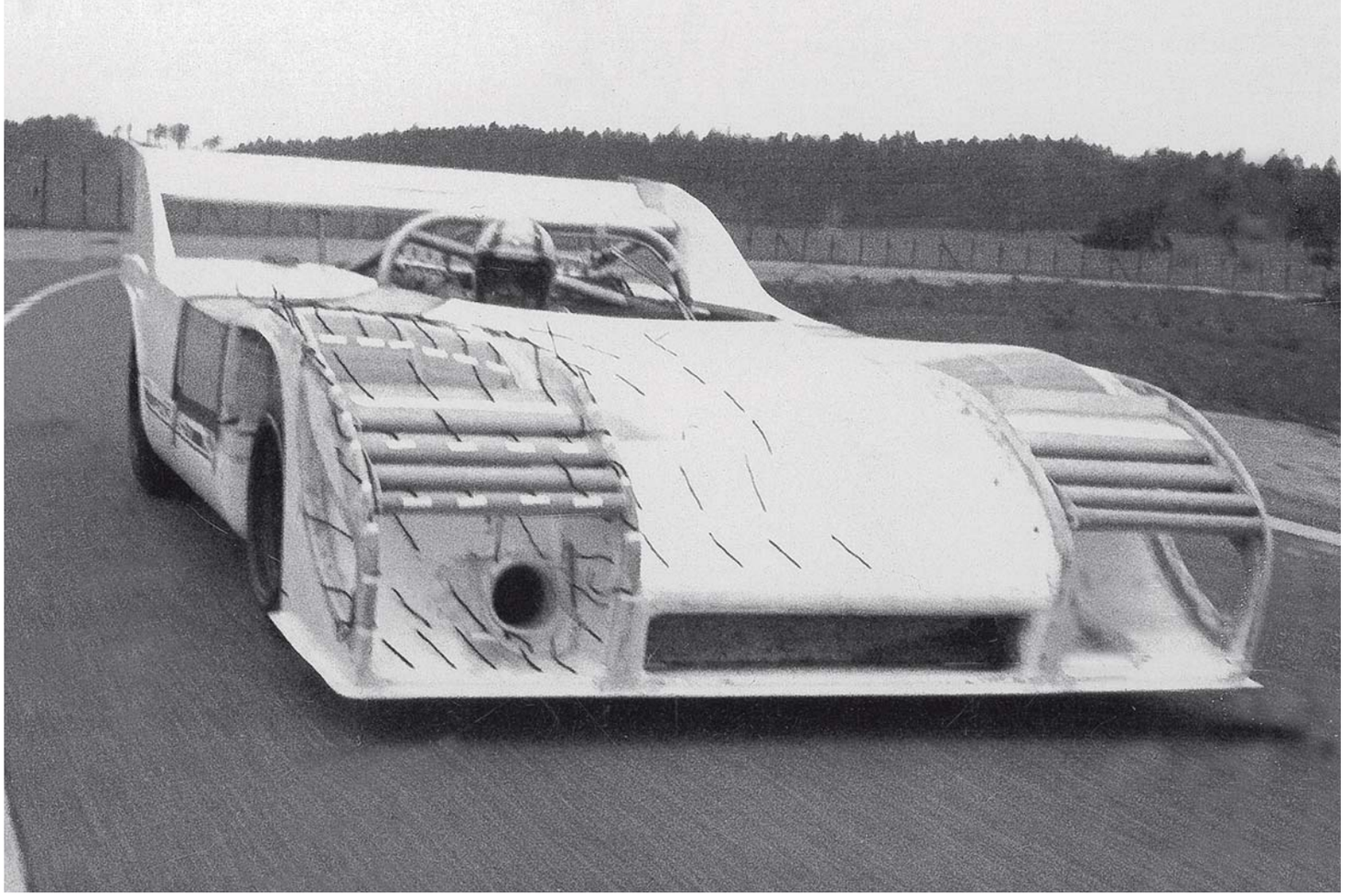
"So we go there," Schäffer recalled, "and we ran . . . 4 seconds faster around the track than McLaren's lap record! On our first day. The other drivers said, 'Oh! That's a rumor. That cannot be!' Then we were fastest in qualifying." The race started and Donohue disappeared, remaining far ahead of the other entries until he pulled into the pits on lap 19.

"No boost!" he shouted. As Schäffer and Penske's mechanics investigated the usual suspects, the rest of the field thundered past them. They lapped him a second and a third time. Finally, Schäffer scrambled up onto the engine and looked down.

Mark Donohue accomplished his first driving tests in Porsche's prototype 917 Can-Am Spyder. After a few laps done for journalists and VIPs, he knew the car needed work. *Porsche Archive*

Penske racing lines up against Porsche as Mark Donohue, far left, Roger Penske (in turtleneck), and Penske's technical director Don Cox hear what 917 project engineer Helmut Flegl has to say. *Porsche Archive*

This second 917 tube-frame chassis drawing illustrates the geometry at play supporting the power and torque of the 917/10 engines with 850 and 1,000 horsepower. The "Can-Am *Fahrzeug ohne Karosserie*" is "Can-Am car without body." *Porsche Archive*



"There was the main throttle," he said, "and there was another special throttle that opens so the turbo could work. Maybe it never had been so hot in testing as it was in that race, but it stuck open so no boost could come from it. I asked the mechanics for a hammer. And another hammer. I banged on both sides and it released."

Donohue resumed the chase. Over the next hour and 45 minutes, Mosport's crowd of seventy-five thousand clung to the fences as he unlapped himself twice on Peter Revson's McLaren and nearly a second time on Revson's teammate Denny Hulme to finish just seconds behind Hulme on the same lap. Milt Minter and Peter Gregg finished fourth and fifth driving other 917/10s. Nine McLarens and Lolas pursued them. Porsche had again served notice on its competitors.

Donohue had a massive crash during testing at Road Atlanta before the season's second race. With him in the hospital, Penske put George Follmer in the driver's seat. Follmer had driven for him in the 1967 Can-Am and was headed toward the Trans-Am championship for Penske's team even as he took over for Donohue. (Driving two or more series for the same owner was common in those days.)

"When you drive for the Captain [Roger Penske], you are there to perform a service, to do it his way, which was fine," Follmer recalled in an interview in 1991. "The problem was that car. That awesome car." Up to that point, he had not driven Road Atlanta and, he said, "I'd never driven a car with that kind of horsepower! I mean at that point, we probably had 850 to 900 horsepower." In fact, the 912/51 had reached 1,000 horsepower at 7,800 rpm by the time Follmer got to it. Still, George was professional, and following his Thursday morning tryout, he set the second fastest qualifying time for Sunday's race.

"When we started," Follmer remembered, "Denny Hulme had the pole and the outside position—which was considered to be the line for the first corner. But he didn't get there first.

"The 917/10 was the kind of car you just drove into the corner on the brakes," he explained. "There was no compression, and downshifting didn't do a thing. So you set the car with the brakes and you hit the throttle right at the beginning of the turn. That would get you through the corner, probably to the apex, and from that point on, you start having the power. But you *had* to be sure the thing was going in the right direction because when it came in. . . . I mean it didn't just come in trickles. It went from 400 to 850 horsepower pretty quick." Follmer won the Atlanta race by a full lap over the second-place Hulme.

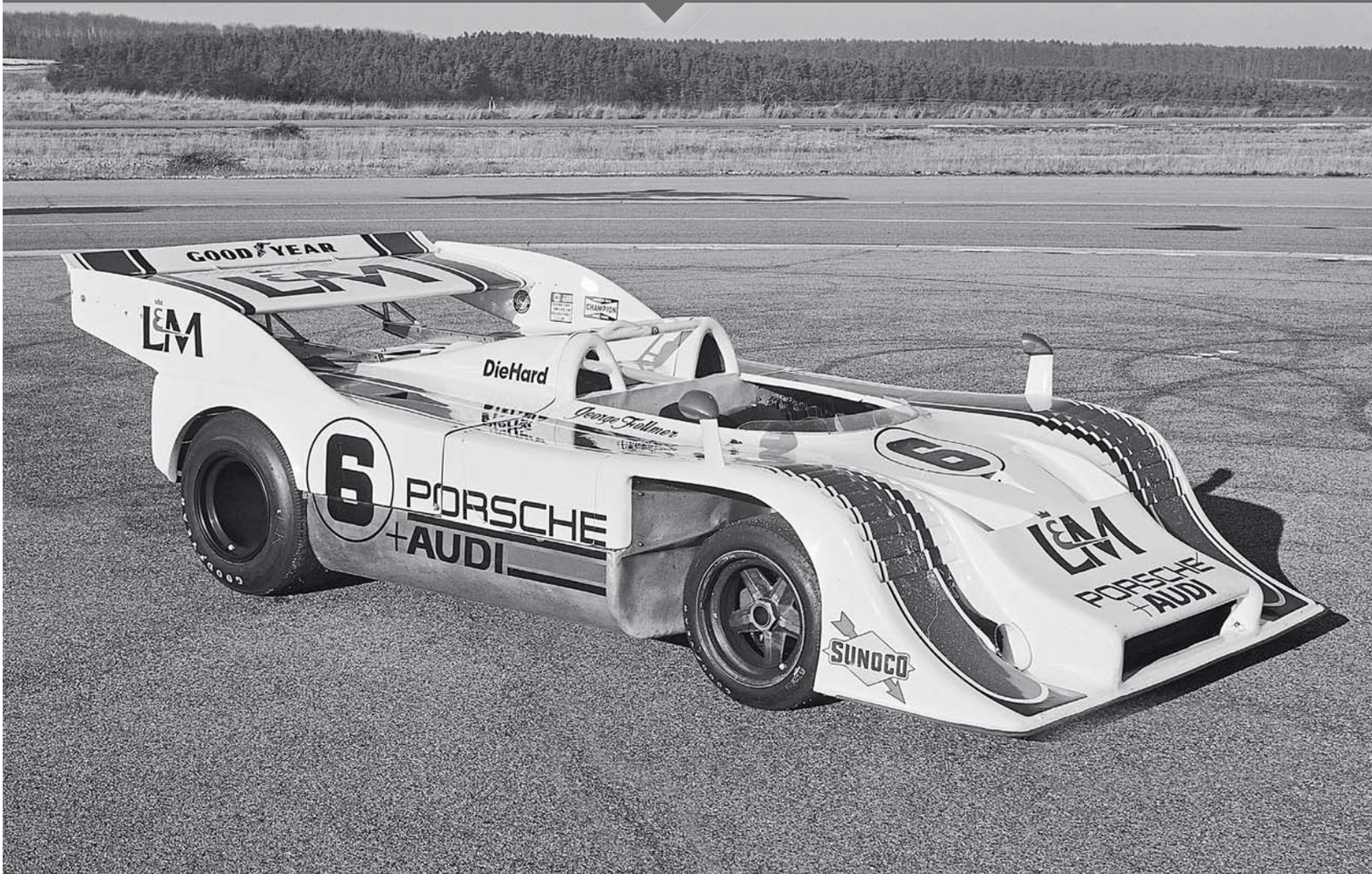
By September, Donohue was back to good health, so Penske added a second car because Follmer was en route to claim the 1972 Can-Am title. Follmer won the two final rounds in California, cinching the 1972 championship for himself, Penske, and Porsche.

By this time, Donohue and Weissach racing engineer Helmut Flegl, working with Valentin Schäffer and Hans Mezger, had perfected the next generation Can-Am Spyder, the 917/30. To ensure better handling, Flegl invented a variable-wheelbase 917/30. Mechanics—with considerable work—could change it from the 90.6 inches of the first-generation Spyders up to 98.4. The extra 8 inches stabilized the car. Simultaneously, Mezger and Schäffer developed the 917/52 engine with 5,374cc displacement. In 1972 Kühnle, Kopp & Kausch A. G. absorbed Eberspächer's turbocharger manufacturing and introduced the KKK turbo series. Porsche strengthened its relationship with the new

At Weissach, Flegl's engineers experimented with ever more radical nose treatments for the next generation 917/30 Can-Am cars. *Porsche Archive*

As the Can-Am series continued in the United States and Canada, Europe launched its own version called the Interserie. Porsche's factory driver Herbert Müller campaigned a 917/10 with Martini sponsorship and won the 1972 season championship. *Porsche Archive*

Early into the 1972 season, Penske's driver Mark Donohue endured a serious crash when bodywork separated from the race car at speed. While Donohue recuperated in the hospital, Penske brought his Trans-Am champion George Follmer in, and George continued Penske's winning streak. *Porsche Archive*

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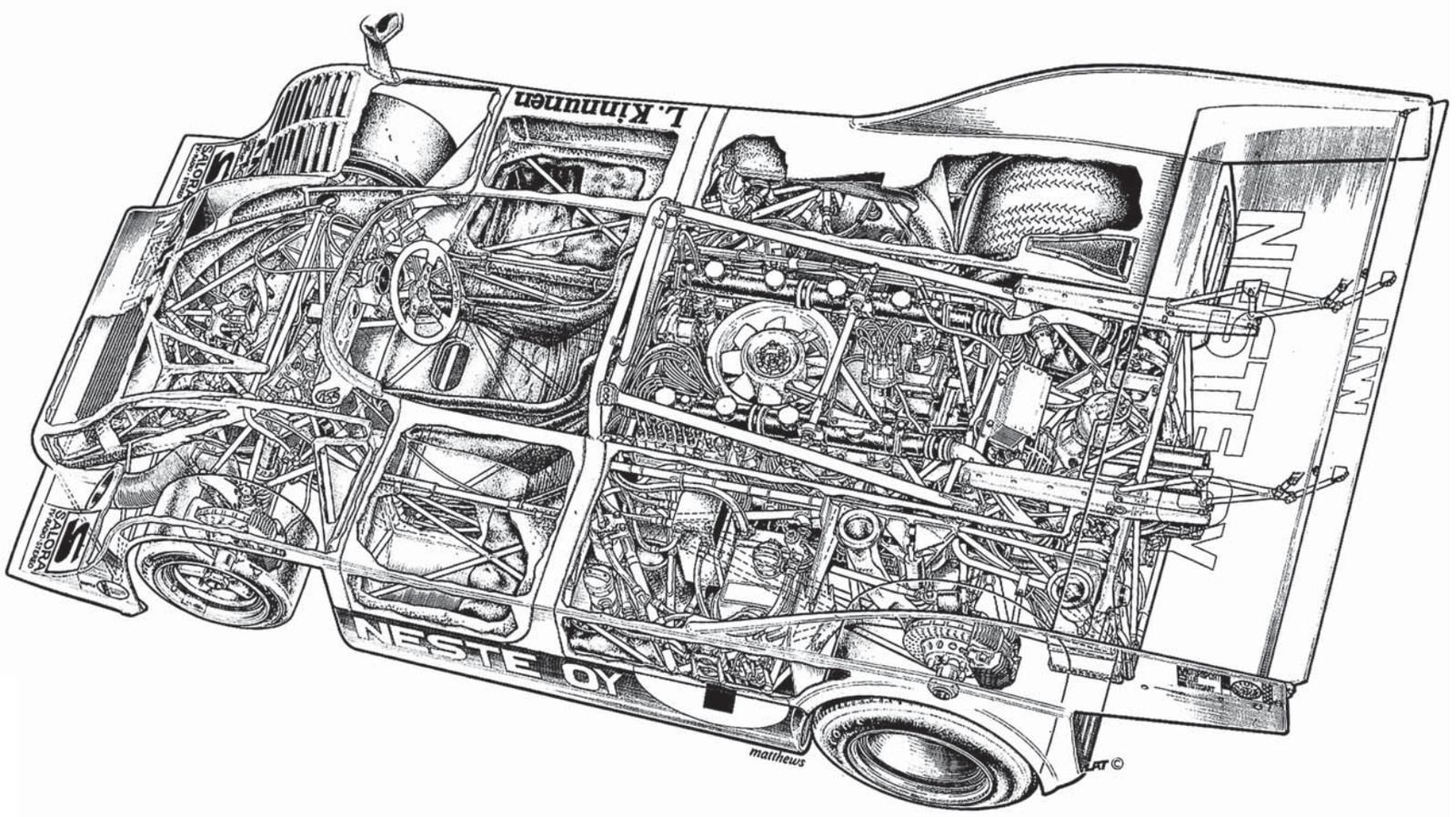


The Typ 917/51 engine in Leo Kinnunen's 917-10 Interserie entry, shown in this cutaway drawing, produced 1,000 horsepower at 7,800 rpm from 4,998cc. It developed 730 pounds-feet of torque at 6,400 rpm and gave Kinnunen the Interserie championship in 1972 and 1973. *Porsche Archive*

Mark Donohue's 917/30 got attention here from a group of Roger Penske's mechanics. On the nearside of the car at center, Porsche engineer Helmut Flegl supervised their efforts. The engine of the 917/52 used bore and stroke of 90 by 70.4 millimeters. *Porsche Archive*

Swiss racer Herbert Müller dominated the 1974 Interserie throughout Europe. This particular 917/30, serial No. 1, was constructed on a variable-wheelbase chassis. *Porsche Archive*

owners, and soon engine output reached 1,100 horsepower at 7,800 rpm with twin KKKs. Schäffer knew it had more power in it.

"We like to do a measure; we did it all the time," he said. "The mechanic [would take] the engine speed up and up, and when it was steady, we wrote it down. One time we took it up and it didn't come back down. The throttle stuck. It was going up and up, and it stuck there for just a second and we could see 1,200 horsepower.

"But it was not the 'right' horsepower. Normally, we read the horsepower on all engines at their speed, holding for maybe 5 seconds or so. We could read the number on the gauge. So we always took care not to stay too long on open throttle. Twelve hundred. Yes.

"Was that the most we ever saw? . . . Excuse me! Fourteen hundred was the most! Exactly that number. Exact. Twelve hundred was the *regular*," he emphasized, "with the 5.4-liter engine when we used the boost to 1.3."

With 1,200 horsepower as "the regular," Donohue made the 1973 Can-Am season a one-car race. Still, he teased Schäffer, reminding the Hungarian turbo engineer he had only enough power when he could spin the wheels the entire length of a straightaway. Donohue won the 1973 title.

Can-Am had become a series of single-marque successes. Lola won the inaugural championship in a Lola in 1966; between 1967 and 1971, McLaren cars claimed the titles. The 917 reignited spectators' interest, yet they found it hard to fathom the car's subdued engine noise. Mezger explained the spectator angst: "The car doesn't look as fast as the other Can-Am cars without the noise. We thought it wasn't fast until we saw the times." Twin turbochargers swallowed engine sounds, although as these cars shot away from the Lolas and McLarens, excitement returned. But through the 917/30 era, crowds drifted away. Then it got worse.

Racing suffered badly after the October 1973 announcement from the Organization of Petroleum Exporting Countries (OPEC) that it would be curtailing shipments to Western nations. The SCCA suspended its 1974 Can-Am season after just five events. Racing seemed to waste resources, and fewer spectators could afford the price of gas for their weekend outings. The series returned in 1977, but Porsche and its turbos had found others to contest in North America. In Europe, the similarly run Interserie persevered, and Porsche's Swiss-born team driver Herbert Müller won championships in 1973, 1974, and 1975, driving that variable-wheelbase 917/30-001 prototype in Martini racing livery. After that, Porsche withdrew; it had other ideas for its turbos.

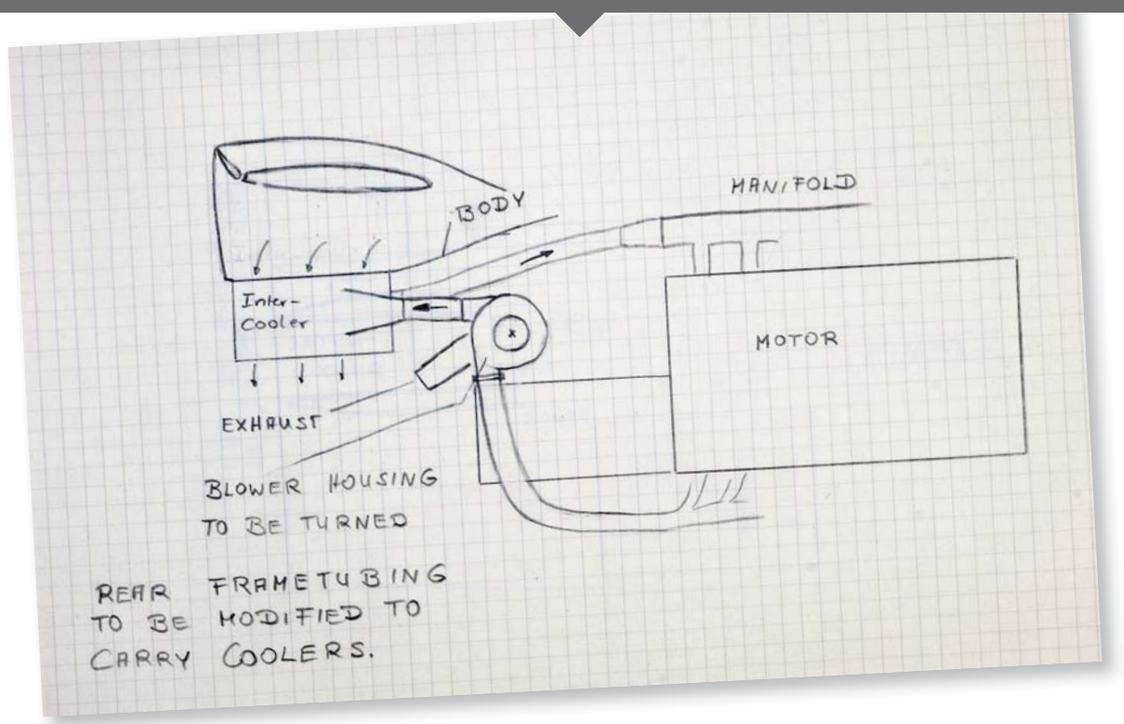
THE RECORD RUN

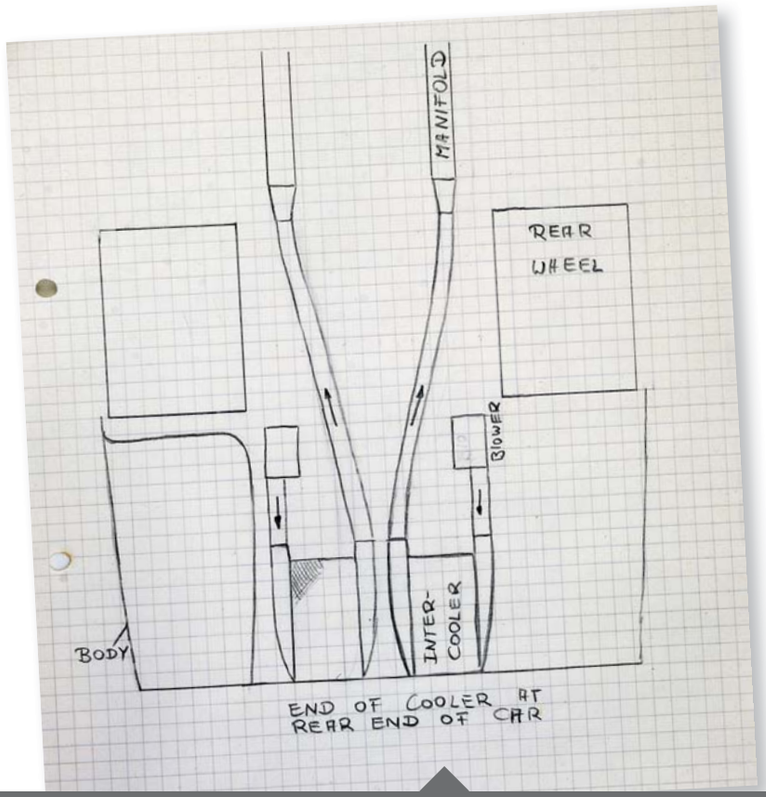
Donohue's experience with the twin-turbocharged 917/30 inspired Roger Penske; he was sure the car still had more to prove. In 1975 he convinced Flegl, Mezger, Schäffer, and Donohue to attempt a world speed record on a closed course—that is, on a racetrack as opposed to Bonneville's salt flats or other open venues. Penske and Donahue had tried in March 1972 at Daytona in Penske's normally aspirated Ferrari 512. They established a track record of 199 miles per hour, but two years earlier a NASCAR Dodge had lapped Talladega at 201 miles per hour. The 2.66-mile triangular oval track at Talladega, near Lincoln, Alabama, remains the longest of any closed oval in the United States, and its 33-degree banking in turns 1 and 3 makes it the steepest.

The second race of the 1973 Can-Am season took place at Road Atlanta near Braselton, Georgia. While Mark Donohue qualified fastest in his 917/30, it was George Follmer in the No. 16 RC Cola 917/10 who won the race. *Porsche Archive*

Mark Donohue's Sunoco 917/30 led the pack after the start of the eighth and final Can-Am race of the season, at Riverside International Raceway. Donohue won the race and the series championship. *Porsche Archive*

Don Cox, technical director for Penske racing, made this drawing to show what he believed was the optimal position for intercoolers for the speed record run. This horizontal mount allowed mechanics to pack the tops with ice for the run. *Porsche Archive*





As Donohue explained to Porsche's head of sales Lars Schmidt in June 1975, the 917/30 "was originally designed to run on road-racing courses. . . . It has a lot of aerodynamic downforce and lots of horsepower. But since top speeds were never much over 200 miles per hour or so, no thought was given to the drag, the aerodynamic drag of the car." Helmut Flegl returned to the wind tunnel, reshaping the body to reduce drag and maximize high-speed stability.

The engine raised other concerns. Donohue sent a telex to Schäffer explaining that they twice had attempted a record run but both times failed because overheating destroyed the engine.

"Mark, that is no surprise," Schäffer wrote back on a telex filed in Porsche Archives. "The engine is no good for three laps with full open throttle. You have to lift and the engine needs to cool."

"What do we need to do?" Donohue asked.

"Take a 5-liter," Schäffer replied. "It's a stronger engine. Cylinders are smaller, greater wall thickness, better cooling. It has not so much horsepower, but you can use more boost!"

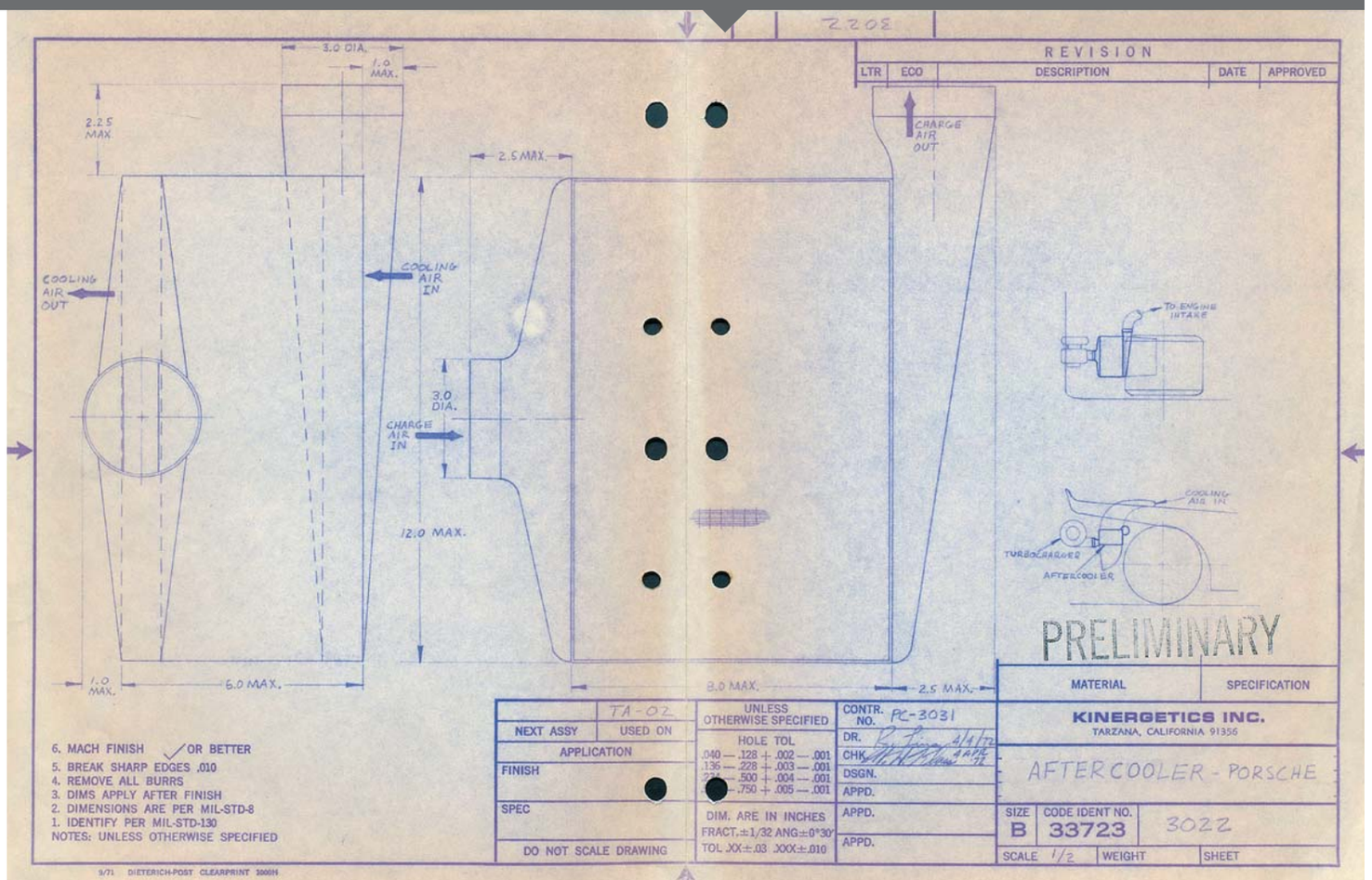
"Can we use an intercooler?"

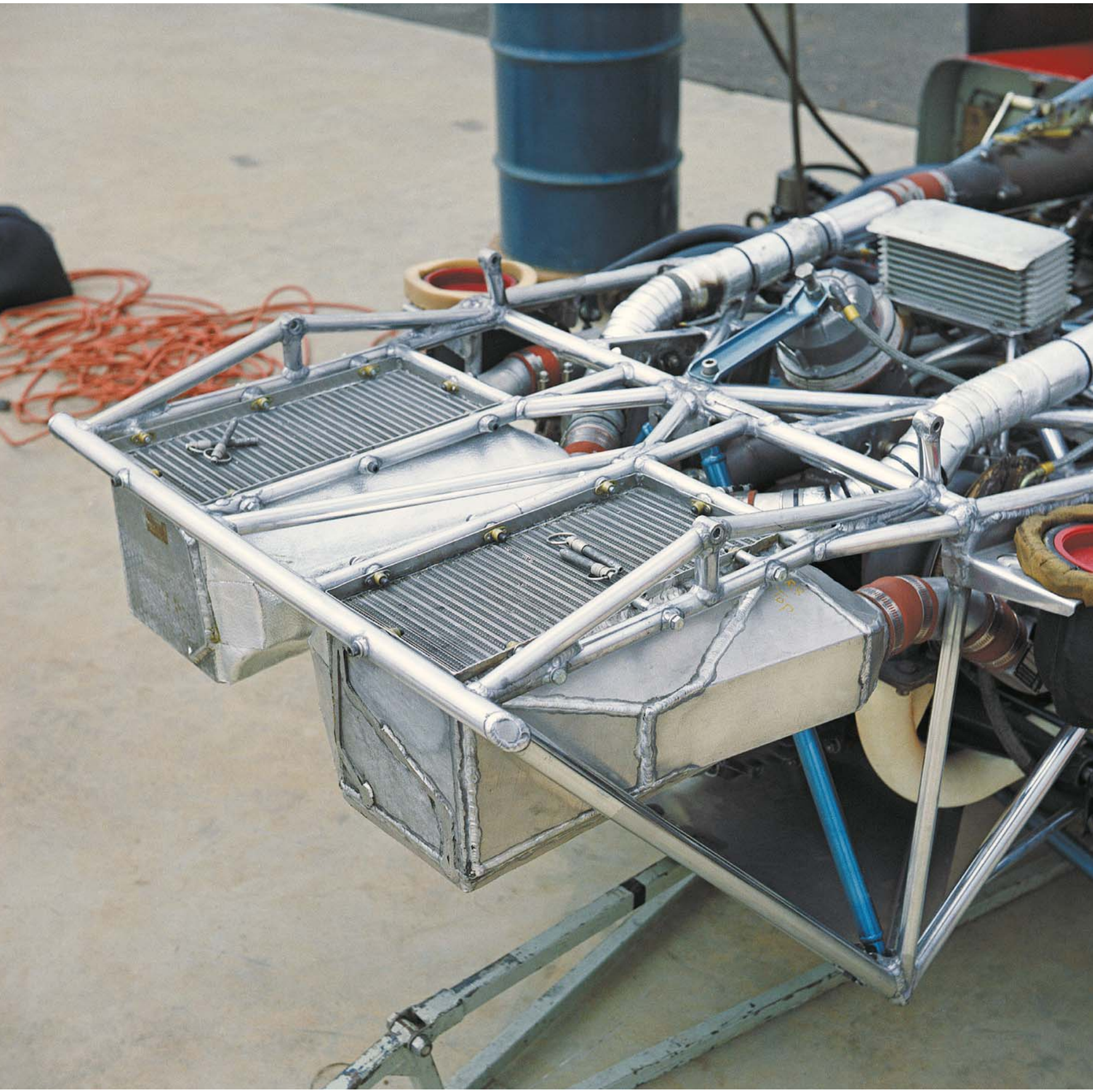
Schäffer had used an intercooler on a prototype the year before. Donohue sent him a drawing by a southern California supplier; Porsche produced

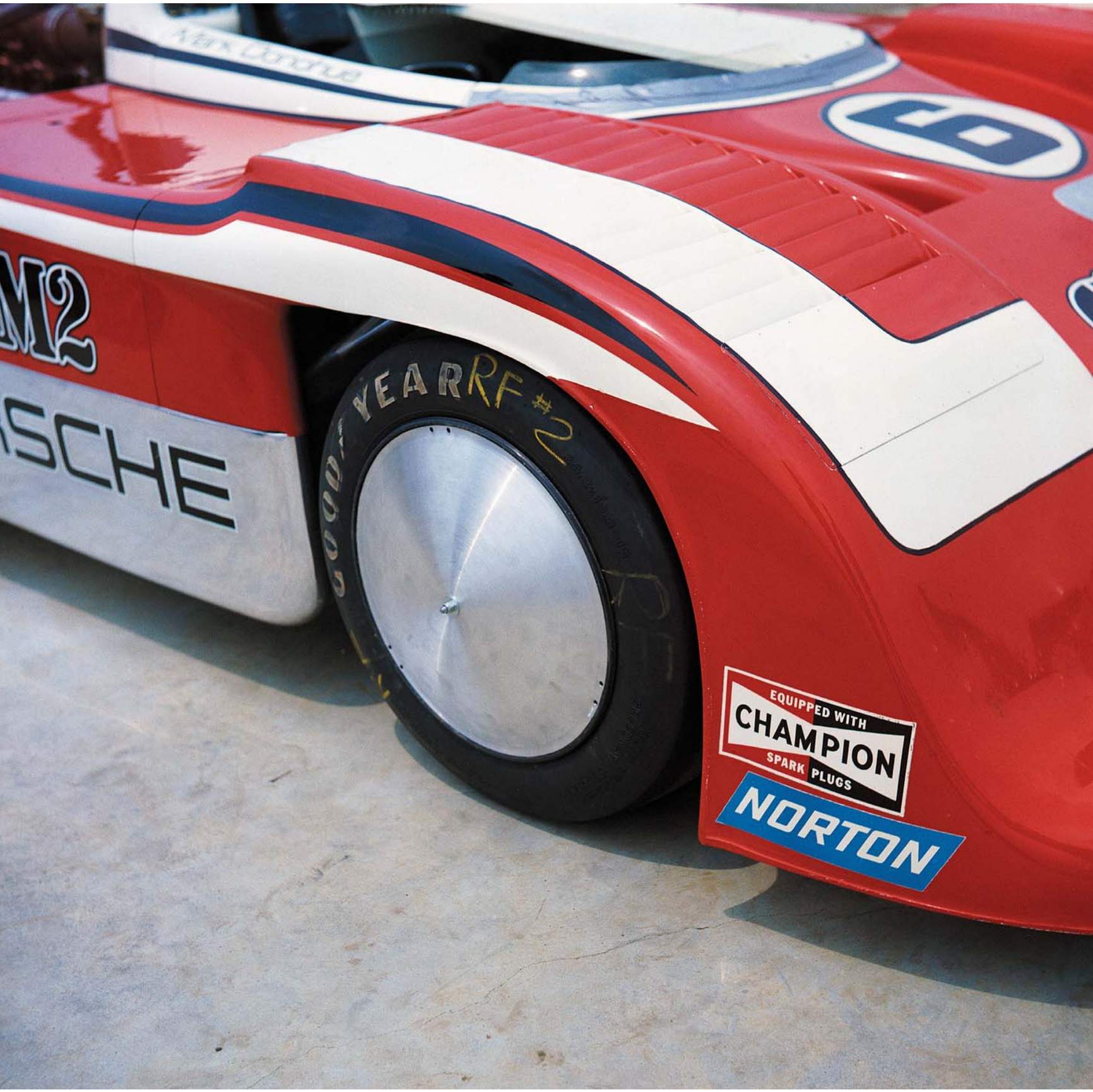
Cox's overhead view of the twin intercooler installation showed not only placement but also intake air flow. *Porsche Archive*

Kinergetics, Inc. in Tarzana, California, developed this plan for a turbocharger "aftercooler" in April 1972. These units, 8 by 12 by 6 inches, were meant for vertical installation below the car body. *Porsche Archive*

The long insulated hoses from intercoolers to intake probably caused significant lag between throttle inputs and engine reaction. But it was unimportant because once Donohue got up to speed, he never lifted until he achieved the record speed. *Porsche Archive*






M2
SCHE
YEARRF #2
EQUIPPED WITH
CHAMPION
SPARK PLUGS
NORTON

a pair that it tested along with other ideas. "I measured the temperature from the top, from the bottom," Schäffer recalled. "I had nearly 300 degrees [Fahrenheit] difference from the turbo on the bottom through the cooler on the top. And that meant 40 horsepower more just from the cooling!"

Flegl and his engineers fabricated intercooler platforms behind the engine. They revised the Can-Am nose for better air management, fitted a tonneau over the passenger-seat area, and fitted flat wheel covers. They strengthened the suspension to accommodate centrifugal-force loading that squashed the car onto the banking. Ready to run, 917/30-003 weighed 1,975 pounds without racing fuel and driver. Engineer and racing historian Paul Frère noted in his book *Porsche Racing Cars of the '70s*, "The cooling air for the intercoolers was taken in on the surface of the rear deck and the ducts were packed with ice for the attempt. This in turn enabled them to get the 1,100 horsepower normally produced by the 5.4-liter engine from a 5-liter unit."

Donohue's college friend Burge Hulett was with him at Talladega on Saturday, August 9. According to Hulett's account in *Automobile Quarterly*, the weather threatened rain. Donohue took off, running a warmup lap and then inching the car higher on the steep banking. Hulett wrote:

Every other time Donohue has taken the Porsche out he lifted off the throttle slightly to let the engine cool. This time there is no let up.

The 917-30 shoots around the first and second turn. It wobbles imperceptibly as it picks up speed. Donohue's foot is flat on the floor.

A drop of rain falls and the now-black clouds are almost on the roof of the grandstands. The air is still and suddenly feels cold. . . . All you can hear is the sound of the engine straining against the red line.

Spectators in the pits can't see the 917-30 on the back straight or in the third turn. Suddenly the bright red car bursts out of the [last] turn and slams onto Talladega's front straight at more than 250 miles per hour, inches from the outer wall. It's gone before anyone can utter a word . . .

Finally we realize Donohue has the record.

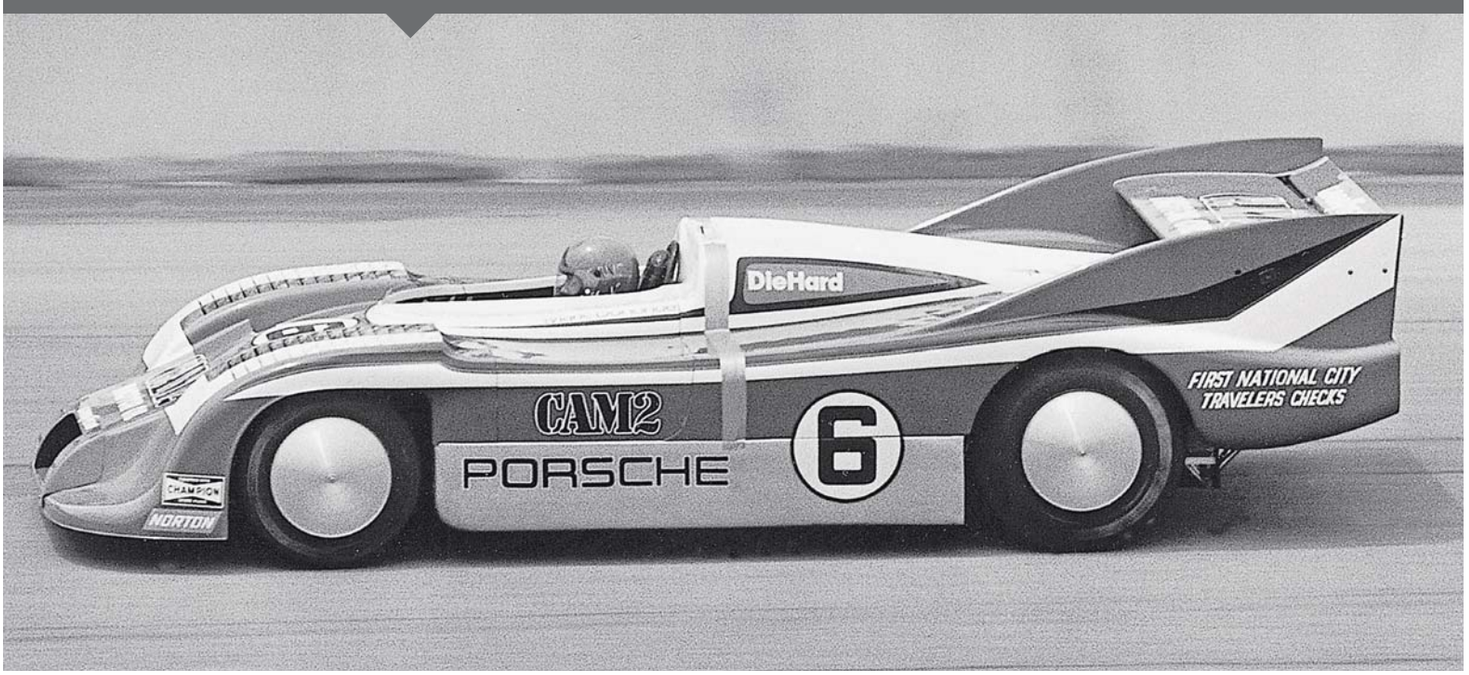
Donohue had run Talladega's 2.66 miles in 43.1 seconds, covering each mile in 16.2 seconds for an average speed of 221.12 m iles per hour. This established a new world closed-course record and exceeded the previous one, set by an Indianapolis turbocharged racer, by 2.78 miles per hour. Turbos had been around Indy since 1952 and, as racing historian Ian Bamsey wrote in his book *A History of the Turbocharged Racing Car*, "By the end of the sixties turbocharger technology was well established at the Brickyard. With its wide-open curves, throttle lag was not of serious concern and the methanol fuel was ideal in the face of increased heat. Road racing was another matter altogether."

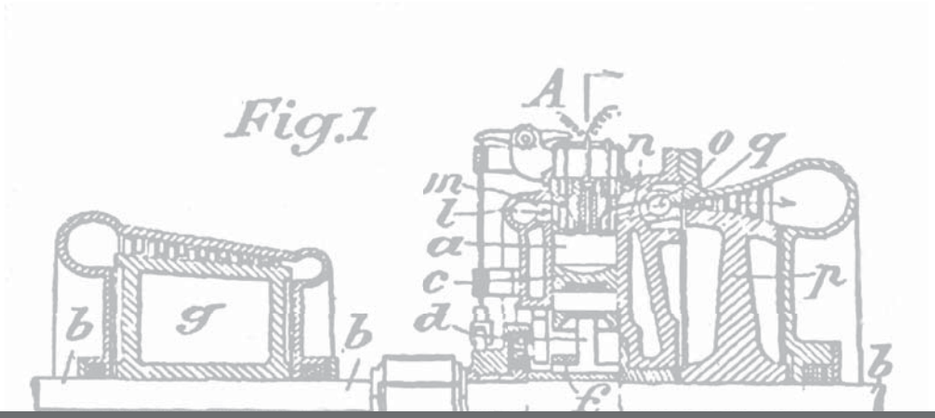
That was true until Valentin Schäffer and his colleagues at Porsche perfected what Mark Donohue later referred to as "the Unfair Advantage." What that inspired became legend and legacy.

And then heritage. And then a product plan.

Wind tunnel time suggested a number of small improvements to streamline the 917/30 for its top speed run. Disks like this covered all four of the deep wheels, eliminating one area of turbulence. *Porsche Archive*

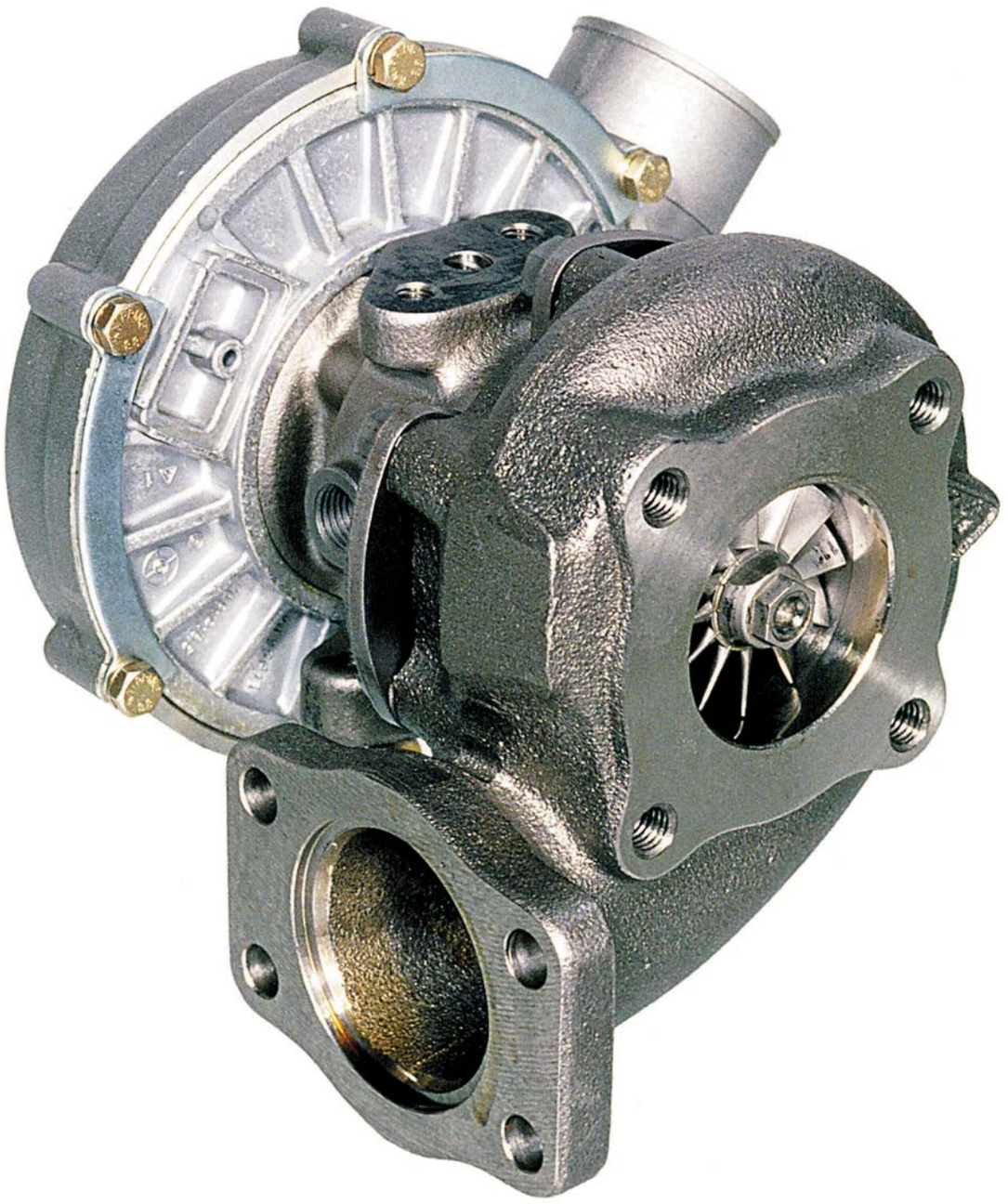
Penske's mechanics went so far as to apply racer tape to the body seam ahead of the engine compartment. Donohue set a record of 221.12 miles per hour. *Porsche Archive*





Chapter Two

WHAT IS **TURBOCHARGING** AND HOW DOES IT WORK?



For most of the history of self-powered vehicles, internal combustion or diesel cycle engines inhaled air on demand to mix with fuel and facilitate combustion. This system is known as normal aspiration, and the air/fuel mixture enters the engine through carburetors or fuel-injection systems at the same atmospheric pressure at which humans breathe: 1 bar, or 14.5 pounds per square inch (psi) at sea level.

The gas-fired internal combustion engine dates back to 1860, when a Belgian inventor named Jean Joseph Étienne Lenoir assembled the first of his many attempts that used pistons sliding inside a cylinder attached to connecting rods mounted on a crankshaft that spun a flywheel to create rotational energy suitable to move a vehicle. By 1876, German engineer Nikolaus Otto had developed the four-cycle engine from Lenoir's ideas. Otto's Silent Engine was the precursor to the modern gasoline automobile engine. About a decade later, in 1885, two other German engineers, Gottleib Daimler and Wilhelm Maybach, invented the carburetor as a means of forcing the air/fuel mixture into the cylinder.

Following different inspiration, Rudolf Diesel demonstrated his engine concept at the 1900 Exposition Universelle, the world's fair in Paris. Unlike the Otto-cycle engines of Daimler and Benz—which used an open flame in a tube or a spark inside the cylinder to ignite the gasoline fuel mix—Diesel's invention, a compression engine called the spark-ignition engine, relied on extremely high cylinder pressure. With nearly six times the compression ratio of Otto's internal combustion version, the intense heat this generated ignited the fuel.

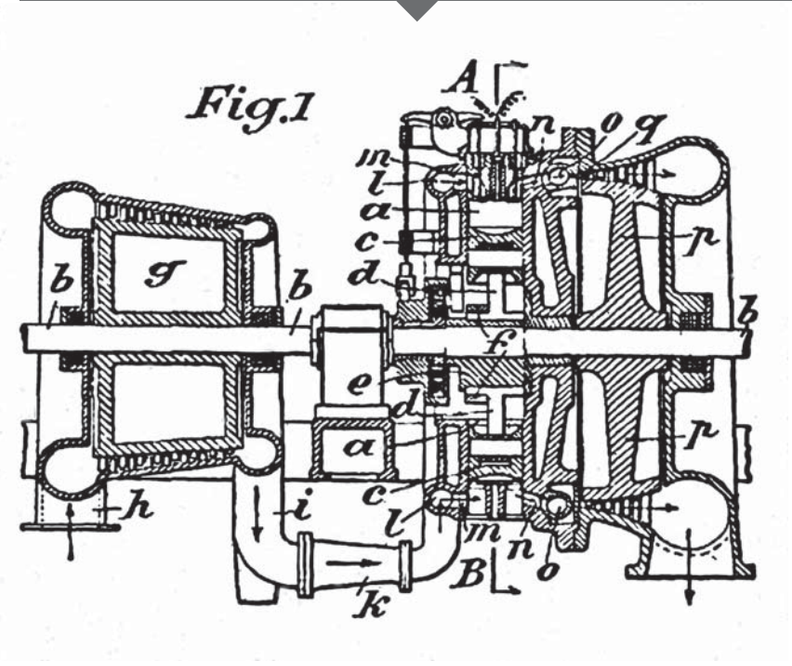
Throughout the 130 years since Daimler's forced-air patent, more aggressive means of forced induction have required belts, chains, gears, or the engine crankshaft to drive them. Principal among these has been a compressor known as a supercharger. This technology has evolved and improved over the decades. "The term *supercharging*," John Heywood wrote in his 1988 book *Internal Combustion Engine Fundamentals*, "refers to increasing the air (or mixture) density by increasing its pressure prior to entering the engine cylinder. . . . The first [method to accomplish this] is *mechanical supercharging* where a separate pump or blower or compressor, usually driven by power taken from the engine, provides the compressed air. The second method is *turbocharging*, where a turbocharger—a compressor and turbine on a single shaft—is used to boost the inlet air (or mixture) density. Energy available in the engine's exhaust stream is used to drive the turbocharger turbine, which drives the turbocharger compressor, which raises inlet fluid density prior to entry to each engine cylinder." (All italics Heywood's.)

Heywood added, "Charge cooling with a heat exchanger (often called an aftercooler or intercooler) after compression, prior to entry to the cylinder, can be used to increase further the air or mixture density." But this surges ahead of turbocharging history.

That began in 1905 when a Swiss engineer named Alfred Büchi at Gebrüder Sulzer Maschinenfabrik (where Diesel had interned years before) received patent number CH 35 159A for an improvement "through the energy of the exhaust of the engine to increase the fuel-air mixture flow and thus the performance can be increased." The patent stated that the exhaust's kinetic energy drove Büchi's turbine shaft, which served

Engineers work to position these turbochargers as close as possible to engine exhaust and intake manifolds to lessen the delay—or lag—between increased power demand and delivery. The turbine blades visible on this turbocharger typically vent straight into the vehicle's exhaust system. *Porsche Archive*

In 1905, Swiss mechanical engineer Alfred Büchi received a patent for an exhaust-driven turbo supercharger for internal combustion engines. A decade later his prototype of this device was not successful, but in 1925 he met success, getting an updated design to work consistently with diesel engines. *Porsche Archive*



as a "precompressor for the cylinders through a cooling system [of an] incoming air-fuel mixture."

Turbocharging appeared on large-ship diesel engines between World War I and World War II. Ground-based vehicle adoption, however, was scarce. It was not until 1938 that a Swiss engine manufacturer, Adolph Saurer A.G., introduced its D1 KT turbocharged diesels in commercial trucks.

The aircraft industry quickly saw the benefits. Before World War II, airplane engine makers used turbos to increase power and raise service ceilings for their engines. This compression re-created the atmospheric conditions of much lower altitudes. Turbo-superchargers (as manufacturers referred to them) gained use in World War II piston-engine fighter and high-altitude bomber aircraft. This happened despite the fact that these systems required considerable extra plumbing and hardware, which took up precious space and added weight and cost. The tradeoff was that these engines maintained high-horsepower output even at 30,000 or 35,000 feet, necessary for high speed or for heavy bomb loads. On the ground, however, the auto industry remained skeptical.

In 1950, Cummins Engines entered an aluminum-block Model JS-600 diesel in the Indianapolis 500. With its gear-driven Roots-type blower, this inline six-cylinder, 401-cubic-inch powerplant developed 345 horsepower at 4,000 rpm and qualified at 129.2 miles per hour. But because it was an experiment, it started at the back of the thirty-three-car pack. Impressively, it had worked its way up to sixteenth position on by fifty-second lap, when it retired with a mechanical failure. It seemed that only Cummins engineers noticed the advances here; this was the first step.

The second step came in 1952 when Fred Agabashian entered a next-generation Cummins diesel-powered car, and with it were more innovations: Cummins had turbocharged its NHH diesel, and it developed 380 horsepower at 2.1 bar of boost. The engine maker had developed an aluminum block and cylinder head and used a magnesium crankshaft. Kurtis Kraft designed and manufactured the race-car body, testing it in a wind tunnel to improve its aerodynamics. Engineers mounted the inline six nearly horizontally in the Kurtis Kraft to lower its center of gravity and improve handling through Indy's banked corners. Remarkably, Agabashian qualified the car on the pole with a fastest lap of 139.104 miles per hour, a full mile per hour faster than the second quickest entrant. He ran well, completing seventy-one laps before tire debris from other cars plugged the low-mounted turbocharger's air intake and starved the engine. But another decade passed before turbos returned to Indianapolis; in the meantime, the technology dropped from sight.

In 1962, General Motors, alone among all Detroit makers, offered Oldsmobile F85 Jetfires and Chevrolet Corvair Monza Spyders with Garrett AiResearch turbochargers. The engines suffered from insufficient development and proved troublesome, and GM dropped the Olds in 1963 while Chevrolet dealers sold the occasional turbocharged Corvair Corsa model through 1966. Turbos disappeared for another few years before emerging on aftermarket Ford Capris and then on series-production BMW 2002 Turbo models in 1973. During that time, engineers and product planners worried that excessive turbo lag—the delay during acceleration as exhaust pressure increased enough to spin the turbo and boost the horsepower—posed a risk to drivability and safety.

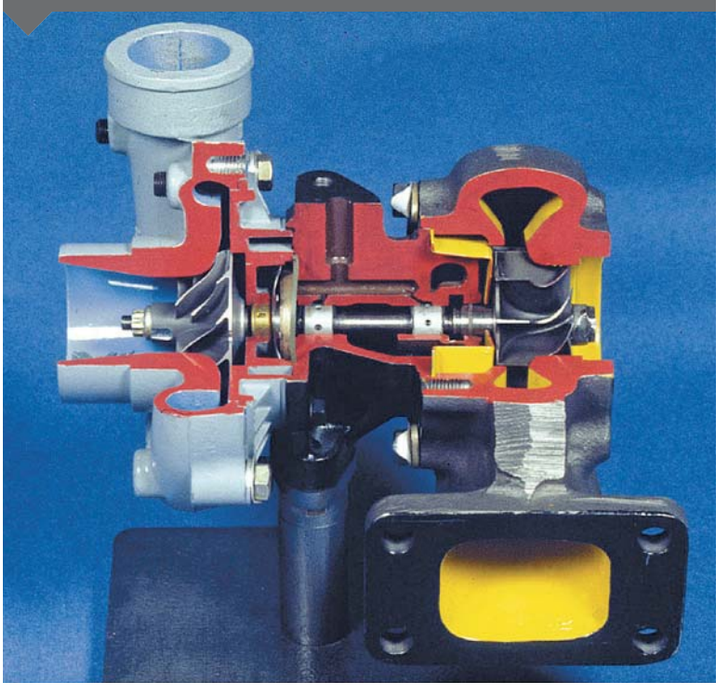
That was only one consideration. The late-1973 OPEC petroleum blockade redefined any kind of performance automobile as a villain. BMW withdrew its 2002 Turbo model at the end of the 1974 model year.

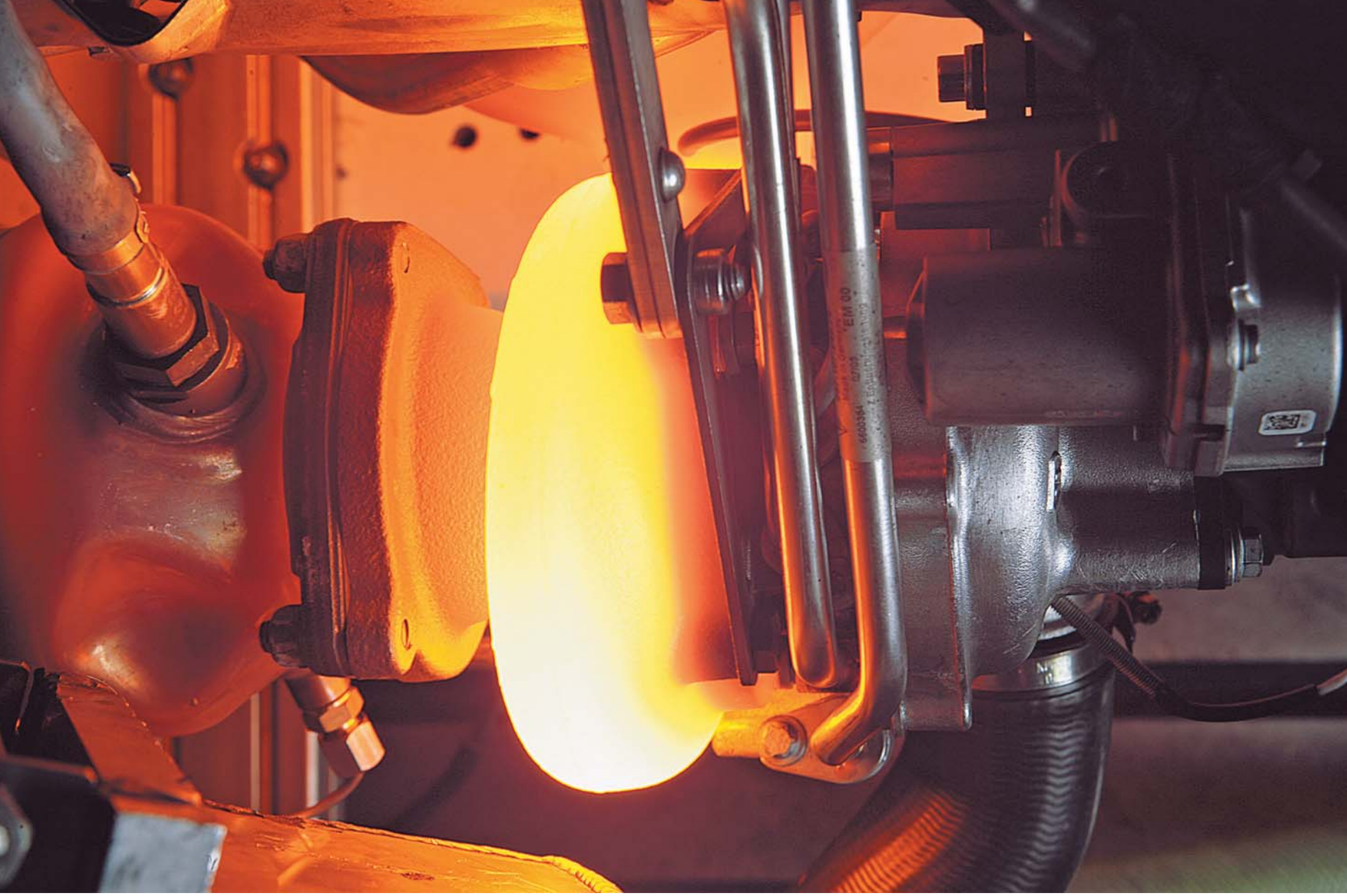
Yet Porsche bucked the trend; that was the year it debuted the 911 Turbo following several years of racing success.

While turbo lag challenged drivers, the other risk with all turbochargers was too much exhaust pressure. "The problem of overspeeding the turbocharger and generating very high cylinder pressures," Heywood wrote, "often requires that some of the exhaust be bypassed around the turbine. The bypass valve or *wastegate* [italics Heywood's] is usually built into the turbocharger casing. It consists of a spring-loaded valve acting in response to inlet manifold pressure on a controlling diaphragm. When the wastegate is open, only a portion of the exhaust gas will flow through the turbine and generate power; the remainder passes directly into the exhaust system downstream of the turbine." Typically, Heywood explained, "About 30 to 40 percent of the exhaust bypasses the turbine at maximum pressure and load."

Exhaust gas enters the turbo through the yellow inlet channel, pushing on the scoop-shaped turbine blades before escaping through the opening on the right. Air enters the turbo through the round blue opening at the top, sucked in by the spinning turbine with angular blades on the left, and forcing air under pressure out the blue opening on the left. *Porsche Archive*

Gasoline engine exhaust temperatures typically reach 1,050 degrees Celsius—a little bit more than 1,900 degrees Fahrenheit under sustained heavy load. Under conditions such as these, the turbines can spin as fast as 150,000 rpm. *Porsche Archive*



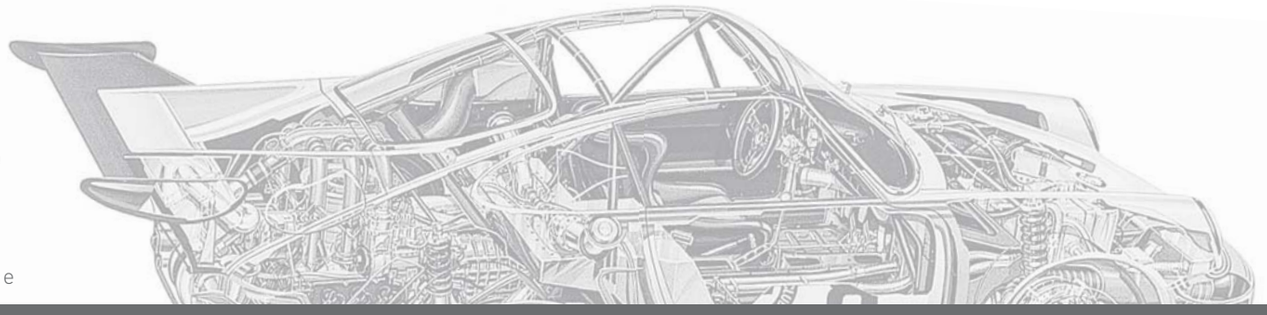


Charge cooling or intercooling provides great advantages to engine performance. As N. Watson and M. S. Janota wrote in their 1982 classic text *Turbocharging the Internal Combustion Engine*, "It is impossible to compress air without raising its temperature unless the compressor is cooled. Clearly it is attractive to try to cool the air between compressor delivery and the intake to the cylinders." As they explained, "Since the charge density increases with aftercooling, more fuel can be burnt raising the power output in proportion to the density. . . . The additional cost of the intercooling equipment is offset by this higher power output."

The properly designed turbocharging system delivers more horsepower and torque than the same engine under normal aspiration. Torque is what drivers and enthusiasts often refer to as the "grunt" energy of an engine. In their 1944 textbook *Internal Combustion Engines: Analysis and Practice*, coauthors Burgess Jennings and Edward Obert explained this force simply: "Torque is a measure of the capacity of an engine to do work, while power is a measure of the rate at which the work is done." This was perhaps the first use of this analogy among engineers and historians. The *Encyclopedia Britannica* formally defines horsepower as "a unit of power equal to 550 foot-pounds per second, equivalent to 745.7 watts." The figure 550 refers to the amount of work required to raise 550 pounds 1 foot in 1 second. According to the *Encyclopedia Britannica*, this "is actually about 50 percent more than the rate that an average horse can sustain for a working day." Another term in vehicle use is *brake horsepower*, referring to the "horsepower at the output shaft of an engine, turbine, or motor."

Turbocharging (or supercharging) crams more air/fuel mixture into the cylinder, increasing the intensity of the spark-ignited explosion, thereby creating more horsepower. This also pushes harder on the piston connected to a rotating crankshaft, which, receiving greater pressure, exhibits more twisting energy or torque. While there is a relationship between these two ratings, they do not happen in parallel with peak torque occurring and then running down at engine speeds somewhat lower than peak horsepower (which also tops out and begins to decrease at a certain engine speed). Engineers, working with computers to design these engines and with other computers in the vehicles to operate the engines, turbochargers, and intercoolers, can create them to meet and sustain torque and horsepower targets based on the precise performance, fuel economy, and emissions goals of the vehicle.

These engineers are enthusiasts. For decades, Porsche has acknowledged that its first responsibility with any new model is to improve performance over the previous generation. Porsche's general manager for the 911 Turbo and all-wheel-drive product line, Erhard Mössle, summarized the company's responsibility and goal: "With our turbos, we are designing the kinds of cars we want to drive."



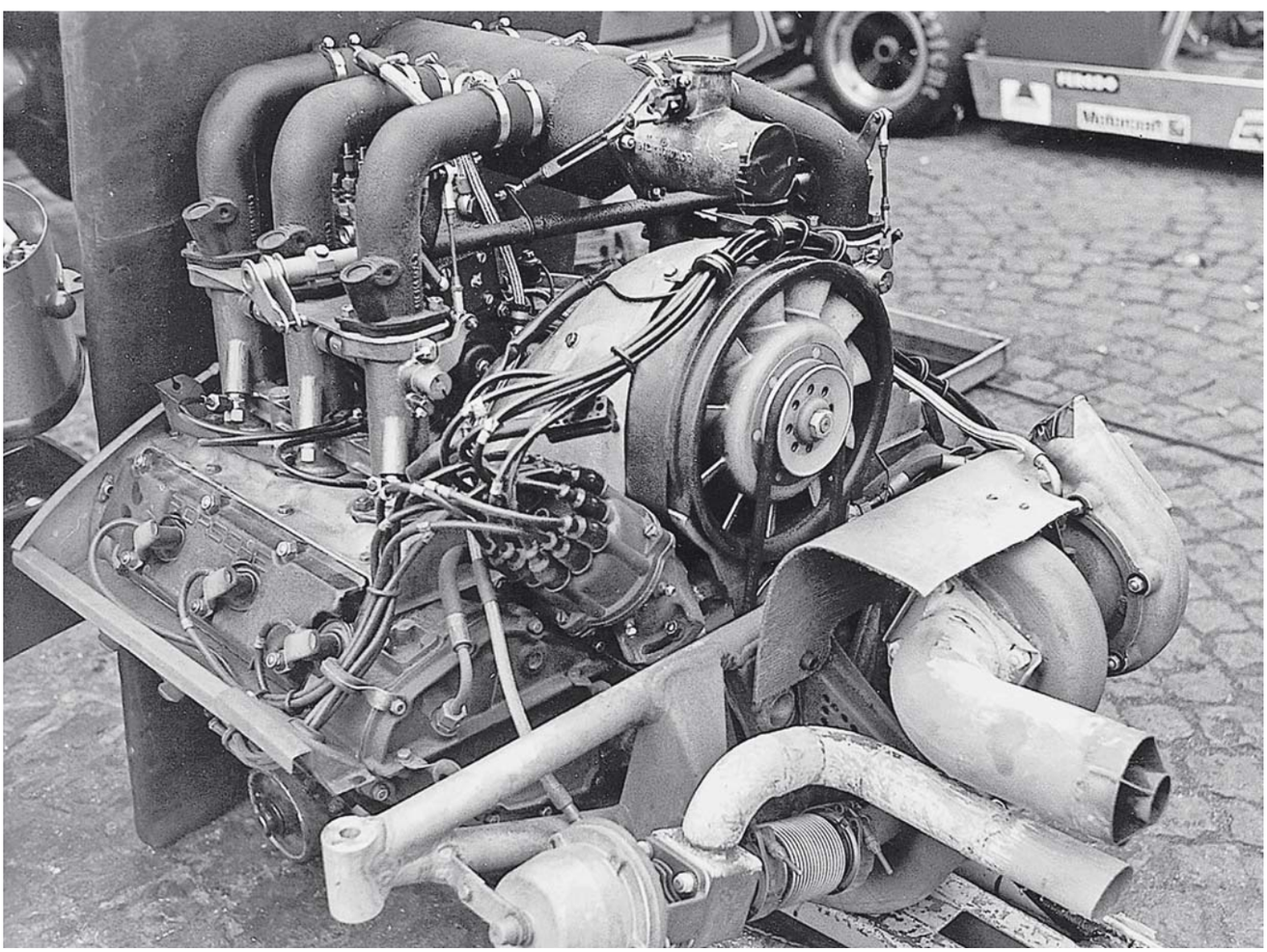
Chapter Three

FROM HOMOLOGATION SPECIAL TO **KEY** COMPONENT

The first track tests with the 911 Carrera RSR Turbo 2.1 took place in France. They revealed a car with massive performance potential. *Porsche Archive*

Racing grew complicated in 1972 and became more so in 1973. In North America, the SCCA had introduced a fuel-consumption regulation for the Can-Am series, so Porsche retired its thirsty 917 turbos. The European Interserie continued as a venue for these 917 Spyders through 1974 and 1975. However, the CSI's revised 3-liter maximum displacement rules rendered Porsche's 908/3s uncompetitive. As Paul Frère characterized it in *Porsche Racing Cars of the '70s*, "This put the company at a double disadvantage because the 908s were obsolete and in need of significant further development to win again in the World Championship of Makes (WCM) in Europe in 1973." What's more, CSI's parent, the Fédération Internationale de l'Automobile (FIA), let on it was thinking that the next set of WCM regulations likely would be to demand endurance racers be based on series-production automobiles, so-called "silhouette racing."

History—certainly the history most 911 enthusiasts know forty years after the fact—makes it clear Porsche already recognized this inevitability. The 917s had enjoyed generous, though not so well publicized, support from Volkswagen. In 1969, VW was worried about flagging sales for its long-lived air-cooled Beetle. In a quiet agreement between VW and Porsche, Volkswagen sales chief Carl Hahn had offered significant support to Ferdinand Piëch's racing efforts so long as any Porsche competition



This was the first version of the six-cylinder exhaust-turbocharged 2,142cc Typ 911/78 engine with its vertical cooling fan. In this configuration, it produced 450 horsepower at 8,000 rpm. *Porsche Archive*

car used an air-cooled engine. Hahn knew VW had a replacement in development; Porsche was designing and engineering a new model for the company with a water-cooled engine mounted under the rear seat. To maintain VW customers' belief that air-cooled engines were modern with great potential, it provided Porsche millions of deutsch marks to develop the 917s and to achieve so many victories.

Piëch and his engineers and drivers achieved his goals and VW's. But behind the scenes, the dramas approached the wildest any American television producer could fold into a primetime soap opera. When the proverbial viewing season ended, the Porsche and Piëch families had given up posts inside the company, making way for outside independent managers. Porsche founder Ferry Porsche stayed on as chairman of the supervisory board, and he and the board promoted some people from within. They also hired people back, including Ernst Fuhrmann, an engineer known for his four-cylinder engine work. He had left Porsche a decade earlier when the board had passed him over for a promotion. Ferry made him chief executive of the company and Fuhrmann returned to Zuffenhausen in September 1971.

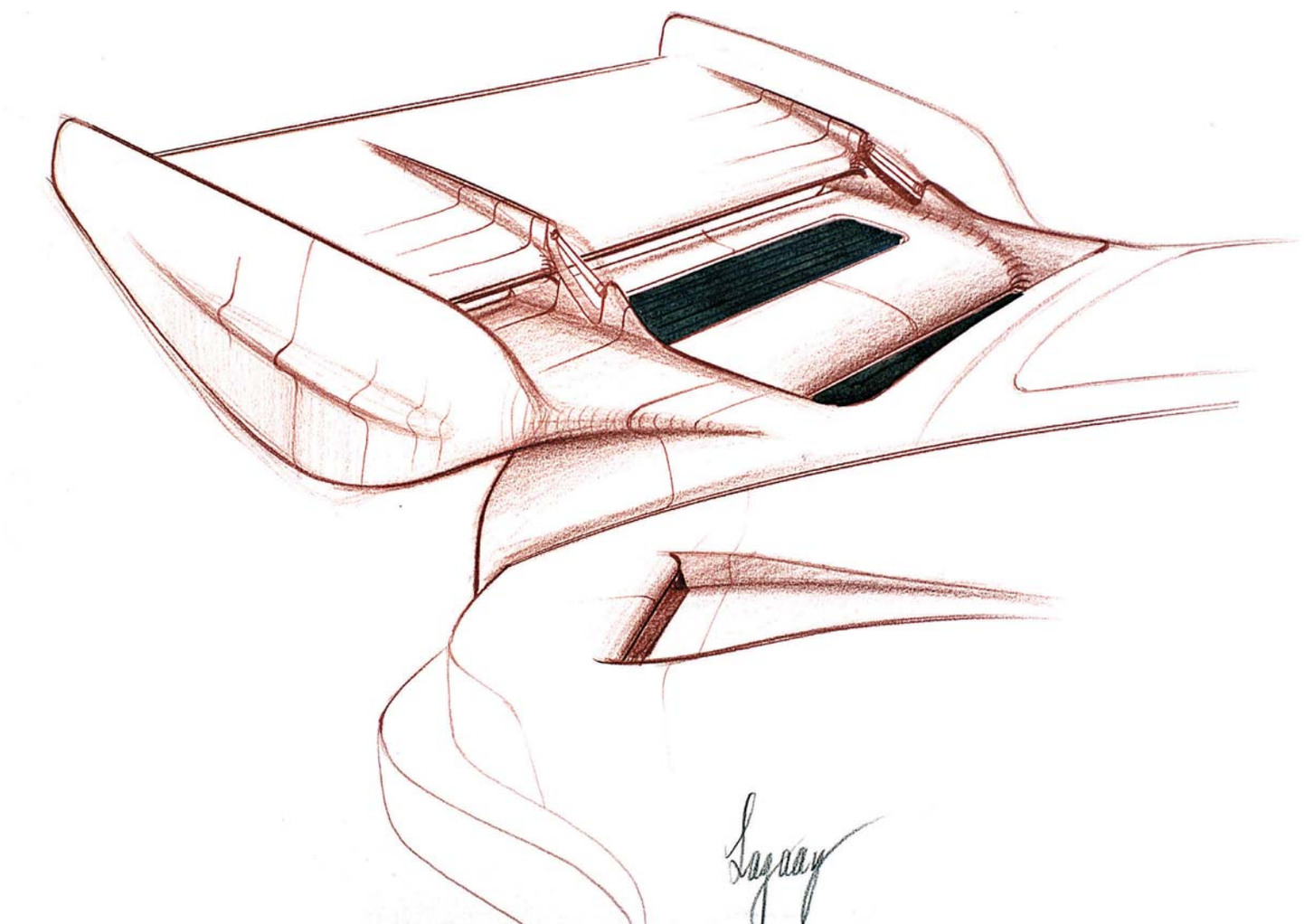
"I came in a terrible situation," Fuhrmann recalled in an interview in October 1991. Piëch's experimental staff had created a midengine car, the EA266, as part of Porsche's ongoing contractual works as VW research and design—an agreement that had existed since VW began.

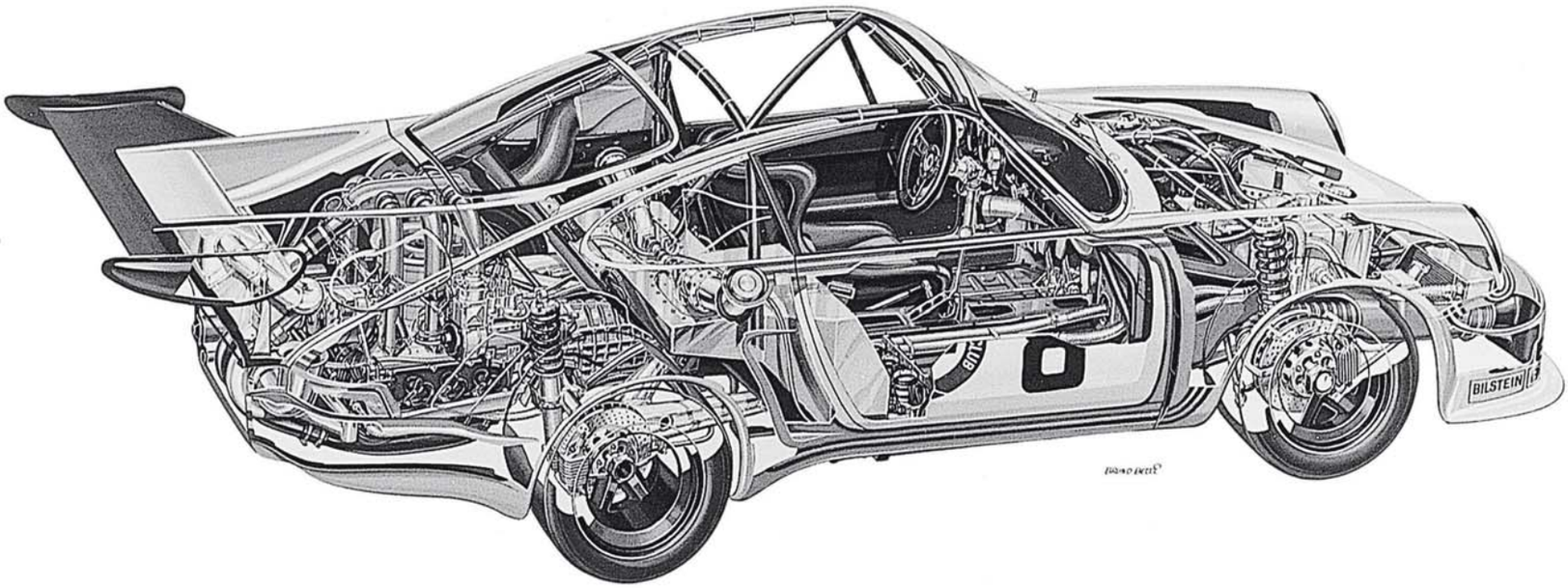
"There was a competing program," Fuhrmann continued, " which was the Golf. Porsche's success depended on the program by Mr. Piëch, the middle-engine car." However, right after Fuhrmann arrived, VW's board fired the chairman who had collaborated with Porsche on that car. His successor had led development of the competing car. "There was the decision to make the Golf with the other engine and not the Porsche design when I had been only six or eight weeks with the company," Fuhrmann explained.

While the EA266 was a VW project, Porsche had its own designation and destination for it, the Typ 1966, as the foundation of the company's plans to replace the 911 in 1973. With EA266 dead, Typ 1966 died as well. VW threw Porsche a bone, an assignment to design a sports car, but then withdrew from that as well. Porsche adopted it as its Typ 924. "So," Fuhrmann recalled, "I had no work after the end of that year for Weissach. And I had no successor for the 911!" With nothing to replace the 911, and barely enough funds for the 924, Fuhrmann took a big step.

"All my life . . . all my automobile life, I was of the opinion that racing must have a connection to the normal automobile. We were very successful with the Interserie in turbocharged cars. When this race car came, it was noiseless. And the next version was better. I said to my people, 'Why don't we put this success into our [production] car?' They said, 'Oh, it was tried already.'" (According to Paul Frère in *Porsche 911 Story: The Entire Development History*, "Back in 1969, experimental turbocharged type 901 engines of 2-liter capacity were built for use in both the 911 and the newly announced Type 914-6 VW-Porsche, but the plan was dropped as being premature.")

"But not in a car that was done right!" Fuhrmann challenged. "They said, 'It was refused by the management.' 'It was impossible,' they said. 'Not enough room.' This was my contribution: I looked in the engine compartment and said, 'There must be room!'"



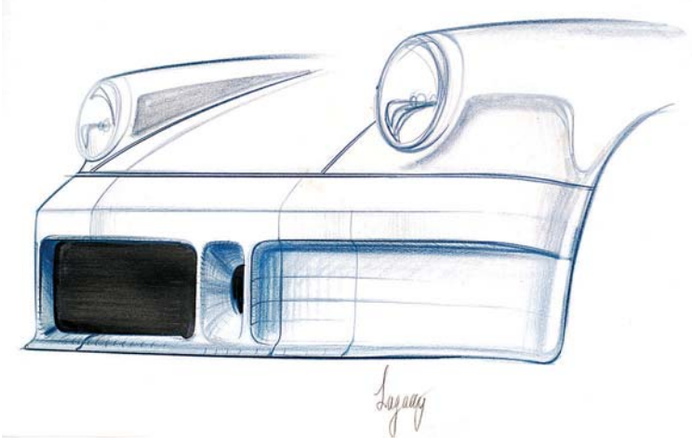


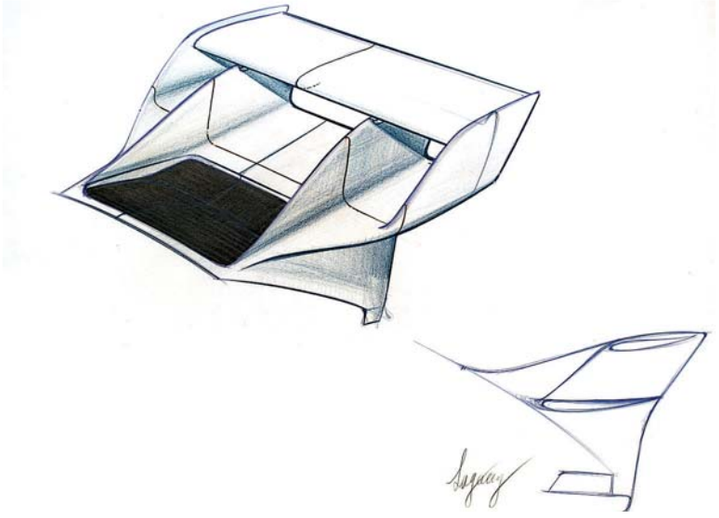
As a young designer, Harm Lagaaij developed a series of rear wing and front spoiler proposals for the RSR 2.1. Rods in the wing struts adjusted wing angle.
Porsche Archive

Lagaaij's concept for the RSR nose looked smart and proved aerodynamically sound. It was remarkably close to the nose with which the car raced.
Porsche Archive

The rear wing for the car was the subject of dozens of concepts and dozens more hours of wind tunnel testing. This version Lagaaij drew had not yet accommodated the intercooler openings.
Porsche Archive

This see-through drawing represents the Carrera RSR Turbo 2.1 in its final configuration. The flat cooling fan is visible through the forest of intake runners.
Porsche Archive





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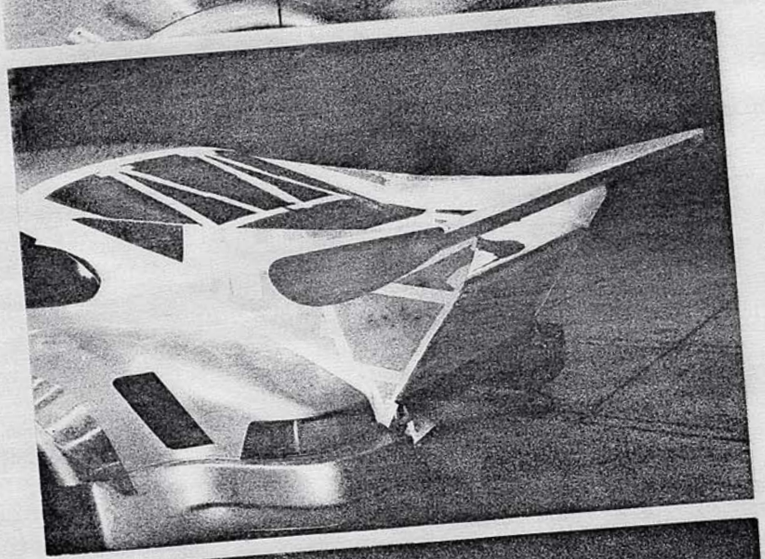

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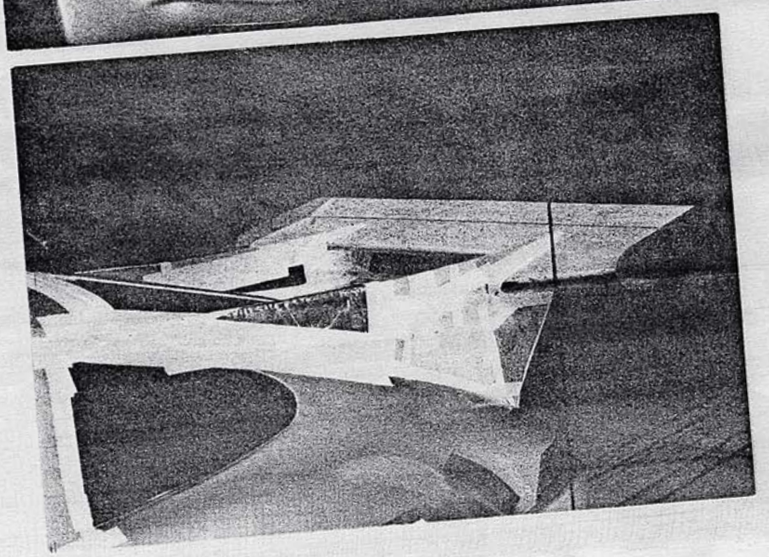

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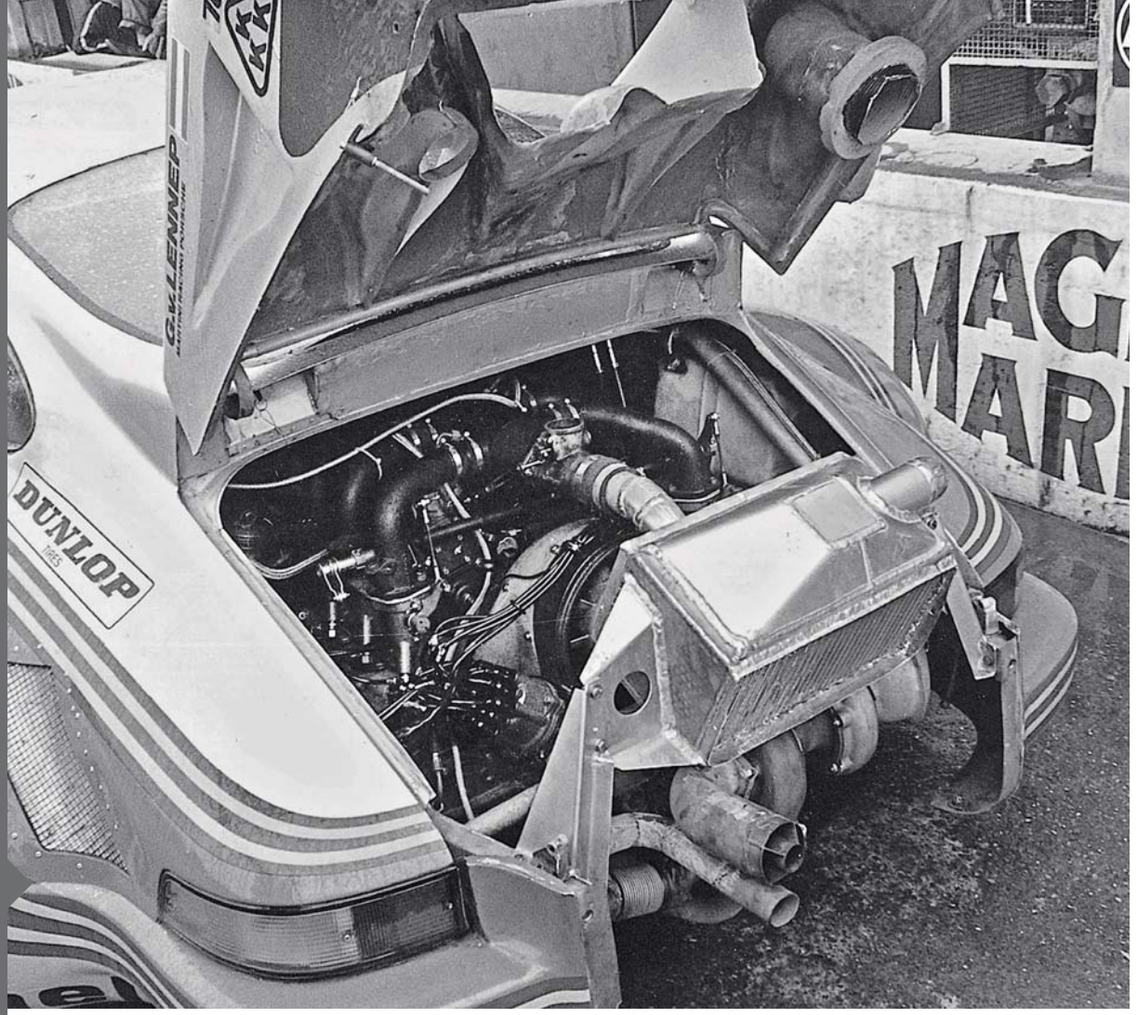

The intercooler sat outside the body "package," projecting up into an airstream directed by a massive set of ducts formed into the large rear wing assembly. *Porsche Archive*

This was a photographic record of a series of rear wing variations that engineers tested in the wind tunnel. Data reported impact on coefficient of drag and on lift or downforce that the wing generated. *Porsche Archive*

LOOKING FOR SOLUTIONS

Ernst Fuhrmann already had made significant contributions to the 911. In early 1972, he watched 911 racers at Hockenheim struggling to control their cars on corners. He challenged his staff, and within a short time a young aerodynamics engineer named Tilman Brodbeck developed a front air spoiler that split the airflow around the front end and significantly reduced front lift. Ferdinand Piëch, in one of his last acts before departing from Porsche, accelerated the testing schedule so that the front spoiler went into production as standard equipment on 1972 911S models. When Piëch left, Fuhrmann appointed another young engineer, Helmuth Bott, to take his place. The new front spoiler exaggerated rear lift, so Bott sent Brodbeck back to the wind tunnel and, together with a stylist, they devised a rear spoiler, now well known as the *Bürzel*, or ducktail. This debuted in October 1972 on the 911 Carrera 2.7 RS, a car created specifically to qualify 911 models for FIA Group 4 production class racing.

During the following eighteen months, the 2,687cc engine grew to 2,806cc for a competition version, then again to 2,993cc for a 1974 road-homologation RS and a competition RSR. These cars achieved great success as engineers meticulously improved every part while studying racing rules in great detail. But other competitors were not standing still. Enzo Ferrari had a powerful 4,390cc Daytona 365 GTB four-cam, 4,390cc V-12 coupe and Alessandro de Tomaso had installed 5,752cc Ford 351 Cleveland V-8s in his Pantera. The Panteras were exceptionally fast while they lasted, but the Ferraris were both fast and durable. Ernst Fuhrmann's words echoed in his engineers' ears: "There must be room."

FINDING ROOM

Hans Mezger and Valentin Schäffer labored in the competition shops to turbocharge a flat six for the World Endurance Championship. Group 5 was of particular interest, a category Ian Bamsey described in *A History of the Turbocharged Racing Car* as "catering for radically modified production cars, retaining little more than the engine block, engine position, and the silhouette of the base model. . . . The new category was slated for introduction in 1975 so in '74 Porsche entered an experimental turbocharged derivative of the Carrera RSR GT model in World Championship of Makes races, exploiting the freedom of Group 6 prototype regulations."

The Typ 911/76 engine for 1974 had to fit within Group 6's maximum displacement of 3,000cc. In this category Porsche competed against 480-horsepower, ultra-low drag-sport-racing prototype V-12 Spyders from Matra. Ford Cosworth 2,993cc double four-valve (DFV) V-8 engines adapted from Formula One delivered 450 horsepower in sleek Spyders from Mirage, sponsored by Gulf. Pushing the weight and shape of the 911 through the same air as these slinky competitors made turbocharging mandatory to produce enough power to become competitive.

However, CSI regulations stated, as Paul Frère reminded readers, that while "supercharged engines of any kind used for any sort of racing, except Formula 1, were considered to have a capacity 1.4 times actual swept volume (in Formula 1 it is twice), it also meant that the engine capacity had to be reduced to no more than 2,142cc in order to fall within the 3-liter capacity limit." Helmuth Bott's competition engineers went to work.

While they adapted the fundamental steel body structure, they fitted wafer-thin fiberglass front and rear deck lids, fenders, doors, and front and rear valences in place of stock steel. As Frère pointed out, these cars had "no bumpers in this case, not even token ones!" As the car was a prototype, Weissach's inventors were allowed to move the 31.7-gallon fuel tank from the front to the passenger compartment, very close to the car's center of gravity. Rules demanded they mount it inside a welded-steel shield. In this position, as the car consumed fuel supply and weight, this no longer affected handling. Relocating the tank from the front trunk made space available for front brake-cooling air ducts, although this eliminated the spare wheel (required by Group 6 rules), and the fuel lightened the front end. Bott's engineers bolted an aluminum tube framework into the body rear to support the engine, transmission, and rear suspension. This allowed them to remove the stout cross tube that anchored the suspension and supported the engine on series-production cars.

At one point when Fuhrmann was concerned about the car's weight, he suggested engineer Norbert Singer adopt American NASCAR techniques. Singer explained the concept in an interview in 2005: "The NASCAR teams soaked the car bodies in acid to get rid of metal and weight. Dr. Fuhrmann said we should reduce the thickness of our metal by half everywhere it was practical. He thought this might take maybe [150 pounds] out. He had us at a dinner and said no one would eat until we agreed to a plan for this. So I said okay and we ate."

Singer searched throughout Germany and found a company that said it could do it. "They quoted 50,000 to 80,000 deutsch marks [roughly $19,400 to $31,000 at the time], which was *very* expensive," he said. "I asked why. They said they had to build a tank big enough and buy the acid for it! Dr. Fuhrmann was surprised, and when I explained the reason, he was angry. Then he said, 'No! We don't do that!'"

By the time engineers finished with their more sensible modifications, some weight shedding, and a radical front and rear suspension reconfiguration, they had reduced the 1974 RSR's weight to 1,819 pounds. This was still heavy, however; Group 6 operated under Group 5 weight limits, and the minimum permitted was a startling 1,433 pounds.

Another series of wind tunnel experiments began to bring the rear wing nearer to its racetrack appearance. *Porsche Archive*

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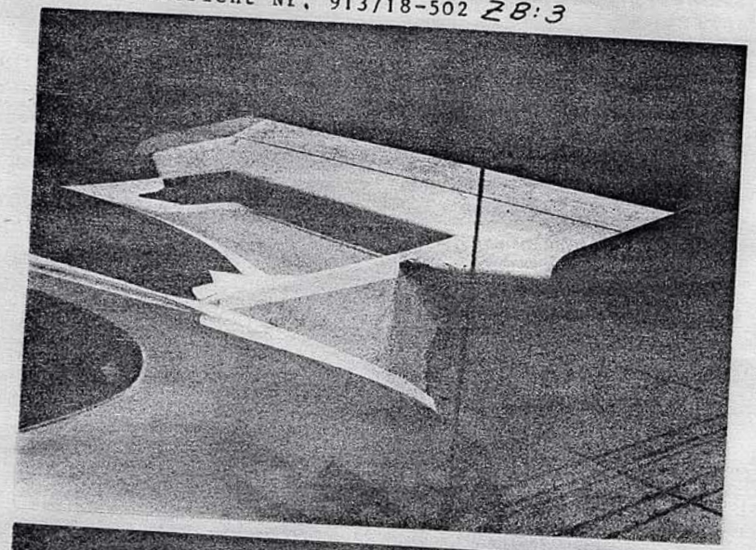

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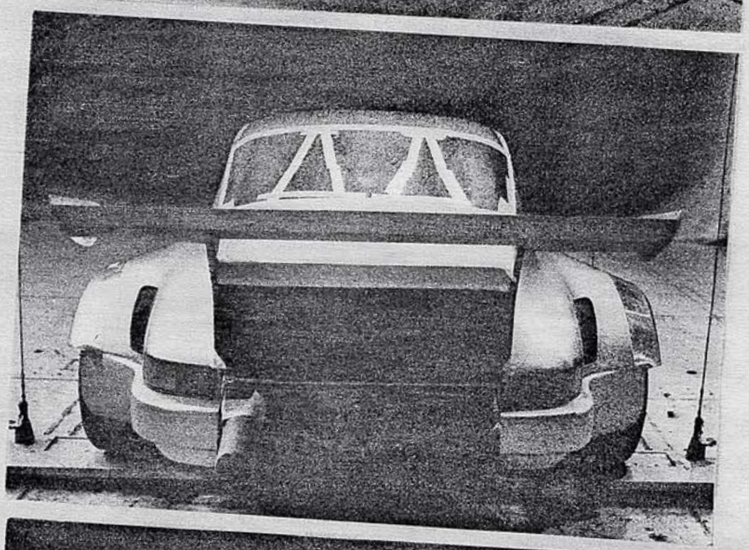

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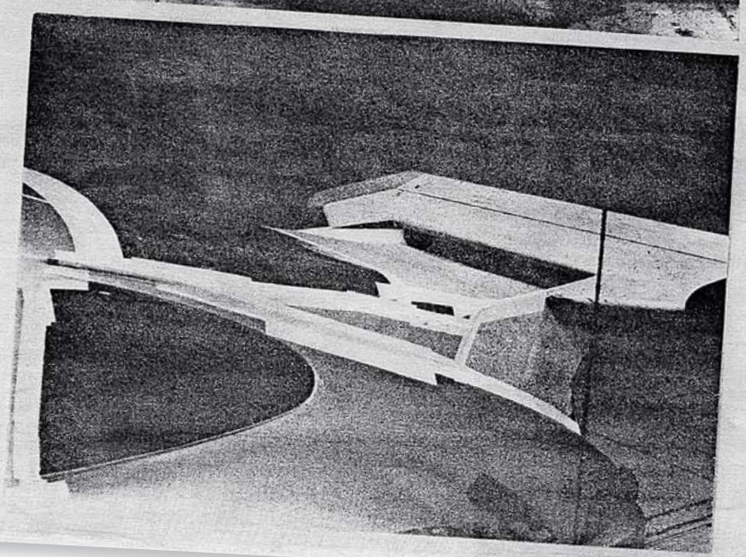

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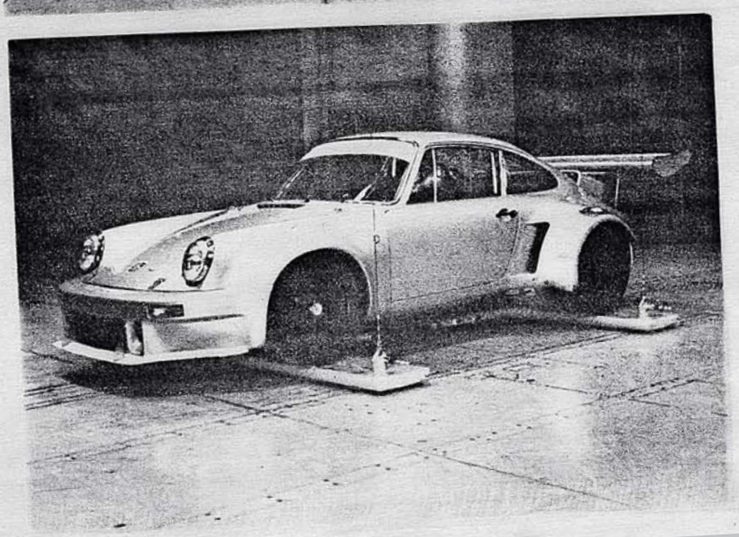

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Yet another iteration of the rear wing appeared. NACA-style ducts in the wing supports directed air to the intercooler. *Porsche Archive*

Early 1974 wind tunnel tests suggested vertical lips at the outside edges of the rear wing channeled air more efficiently over and under its surfaces. *Porsche Archive*

Any further racing advantage had to come from Schäffer and Mezger. For Le Mans, they cast aluminum crankcases in the interest of durability and longevity; for shorter contests, they adopted the lighter-weight production-based magnesium cases introduced with the Carrera RS 2.7. Into these blocks they fed a carefully tested production 2-liter crankshaft that provided 66-millimeter stroke. Titanium connecting rods and pistons operated inside Nikasil 83-millimeter cylinders and cylinder heads, which adopted the slightly larger valves from the 1973 flat sixes of 2,247cc and 2,492cc displacement, along with a twin-plug ignition.

"The development time was comparatively short," Frère wrote, "thanks to the experience gained with the turbocharged type 912 engine in the type 917/10 and 917/30 cars, particularly as the 6-cylinder turbocharged engine was almost exactly half the size of the 4.5-liter version of the flat-12. Consequently, a turbocharging installation almost identical to that employed by one bank of the flat-12 was used." According to Porsche's racing historian, Jürgen Barth, "Additional combustion air volume was provided by the addition of an induction air cooler [intercooler] interposed between the supercharger [turbocharger] and the single plenum [intake] chamber. It was located approximately where the normal Carrera had its ducktail spoiler."

By the end of the 1974 season, with the single large KKK turbocharger adjusted to 1.4 bar of boost, the 2,142cc Typ 911/76 engine produced 500 horsepower at 7,600 rpm and 405 pounds-feet of torque at 5,400 rpm. With Le Mans gears, this provided 192.6 miles per hour along Mulsanne. Porsche entered four of the cars; three, campaigned by French entries, finished twelfth, thirteenth, and fourteenth. The factory entry with Gijs van Lennep and Herbert Müller took second overall, six laps behind a Matra-Simca sports racer.

This was a handful of a car. With the new engine subframe and its enormous rear wing, too much weight of the car hung behind the rear wheels. In fact, weight balance with driver and full tanks was 30 percent at the front and 70 percent at the rear. To maintain control of nearly 500 horsepower with that kind of weight bias called for uncommonly large tires riding on 10.5-inch-wide wheels at front and 17s at the rear, running, according to Barth, 245/575-15 Dunlop racing tires up front and 340/575-15s in back.

In an interview in 1991, Norbert Singer recalled that when Fuhrmann first saw the prototype, he felt scandalized by the "airplane wing," the *Eindecker*, on the back of the car. As an engine man, he wondered why, and if, such a large structure was necessary; it was, Singer assured him, especially for straight-line, high-speed stability. To minimize his own discomfort, Fuhrmann ordered Singer to paint it flat black.

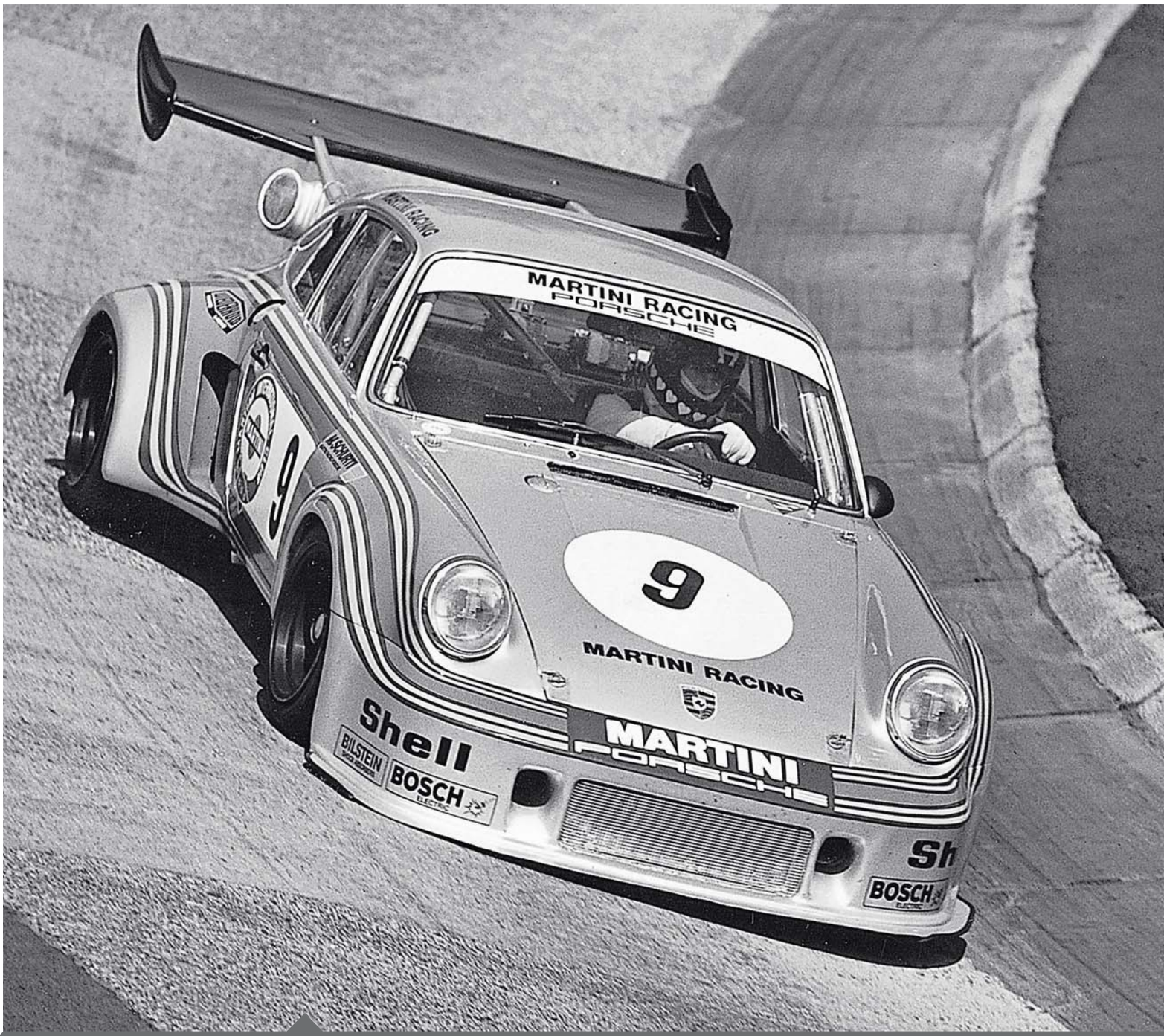
Race reports from Le Mans over the June 15 and 16, 1974, suggest that Porsche's RSR 2.1 Turbo could have won the twenty-four-hour race. Singer and his engineers determined the production-derived Typ 915 five-speed transmission was up to RSR power. In an ideal world, Singer would have wanted the new, stronger four-speed Typ 930 transmission, but it was not ready.

Meanwhile, Matra had asked Porsche to design and develop new synchronized transmissions for its V-12s. As part of the contract, Porsche guaranteed race support, and on Sunday morning, Matra needed it.

The team's leading driver, Henri Pescarola, pulled off to the side of the Mulsanne Straight with no gears. After some struggling, he found something that connected and he limped into the pits. At this time, van Lennep and Müller were closing on the lead Matra. Singer was there when two Matra crewmembers, arrived asking for help. The Porsche gearbox needed a rebuild, something Singer's transmission guys could do more efficiently than the Matra crew.

"This gave us quite an interesting dilemma," Singer recalled. Ultimately, the decision went to Fuhrmann, who replied that Matra was a customer and Porsche must help. Singer sent two of his best transmission mechanics and they got Pescarola's gearbox repaired in 45 minutes. During that time, the RSR took the lead. But with all the Matra's gears working and its Mulsanne stop speed near 200 miles per hour, the RSR strained to keep up. Then its Typ 915 transmission lost fifth gear.

"It was a production gearbox," Singer explained, "and the high power and torque were too much for it. With the Matra, our guys could rebuild the



Teammates Gijs van Lennep and Herbert Müller driving car 8 in the same 1,000-kilometer race finished sixth overall. Ernst Fuhrmann (in khaki slacks and blue shirt near the fire extinguisher) was appalled by the size of the rear wing needed for handling that he ordered them painted black to be less obvious. *Porsche Archive*

Manfred Schurti and Helmuth Koinigg shared driving duties during the 1,000 Kilometers of Nürburgring on May 19, 1974. The snorkel on the rear wing support captured engine intake. They finished seventh overall. *Porsche Archive*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MARTINI RACING
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At the April Le Mans trials, the two factory RSR Turbos ran with engines developing 500 horsepower. For the June race, the car wearing No. 22 finished second overall behind a low-slung Matra prototype. *Porsche Archive*

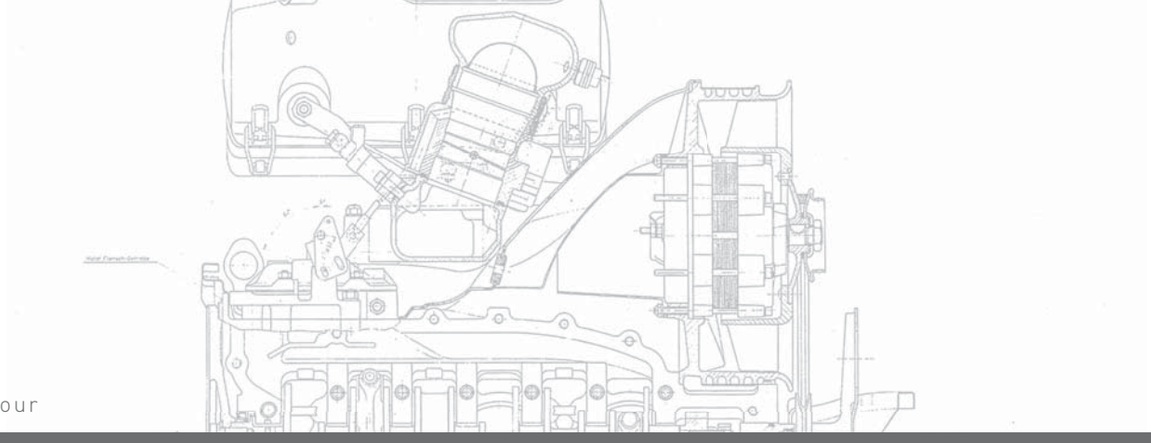
The Schurti/Koinigg RSR Turbo 2.1 headed for the pits during the 1,000-kilometer race at Nürburgring. Without the front bodywork, air dam, and low front lip, rear wing aerodynamics destabilized the car. *Porsche Archive*

transmission while it still was in the car. We had to take the engine out to do that on our car, so it was impossible. Van Lennep and Müller had to go on with just four gears." Running in fourth gear along Mulsanne slowed the RSR, but at the same time it improved fuel economy so much that Porsche eked out three extra laps on each tank. The car held off the second Matra and finished ten laps ahead of it.

The rest of the year proved the strength and brilliance of the turbo flat six. For cars that seemed outsized and overmatched at the start of the season, these production-derived race cars finished the 1974 WCM in third place behind outright sport prototypes from Matra and Gulf.

The FIA had told entrants and manufacturers to expect Group 5 regulations in effect for 1975. Instead, the group delayed introduction for one year, giving Porsche a breather to improve its planned entries. Helmuth Bott assigned Singer to assist privateer Reinhold Jöst through the year with his 908/3 Turbo, which finished fourth overall at Le Mans.

"That year [Jöst] did most of the World Championship races," Singer wrote in his fascinating autobiography, *24:16*, "something which gave us a lot more experience with the turbo engine. This would be the key component of all our racing cars in 1976. These were to be based on the road going 911 Turbo model which had now gone into full scale production."



Chapter Four

FROM HOMOLOGATION SPECIAL TO FLEET **FLAGSHIP**

The Frankfurt and Paris auto-show car was startling in appearance with its vastly widened rear fenders and the bold graphic *Turbo*. Along the lower doors, stylists paid homage to the 1973 Carrera using the Porsche logo in similar silhouette-style lettering. *Porsche Archive*

"Robert Pindar was the head of the engine-design department." Mechanical engineer Herbert Ampferer began to laugh at the memory. "He came to me. He said, 'You! You are young, inexperienced! I have a project for you. I need a layout designer for the new turbo engine!"

Ampferer had *some* experience. He had joined Pindar's engine design department in time to work on the midengine EA266 project for Volkswagen with future application as the Typ 1966 meant to replace the 911. "It was really complicated," Ampferer recalled during an interview in 2004, "with drives running around the corners, bent drives."

Turbo applications for racing, once Valentin Schäffer tamed them with the wastegate and more efficient plumbing, were fairly straightforward by this time. On the gas. Off. On. Off. Challenges still remained for series-production automobiles.

"The turbo technology in those days was not sophisticated," Ampferer continued. "It was technology derived from trucks, not really matched to smaller engines with the need for good response."

Weissach engineering acquired a turbocharged car just as Ampferer started on the design layout. This sporty coupe bore the complicated name Ford Capri Turbo May. Historian Jerry Sloniger, writing in *Popular Science* magazine in May 1970, called Michael May a "Swiss genius" whose "success story began when he combined with Germany's largest Ford dealer to produce a turbocharged version of the Capri." May had racing experience; he won Europe's first Formula Junior championship, and before that, he gained notoriety racing his Porsche 550RS Spyder with a huge wing mounted over the cockpit. With an Eberspächer turbo on the Capri,

Porsche unveiled its Typ 930 Turbo at the September 1973 Frankfurt International Auto Show. Publicity materials announced a 2.7-liter engine that developed 280 horsepower. *Porsche Archive*

May boosted Ford's 108-horsepower V-6 to 180 horsepower at 5,750 rpm "with little increase in fuel consumption, greater tractability, and no internal modifications whatsoever." He charged $800 for the kit, installed, though Ford chose not to offer it as an option and even refused to guarantee the car's paint after installation. May developed a 250-horsepower competition version; it finished one race in fourth but did not make it to the end of its one other racing trial.

The same year, May turbocharged a customer's BMW 2002, a project that caught engineers' eyes in Munich and inspired BMW's own 170-horsepower version in 1973. BMW used a KKK turbo with a Kugelfischer fuel-injection system adopted from its 2002tii model. However, the turbo car that Porsche sampled was May's Capri.

"For us to get the feeling of what it means to have a turbocharger on a really small engine, in terms of drivability, we bought that car and had a look at it," Ampferer recalled. "The durability of that system was not good. The response was horribly bad. I made a little tour out of Zuffenhausen, and after a while, I stopped and went back. I made a U-turn in a small road. I gave the gas pedal a push and the car made a huge jump. I told my boss I was not yet in the direction I wanted to go. I was in the direction of a huge concrete wall!" He recovered, but it gave him a lasting respect for turbo response.

Turbocharging the series-production car was necessary if Porsche hoped for homologation in certain FIA and CSI racing classes. But there were other influences.

"The driving force at Porsche was that we had a rather small car and a rather small engine bay," Ampferer explained. "We had a given engine concept, that the air-cooled flat-six engine in those days was at a certain limit. We looked for a way to increase the power without changing the engine concept totally. This was something I would call a downsizing concept today. Smaller displacement but giving out more performance."

As he considered this new technology, Ampferer developed questions for Pindar.

"Tell me, do we need air conditioning for that car?"

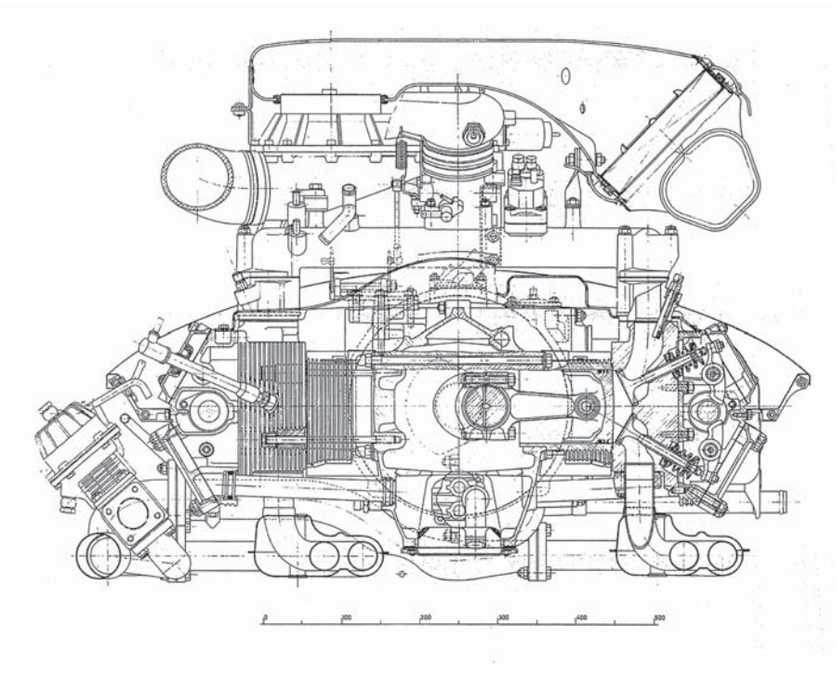
"No. We don't need it."

"Do we need a rear wiper for that car?"

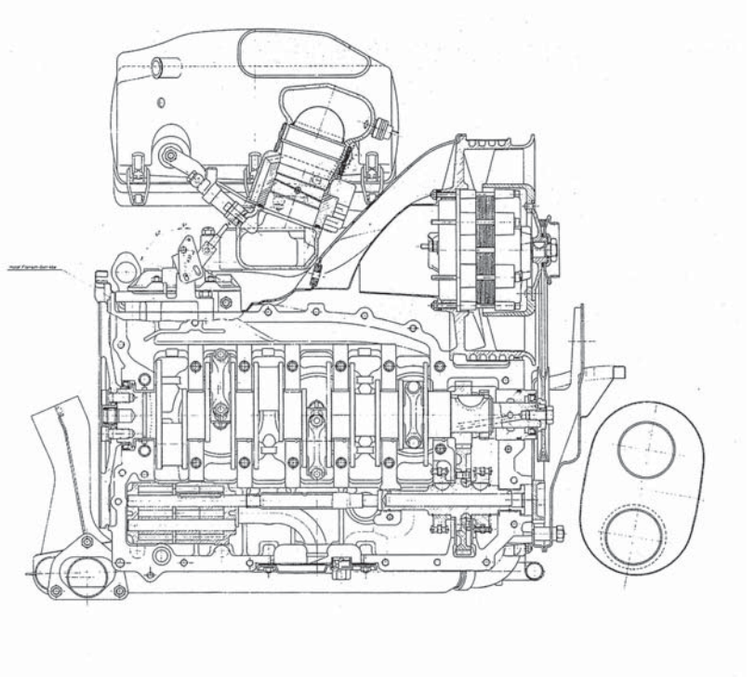
"No, we don't need it."

Ampferer began to laugh again at the reality that followed. "So if you just imagine the engine bay for that car with an air conditioning compressor and the rear wiper that used a big electric motor in the engine bay. . . . If you don't have to worry about them, it's not too bad."

"This is only two hundred cars or something," Pindar told him.



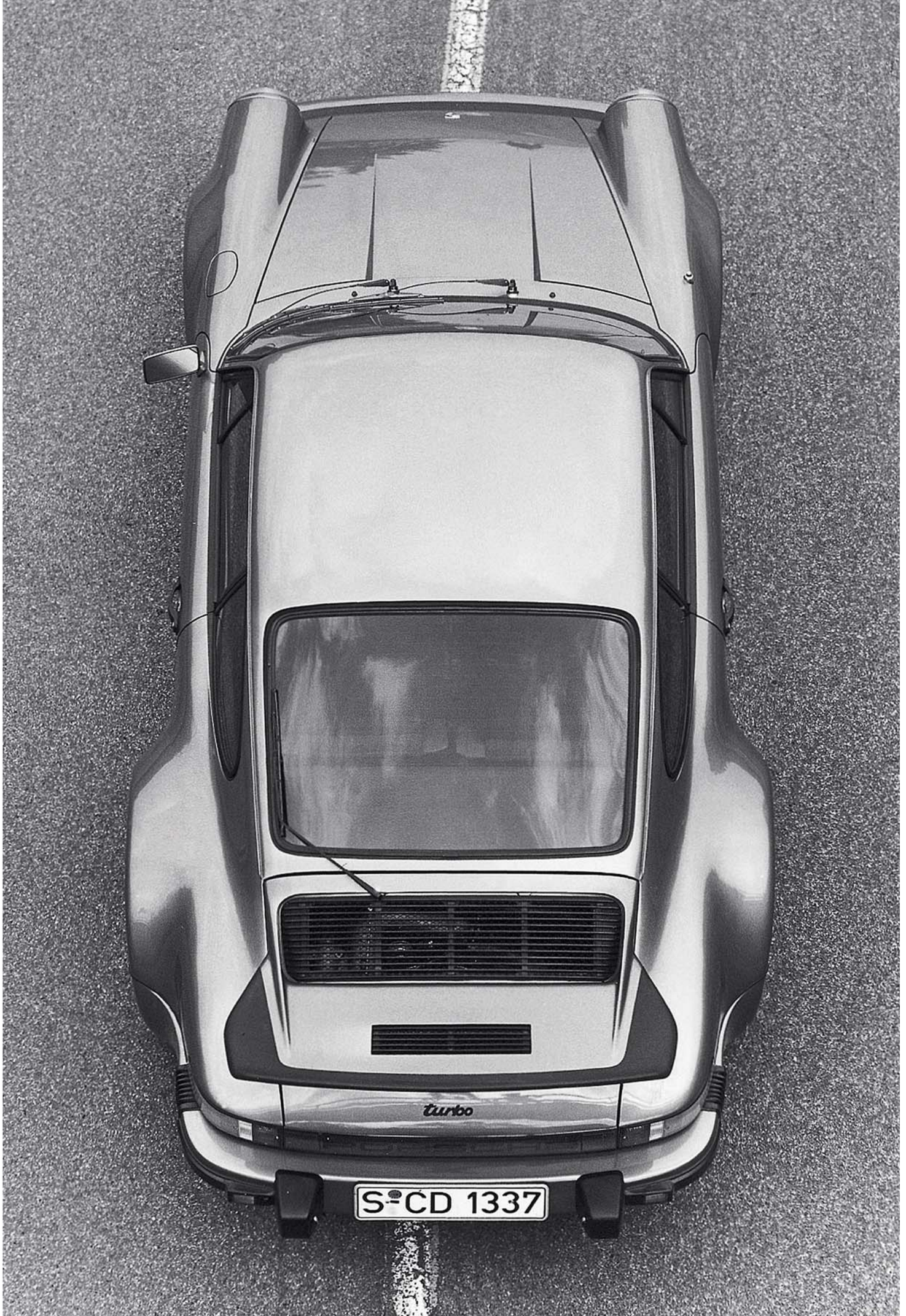
This was the end-view drawing of the Typ 930/50 flat-six engines. The turbocharger was not included in the drawing. *Porsche Archive*



This side-view cutaway drawing of the 930/50 engine slices through the intake system, cooling fan, and exhaust muffler. *Porsche Archive*

Following its debut at the Frankfurt show, this coupe went next to Paris for its unveiling in France. The engine was a mockup using a 2.7-liter production version with wooden pieces modeled and painted to resemble the production turbocharger. *Porsche Archive*


DUNLOP RACING
DUNLOP RACING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"Forget it!" Two hundred cars was exactly the number the CSI required for homologation.

Ampferer got started. But then the sales and marketing department came knocking on his door. "'We think we can sell many more. But we need an air conditioner. And the rear wiper.' So we started from scratch. Completely! And the car went into production with the air conditioning system and the rear wiper. It was a case of not knowing what the market was in front of us for this new car!"

HOW IS IT GOING TO LOOK?

"It was a very funny situation," Peter Reisinger recalled. He had joined Porsche as a body-design modeler in 1970, coming from Opel, where he had worked on the production Opel GT and the CD concept. "We had this big energy crisis in October 1973. But a while before that, Dr. Fuhrmann came to us and said, 'We have to do something for the auto show in Frankfurt. There is a plan of the Turbo. Could you think about it?'"

Reisinger remembered the challenge. The designers and modelers had worked on the EA266 for Volkswagen and they had started the EA425, the 914 replacement that became the 924. With the Typ 1966 there as well, he said, "there was no room in the studio. Models of the turbo with the wide fenders were done by a model maker shop, Stern, near Böblingen, which

This pilot-production 1974 version of the 2,994cc Typ 930/50 developed 260 horsepower at 5,500 rpm. It produced 253 pounds-feet of torque at 4,000 rpm. *Porsche Archive*

This was the 1975 version 930/50 engine, as installed in one of the model year's series production coupes. Porsche manufactured 274 of the car's models during the 1975 model year. *Porsche Archive*

The flat edges of the rear wing were rimmed with hard rubber to protect distracted pedestrians from harm if they walked into it. The smaller air vent ducted directly to the engine-cooling fan. *Porsche Archive*

always did models for us. Studio manager Dick Soderberg drove every two or three days to see the wider fenders and everything. We did the minimum that was necessary, wider wheels, more aerodynamics." Their target was the Frankfurt show in September 1973, followed by Paris in October.

"But the whole car was a fake," Reisinger continued. "The normal engine was used, and all the add-on technical parts, the turbo, tubing, and everything, were done in wood and painted like they were real. You couldn't tell by looking at it, but you couldn't drive it! We had to make it a little more visible, so we made the Turbo lettering on the sides in the style of the Carrera script. But for us, as designers and model makers, it was a caricature. That nice 911 body shape . . . clean and everything? This had so many add-on pieces! That's the reason we were really skeptical at the time."

Skepticism turned into relief at Frankfurt. The theme of the show—"With the Automobile into the Future"—emphasized the more than 20 percent reduction in toxic exhaust emissions, improvements in active and passive safety, reductions in costs of living, and increases in wages that were making automobiles more affordable. The rates of currency exchange between the deutsch mark and the dollar had taken the American currency from DM 3.65 during 1970 to 2.65 through 1973, partly as a result of a January 1973 stock-market crash. This revaluation rendered VW's basic Beetle more expensive than a base Chevrolet Vega or Ford Pinto in the United States and elevated the 911S price for 1973 to $11,000, more than any single American-made auto. Wankel engines, viewed as the powerplant of the future, were on display everywhere—including one midmounted in a show-stopping Corvette concept—and Daimler, Fiat, and Volvo displayed "safety" cars. Porsche lavished considerable display space on its twenty-year Long Life car, boasting that nearly 50 percent of the raw materials used to make it were recyclable.

Porsche testing and race driver Herbert Linge took a model year 1975 3.0 Turbo for a spin in the snow. The 2,470-pound car's rear weight bias had to be dizzying in such conditions. *Porsche Archive*

Two US–specification 1976 model year Porsches show off their engines. At left, a 2.7-liter 911 S Targa sits alongside a 3-liter Turbo coupe. *Porsche Archive*

In this politically correct environment, two of the carmakers offered something for performance enthusiasts. "The biggest technical attraction on the BMW stand," Paul Frère wrote in his Frankfurt show review for *Road & Track*'s December 1973 issue, "was the exhaust-turbocharged 2002 Turbo added to the slightly face-lifted evergreen 1600–2002 range." BMW, using its 1,990cc inline four-cylinder engine boosted to 0.55 bar (8 pounds per square inch), claimed 167 horsepower at 5,800 rpm and 177 pound-feet of torque at 4,000 rpm, compared to 130 horsepower and 130 pounds-feet torque from the normally aspirated 2002tii. "Externally the Turbo is easily recognized not only by a lateral paint flash but also by its large front spoiler, a small spoiler on the rear deck lid and screwed-on fender flares. None of this makes the car more elegant, but there is no doubt about its purpose!" Frère added, devoting nearly a full column of type to the BMW Turbo in a story running across six pages. But it was not until the final quarter page that he backed his way into introducing Porsche's version.

"In addition to the 20-year car, Porsche had another special exhibit on its stand—a turbocharged road going Carrera based on the lightweight body shell," he wrote. "It's turbocharging set up is very different from the one used on the BMW." Three sentences later he concluded with, "The power output claimed is 280 bhp DIN, giving a maximum speed of 176 mph, and the car is appropriately shod. It is fully developed and not unlikely

Ferry Porsche and his company management presented his sister Louise Piëch with the first production 3-liter 911 Turbo for her seventieth birthday. She can be seen smiling in the cream-colored sleeveless dress. *Porsche Archive*

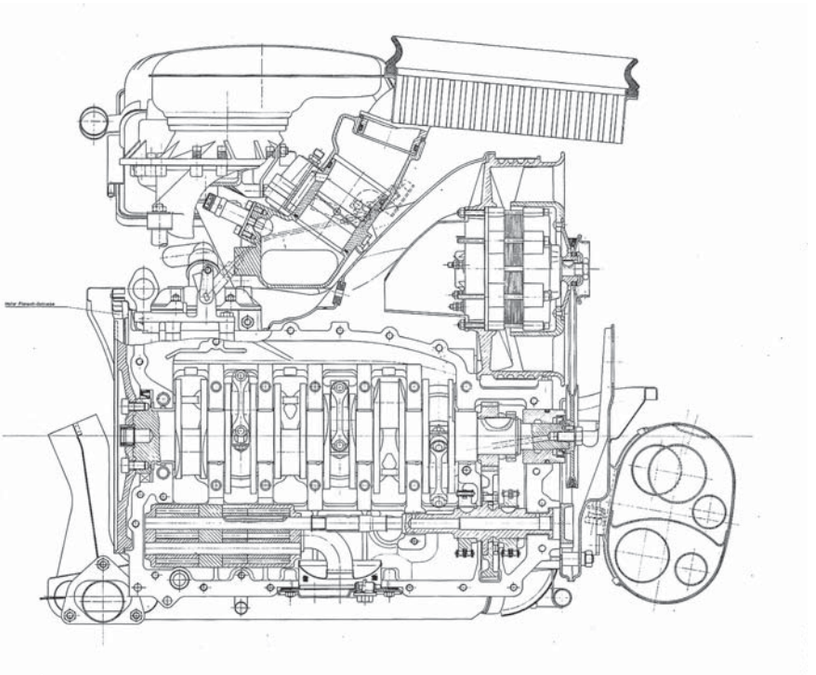
to be produced on limited scale someday." Two photos of the 911 Turbo accompanied the story; one was a three-quarter rear view that made the Turbo graphic, the new rear spoiler, and the widened wheel arches very clear. The caption read, "One step further: with the Carrera now safely tucked into the production program, Porsche showed what we should have expected, a turbocharged 911. Spoiler shape and 'bumpers' are also new."

The Frankfurt show ran from September 13 through September 23, and then the show cars headed across the border to the Paris Auto Salon from October 4 through October 14. The German cars rated no mention in *Road & Track*'s show wrap-up from France in January 1974. Of course, by that time, the auto-enthusiast world was reeling from an announcement made on October 16, two days after Paris closed. On that date, OAPEC, the Organization of Arab Petroleum Exporting Countries, announced its intention to raise the per-barrel price of crude oil from $3.00 to $5.11. A day later, the organization targeted nations sympathetic to Israel, initiating an embargo on oil exports beginning with a 25 percent reduction and promising further cuts that sent the barrel price to nearly $12.00 by March 1974.

If Porsche was worried about the wisdom of introducing the world's fastest production automobile in its new Turbo, the carmaker wasn't alone. Within months, those manufacturers who showed rotaries quietly cancelled further development on the thirsty engines. BMW kept the 2002 Turbo in production through the 1974 model year and manufactured 1,672 in all.

During this time, Porsche continued engineering and developing its Turbo, with the earliest "production" models slipping out to the company's closest friends and best customers in late 1974. The very first of these went to Ferry Porsche's sister, Louise Piëch, for her seventieth birthday on August 29, 1974—a silver coupe with a *Porsche* side graphic backed in red-and-black plaid that echoed the interior upholstery. The narrow-body coupe used a prototype 2,687cc Turbo engine, and because Louise was a *plein air* nature painter, the car had no tint on any window, so as not to alter her view of her surroundings.

The press department got Frère into Ernst Fuhrmann's personal Turbo for a test drive around Weissach, resulting in perhaps the first published driving experience, in March 1975. Frère pointed out the



This side-view cutaway drawing shows the model year 1978 Typ 930/60 Turbo engine. It displaced 3,299cc. The drawing shows the intercooler mounted above the cooling fan.
Porsche Archive

differences between the 2,164cc racing version he drove earlier that day and Fuhrmann's 2,994cc production model, writing, "With a big engine giving good torque and less blower pressure to boost it, the delayed response [turbo lag] is hardly noticed. All you note when you push the accelerator is a tremendous surge of power that goes on and on and on . . . and by then, if you are in an intermediate gear, it's probably high time you changed up!

"This Turbo Carrera certainly offers the finest blend of ultimate performance and refinement I ever have come across."

There are those who suggest that Turbo refinement stopped just ahead of the rear wheels. The skepticism modeler Peter Reisinger spoke of was not just his feeling alone. Harm Lagaaij, who became Porsche's chief of design in 1989, first joined Porsche in 1971 in his mid-twenties. He watched the Turbo evolve as studio manager Dick Soderberg brought the outside model concepts in house.

"There was this thing we knew that whenever it's going to be faster, it has to be wider," Lagaaij explained in an interview in November 2014. "It became known as the Turbo look, which you could ask for without even having a turbo! Turbo means faster, wider, more spectacular looking. The designers who did the aesthetic thing loved making cars wider and making fenders wider. But we didn't quite understand how to shape those fenders; therefore, the

first Turbo—1974—just had extended wheel arches. But not particularly well designed. It just was a mechanism, a lot of concave shapes."

"It's important to remember the 1974 Turbo," he emphasized. "Today, we think of a 1974 911 Turbo as, 'Oh, yes, wide . . .' But in those days it was *really* wide. It was an *extremely* wide car."

As company executives got their opportunities to drive the cars with prototype bodywork on them, not every loaner came back unscathed. In those days, as today, when work crews made repairs on the German autobahns, they narrowed one of the lanes in these construction zones. After one weekend, one of the early cars returned with large black tire marks on the rear fenders, scorched onto the bodywork by the large trucks the driver had squeezed against in the narrowed lanes.

Even the production rear wing was controversial. The ducktail, or *Bürzel*, evolved into the larger wing because engineers asked for more downforce in the rear. "So why don't we go all the way out?" Peter Reisinger recalled his design boss Tony Lapine asking. "But then the safety engineers came and said, 'We'll make this in fiberglass, but safety regulations say that up here'"—Reisinger gestured to his waist height—"'where pedestrians are walking, there can be nothing extremely hard.' So we made the edge in rubber, from the regulations for pedestrian safety."

Porsche highlighted the most distinctive change in the 3-liter Turbo's appearance in its 1978 model sales brochure. Engineers asked for better airflow control and added side edges to the previously flat spoiler. *Porsche Archive*

"Few cars of any kind are as imposing as this fleet Porsche," the writers of the 1978 sales brochure boasted. "More than merely spectacular, the body design contributes to the Turbo's superb road performance." *Porsche Archive*

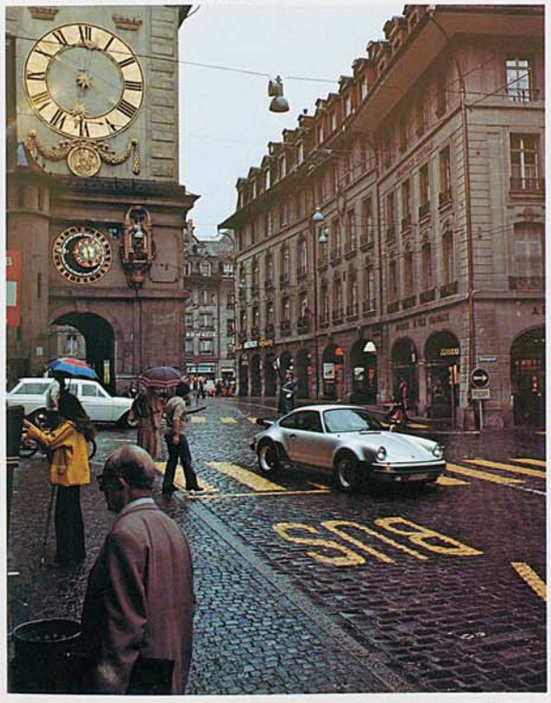
Turbo:
Superlatives on Wheels

Porsche's Turbo was the product of exceptional vision. It took vision on the part of Porsche's executives and engineers to see the potential for road cars with exhaust turbo-charging, an advanced power-boosting technique that had hitherto been used mainly for racing cars. It took vision also to see how turbo-charging might be used in concert with the 911 concept to create an ultimate Porsche, a sports car that at one and the same time attained new heights of both performance and luxury. That vision of a new kind of Porsche car has since been vindicated in the automotive world, which hailed the Turbo as a motoring classic from the very day of its introduction. Now, that classic has been further improved.

Those owners of Turbo who have experience of other sports cars of extremely high performance have found that this ultimate Porsche is by far the most practical car in its class for day-to-day operation in the real world. Built into it as standard are all the anti-corrosion provisions of the 911SC: hot-galvanized steel, baked-on factory undercoating, and the use of rustproof and light weight aluminum for such vital parts as the engine and transmission housings, front suspension crossmember, rear suspension arms and road wheels. Headlight and windshield washers, a rear-window wiper, fog lights, tinted glass, air conditioning, and the automatic heater control – – all standard – – equip the Turbo to cope with all weather conditions.

The Turbo owner also enjoys the same long 15,000 mile intervals between major servicing (see owners' manual for full details), as do other Porsche drivers. It has the same simple and precise mechanical CIS fuel injection system. The Turbo also uses a maintenance-free breakerless transistor ignition system. This assures proper ignition timing over extended mileages. It also delivers a powerful spark that keeps the plugs from oiling up during slow driving. Even after hours of idling in creeping traffic the engine is ready to deliver its full power at a touch of the accelerator. Others may pretend to the Turbo's performance but not with this great Porsche's suave versatility.

Few cars of any kind are as imposing in appearance as this fleet Porsche. Its brilliance and fortitude are aptly expressed by its unique form: black anodized exterior trim, wide wheel flares, and bold front and rear spoilers. More than merely spectacular the body design contributes to the Turbo's superb road performance. The deep spoiler below the nose helps reduce air drag, and also minimizes lift, to maintain road feel at all speeds. The rear deck spoiler, a trademark of the Turbo, has been enlarged and reshaped for the new model. This makes it even more effective in stabilizing straight-line running and in improving performance during braking, cornering and cross-wind driving. In this way Porsche balanced the increased output of the Turbo's new 3.3-liter engine.



Lagaaij, one of the youngsters in the studio at the time, remembered how the others described it: "The first big rear spoiler was unusual. They even had a nickname for it; they called it *Geweihstangen*, antlers, like what grows on the head of a deer." English-language markets quickly christened it the Whale Tail.

Porsche began delivering the 911 Turbo, known internally as the Typ 930. Its 2,994cc flat-six Typ 930/50 engine produced 260 horsepower at 5,500 rpm and 253 pounds-feet torque at 4,000 rpm. (This contrasted with its normally aspirated sibling, the 2,994cc 1976 Carrera 3.0 with the Typ 930/02 engine that developed 200 horsepower and 188 pounds-feet of torque.) Porsche historian Jürgen Barth reported the company assembled 274 of the Turbos in 1975. It cited Turbo top speed at 155.3 miles per hour compared to 149.1 for the Carrera 3.0. It was the width of the car and the drag it caused that held the Turbo back from higher speed potential. A normally aspirated production 1975 911S was 63.4 inches wide, while the Turbo stretched out 6.4 inches further to 69.8 inches. Porsche CEO Ernst Fuhrmann was no fan of the wide body, and when regular series production began, he ordered his company Turbo in a standard 911 Carrera body. He was pleased when he discovered his car was nearly 6 miles per hour faster than the wide ones.

Specifications did not change from 1975 through the 1977 models. Weissach engineers introduced the new Typ 930/60 engine for the Turbo starting with the 1978 model year. This new engine displaced 3,299cc, achieved by enlarging bore from 70.4 to 74.4 millimeters and lengthening stroke from 95 millimeters to 97. That was nothing, however, compared to the impact Porsche achieved adding an intercooler to its 930 engine. This was the first time any automaker had installed such a device on a series production car. Cooling the fuel-air mixture increased engine output by 40 horsepower, so the Typ 930/60 developed 300 at 5,500 rpm, and by 51 pounds-feet torque, to 304 at 4,000 rpm. Porsche published a top speed of 161.6 miles per hour. (US models, Typ 930/61, produced 265 horsepower.)

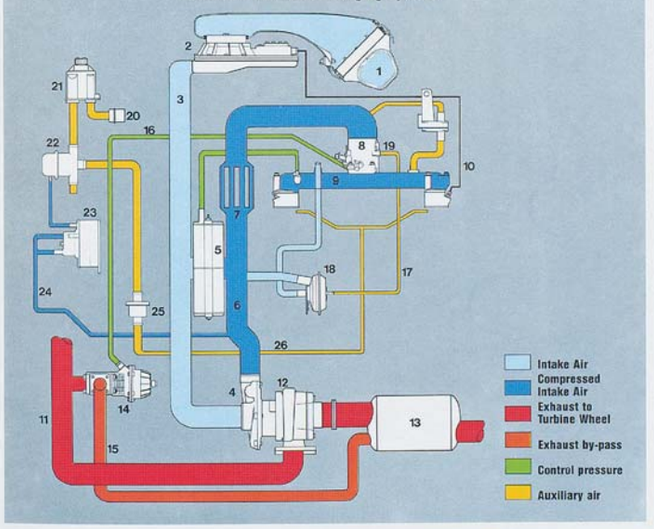
The most noticeable change to the body was the antlers. "For this one," Reisinger recalled, "the engineers came and said we need more side stability and that's the reason for the 'lip'; with the lip you get more side stability." In English-language markets, this became known as the "tea tray."

creases its density. With the new Turbo, Porsche is the first auto maker in history to offer a production model equipped with a true intercooler.

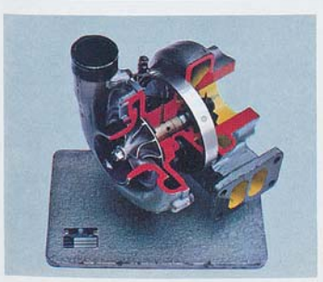
Porsche's engineers did not rest with intercooling as a means of improving the new Turbo. They also expanded its cylinder capacity from 3.0 to 3.3-liters, chiefly to add still more to its already impressive low-end power and torque. To accomplish this, both bore and stroke dimensions were increased. The changes keep for the Turbo its title as the most powerful roadgoing Porsche, with a net SAE output in excess of 250 horsepower. Prodigious though it is, this power is always under total control. In fact it is one of the attributes of the turbo-charger that it is only called into play when the driver summons maximum effort from the engine room. At other times the turbo-charger idles and customary Porsche docility and fuel economy* prevail. Matched to the new Turbo engine are a higher final drive ratio, for quieter and more economical* cruising, and a stronger transaxle. It makes use of a more robust differential. The turbo-charged engine's vast reserves of torque are such that four forward speeds are completely sufficient to bridge the Turbo's entire speed range. An improved clutch disc design gives smoother drive engagement. Such subtleties show how far Porsche has been willing to go to add to the attributes of the automobile that many have already called the finest sports car in the world.

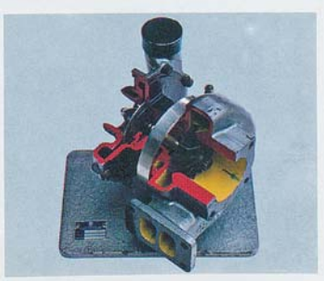
* Based on 1977 EPA estimates 24 highway, 14 city mileage with manual transmission. Your actual mileage may vary, depending on where and how you drive, your car's condition and optional equipment. 1978 data not available at printing time. Ask your dealer for a free copy of the EPA/FEA Gas Mileage Guide for New Car Buyers.

Schematic for Turbo-Charging System



1 Air cleaner
2 Fuel distributor
3 Air intake line
4 Impeller housing (Compressor)
5 Pop-off valve
6 Manifold pressure line
7 Intake air cooler
8 Throttle valve housing
9 Intake manifold
10 Fuel injection
11 Exhaust manifold
12 Turbine housing
13 Exhaust muffler or silencer
14 Waste gate
15 Exhaust by-pass
16 Waste gate control
17 Control pressure for deceleration valve
18 Deceleration valve
19 Manifold pressure safety switch
20 Air-cleaner
21 Air-pump
22 Divertor valve
23 Control for divertor valve
24 Pressure control line
25 One-way valve
26 Air-injection line





Brochure text for the 1978 model emphasized the new 3,299cc flat six-cylinder turbocharged engine with its intercooler.
Porsche Archive

The rubber lip surrounding the rear spoiler "makes it even more effective in stabilizing straight-line running and in improving performance, curing braking, cornering, and cross-wind driving." English speakers soon nicknamed it the "tea tray."
Porsche Archive

turbo
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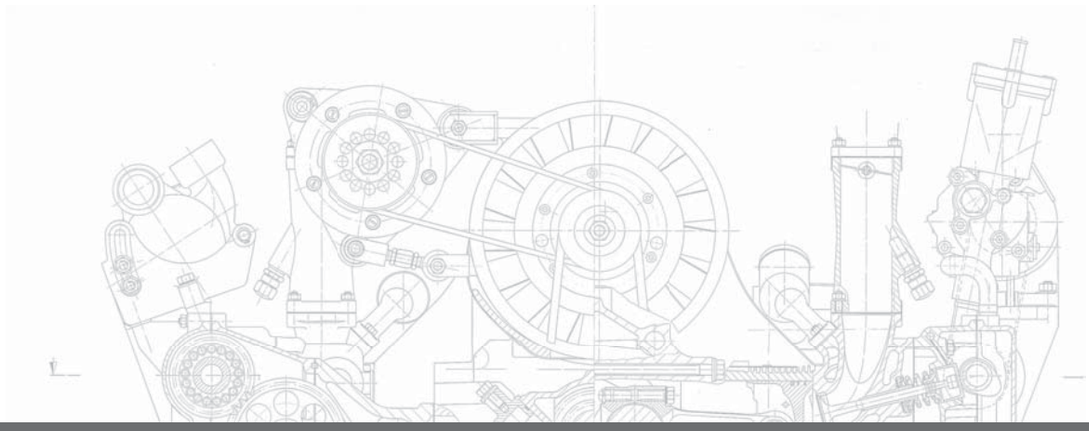


Chapter Five

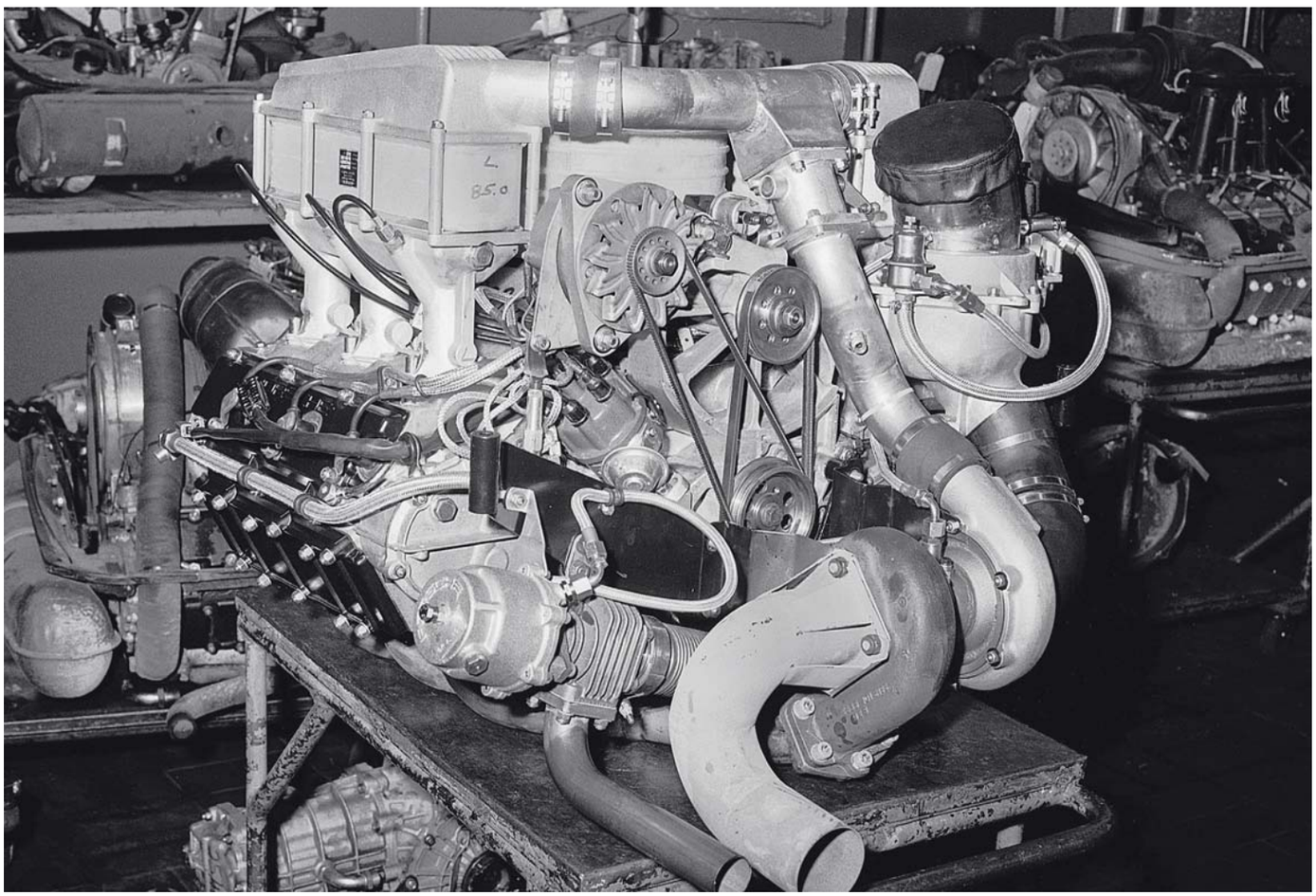
PARALLEL **UNIVERSES:**
RACING TURBOS IN 1975 AND 1976

Helmut Kelleners drove Max Moritz's Typ 934 in the 300-kilometer ADAC European GT Championship in early April 1976. The race took place at the Nürburgring. *Porsche Archive*

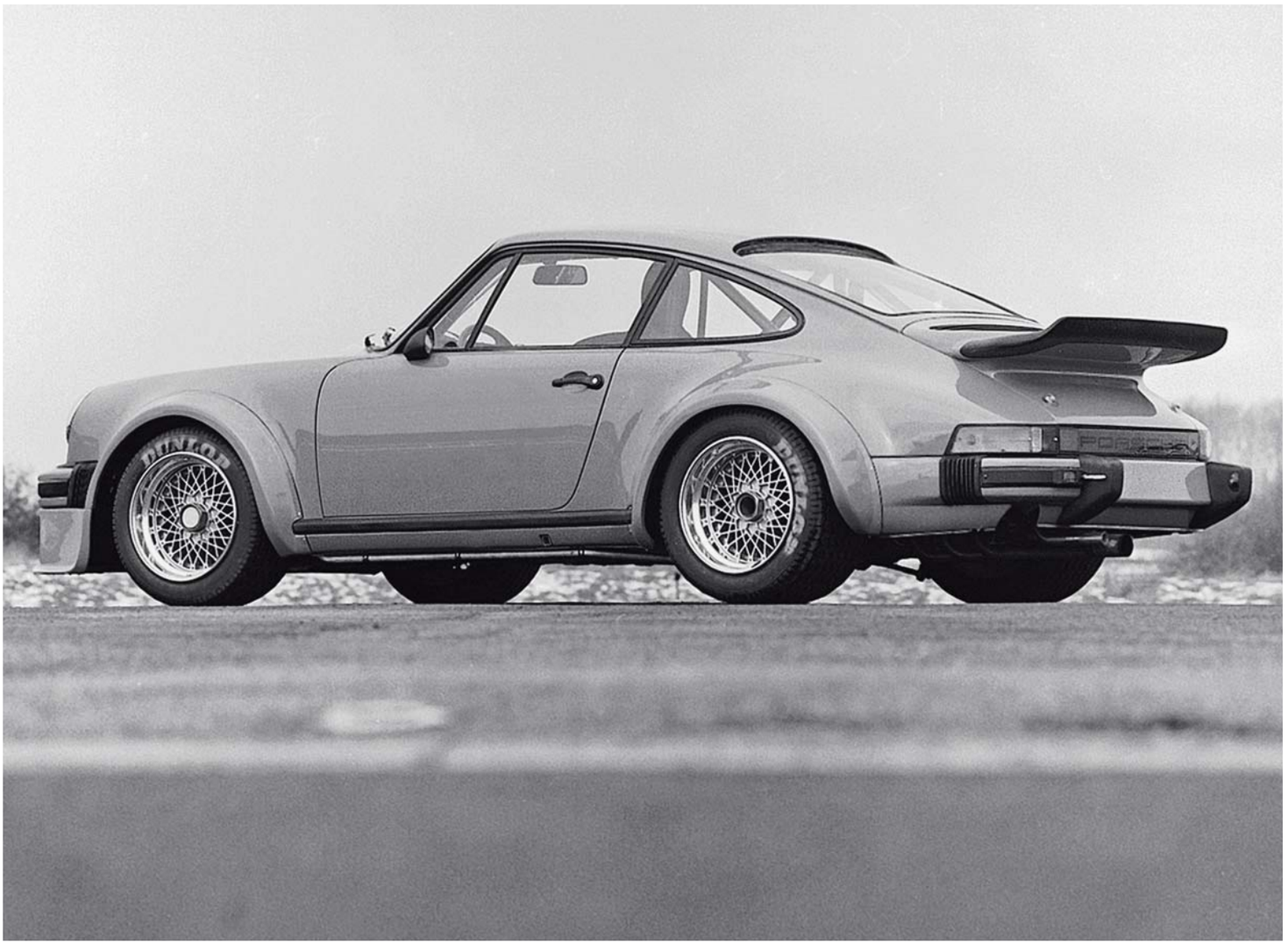
The series-production Typ 930 Turbo was a success in both sales and racing terms. While Porsche assembled 274 of them in 1975, the carmaker added another 1,174 in 1976, a number of those reaching anxious US buyers. Not only did it make the company money, this quantity was triple the FIA homologation requirement of four hundred cars over two years of manufacture. This legalized it for Group 4 as a limited-production Grand Touring Car. New rules for this category for 1976 established a minimum weight based on engine displacement. "This rule had two main objectives," Paul Frère wrote in *Porsche Racing Cars of the '70s*—"to discourage cheating on the homologated weight and to allow luxuriously equipped (and consequently rather heavy) production cars to become more competitive."

1975 TYP 934

What happened instead was that the Turbo Porsches for Group 4 (at first called the Turbo RSR and later relabeled as Typ 934) sent competitors scrambling when they arrived in 1976. For 1975, the Le Mans entry list had recorded several 4,390cc Ferrari 365 GTB/4 Daytonas, one 7-liter Corvette, a 5.8-liter De Tomaso Pantera, and even a 2,393cc Datsun 240Z, as well as fourteen of the 2,993cc normally aspirated RSRs, taking up twenty-five of the spots on the entry list. For 1976, of sixteen cars entered in Group 4, thirteen were the 2,993cc 934 Turbos.



The Typ 930/25 engine for the 934 race car displaced 2,993cc, although with the FIA's 1.4 times displacement rule, it was classified as 4,190cc. It developed 485 horsepower at 7,000 rpm. *Porsche Archive*



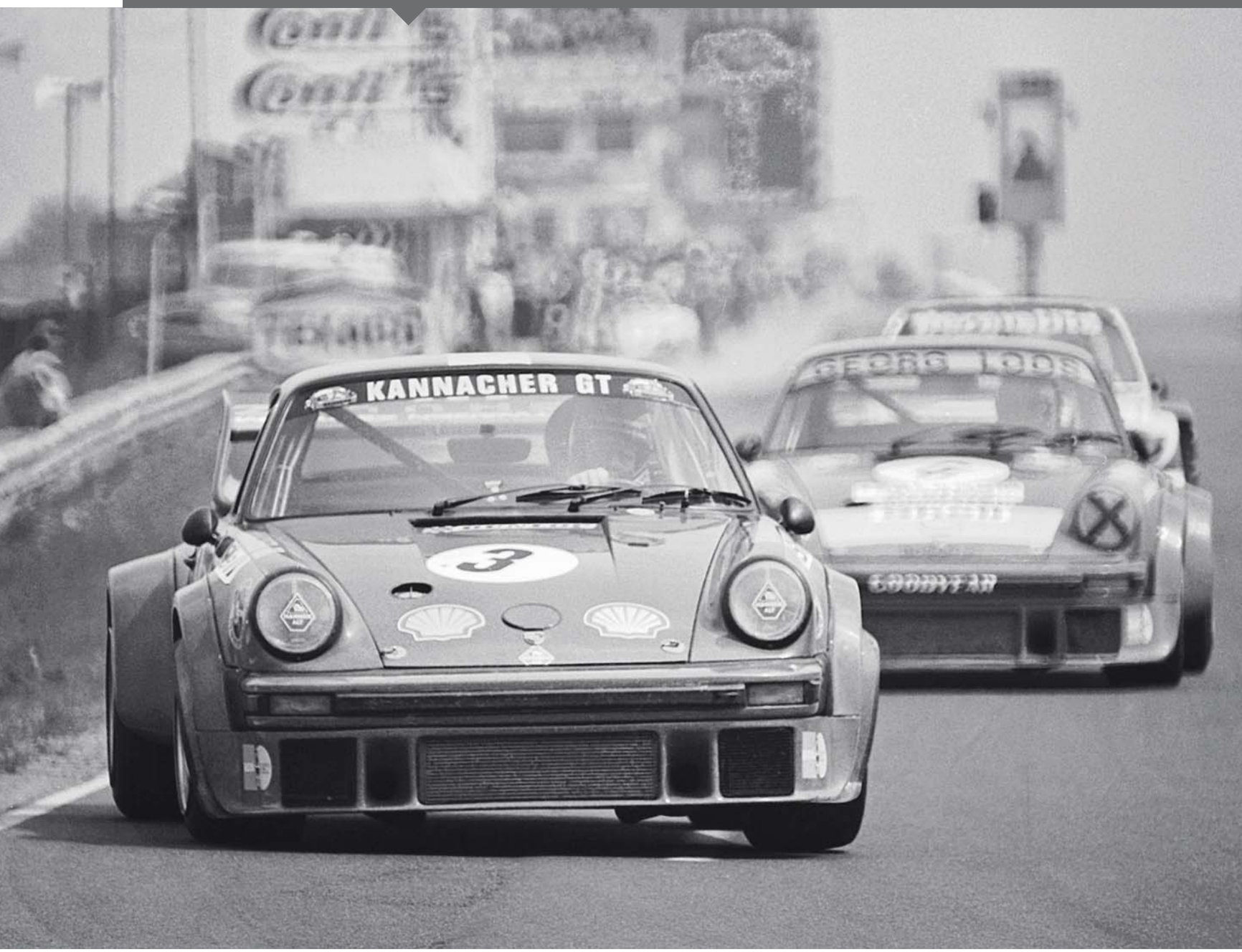
The FIA also had created a new class to contest the World Championship of Makes (WCM). As historian János Wimpffen explained in *Time and Two Seats*, "The new Group 5 was formally called Special Production, but [it] was universally referred to as Silhouette. There was no minimum production number, and the cars needed only to be 'derived' from any models recognized in Groups 1 through 4. Nearly any modifications to the coachwork, aerodynamics, suspension, brakes, and chassis structure were allowable so long as the basic shape and configuration of the original was retained. Engine displacement was free as well. Group 5 effectively became the sports car version of drag racing's Funny Car category."

Regulations allowed wheels as wide as 16 inches for cars with more than 3,000cc displacement and the appropriate add-on fender extensions. Tony Lapine's designers and modelers conscientiously made these extensions obvious, going so far as adding contrasting body sealant, the better to emphasize the production beginnings of the race car. Entrants had to retain "the basic body shell, the cylinder block and crankcase, all the main castings and their location, the principle of the suspensions and the general layout of the basic model," according to Frère. Intentionally, Porsche had created the 1974 Carrera 3.0 RS and the 930 Turbo with a wider body and some suspension changes (a short-arm rear suspension and a front configuration that resisted front-end dive on hard braking) so that Weissach engineers, designers, and modelers already had fundamental upgrades homologated into the car. A new four-speed Typ 930 transmission took advantage of the cases and configurations of the 911 normally aspirated series-production Typ 915 five-speed gearbox, using its generous space to accommodate wider gears. Weissach conservatively rated its torque capacity at 326 pounds-feet, giving it the capability to handle much higher loads for twenty-four hours of a race. Porsche designated its WCM Group 5 entry as the Typ 935.

Because of its production origins, the FIA applied its 1.4 multiplier rule for supercharged or turbocharged engines, and it rated the 2,994cc Group 4 Typ 934 as 4.2 liters displacement. Slotting into the 4-to-4.5-liter displacement class meant the car weighed at least 2,469 pounds. This allowed Porsche to create the Group 4 cars intended for its customers

The basis of the Typ 934 came from the Typ 930 series production cars. The fender flares—permitted by FIA Group 4 rules—were conspicuously added on. *Porsche Archive*

During the ADAC 1,000 Kilometers of Nürburgring in 1976, the 934 driven by Team Georg Loos finished second ahead of the 935s. *Porsche Archive*




MARTINI PORSCHE
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Turbolader
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BOSCH
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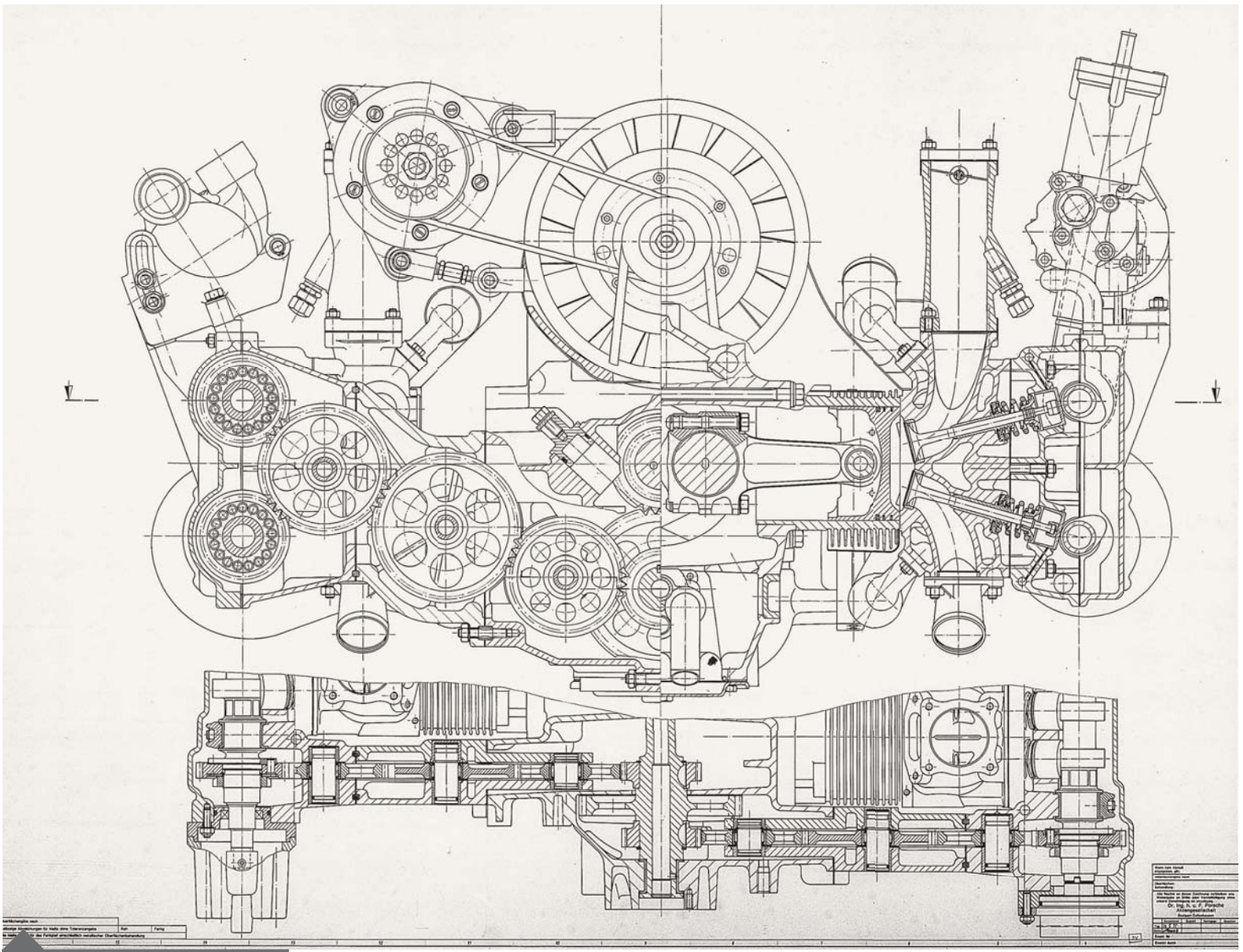
PIRELLI



This construction drawing of the Typ 935 motor was dated May 16, 1975. It was labeled "View and Section of Drive Control." *Porsche Archive*

This early 935 bore more resemblance to its sibling 934 than the swoopy streamliners later versions became. The nose and tail carried over bits and pieces from the RSR Turbo 2.1. *Porsche Archive*

from production 930 bodies and platforms. As typical of Norbert Singer's race preparation, his staff (with Wolfgang Berger in charge) removed soundproofing, rear seats, and some trim. But even after adding the required aluminum-tube roll cage and fire-protection requirements, the car came in 88 pounds underweight. This let Berger position ballast in the nose of the car, which improved weight distribution and balance and lowered the car's center of gravity, enhancing cornering.

Hans Mezger and Valentin Schäffer continued their development work on the engine. The obvious visual distinction between the production Typ 930/50 and the racing Typ 930/71 for the 934 was the race car's horizontal fan. Mezger and Schäffer made internal changes in intake and exhaust valve sizes and fitted more aggressive camshafts because regulations allowed only those modifications to the homologated series engine. One upgrade they permitted was adding an intercooler, but the car's bodywork stymied Berger's engineers. They used an air-to-air cooler on the 2.1-liter Turbo running as a prototype; it was too large to fit within the body of the production-derived 934, so engineers settled on an air-to-water cooler for each bank with radiators mounted some distance away behind the front air dam. Run at full boost—1.4 bar—the coolers reduced intake air temperature from about 325 to 150 degrees Fahrenheit. This not only

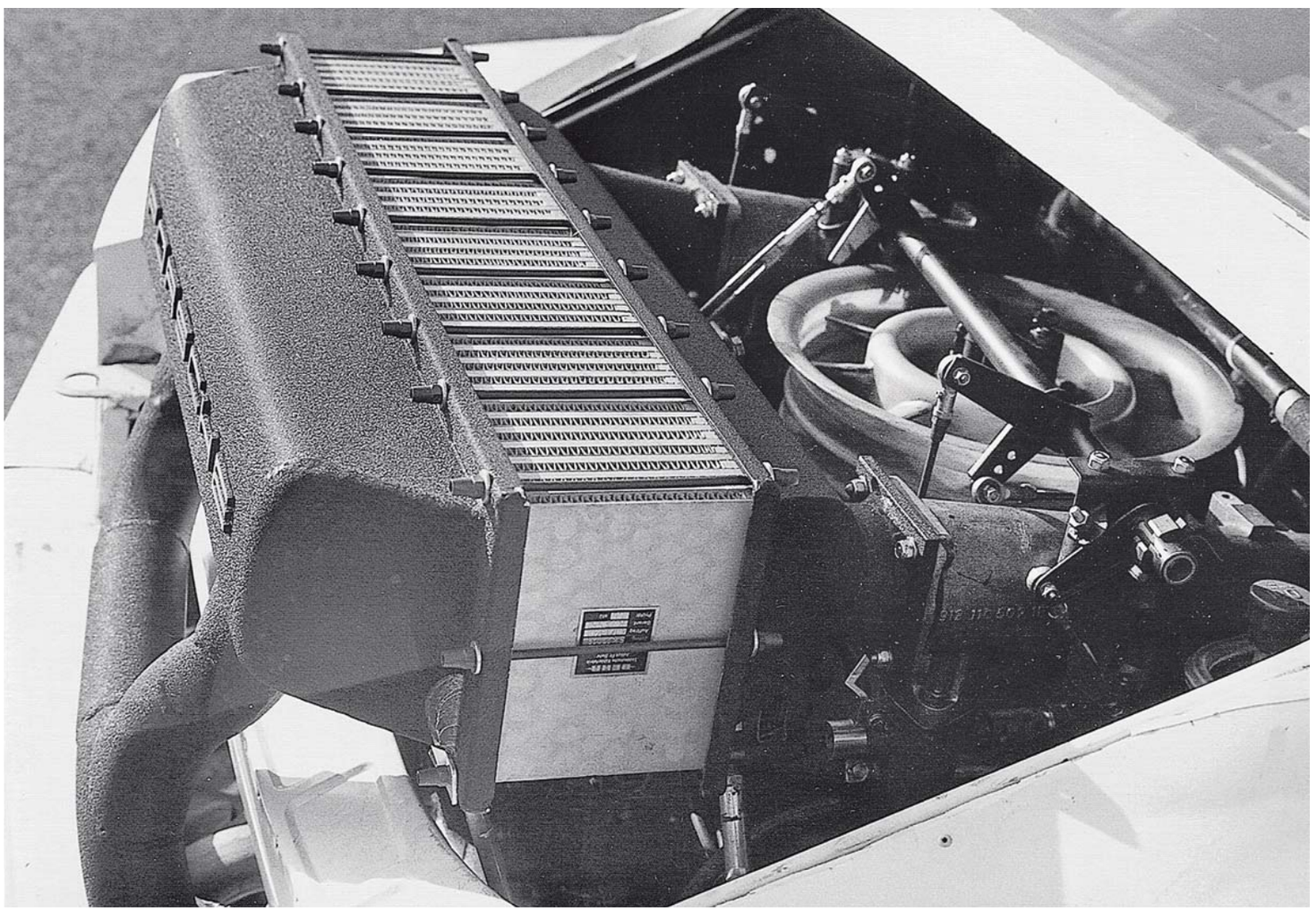
rendered the air/fuel mix considerably denser but also helped protect the engine's internal components. First versions of the Typ 930/71 engine for the 934 developed 485 horsepower at 7,000 rpm and 434 pounds-feet torque at 5,400 rpm. Fairly quickly, output reached 500 horsepower with more aggressive camshafts. Even with its weight, the 934 became a very effective competitor. Amusingly, the weight restriction allowed Berger's engineers to leave the luxurious 930 electric window lifts in place. Norbert Singer insisted for years that this was an advantage: manual cranking mechanisms weighed more than the motors! Porsche sold the 934s, about thirty-two in 1976, to well-known private racers.

1976 TYP 935/76

Porsche had no electric window lifts in the Typ 935/76. This was its WCM warrior, and Singer and his crews scrutinized every regulation with extreme care. They concluded that by reducing engine capacity to just less than 4,000cc, as calculated by that 1.4 multiplier, they could reduce the 935's weight another 121 pounds below the 934. Hans Mezger slimmed cylinder bore from 95 millimeters to 92.8 while retaining the 70.4-millimeter stroke. This yielded 2,856cc, resulting in 3,998cc with the multiplier.

Singer's suspension changes primarily eliminated the tire-camber variations inherent in series-production cars, but they also simplified ride-height adjustments and saved weight. Furthering the car's diet regimen, his engineers discarded as much nonstructural metal bodywork as possible, replacing (according to Frère) the doors and rear deck lid with the same composite material from which they fabricated the 908/3 prototypes. Taking it even further, Frère revealed that engineers created the entire external front bodywork—comprising the luggage-compartment lid; the large, one-piece, quickly detachable assembly incorporating the two fenders; and the bumper-cum-air-dam—of this same polyurethane foam sandwich. They eliminated all interior trim and replaced glass with Plexiglas sliders for the doors and fixed windows along the sides. These severe modifications brought total weight down 198 pounds below regulation minimum. Once again, they created the opportunity to place ballast where it was most useful. As Frère reported, when they were done and the car was loaded with 30.1 gallons of fuel and a driver, weight balance was 44 percent on the front and 56 percent on the rear. Without them, the 935 tipped the scales at 1,940 pounds.

The engine and running gear got a lot of consideration, not only from weight balance but from engineering innovation. The new 2,806cc Typ



The Typ 930/72 engine displaced 2,806cc and developed 590 horsepower at 5,400 rpm. The compact intercooler sat beside the horizontal cooling fan.
Porsche Archive

Wind tunnel testing and careful reading of the rules yielded the working model 935 whose well-managed "face" suggested little of the sophisticated aerodynamics at work from the air dam to the rear fenders to the rear wing.
Porsche Archive


Shel
MARTINI PORSCHE
hell

930/72 engine developed 590 horsepower at 5,400 rpm using 1.4 bar boost. Porsche ran shorter races at 1.5 bar, and this gave drivers as much as 630 horsepower at 8,000 rpm. Singer preferred an air-to-air intercooler for the 935 for its simplicity and reduced weight over the more complicated water-cooling systems. But, after the car's inaugural race, FIA and CSI scrutineers concluded that Porsche's intercooler installation in a box (which also supported the rear wing) violated the rules. Singer reverted to a pair of water intercoolers similar to those Berger had used in the 934, but the change was difficult, and perfecting it threatened the car's efforts for the WCM.

With the 935's lighter weight and greater engine power, handling and road holding were significantly more challenging than with the 934. The FIA limited front and rear wheel width for Group 5 vehicles to 16 inches; however, when Singer and his engineers discovered in the rules that the design, shape, and size of fenders was *not* regulated, this sparked an idea. Following tests with Goodyear and Dunlop bias-ply racing tires and Michelin and Pirelli radials, Dunlop became Porsche's provider of choice to develop tires for the rear to fit wheels with 19-inch rim diameter. These very tall tires lengthened the tire patch.

As Tony Lapine's styling teams worked with competition department aerodynamicist Eugen Kolb, they collaborated on the wide-flared fenders that included partially enclosing the rear wheel arch. The first version of the car incorporated a one-piece removable front end that retained the characteristic 911 "stove pipe" fenders and upright headlamps. As Singer and Kolb reconsidered it, they flattened the front fenders, bringing their contour close to the top of the front tires. Because the rules said only that "fenders are free," engineers opened pressure relief slots above the front tires as they had done on the Can-Am 917/10s and 917/30s to expel high air pressure in the wheelwell at a very low-pressure point on the car body. They mounted headlights low in the front air dam, creating the *Flachbau*—flat body—or slant nose. This provided two benefits: the new bodywork increased downforce on the front end, but also, according to Frère, lowering the front fenders nearly eliminated any impact from crosswinds.

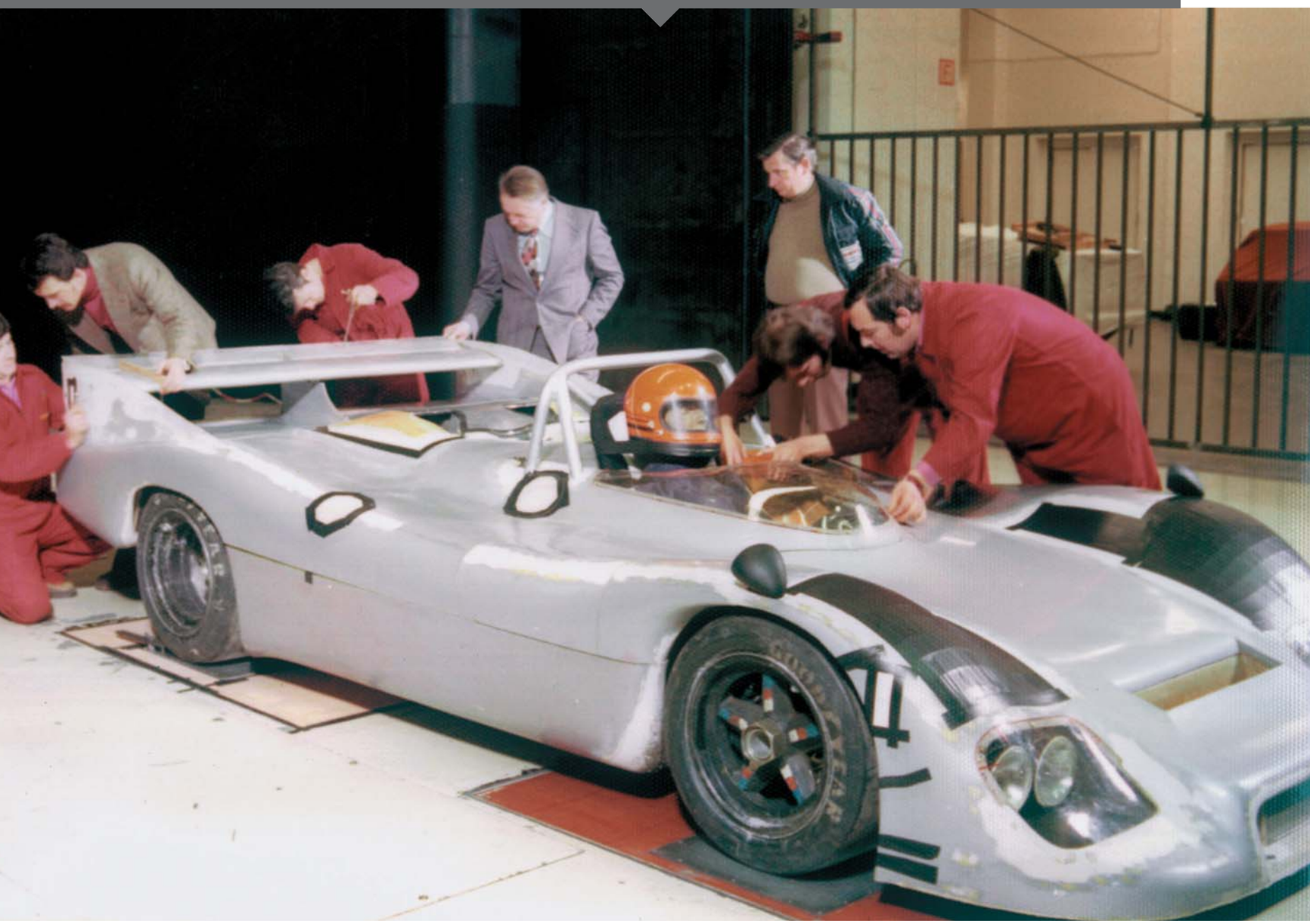
For 1976, Singer's crew assembled two of the cars. The first, 935/76.001, accumulated more than 1,800 miles in testing at Circuit Paul Ricard in France. With Jackie Ickx and Jochen Mass driving, Singer clocked the car at 194 miles per hour on the 1.1-mile Mistral straight. The second car, 935/76.002, became the racetrack workhorse (with occasional backup support from .001), fighting steady and insistent challenges from BMW's turbocharged CSL coupes.

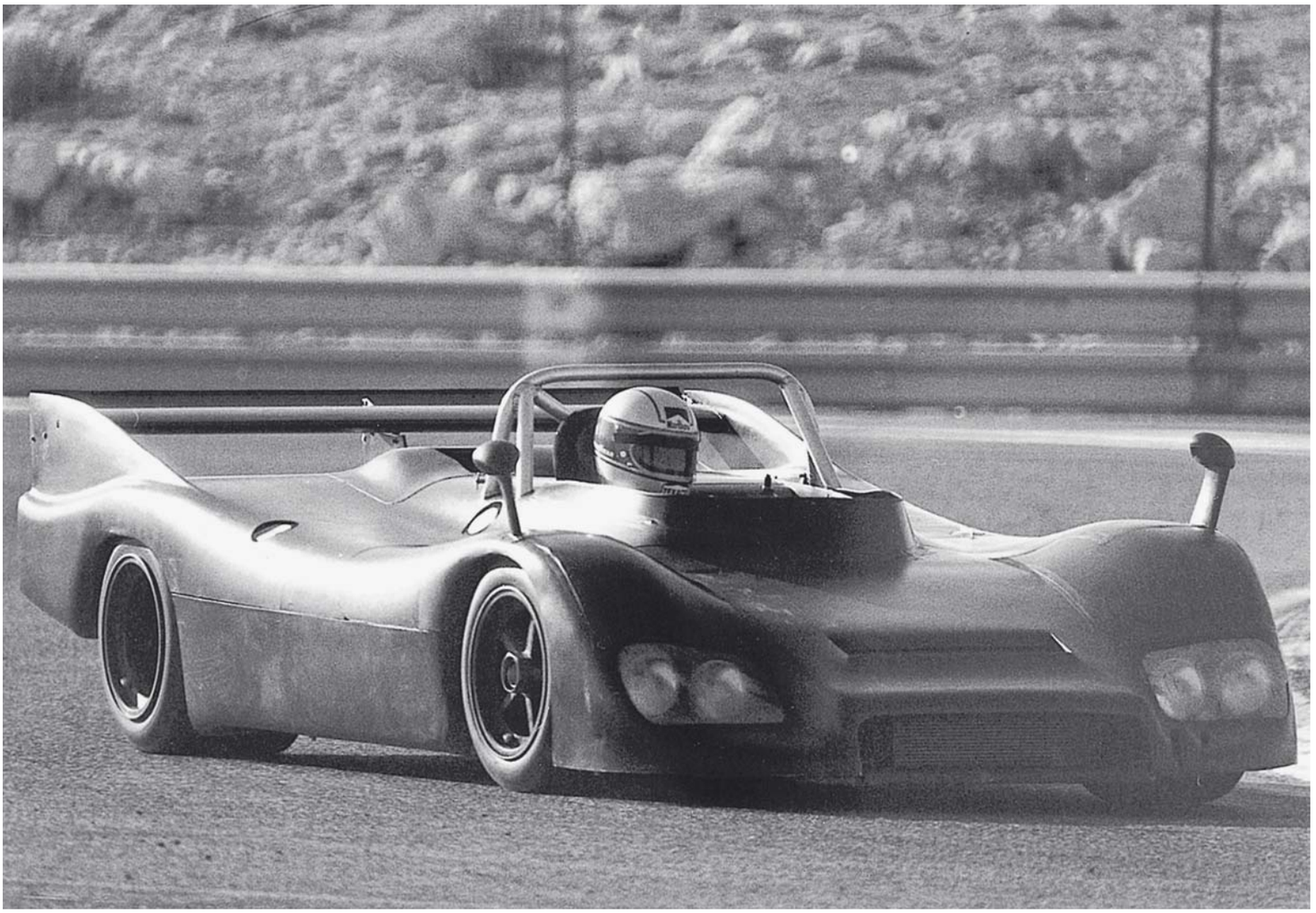
Racing engineer Norbert Singer (left) talked with driver Manfred Schurti (right) following his testing sessions at Paul Ricard in early 1976. Engineer Günther Gutekunst listened in. *Porsche Archive*

While Porsche has consistently denied its 935 was a street-legal vehicle, this one was spotted on an autobahn in 1983. *Porsche Archive*

In late 1975, Weissach engineers took the prototype 936 into Stuttgart University wind tunnel. Helmut Flegl (in tan jacket and red shirt at the rear wing) was project manager, working for engineering chief Helmuth Bott (in the grey suit) while racing engineer Norbert Singer (blue jacket) looked on. *Porsche Archive*

The prototype 936 was a mix of Typ 908/03 and 917/10 chassis and body pieces. Engineers installed the Typ 911/78 flat six of 2,142cc displacement, developing around 520 horsepower. *Porsche Archive*





1976 TYP 936

"What do you think about these new Group 6 regulations?" Ernst Fuhrmann asked in mid-September 1975. He was meeting with Singer, Berger, and their colleagues. "That brought all conversation to an immediate halt," Singer recalled. The competition department as well as engine men Mezger and Schäffer were slaving over 934 and 935 drivetrain, chassis, and body preparations for midwinter development tests and season debuts in the spring of 1976.

The FIA had run a Group 6 category from 1966 through 1971 as prototype sports car class. At first, there was neither a minimum production requirement nor a maximum engine displacement. Those arrived in 1968 when Group 6 (and Group 4) became the International Championship for Makes (ICM). The group's rules limited displacement to 3 liters, and Porsche had won the 1969 ICM with its 908/2 Spyder, the car with the undulating body nicknamed *Flunder*, the Flounder. Through 1970 and 1971, this was a fiercely contested class, with 3-liter V-8 Alfa Romeo T33/3s and V-12 Matra-Simca MS650s challenging Porsche in 1970. But the 908s ruled, and at Le Mans in 1971, a single factory Simca-Matra and a lone factory-entered Ligier powered by a Cosworth DFW V-8 were among the six Group 6 entries. Disheartened, the FIA ended the classification that year, though the association resurrected it for 1976.

Group 6 addressed "the problem of what to do with the existing sports-racing series," János Wimpffen wrote. "The purpose built two-seater racing cars were still faster than the production based Silhouettes [of Group 5]. If they were to be allowed to run with the new Group 5 cars, then the intended premier class would be shown up by the older cars." To satisfy long-established teams, the FIA created a new series, the World Sports Car Championship. It renumbered this class as Group 6, retaining the rules that had defined these cars in the past. This represented a risk for the FIA. Without enough viable entries to launch Group 5 as it had intended in 1975, it postponed the Manufacturer's Championship until 1976. "But the FIA was determined to not allow mixing of the Groups 1–5 with Group 6," Wimpffen continued. "To ensure this, the Silhouettes series retained the traditional endurance events, which had to run to a minimum of six hours or 1,000 kilometers. The Sports Car Championship races now became sprints, run to a *maximum* [italics Wimpffen's] of four hours."

Fuhrmann had little money to develop yet another competition car, but he had an idea. "We have a lot of spare parts from the 917," Singer remembered him observing. "It should be easy to make a sports prototype car out of the parts." The room burst into protest and Fuhrmann listened. But FIA officials in Paris had hinted that Renault was creating a sports prototype. Eric Broadley's Lolas represented another threat. Group 6 was the natural successor to Porsche's 917s, and Le Mans was still the race that enthusiasts revered and where manufacturers proved the engineering of their race cars, whether the event was on or off the WCM calendar.

"Okay, I'll tell you," Fuhrmann said as he left the meeting, "we'll do it." As Singer related, engineers worked on their other projects in a kind of stunned denial. A few initial studies and proposals surfaced, but the Group 5 and 4 cars consumed them, and Weissach had no spare personnel. Two weeks later, the competition group met Fuhrmann and he listened again to all the good reasons it was not possible. "We do it," he said again, but then he added, "You take the parts from stock, make a new space frame, just make a body . . ."

Singer spotted an opportunity: "Well, with a new body, we need a wind tunnel." But Fuhrmann wasn't moved.

"You have a lot of experience. You don't need a wind tunnel. Just make it!"

"That's it," Singer said. "That's the whole story. Took us half a year. Started in November. And the car was running in March. The first time in Paul Ricard, testing. The first time in the Nürburgring, racing."

Fuhrmann pulled Helmut Flegl back into the competition arena. He had supervised the 917 coupe evolution and run the incredibly successful turbocharged Can-Am 917 program. Then Flegl shifted to series production to lead development of the front-engined, water-cooled V-8 flagship 928. This

Count Rossi saw the car while it was still black during testing and liked its sinister appearance. He asked Fuhrmann to enter the car with Martini colors but otherwise unchanged. At its April debut during a 300-kilometer sprint race at Nürburgring, the Typ 936 still wore the matte-black paint finish. *Porsche Archive*

Wearing the first layers of their new color scheme, Porsche's mechanics unloaded the cars and spare parts from transporters. Jacky Ickx and Gijs van Lennep drove No. 20 to overall victory in the 24-hour race. *Porsche Archive*

In the typical spring weather at the Nürburgring, the black 936 disappeared into the fog and rain making it hard for photographers to shoot it. When little coverage of the car appeared, Rossi ordered no more black cars. *Porsche Archive*


PORSCHE 17
MARTINI PORSCHE
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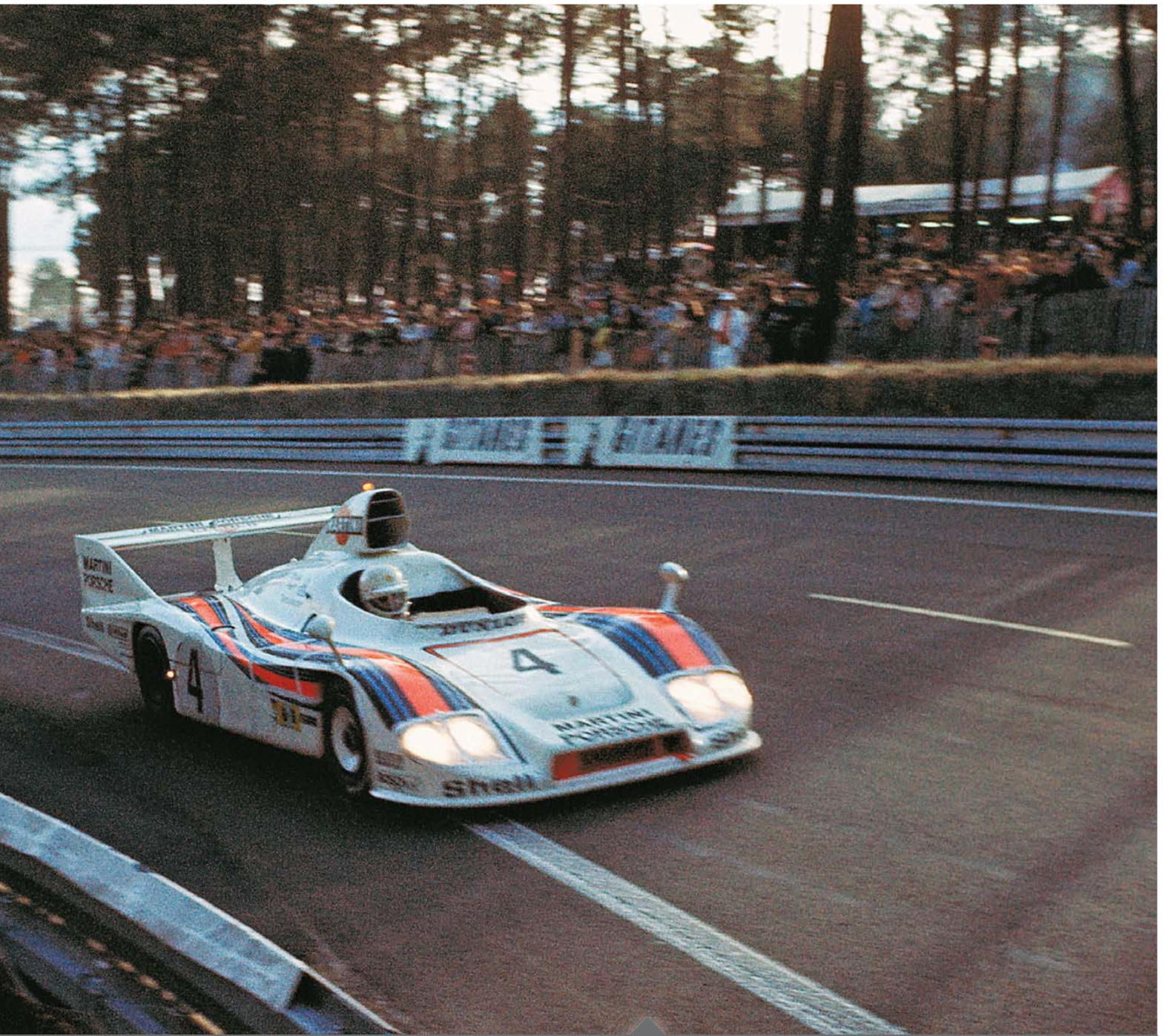
20
Shell


MARTINI
Shell



At the end of 24 hours in 1977, Porsche's 936 had won Le Mans. Again. Jürgen Barth, Hurley Haywood, and Jacky Ickx had driven 2,903 miles and finished not even a full lap ahead of second place. *Porsche Archive*

In advance of the 1977 Le Mans trials, Singer and Flegl returned to the wind tunnel. Here, on a 936/76 chassis, they experimented with a long nose and low, flat air box. For the race, they used the tall one. *Porsche Archive*

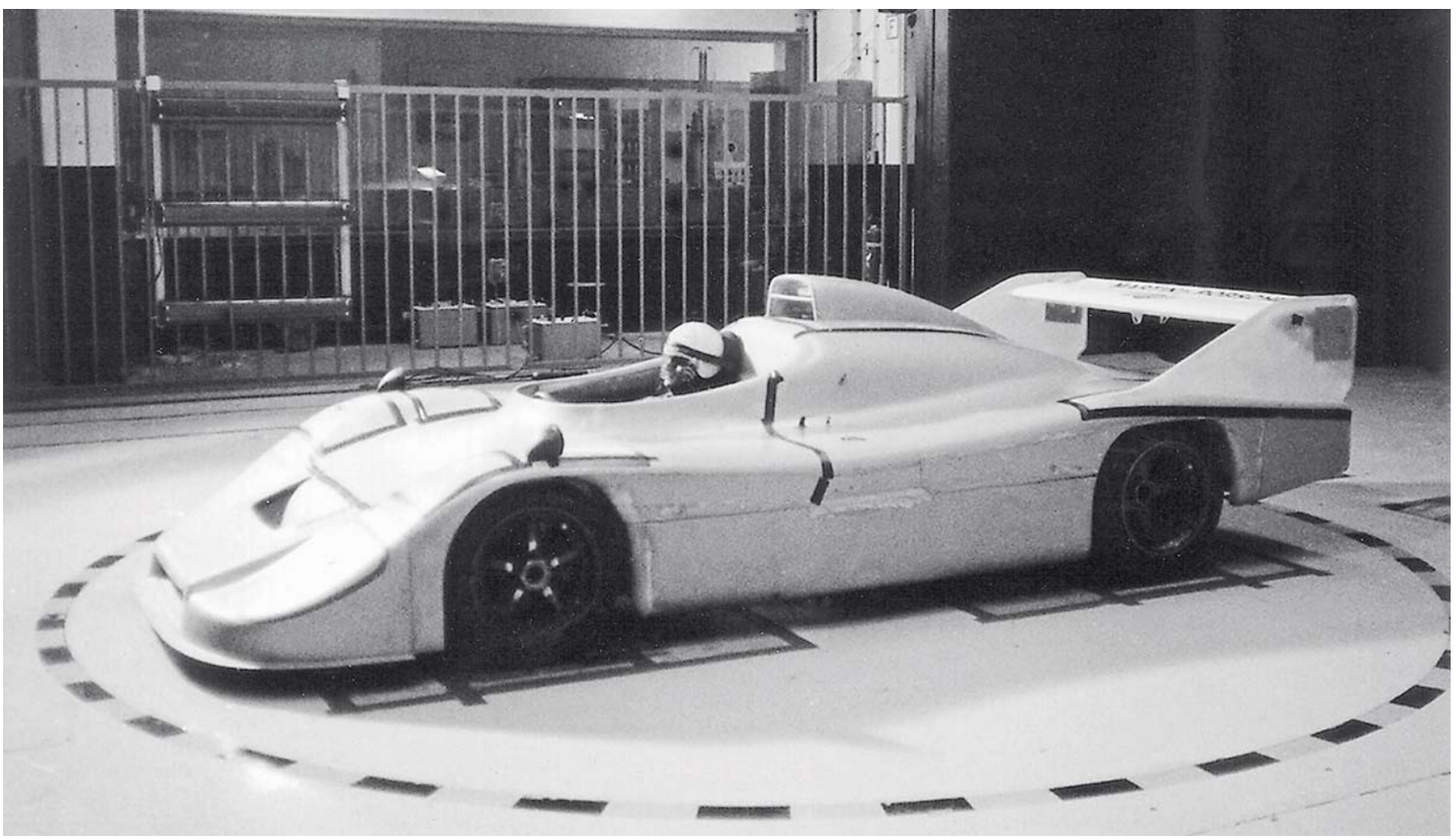
936, as Flegl characterized it in an interview in 2011, was a kind of collage. His familiarity with the 917 made parts choices easy: brakes, springs, shocks, sway bars, an unused prototype five-speed transaxle gearbox, as well as wheels, suspension parts, and steering pieces. Hans Mezger and Valentin Schäffer performed some magic on the 2,142cc flat six of the Turbo RSR and coaxed out 520 horsepower at 8,000 rpm. With a weight limit of 1,540 pounds, Flegl's engineers developed an aluminum tube-frame chassis and a paper-thin fiberglass body that incorporated clever design and aerodynamic innovations that competition car body man Eugen Kolb devised including integrating a large Can-Am size horizontal rear wing.

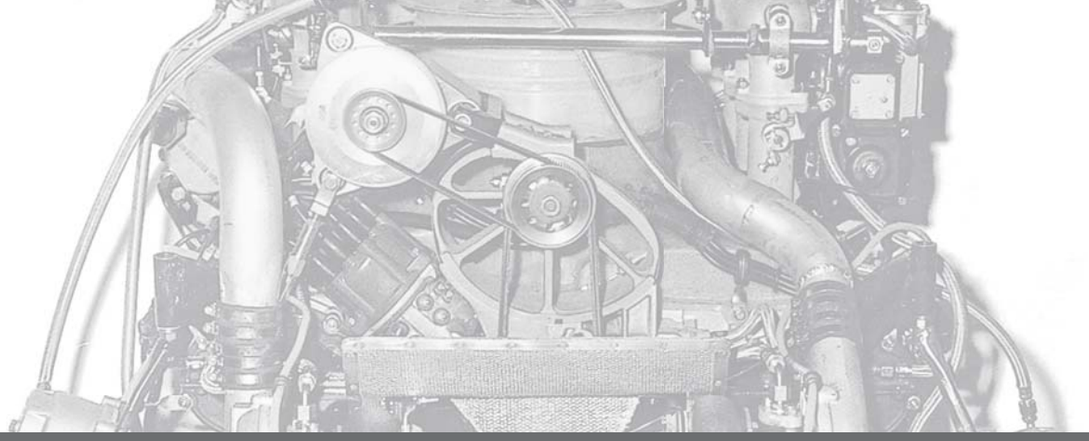
"This was a real secret, this car," Singer explained. "Nobody was to know we were doing a new sports car. So Mr. Fuhrmann had the funny idea to paint it black. Nobody should see it when it is running." At the season-debut Group 6 spring event at Nürburgring in early April, Porsche arrived with 936.001, but Renault showed up with two of its Alpine-Renault A442 Spyders, still in 1975 Group 5 configuration with tires and a rear wing that didn't comply with the new regulations. The FIA gave Renault a one-race exemption, and their two cars qualified first and third, with the new 936 sandwiched between them. Any advantage of the waiver proved moot when a first-lap accident initiated by one of the Renault drivers took out both of them while Rolf Stommelen slipped through unscathed in the 936. He finished fifth overall behind a highly competitive Reinhold Jöst in his turbocharged 908/3 (ironically awarding winner's manufacturer points to Porsche).

The rest of the 1976 season proved the wisdom of Fuhrmann's challenge to his overworked engineers. By season end, Porsche had scored 140 points compared to Alpine's 47, all without considering the ever-important (but non–Sports Car Championship) 24 Hours of Le Mans, where Porsche ran a two-936 entry.

"It is now history," Paul Frère wrote, "that 936.002, driven by Jacky Ickx and Gijs van Lennep, started the race from pole position, after Ickx had lapped in 3 minutes 39.8 seconds, and led from start to finish, Ickx also recording the fastest race lap of 3 minutes 50.0 seconds. The car's otherwise completely trouble-free run was marred only by a cracked exhaust pipe, which made the turbocharger inoperative and took 34 minutes to replace." Here, Wimpffen picked up the narrative: "Ickx/van Lennep lost five laps having this done, but it merely reduced the lead from astronomical to substantial. . . . So the first Group 6 vs. Group 5 confrontation went to a car which was nothing but a disassociated pile of parts a few months previously."

The end of the 1976 racing year saw Dutch driver Toine Hezemans claim the FIA GT championship in a 934. In the United States, the SCCA's Trans-Am series adopted FIA regulations and welcomed Group 4 and Group 5 cars as part of its Category II; former 917/10 Can-Am champion George Follmer took the eight-race season championship driving a 934 for Vasek Polak, a former Porsche racing mechanic who came to the States and found success. Porsche owned the WCM in Europe with its 935s and the Sports Car series with the 936. Although BMW had battled Porsche's 934s and 935s, there had been little other serious competition, and Porsche's outstanding success discouraged others as racers looked ahead to 1977.





Chapter Six

BODIES IN **ORBIT:**
AROUND RACING CIRCUITS, 1977 TO 1981

Edgar Dören drove this 934/5 during the May 1, 1977, ADAC Eifelrennen at Nürburgring. *Porsche Archive*

1977 TYP 934.5

Two competing sanctioning bodies controlled sports-car racing in 1976 in North America. IMSA, the International Motor Sports Association, ran a production-car-derived series known as the Camel GT Challenge. This operated under silhouette regulations similar to FIA's Group 5. After fielding complaints from BMW and Corvette racers, IMSA banned Porsche's new turbocharged 934 from competition. The marque still did well with normally aspirated Carrera RSR entries, but those intending to compete with the newest car looked elsewhere and found a willing home with the Trans-American Challenge organized by the Sports Car Club of America (SCCA). In the Trans-Am, competitors discovered that Category II included FIA Groups 4 and 5. For 1977, the SCCA expanded the schedule to ten weekends, and the organization welcomed Porsche's turbocharged race cars. Ludwig Heimrath claimed honors in his 934, though not without some controversy.

SCCA's competitive Trans-Am series forced IMSA to allow—reluctantly—the 934 to compete. For this new venue, Porsche upgraded its 934 to match IMSA regulations. Known variously as the 934.5, the 934/5, or the 934½, the race car retained most of its 934 mechanicals as well as the front end with its large air dam, upright headlights, and added-on front fender extensions. The rear of the car revealed the biggest changes, replacing add-on fenders with the 935's integrated bodywork and a more radical rear wing. With certain modifications, the Typ 930/73 engine developed as much as 600 horsepower at 7,000 rpm and 434 pounds-feet

In 1977, W. H. MacEachern sponsored Canadian driver Ludwig Heimrath in this 934, winning the Trans-Am championship. For 1978, MacEachern added the 935 rear bodywork and Heimrath won at Westwood Motorsports Park in British Columbia and at Mexico City. *Randy Leffingwell*

of torque at 5,400 rpm. Weissach's competition department assembled ten of these cars, the first going to Peter Gregg at Brumos Racing in Florida. Gregg and his chief mechanic, Jack Atkinson, were perpetual tinkerers and inventors, and when Gregg reached tech inspection for the season opener at Atlanta, IMSA scrutineers refused to approve his car. Gregg quickly transferred to the Trans-Am, where he won six races. Then at Mosport, near Toronto, fellow competitor Ludwig Heimrath protested Gregg's improvements and SCCA scrutineers disallowed all of Gregg's wins, handing the season championship to Heimrath, who had finished second several times behind Gregg.

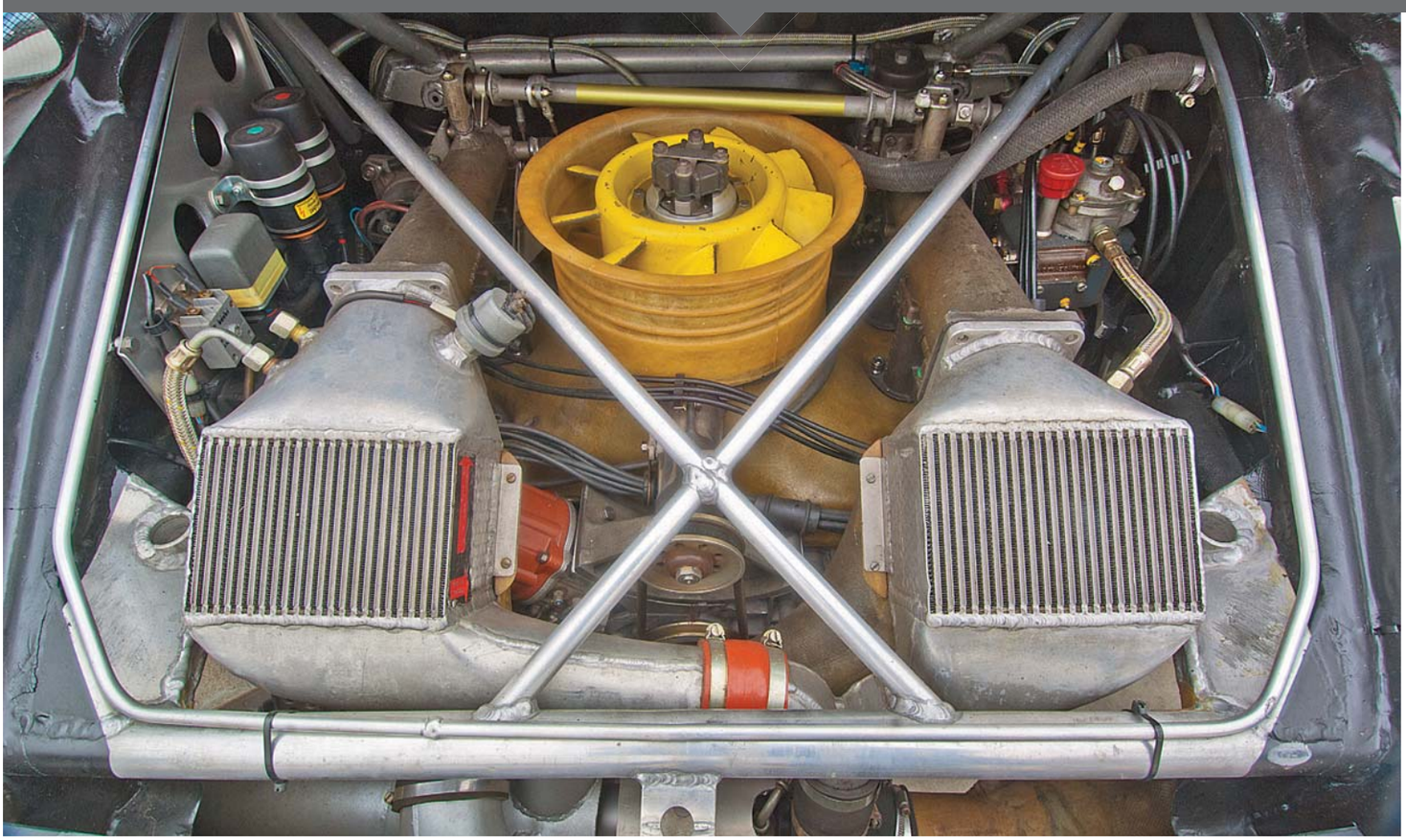
Through the 1977 racing year, owners converted many of the 934.5s and even more of the 934s to full 935 specifications, leading to starting grids and winners' circles filled with Group 5 Porsches and drivers. Those who bought new cars found the 935/77 had significant improvements, the result of rules changes that allowed Singer to install a larger and more efficient air-to-water intercooler and to revise front and rear suspension mounts and hardware. Singer also substituted two smaller KKK turbochargers for the single large unit in the 935/76. This did not change 935 engine output; it remained at 630 horsepower at 8,000 rpm and 434 pounds-feet torque at 5,400 rpm. However, throttle response improved because of the smaller turbos spinning up more quickly. Singer, Mezger, and Schäffer began a complete redesign of the 2,804cc Typ 930/72 engine to address, as Frère put it, "the combination of thermal and mechanical stresses [that] had reached a point where any further increase in power was bound to cut into the engine's reliability." Porsche intended its debut for the 1978 season.

Singer and aerodynamicist Eugen Kolb worked to contain airflow over the smooth slant nose of the Typ 935/77. They fabricated small, boxy fins, faired into the deck lid that rose from the front and covered the outside mirrors ahead of the windshield. FIA's liberal aerodynamic rules also allowed Singer to place an additional Plexiglas back window over the original. This and the accompanying bodywork flattened the rear deck, continuing airflow from the roof to the rear wing. Porsche assembled three cars as works/factory team entries and seventeen more for its customers. Singer also created one unique compact race car, nicknamed *Baby*.

For the 1978 season, MacEachern's 934/5 ran as a 935. This conversion included not only body panels but also significant engine upgrades. The car participated in Rennsport Reunion IV at Mazda Raceway Laguna Seca in 2011. *Randy Leffingwell*

Strictly to capture television broadcast attention, Ernst Fuhrmann set his engineers to work creating a 935 for the "under 2-liter" category. The front-deck-lid humps shrouded outside mirrors and more efficiently channeled air over the car's roof. *Randy Leffingwell*

Displacement of the unique Typ 65/2 engine was 1,425cc and with FIA's 1.4 multiplier for turbocharged engines, it rated 1,995cc. It developed 370 horsepower at 8,000 rpm. *Randy Leffingwell*

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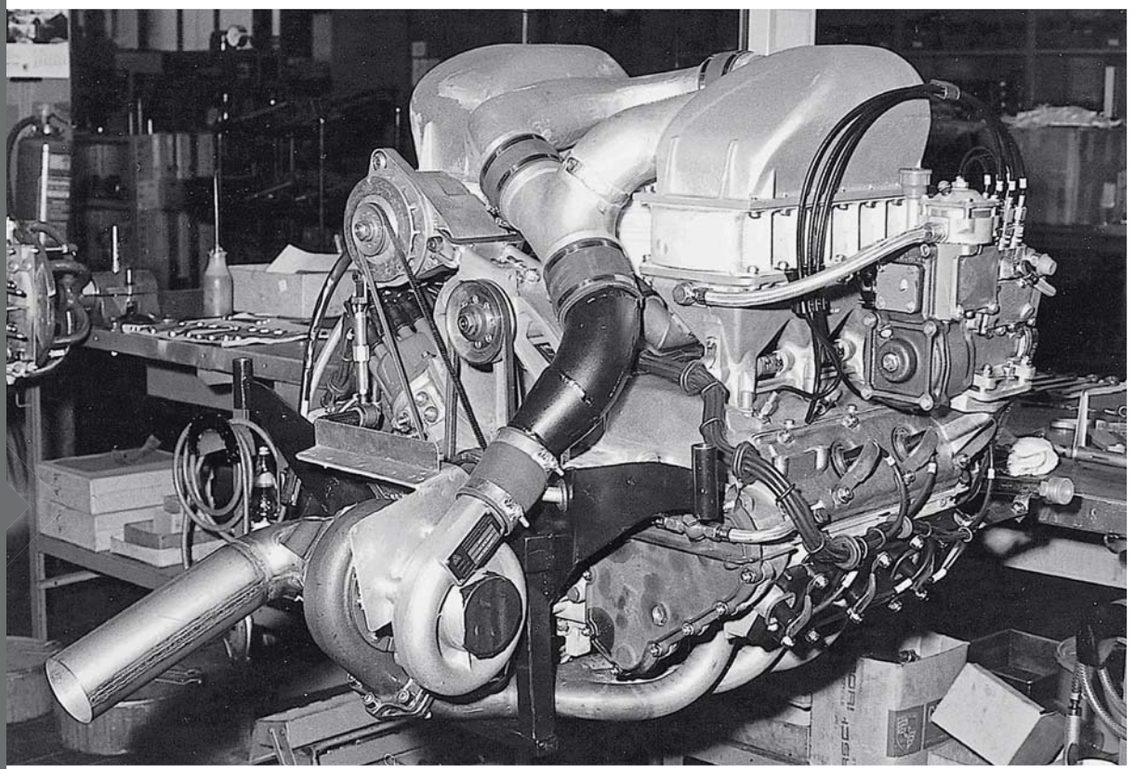


This Typ 930/78 engine, for factory entry 935/77 race cars, developed 630 horsepower at 8,000 rpm. It produced 434 pounds-feet of torque at 5,400 rpm. *Porsche Archive*

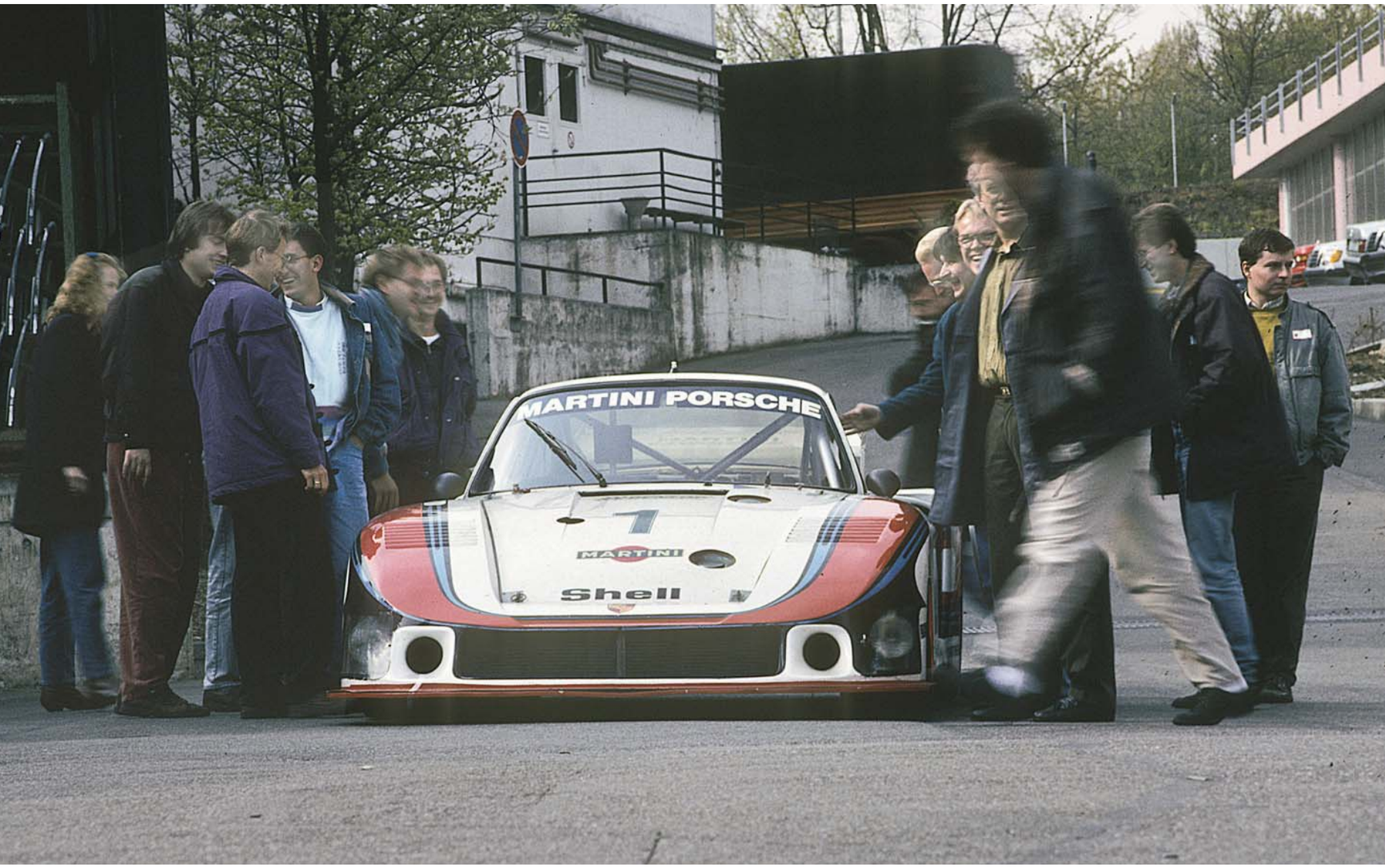
Known as *Baby,* this Typ 935/77-2.0 weighed in at just 1,650 pounds. By the time the 1977 season started, Weissach had accomplished huge aerodynamic advances with the 935 bodies. *Randy Leffingwell*

The Customer 935/77A looked almost sublime on the show floor at the 1977 Geneva Motor Show. All that was missing was a crowd of customers. *Porsche Archive*

1977 TYP 935/2 *BABY*

The Typ 935/2 was another Ernst Fuhrmann idea that emerged from his frustration with competitors who resented Porsche's racing successes. As the Group 5 Division 2 contests (displacement greater than 2 liters) evolved into high-speed 935 parades, BMW, Ford, and others migrated to the smaller-displacement Division 1 of the Deutsche Rennsport Meisterschaft (DRM). Racing fans and the television networks broadcasting motorsports in Germany found the diversity more interesting. When Fuhrmann learned late in March 1977 German TV was broadcasting only the under-2-liter WCM race at nearby Norisring on July 3, which showed few Porsches, he took it as a challenge. On April 5, he announced to his engineers, "We do it!"

To use the Division 1 weight restrictions, Singer's engineers carved 540 pounds off an existing 2,138-pound Typ 935 to reach the severe 1,598-pound minimum. Since DRM events were one-hour sprints, the engineers tore through the car, lightening everything they needed and removing everything else. "The mechanics even suggested they drill holes to lighten all the needles in the gauges," Singer recalled in 2011. Mezger and Schäffer worked miracles, designing a new engine using a 71-millimeter bore and 60-millimeter stroke for overall displacement of 1,425cc. With a single turbo and a simple air-to-air intercooler, this Typ 65/2 engine developed 370 horsepower at 8,000 rpm. However, time was too short for adequate testing, and at its debut at Norisring, turbo lag and incorrect gearing hampered performance, and the hurried chassis was not stiff enough to hold cornering speeds. Three weeks later at Hockenheim, as part of the German Grand Prix weekend, *Baby*, as the 935/2 became known, ran flawlessly. Jacky Ickx qualified on the pole, 2.8 seconds ahead of the next car, and he won the race by 51 seconds. Fuhrmann had proven that Porsche was not just a "big" race-car company, and, with that goal accomplished, he let *Baby* retire to the Porsche Museum.



1977 TYP 936

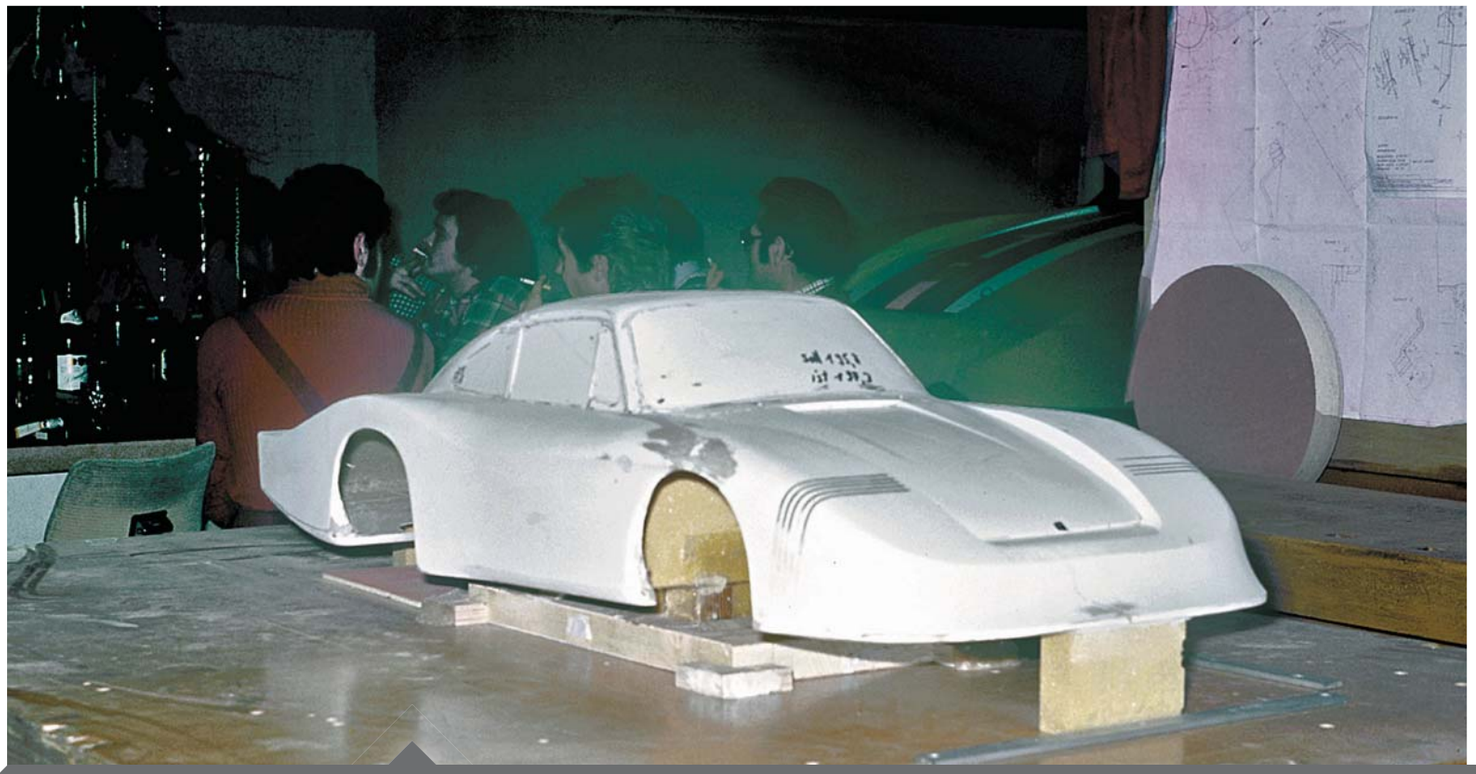
The Group 6 Typ 936 Spyders also underwent extensive work before and during the 1977 season. They shrunk in several dimensions—becoming 1.97 inches narrower in front and 1.18 inches narrower in rear track, 1.97 inches shorter overall, and 2.36 inches lower—following extensive wind-tunnel testing. Mezger carried over the Typ 911/78 engine from the 1977 Group 6 car. As with the Typ 935/77 Group 5 car, this engine also substituted two smaller KKK turbos for a single large one, gaining better throttle response and picking up another 20 horsepower, reaching 540 at 8,000 rpm. Porsche not only carried over the engines but also reused the two cars, 936.001 and 936.002.

When the World Manufacturers Championship reached the season midpoint at Le Mans, it was clear 1977 would be a replay of 1976. Porsche 935s had won each WCM race. At the twenty-four-hour French endurance race, 936.001 claimed the overall victory, while a private 935 took Group 5 honors and a private 934 won GT class. When the season ended, WCM results followed the same order.

1978 RACING SEASON

Where *Baby* resulted from a highly motivated rush, *Moby Dick*—935/78—emerged as a result of careful reading and interpretation of FIA rules, of what was *not* written into them as well as what they included. A new regulation allowed automakers to raise the floor of their cars to even with the bottom doorsill. This helped front-engine manufacturers to run exhaust (and even turbochargers) under the car without violating minimum ground clearances. Porsche's rear engines gave Singer an opportunity, and he lowered the car body to meet the existing floor. This required countless other modifications, including developing light-alloy tube-frame front and rear structures, and dictated all-new suspensions. His engineers started work in September 1977. When they finished, the roof of the 935/78 sat 2.36 inches lower than any previous 935.

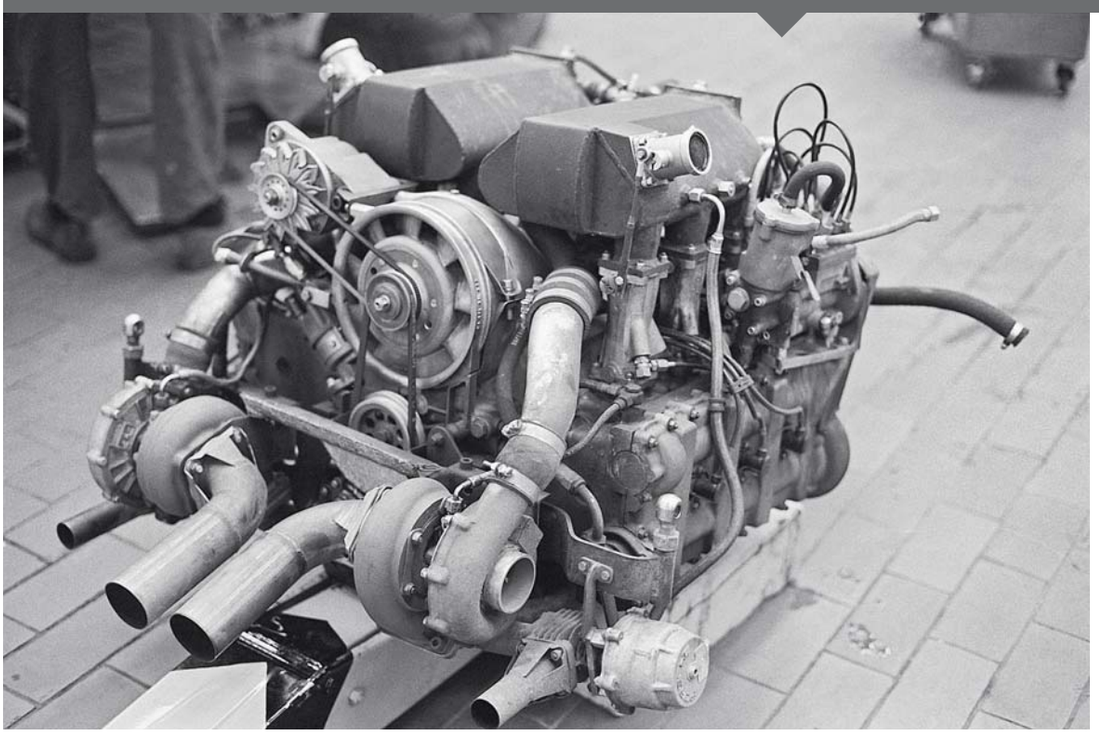
The engine is the heart of every Porsche race car. The lessons Mezger and Schäffer learned about thermal and structural stresses in the 2,804cc flat six of the 935/76 and 935/77 showed that not only could they increase displacement, they also had to improve cooling. A small pile of documents



By the time Norbert Singer had finished interpreting the FIA rules for Group 5 in effect for 1978, little more than the floor pan resembled any other 935. Rules left open front and rear bodywork and this 935/78 sat 2.36 inches lower than previous years' cars. *Randy Leffingwell*

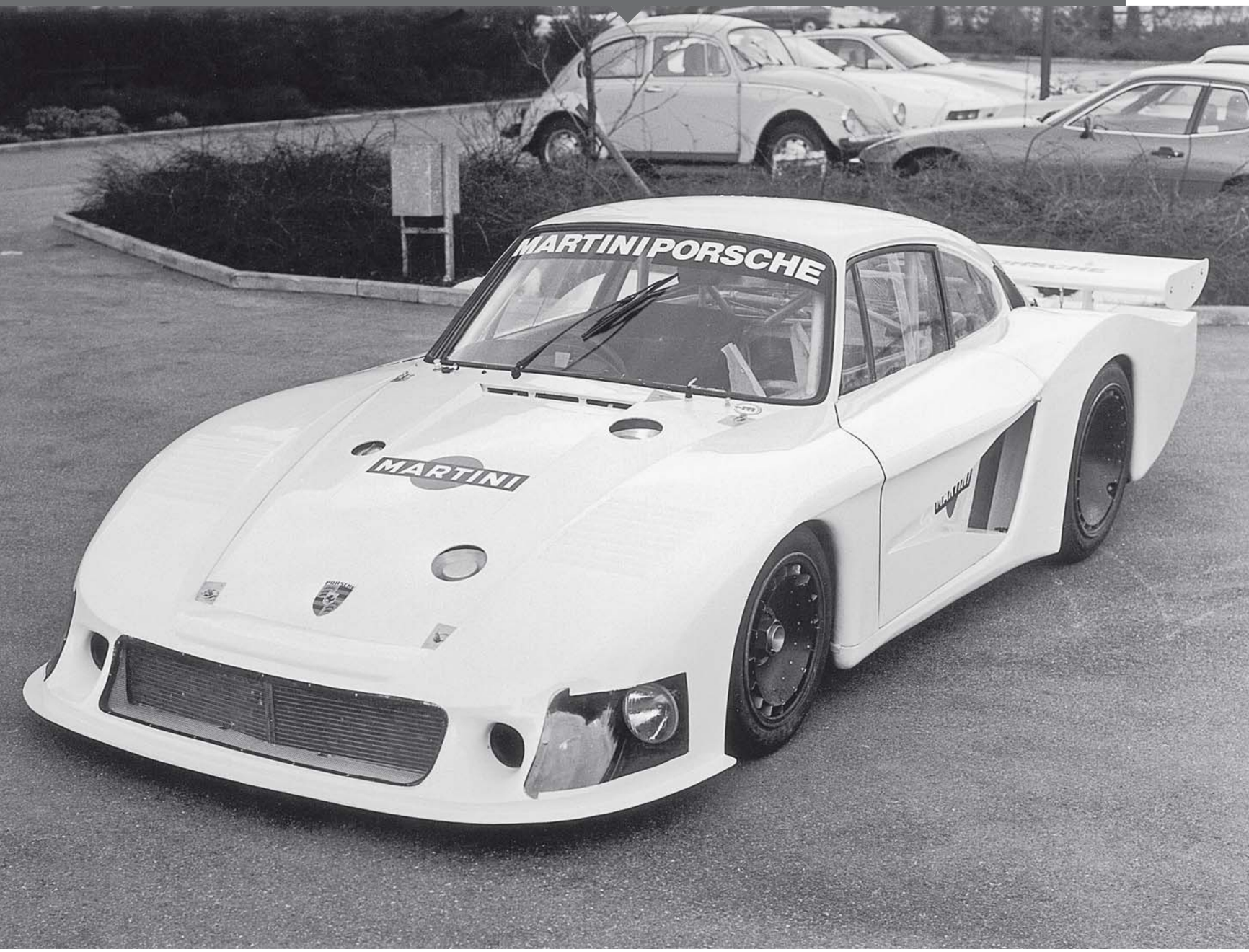
As Singer worked out his ideas for the 935/78, his friends in Tony Lapine's styling department helped him with wind tunnel scale models. *Porsche Archive*

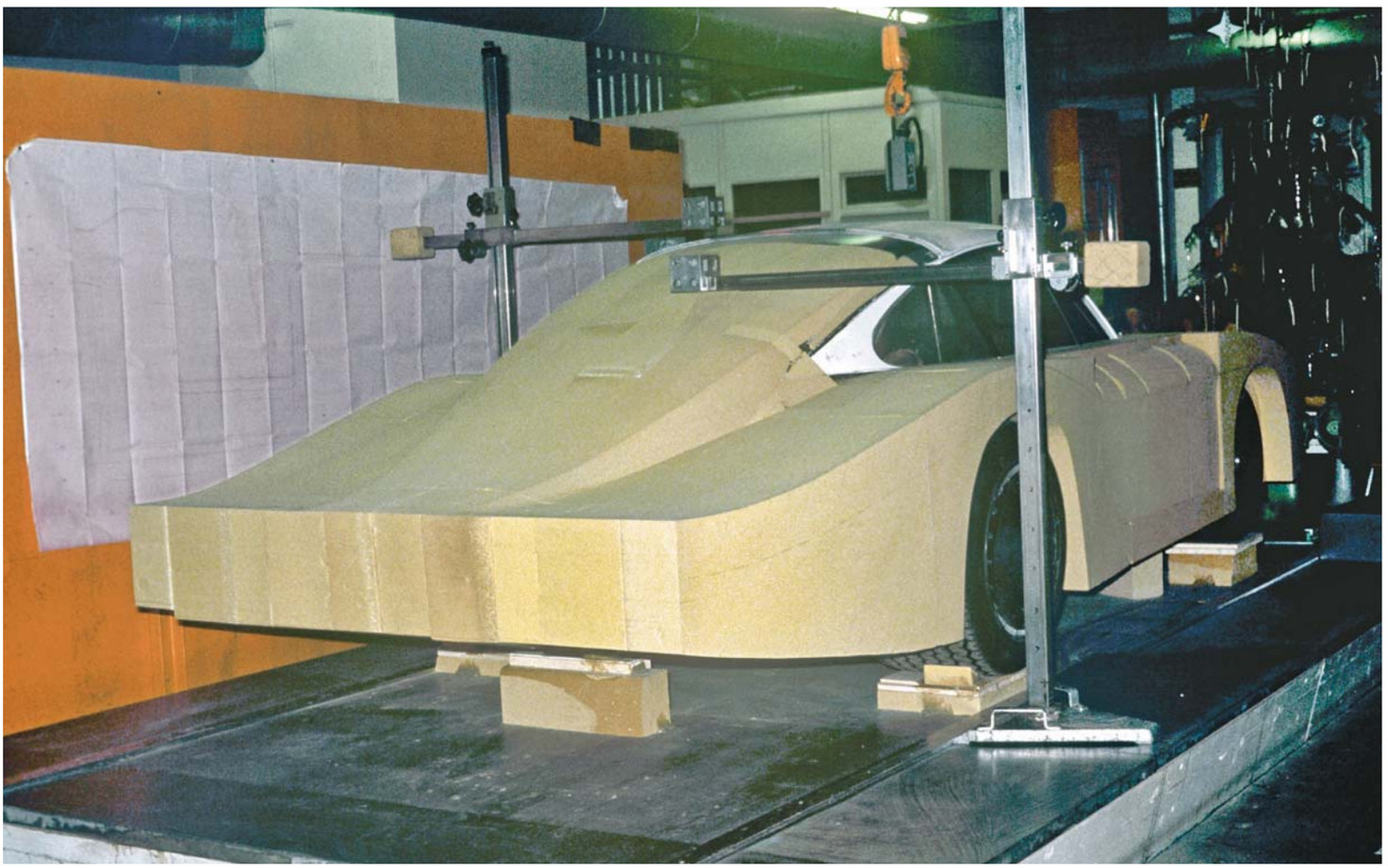
The Typ 935/3.2 twin-turbocharged engine displaced 3,211cc; with the FIA multiplier this made the total 4,495 so the car raced in the class under 4.5 liters. Horsepower was conservatively quoted at 640 at 8,200, but racer and testing driver Jürgen Barth often reported that with boost up, the engine produced closer to 850 horsepower. *Porsche Archive*



FIA inspectors were stunned when they previewed the car. Their rules had been imprecise and Singer stretched his interpretation. When racing journalists first saw the low, white vast car they nicknamed it Moby Dick. *Porsche Archive*

Once Singer was satisfied with his scale model wind tunnel results, modelers converted the scale model to full size, using wood as a mold for the fiberglass panels. *Porsche Archive*





unearthed in the Porsche Archive late in 2014 resurrected a long-forgotten Typ number, the 908/4, though the vehicle was familiar. In 1970, Mezger developed a four-valve, dual-overhead-camshaft version of the 2,997cc Typ 908 flat eight. Experiments with air-cooled four-valve engines literally melted the heads within minutes of startup, so Mezger water-cooled the cylinder heads of this new 908/4 engine. Hence the designation. Mezger and Piëch had intended this engine to continue their involvement in the WCM when the 3-liter limit went into effect for 1972. Instead, Porsche went into the Can-Am and Interserie, and the 908/4 project went into the files until the late 1970s. While Porsche planned several versions, the carmaker produced only two water-cooled four-valve heads, a 3,211cc Typ 935/3.2 for Group 5 and a 2,142cc version 935/78 for Group 6. The 3.2-liter Group 5 engine used 95.7-millimeter bore and 74.4-millimeter stroke, while the 2.1-liter Group 6 engine worked from an 87-millimeter bore and 60-millimeter stroke. Mezger created separate cooling systems for each three-cylinder bank. Cooled water from rear fender-mounted radiators entered the engine on the exhaust side and exited from the intake side, fed by pumps operated from the forward end of exhaust cam. Both engines carried over twin KKK turbochargers, and output, with boost at 1.5 bar, measured 580 horsepower at 8,500 rpm for the 2.1-liter and 750 horsepower at 8,200 rpm for the 3.2. Mezger and Singer knew their Group 6 Typ 936/78 drivers used 1.7 bar boost for qualifying, but everyone throttled it back to 1.4 for Le Mans; the 935/78 drivers ran consistently at 1.4.

The radically lowered Typ 935/78 required engineers to mount the Typ 930 gearbox upside down so its input shaft lined up with the engine crankshaft. This also aligned output half shafts nearly horizontally, reducing driveline stress. Porsche's decision to increase engine size recast the 935 into the 4-liter class because total displacement with the multiplier reached 4,495cc. This raised its weight minimum from 2,138 pounds to 2,260, allowing Singer and his engineers to mount 143 pounds of lead ballast in places that improved balance and handling.

Singer prudently invited FIA scrutineers to Weissach to preview the 935/78 in December 1977. Journalist racer (and, later, Porsche historian) Paul Frère was one of those who came to look as vice president of the

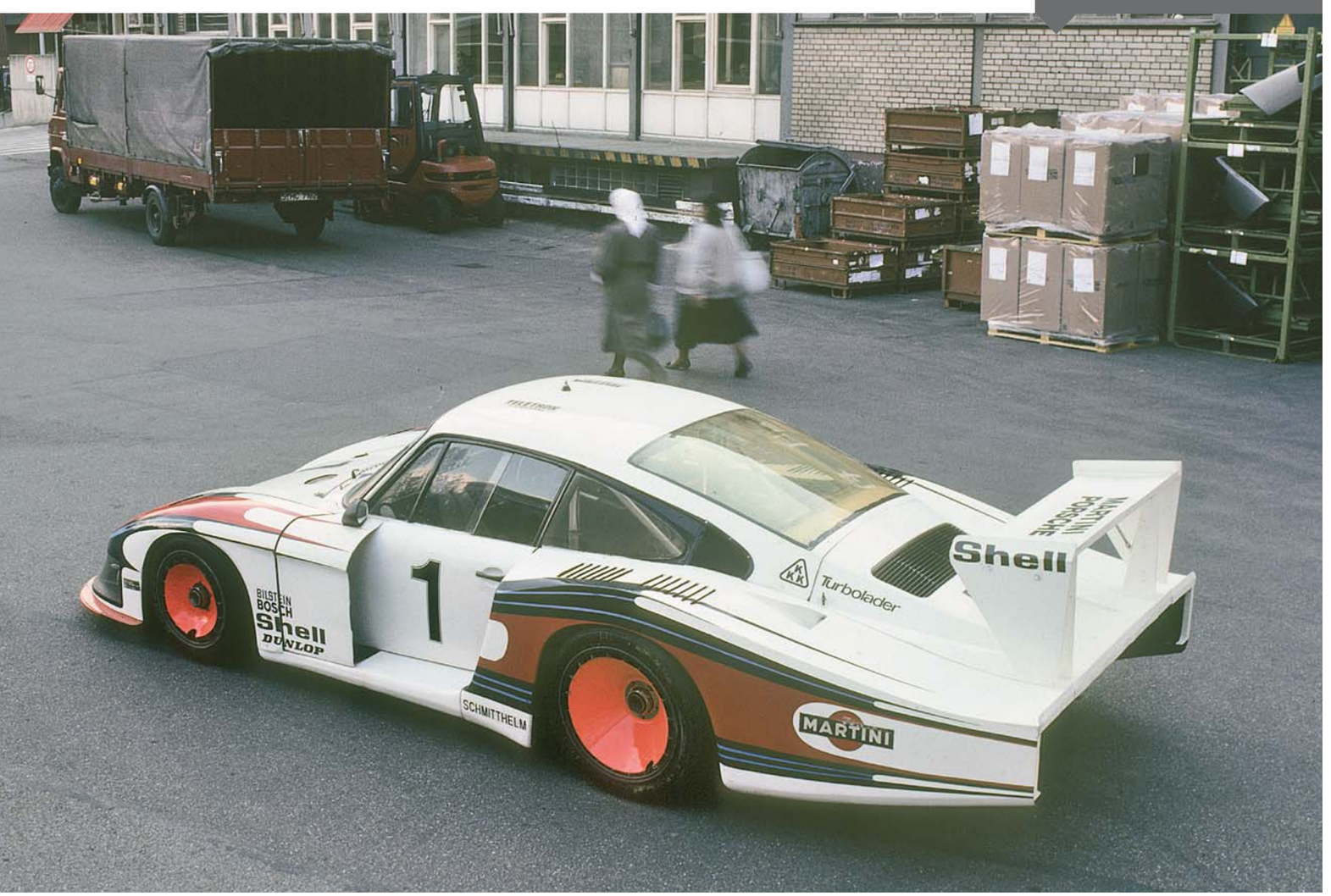
FIA technical committee. Singer had read the rules carefully and found many areas where what was written offered wide interpretation. As Frère said in an interview in 1991, "There was a definition somewhere saying that the body of the car was the part comprised between the front and rear bulkhead, something of this sort. We had already modified another regulation saying that the floor of the body could be raised up to the sill of the door. So Singer saw a magnificent loophole where he could raise the bottom of the car and drop the whole thing between the front and rear—which is what he did—and we couldn't stop it."

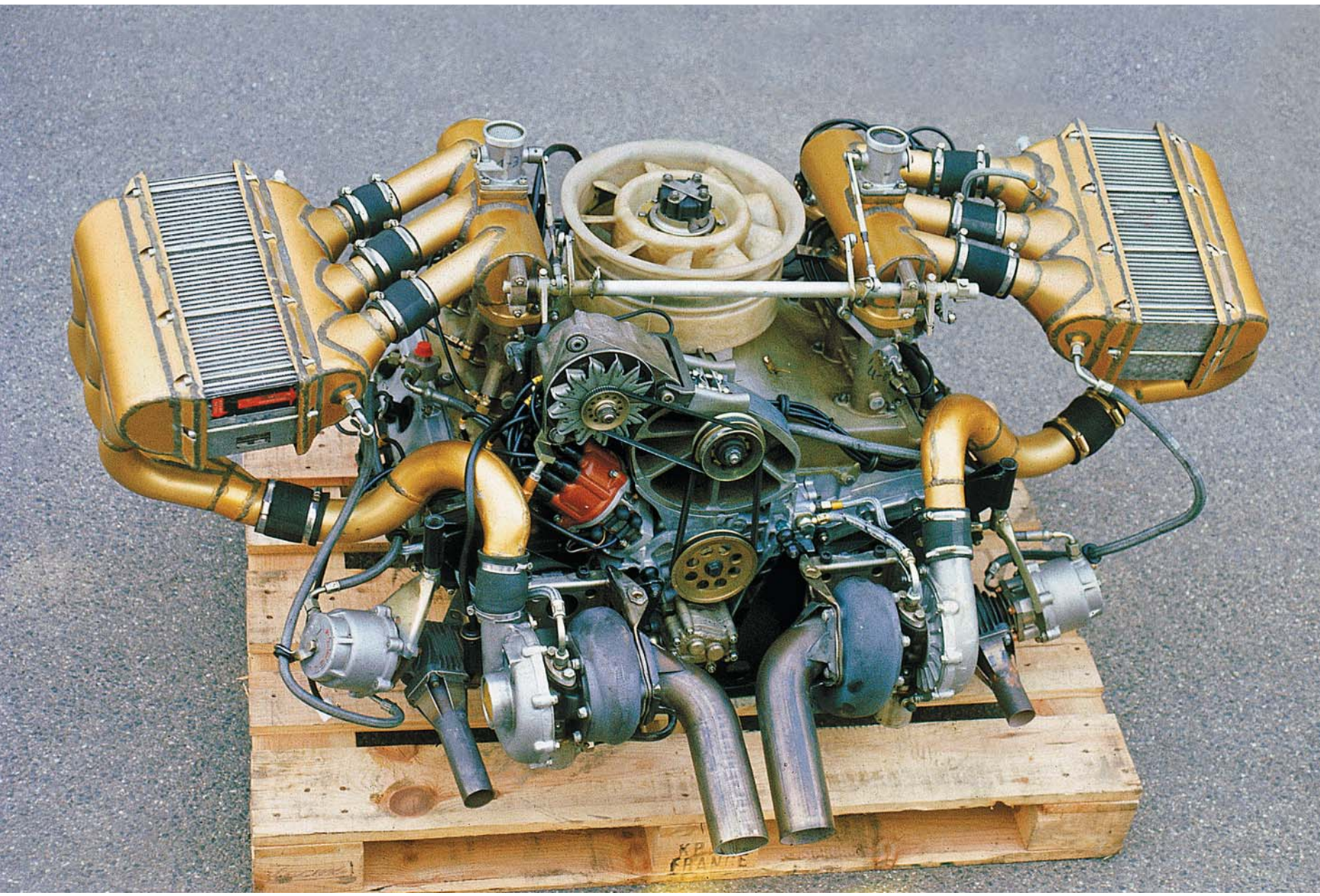
With its clever shape, brilliant air management, and new engine, the car surprised everyone. Jürgen Barth, as factory development and racing driver, was first behind the wheel at Weissach. Everything about the car earned his admiration.

"It was the first car I ever drove that forced me to hold the steering wheel with both hands," he recalled in an interview in 2011. "The standard 935s in that time, in their best tune with full boost, made 650, 680 horsepower. With the boost at 1.7 on this car, we had closer to 900 horsepower. When that power came on, you needed to have good control.

The Typ 935/72 "customer" engine developed 590 horsepower at 7,900 rpm. The twin intercoolers mounted in the rear fenders. *Porsche Archive*

For the racing season, Singer had to replace the low wide rear wing with a narrow one, and he had to uncover the original doors. Close inspection of the rear window revealed the original 935 window still in place beneath the aerodynamically superior flatter one outside. *Randy Leffingwell*





"But the handling was really improved. Normal 935s are a handful. This car was so much lower; so much metal was cut off and replaced with such thin fiberglass. All the weight was at the center of the car, even with its length."

The competition department assembled three chassis and completed two running race cars, 935/78.006 and 935/78.007. The car won its debut at Silverstone by seven laps over a Kremer brothers 935/77, and media outlets, when they saw the car Singer and Eugen Kolb had created—wide, long, low, white with Martini trim—they nicknamed it *Moby Dick*. But Porsche intended the car for Le Mans, and there it raced but did not star. The single Martini 935/78 finished eighth; despite its spectacular speed and excellent handling, it had spent too much time in the pits while mechanics chased an oil leak that turned out to be inconsequential. According to Hans Mezger in an interview in September 2014, the car's

other liability was its thirst. Group 5 regulations limited fuel capacity to 31.7 gallons, and race fuel consumption averaged 4.25 miles per gallon. *Moby* ran dry after 15.9 laps, or 134.7 miles, so Porsche brought the car in every thirteen laps, about every 52 minutes. Between those stops, the car proved fast: team driver Rolf Stommelen reached 227.4 miles per hour along Mulsanne driving 935/78.007; he and teammate Manfred Schurti finished eighth overall, third in Group 5, behind two other 935s. The car ran one final race at Vallelunga in Spain but failed to finish.

1978 TYP 936

Porsche recycled 936.001 and 936.002 for a third year in 1978 with the new four-valve, water-cooled head engines. Their forty-hour endurance test at Paul Ricard suggested the combination might be indomitable. But racing is the ultimate test, and things occur in competitions that flummox even the best-laid plans. Porsche fitted new gear ratios to the 936's five-speed transmissions and, as Barth reported in *The Porsche Book: The Complete History of Types and Models*, "the lightened fifth-gear pinions proved to be fragile; their failure prompted race-deciding additional pit stops. In typical Le Mans fashion, these were failures that had not appeared in testing." Porsche had three 936s at Le Mans, and one had qualified on the pole.

But it was not Porsche's year at Le Mans. At the checkered flag, 936/78.001 finished in second, five laps behind the race-winning Alpine-Renault A442B. The air-cooled head 936/77 came in third. The water-cooled 936/78.002 retired Sunday morning after a crash, ironically, in the Porsche Curves.

In the United States, Porsche's 935s dominated. IMSA created a new class within the Camel GT Challenge, and this GTX category became the next home of Group 5 cars in North America. The 935s took twelve of fourteen race wins.

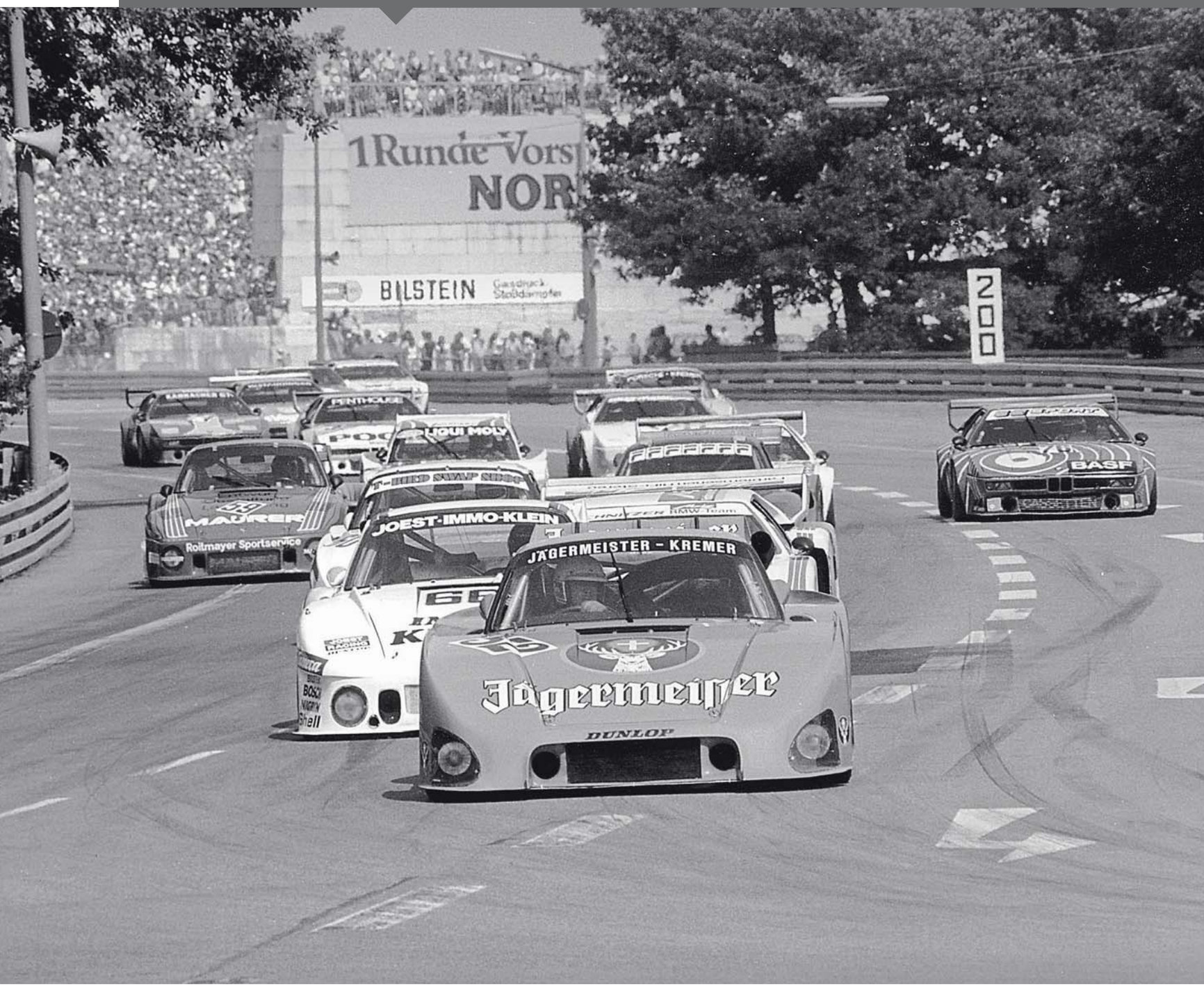
1979 RACING SEASON

Soon after its 1978 Le Mans victory, Renault announced it was leaving endurance racing to contest Formula One. Porsche withdrew as well, ceding the WCM and Le Mans to its customers. Their demand led Weissach to assemble seven new 935s for 1979. Porsche duplicated the 935/77 specifications but adopted the inverted gearbox developed for *Moby Dick*. This brought 935 "production" totals to forty-two cars, of which thirty-five went to customers.

Porsche also intended to retire its 936s until ex–John Wyer team manager John Horsman announced plans to race two 2,993cc Ford-Cosworth DFV-engined Mirage Spyders. Both of these cars were long in the

Bob Wollek and John Fitzpatrick took turns flying their 1977 Kremer 935K during the 1,000 Kilometers of Nürburgring. Despite the seeming abuse, the car finished second overall. The hard edges of the Kremer cars, designed by aerodynamicist Ekkehard Zimmermann managed airflow exceptionally well. *Porsche Archive*

By 1981 Porsche had long quit assembling 935 race cars for customers. The Kremer Brothers assumed that role, and their 935/81-K4 lead a mob of K3-body cars at Norisring. *Porsche Archive*



Jacky Ickx began to pull away from the competition at the start of the 24 Hours of Le Mans in 1981. Pit stops were predictable and brief; mechanics never lifted the hood, and at the end, Ickx and Derek Bell had won, covering 2,998 miles, finishing more than 100 miles ahead of second place.
Porsche Archive

For 1978, Porsche offered four engines for customer 936s, including this 930/80 with 3,160cc displacement. It developed 720 horsepower at 8,000 rpm.
Porsche Archive

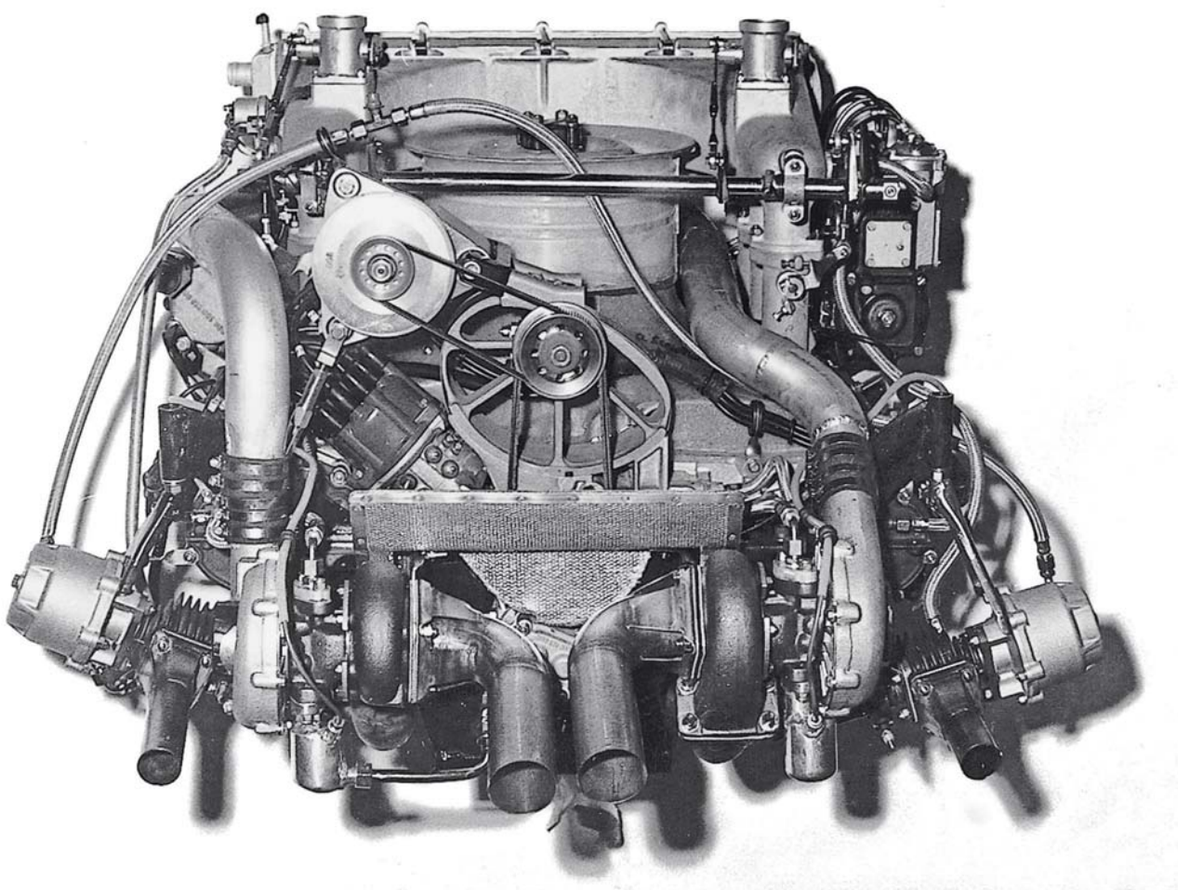
tooth by this time, and while the same could be said of Porsche's 935s (and 936s), the privateers, especially the Kremer brothers in Cologne and Peter Gregg in Florida, had constantly tinkered with and improved the cars.

Erwin and Manfred Kremer were Porsche dealers and distributors in Cologne who started racing their cars in the late 1960s. When Porsche introduced the 935 in 1976, the brothers promptly devised many improvements and labeled their version the 935 K1. They told Paul Frère in late 1979 that their latest version, the K3, "incorporated about 100 modifications which, together, add up to a 1 percent more efficient car, which is all you need to beat the opposition." Among these hundred improvements was using Kevlar for all nonstructural body parts. In various compounds, this DuPont synthetic polymer proved to have as much as five times the tensile strength of steel at one-eighth the weight. Body engineer Ekkehard Zimmermann, founder of Design Plastic (DP), designed and racetrack-tested the Kremer bodies, introducing new forms that included slender raised edges, or "fences," on the slope nose to better channel downforce airflow.

The Kremers used air-to-air intercoolers, believing them more efficient and knowing they saved weight. The 1979 K3 version used their updated twin-turbo 2,994cc Porsche "customer" flat six with 95-millimeter bore and 70.4-millimeter stroke for endurance races, and they ran a 3,211cc engine (with the same bore but 74.4-millimeter stroke) for sprints. Running 1.7 bar boost for qualifying, the larger engine developed 800 horsepower at 8,000 rpm. The combination proved unbeatable, and brothers Dick and Bill Whittington won a hard-fought 24 Hours of Le Mans in their 935 K3, the first time a production-derived automobile had won since 1949, when organizers first allowed prototypes.

In North America, IMSA continued the GTX class in 1979, and Porsche won thirteen of fifteen starts with 935s, an ever-increasing proportion of which were Kremer K3 variants. For 1980, the results sheets make it hard to imagine any other manufacturer contested GTX class because either K3 Kremers, 935J models from Jöst, or replica *Moby Dick* racers from Gianpiero Moretti won every event. For 1981, the 935s claimed thirteen of sixteen wins, and for 1982, the totals went eighteen of nineteen for Porsche.

Throughout Europe, the story in endurance racing grew more interesting as Lancia's Beta Monte Carlo and entries from Alain de Cadenet and from BMW threw challenges at Porsche throughout the season. Le Mans' hometown hero Jean Rondeau won the twenty-four-hour race in his Ford Cosworth DFV-engine prototype, chased by the first of Peugeot's long-distance racers. For 1981, Porsche won the Manufacturer's Championship title over 2-liters once again, and while privateers planned to continue Group 5 and GTX class battles with 935s, the FIA's new Group C drew all of Weissach's attention for 1982 and beyond.



Chapter Seven

INNOVATION AND EVOLUTION:
THE LATE 1970s TO MID-1980s

Porsche introduced this design "Studie" of the Typ 924 Carrera GT at the 1979 Frankfurt International Auto Show. The add-on rear fender extensions and the deck-lid-mounted air scoop disappeared by the time production started. *Porsche Archive*

1979 TYP 924 TURBO

Porsche's 924 started life as a Volkswagen-Porsche joint product known internally as EA425 and initiated in 1970. Harm Lagaaij, then a young designer with Porsche, had designed the body and its 2+2 package, spending time in the wind tunnel to refine its aerodynamics for low drag and minimal wind noise. The car's engine, the Typ 047/8, came from a 1,984cc inline four-cylinder Audi, canted over at 40 degrees off vertical to maintain Lagaaij's low cowl. After substantial work in Weissach engineering labs, the engine developed 125 horsepower at 5,800 rpm and 122 pounds-feet of torque at 3,500 rpm in European trim. The US-destined engine, Typ 047/9, produced 115 horsepower at 5,750 rpm. Fitted with an Audi-designed four-speed manual gearbox mounted at the rear of the car as a transaxle, the 924 had near-ideal weight balance at 48 percent front and 52 percent rear.

Porsche introduced it at the September 1975 Frankfurt Auto Show. It sat on the carmaker's stand near its startling new Typ 930 Turbo. The cars reached dealer showrooms in February 1976 as a 1977 model. Competing against a comparably powered Lotus Esprit (131 horsepower) and Lancia Beta Montecarlo (120 horsepower), a peppier Alfa Romeo GTV (with 156), and a slower Triumph TR7 (92) and Ford Capri (at 99), the 924 was a runaway success, with production reaching 25,656 units for all markets in the first stretched model year. Minor changes appeared for model year 1978, and production dipped slightly to 21,571. But it was model year 1979

The series production 924 Turbo followed the Porsche engineering and design tradition that typically dictates understatement. Four slender symmetric slots enhanced engine cooling while a NACA-style duct, barely visible, fed outside air to the engine. *Porsche Archive*

that redefined the 924. Journalists—and presumably some customers—advocated for more power from the car, and the solution existed already within Weissach's walls: the turbocharger.

"However, in the case of the 924," Jürgen Barth wrote in *The Porsche Book*, "the problem was different. While the 911 Turbo (or, more precisely, the 930 Turbo 3.3) was never intended to be built in large numbers, the 924 Turbo was conceived as a more powerful production version of the 924. High power output was to be combined with complete tractability, and the car was to provide the same sort of comfort as the normal 924. In other words, it was to fill a gap between the 924 and the 911SC."

Longtime 924 owner and Porsche historian Brian Long reported in his book *Porsche 924* that Weissach engineers considered supercharging the inline four. But, as Long reported, "nothing came of it; supercharging was considered decidedly old-fashioned once the turbo era was in full swing."

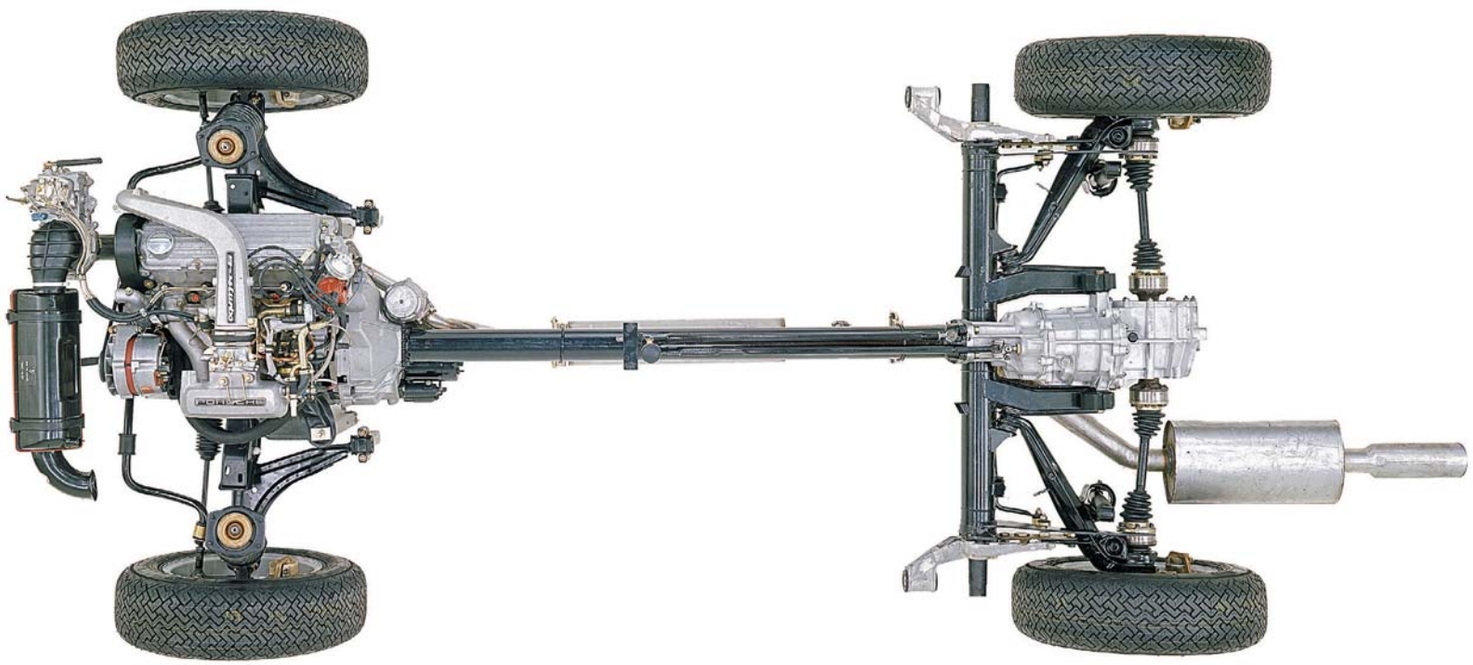
Production engine chief Paul Hensler shepherded the project to production. The new car, internally designated the Typ 931 (and the right-hand-drive models 932), used a KKK model K26 turbo with boost at 0.69 bar. The turbine sat below the exhaust manifold. Hensler and his staff concluded the newly designated Typ M31/01 engine was robust enough on its bottom end to absorb the additional power, but they introduced new alloy heads with larger exhaust valves and redesigned combustion chambers that relocated spark plugs from the exhaust side to the cooler intake side. The original engine's single overhead camshaft remained in place. Output was 170 horsepower at 5,500 rpm and 180 pounds-feet of torque at 3,500 rpm. Weissach engineers increased driveshaft diameter from 20 millimeters inside the permanently sealed torque tube to 25 millimeters. An optional five-speed transaxle for the normally aspirated 924 became the standard for the 924 Turbo.

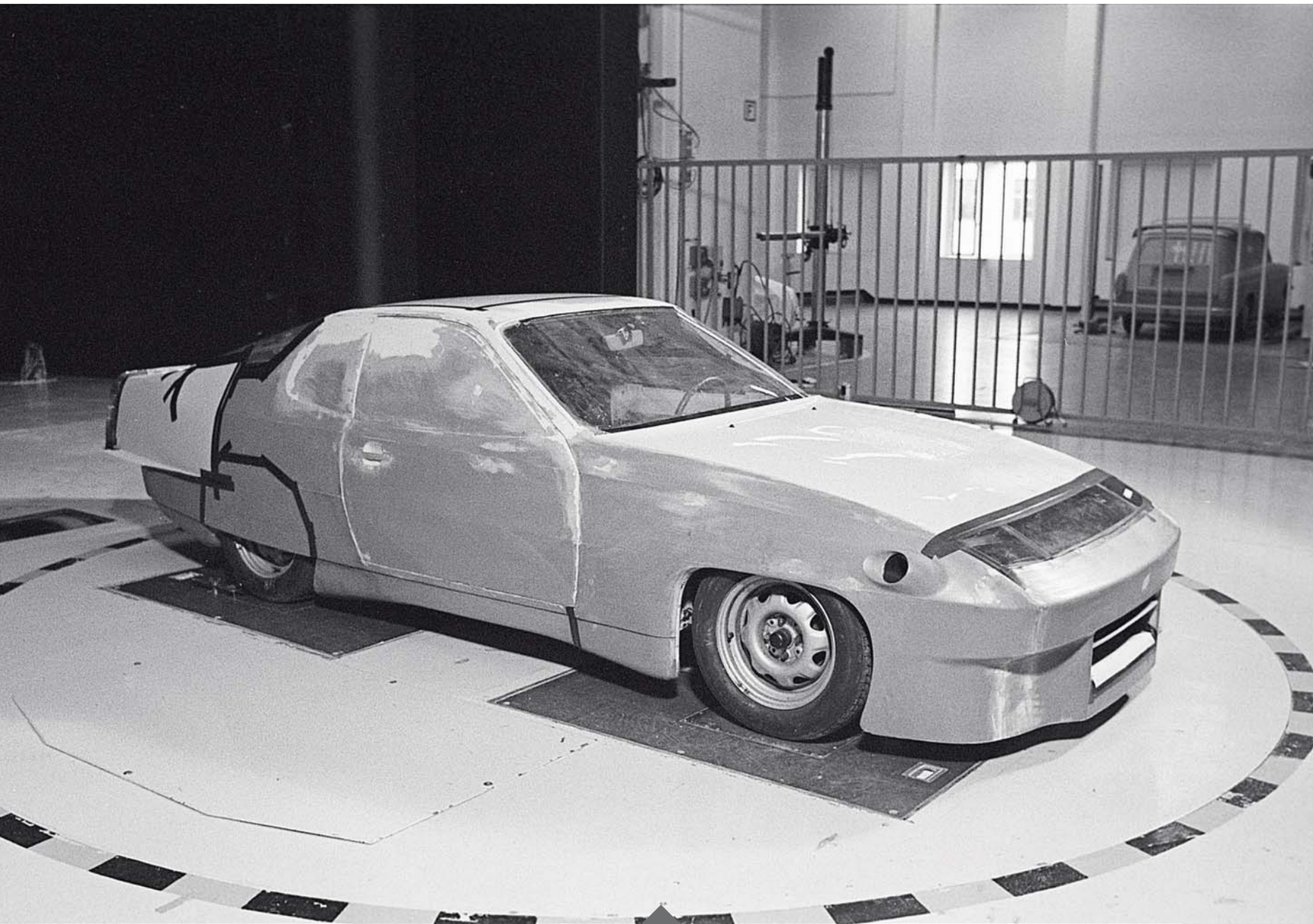
In 1977, Fuhrmann called his competition engineers—Singer, Mezger, and Schäffer—to announce a project for the new 924 and soon-to-be introduced 924 Turbo. In 1976 Daimler-Benz had set a closed-course speed record of 156 miles per hour over sixty hours with its C-111-IID five-cylinder diesel at the giant circle of Nardo Circuit in Italy. Fuhrmann believed the 924 could better this record and should do it in the United States, where the markets would respond with purchase orders. In Tony Lapine's styling department, the idea of enclosing wheelwells had become an obsession as a styling treatment and an aerodynamic benefit. Modeler Peter Reisinger and his team, with Singer's input, modified a 924 body, sealing every seam and covering the wheels to within 0.4 inches of the pavement. This and other subtleties reduced the 924 coefficient of drag from 0.31 to 0.26. Mezger and Schäffer installed one of KKK's largest turbos very close to the intake. They pulled 260 horsepower out of the 1,984cc engine. But Daimler had not stopped developing after its record, and months before Porsche's candidate was ready, it returned to Nardo with the C-111-III, a low, wedge-shaped vehicle with a 0.183 coefficient of drag and a top speed of more than 200 miles per hour. It established nine

The 1981 model year 924 Turbo carried on the optional two-tone paint scheme introduced at the car's sales launch for 1979. The turbocharged engine gave the car performance that its looks demanded. *Porsche Archive*

The two-tone color schemes and plaid upholstery were probably well matched to the times and to the 924 Turbo's target audience. The 1979 model sold in Germany for DM 39,480, approximately $21,575 at the time. *Porsche Archive*

The Typ M31/01 engine for the 924 Turbo developed 170 horsepower at 5,500 rpm for European customers. Power reached the rear wheels via a driveshaft enclosed within a torque tube, mated to a transaxle transmission/differential combination. *Porsche Archive*





Changing tires was not even a consideration when Ernst Fuhrmann challenged his engineers to take on a recent world speed record that Mercedes-Benz had set. Looking to promote the new 924 Turbo model, Fuhrmann set Norbert Singer and a group of engineers to work. *Porsche Archive*

In an interview in late 2014, chief modeler Peter Reisinger explained that in the late 1970s, everyone at Porsche was fascinated by the aerodynamic and styling opportunities offered when they thought about enclosing the wheels. Engineers discouraged it, arguing the difficulty of changing a tire. *Porsche Archive*

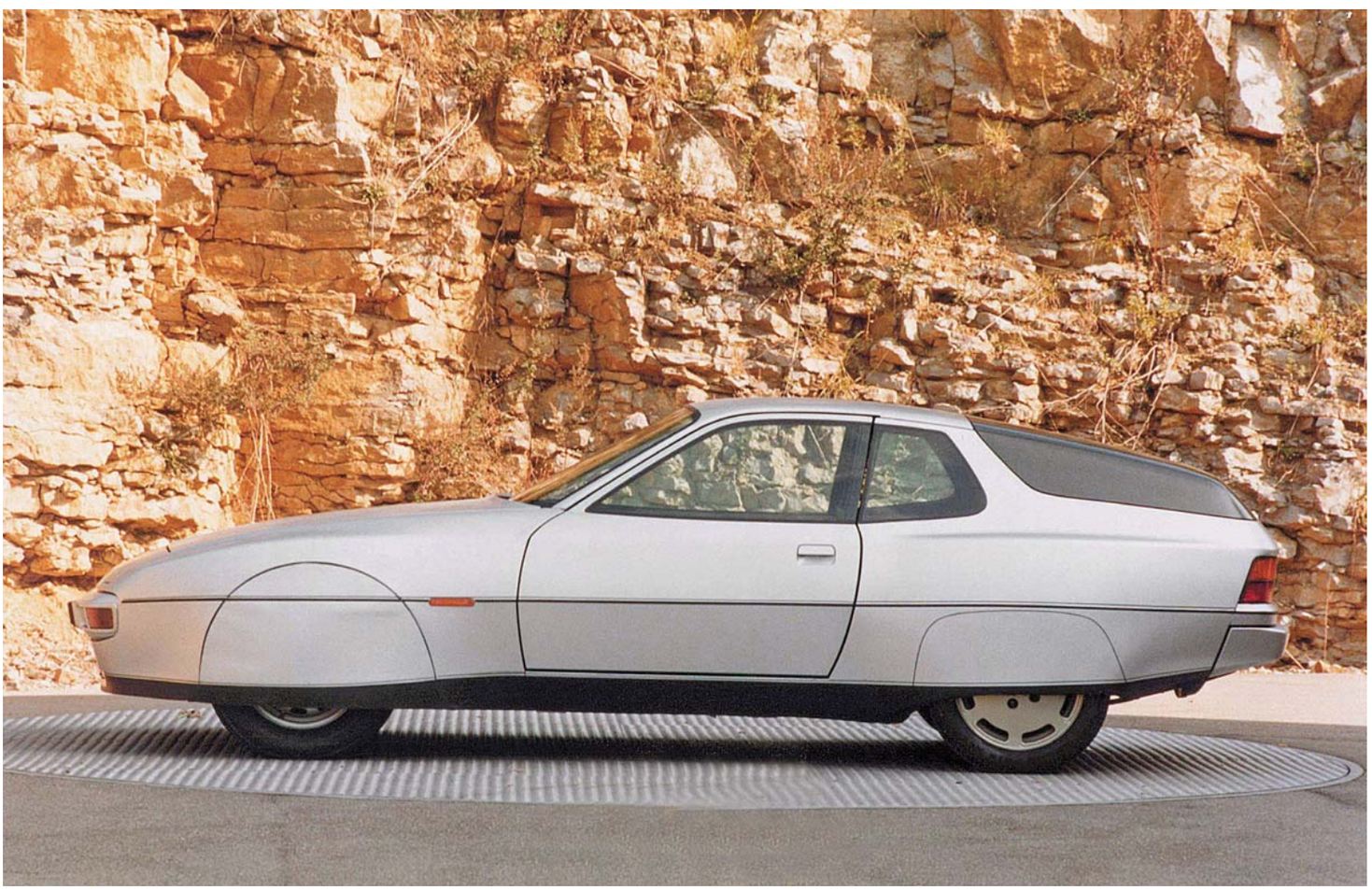
new records, and at that, Fuhrmann cancelled the 924 *Rekordwagen* and consigned it to storage.

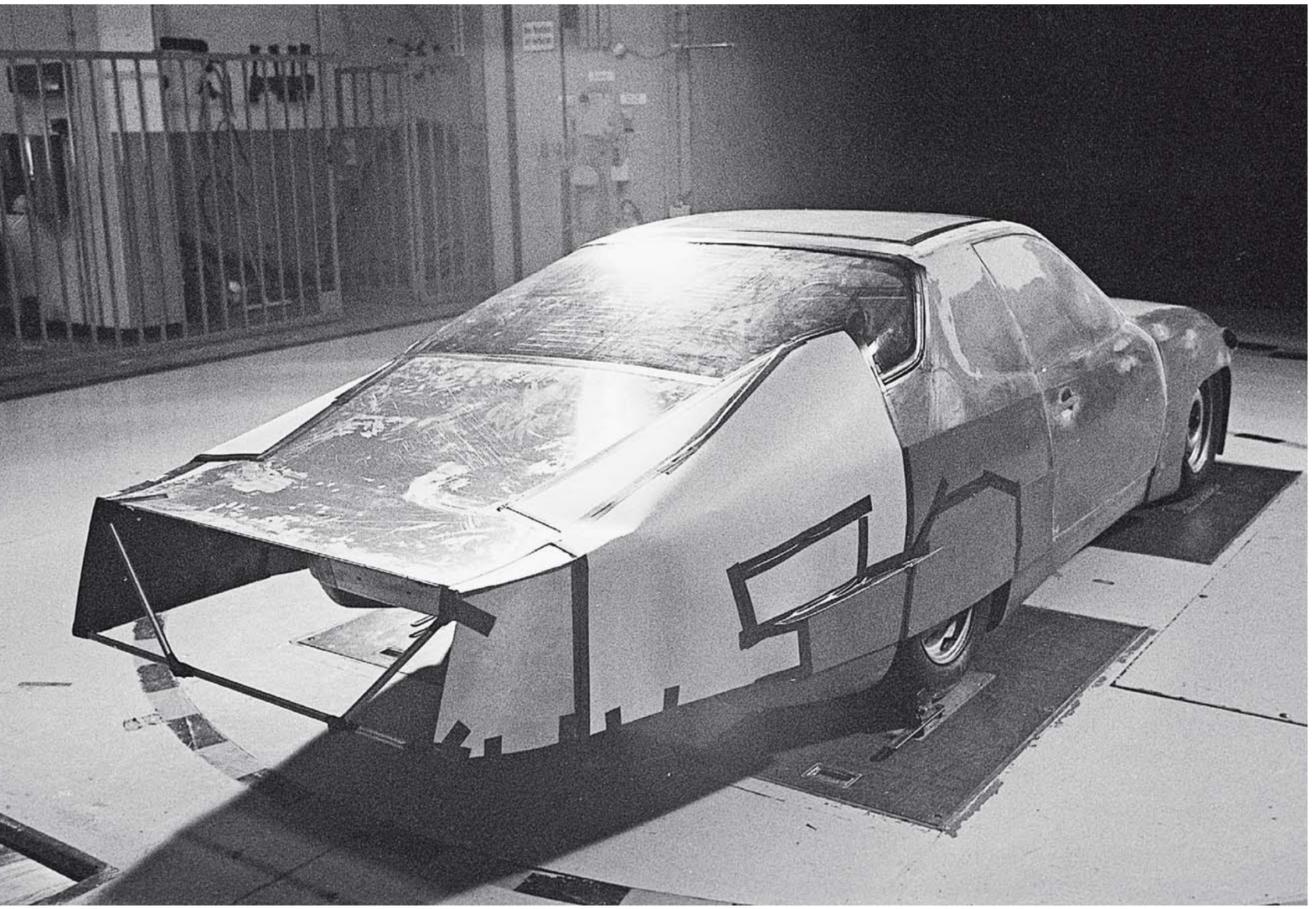
Lagaaij had left Porsche when the board approved turbocharging the 924, so design updates fell to his colleagues. The car changed in subtly aggressive ways; additional horizontal cooling-intake slots sliced into the nose and vertical ones broke up the front spoiler. A NACA duct on the front deck lid hinted that more was available in this model. The bodywork finished up with a modest polyurethane spoiler on the rear hatchback glass. Porsche got these new models to German buyers in February 1979, and Turbo production that year amounted to 1,982 cars; 600 cars reached the United States in July 1979 for dealers and media tests. US-specification models—legal in all fifty states—developed 143 horsepower at 5,500 rpm and 147 pounds-feet of torque at 3,000 rpm.

Porsche Motorsport wasted no time adopting the new car and created four 924 Turbo Rally models, with engine Typ 924/R that were detuned for reliability to 140 horsepower at 5,800 rpm. Racing driver and engineer Jürgen Barth along with friend and colleague Roland Kussmaul (who was Porsche's chief test driver) debuted the car in the 1979 Monte Carlo Rally, part of the World Rally Championship (WRC), in January. Then they ran a two-car entry in the (East African) Safari Rallye in April, though neither car finished the grueling trial. In January 1980, Barth returned with Kussmaul to the Monte Rallye, finishing nineteenth overall. These runs heralded the arrival of a Sport Group Package, the M471 option with disc brakes all around and stiffer suspension.

In September 1979, Porsche introduced the 924 Carrera GT. Presented as a "styling exercise," the 210-horspower car alerted competitors that Porsche had strengthened its intentions for the 924. Porsche's marketing pushed this idea hard, and Ernst Fuhrmann, whose priority was to minimize competition costs while maximizing Porsche's relationship between its racing and its series-production models, entered three of them in the 1980 24 Hours of Le Mans. Because Porsche had assembled so few of these GT versions, the cars had to run as prototype 924GTPs.

Retaining the original 1,984cc displacement, Singer, with Paul Hensler's engine men, enhanced the engines with a larger KKK turbo, an air-to-air intercooler, Kugelfischer mechanical fuel injection, titanium connecting rods, and dry sump lubrication. These and other improvements raised output to 320 horsepower at 7,000 rpm and 282 pounds-feet of torque at 4,500 rpm. The Le Mans cars evolved from the M471 packages for the normally aspirated 924 competition cars, and the GTPs weighed in at 2,068 pounds. Porsche adopted international driving teams with car liveries matching driver's nationalities (mostly). Its best-place finisher came in sixth overall, piloted by 924 veterans Barth with Manfred Schurti, wearing their





German flag. The 924s also captured twelfth and thirteenth overall.

With such performance as this, Porsche pressed ahead with homologation for the 924 as a Group 4 car, but one also positioned for the new Group B classification beginning in 1982. The company assembled 406 of the 924 Carrera GT models (the Typ 937, and the Typ 938 for the seventy-five right-hand-drive models manufactured). It introduced digital ignition to Porsche's series-production models with the Siemens-Hartig system. With its KKK turbo and its intercooler (set right below an aggressive front-deck-lid air intake), the M31/50 engine developed 210 horsepower at 6,000 rpm and 203 pounds-feet of torque at 3,500 rpm. Weissach strengthened the five-speed transaxle, stiffened and slightly lowered the suspension, and simplified the interior; the cars weighed 2,594 pounds.

FIA regulations allowed "evolution" models—interim vehicles that upgraded body, chassis, suspensions, and engines to more competitive levels once the car had reached homologation—and for the 924 in 1981, this was the GTS model. Porsche assembled fifty-nine of these to meet the fifty-car minimum, each one painted red. Power output rose to 245 horsepower at 6,250 rpm and torque output was 246 pounds-feet at 3,000 rpm while the car's weight dropped to 2,470 pounds. For all-out customer racers, the company developed the 924 GTR, trimmed to 2,112 pounds and boosted to 375 horsepower at 6,400 rpm with 299 pounds-feet torque at 5,600 rpm for road competition or 280 horsepower for the rally version. Porsche assembled just seventeen GTR models for 1981.

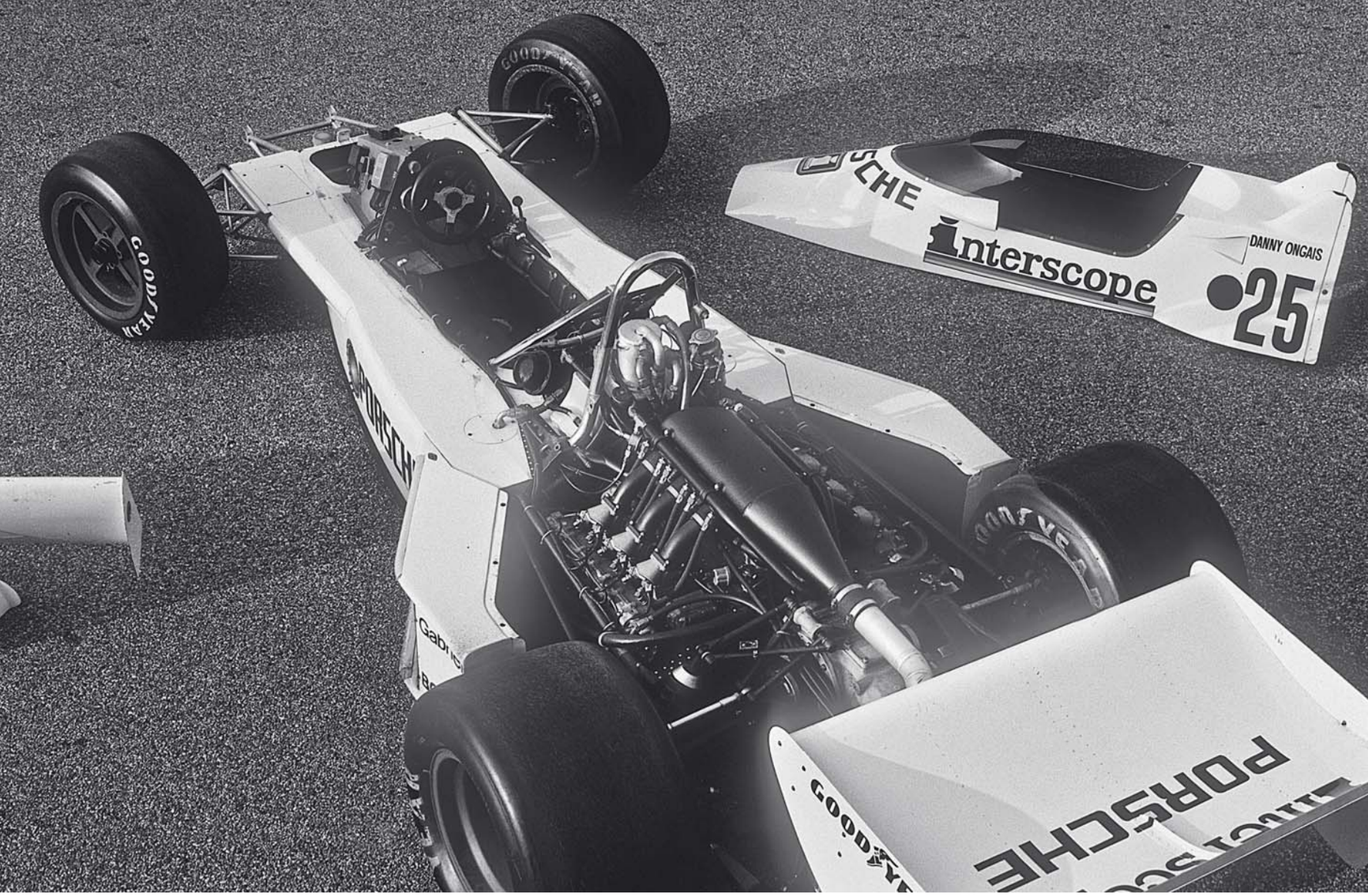
1980 INTERSCOPE INDIANAPOLIS PORSCHE/PARNELLI

Going to Indianapolis was an idea that originated in Jo Hoppen's mind. Hoppen was competition director for the Porsche-Audi Division of Volkswagen of America, and he understood that to the American racing enthusiast, Indy was the Holy Grail.

In California, Hoppen's close friend Vasek Polak had a close relationship with Ted Field, whose Interscope Racing 935s were competing in IMSA. Field had ventured into Champ Car racing, as the Indy series was known at the time. He believed because of Porsche's dominance in sports-car and

The long tail ideas from the late 1960s 906, 907, 908, and 917 models had inspired but also taught Singer and his colleagues. Square-section body ends were more aerodynamically beneficial than teardrops, and the engineers fabricated a number of configurations from cardboard and tin. *Porsche Archive*

Similar to the idea with a 917/30 world speed record run, engineers installed the largest turbocharger KKK produced at that time and routed the pressurized air through an efficient intercooler. Some sources report the 1,984cc engine developed as much as 350 horsepower for this attempt. *Porsche Archive*


DANNY ONGAIS
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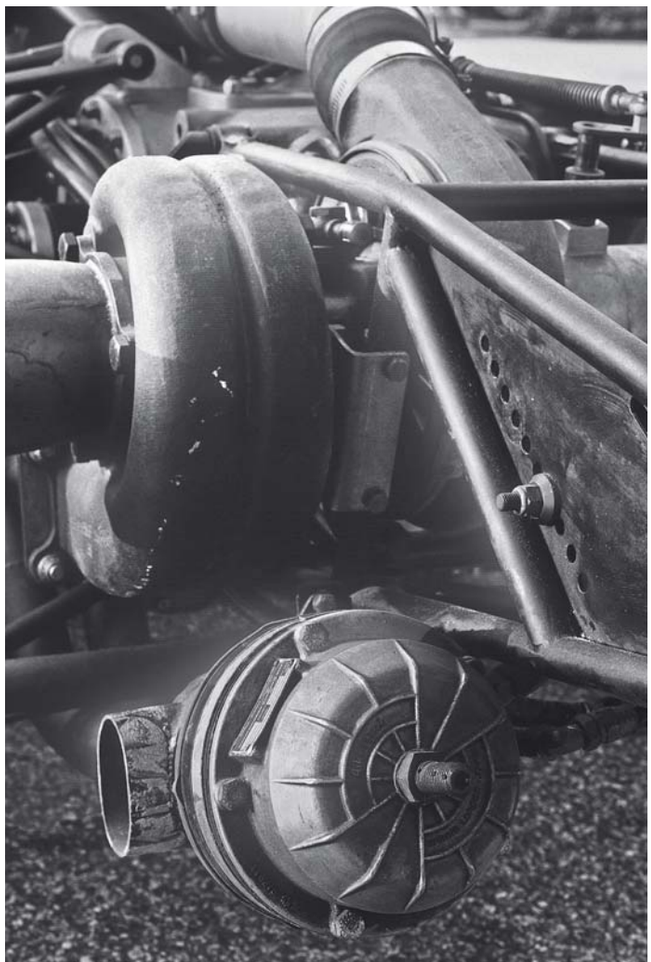
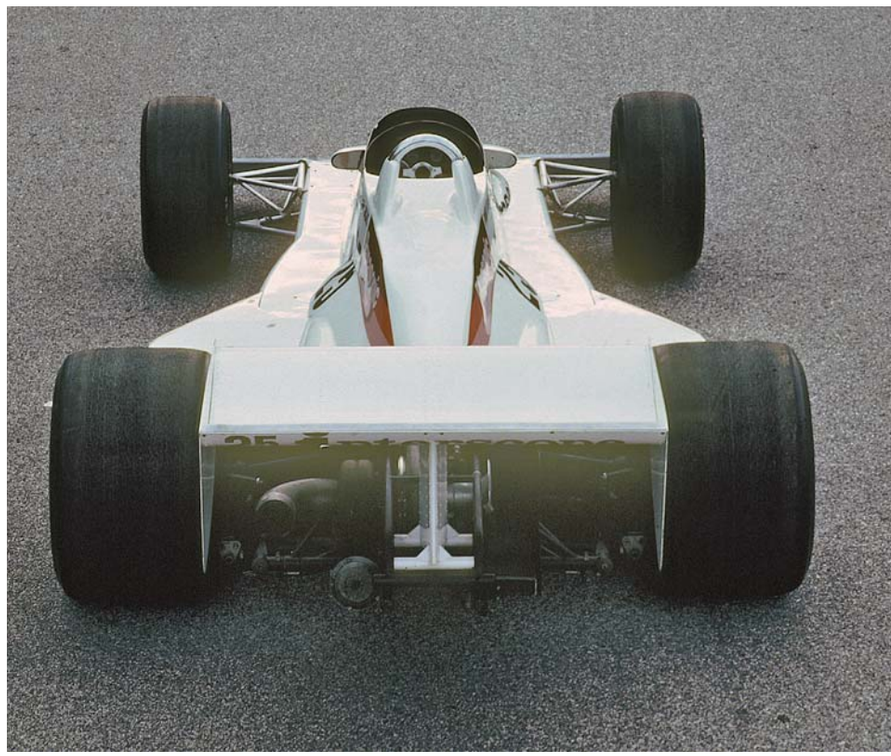




endurance races that, with some development effort, his Interscope team eventually could dominate the Indy car series.

Hoppen went to Zuffenhausen to sell Porsche on the idea, but open-wheel racing was not something highly regarded at the factory. Their past involvement had been more a result of momentum rather than any clearly planned strategy. Ferry Porsche had been a reluctant participant and questioned why his firm spent money on something bearing no resemblance to what he sold to customers.

But Hoppen was prepared. Field was interested, and while the two imagined an eventual Porsche chassis, Hoppen proposed that for the first season or two, Weissach only had to do an engine to fit into Field's chassis.

The logical choice was the water-cooled head engine from 1978 Le Mans Group 6 Typ 936/78. It fit USAC's displacement regulations at 2.65 liters, its development was well advanced, and conversion to alcohol or methanol was not an insurmountable challenge. Ferry Porsche reluctantly agreed. His press boss, Manfred Jantke, later explained that Ferry feared this program might become Porsche's premier racing effort—and it was not in Europe. The easiest sell at Weissach was Ernst Fuhrmann, an engine engineer. He signed on in the fall of 1978.

It proved an unfortunate time to do so; politics split open-wheel racing in America into two camps, devolving into a battle that saw as many courtrooms as racetracks and in which the question of boost became the cause and effect as the United States Auto Club (USAC), Indy's longtime sanctioning body, wrestled with the upstart Championship Auto Racing Teams (CART) for domination.

Hoppen, Polak, Field, and Porsche project manager Helmut Flegl watched this closely. Hoppen had negotiated a turbo boost allowance of 54

The 2,650cc flat six represented the peak of development possible at the time, the final stage as Jürgen Barth called it, with water-cooled cylinder heads. Without fluids or driver, the car weighed just 1,499 pounds. *Randy Leffingwell*

It would have been a contender with excellent credentials: owner and sponsor Ted Field of Interscope already had a number of 935 endurance victories, Porsche's project director Helmut Flegl and turbo engine specialist Valentin Schäffer had brought 917 Can-Am cars to championships, but then racing politics intervened. *Randy Leffingwell*

(Far left) With 630 horsepower at 9,000 rpm and 412 pounds-feet of torque at 6,400 rpm, the performance of this car had the potential to run away with the races it entered; that was why competitors changed the rules on it. *Randy Leffingwell*

(Near left) Interscope Racing had been running its sleek, well-developed Parnelli chassis with a Cosworth V-8. The Porsche engine in this car made it extremely competitive. *Randy Leffingwell*

inches of mercury (1.8 bar). USAC allowed a competing engine, the inline four-cylinder Offenhauser, to run with 60 inches (2 bar), while rules allowed the eight-cylinder Cosworths only 48 inches (1.6 bar). Unfortunately, Hoppen never got it in writing.

In December 1979, USAC management appeared with Hoppen and Field's Interscope Indy team to unveil the new car to the press and invited guests. At this point, USAC believed it had three advantages over CART: USAC operated the Indy 500, it had Porsche, and it had crowd-pleaser A. J. Foyt. But Foyt was wary of Porsche. He had won Le Mans in 1967 in a 7-liter Ford GT, beating two 4-liter Ferraris and another Ford, but the next four cars in that race were 2-liter Porsches. Foyt feared what Porsche could do, given an even chance. He pushed USAC to reset Porsche's six-cylinder boost to the lower V-8 levels.

At Weissach, Porsche supremacy with this 2.65-liter, fuel-injected, single-turbocharged engine was not so certain. Valentin Schäffer labored to convert the engine from gasoline to Indy's required alcohol and to perform in the series' typically limited engine-rev range. Countless engines failed on the dynamometers before it all came together. When it did, it was a powerful package, developing 630 horsepower at 9,000 rpm and 412 pounds-feet torque at 6,400 rpm.

Interscope had begun chassis tests, and it accomplished enough laps to confirm serious competitive potential. Duplicating the Indy 500 four-lap qualifying series, the Interscope Porsche lapped with an average speed of 192 miles per hour. Then on April 21, 1980, barely three weeks before qualifying started, USAC caved after Foyt threatened to move to CART. It ordered Porsche to run at 48 inches, 1.6 bar.

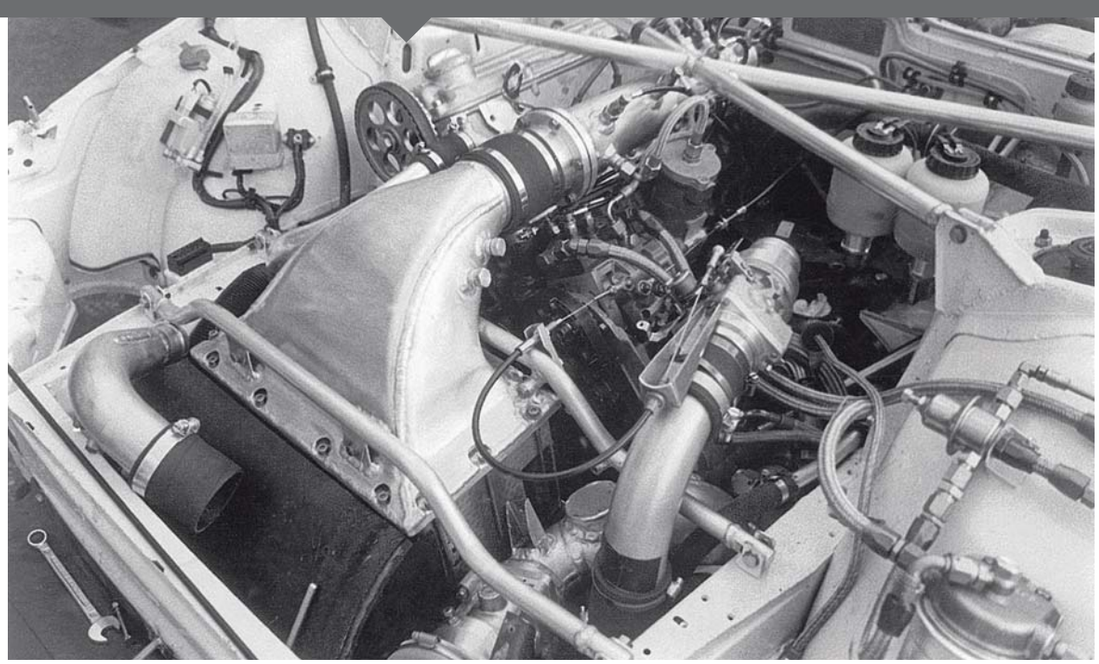
Ferry Porsche steamed: "How can we, at this late date . . . ? We developed the engine for 54 inches of boost! How can you change the rules with one month to the race?" In secret, Porsche also had tested and successfully developed a competitive engine at the lower boost. Instead, however, the carmaker withdrew. All the cars went to a warehouse.

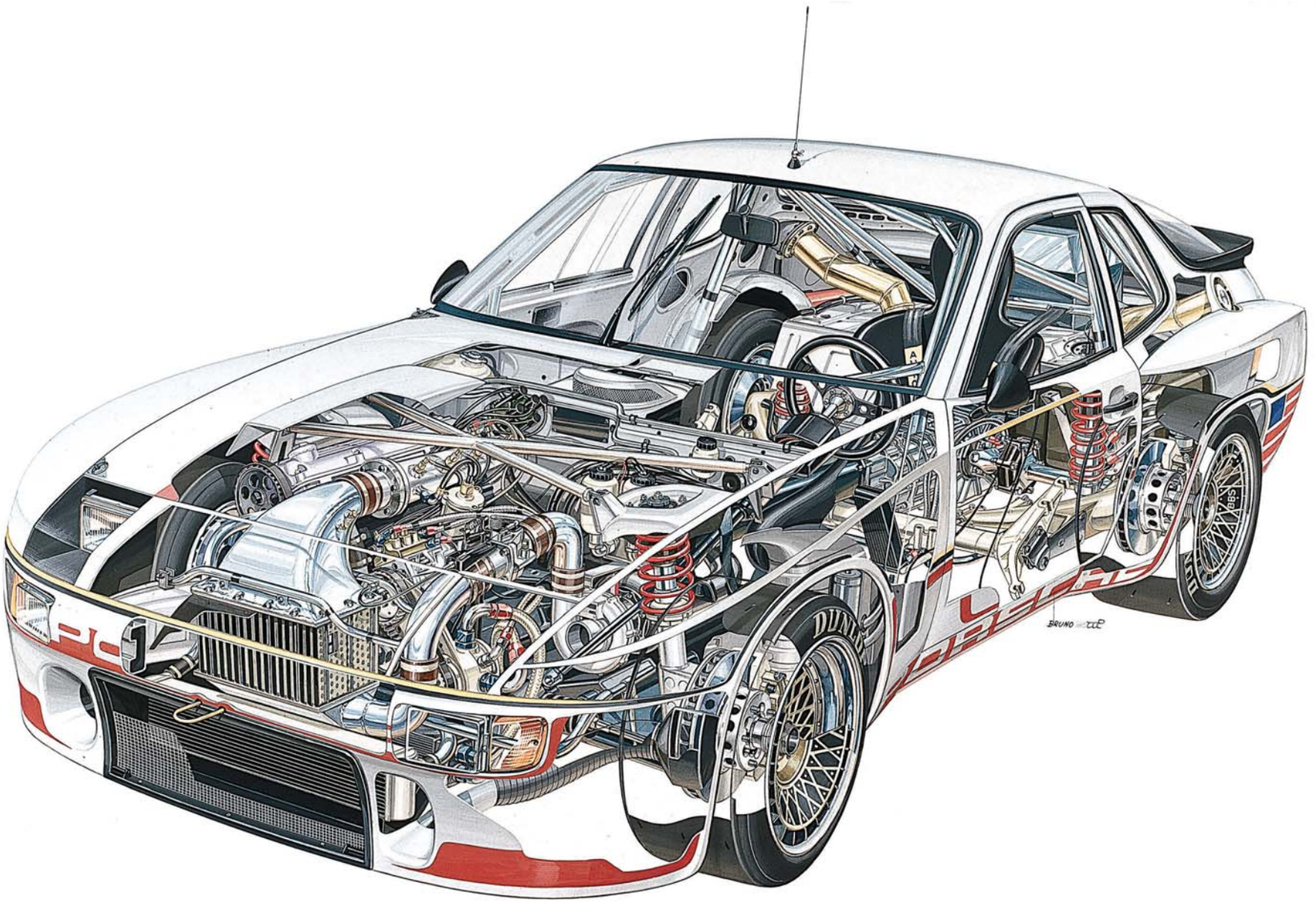
For the 1980 race, Johnny Rutherford, driving a Cosworth V-8-engined Chaparral, qualified on the pole at 192.256 miles per hour. On race day, May 25, 1980, Rutherford went on to win. A. J. Foyt had qualified twelfth, at 185.5 miles per hour, and did not finish. After 173 laps, his four-cylinder Offy engine let a valve go.

By 1979, Weissach's racing engineers had mastered the art of surrounding a series production body with something that still fit within a liberal interpretation of FIA class rules. This 1980 924 Carrera GT "Le Mans" demonstrated their ability to read between the lines. *Porsche Archive*

To promote the new 924 Turbos, Porsche entered three of these 924 Carrera GTs in the 24 Hours of Le Mans in 1980. While a 928 was pace car, two 935 Kremers and a factory-entered 936 occupied three of the four top grid spots, but at the end of the long day, Jürgen Barth and Manfred Schurti brought this car to the finish in sixth overall, behind five racers that resembled nothing like a car someone could buy and take home. *Porsche Archive*

The Typ 924GTP engine, still with 1,984cc displacement, developed 320 horsepower at 7,000 rpm, and it produced 282 pounds-feet of torque at 4,500 rpm. The car weighed just 2,050 pounds. *Porsche Archive*





Weissach engineers began to develop the 1980 Le Mans 924 car in October 1979. Diligent effort in the wind tunnel reduced drag to 0.35. Porsche entered three cars, one each with German, British, and American drivers. *Porsche Archive*

For 1981, Porsche had testing in mind, and it entered a single 944LM as a prototype in the very flexible IMSA GTP category. With a new Typ 944/06 engine of 2,479cc displacement, this 2,100-pound prototype had 410 horsepower available at 6,500 rpm, and that was good enough to factory drivers Jürgen Barth and Walter Röhrl—seventh overall and first in class. *Porsche Archive*

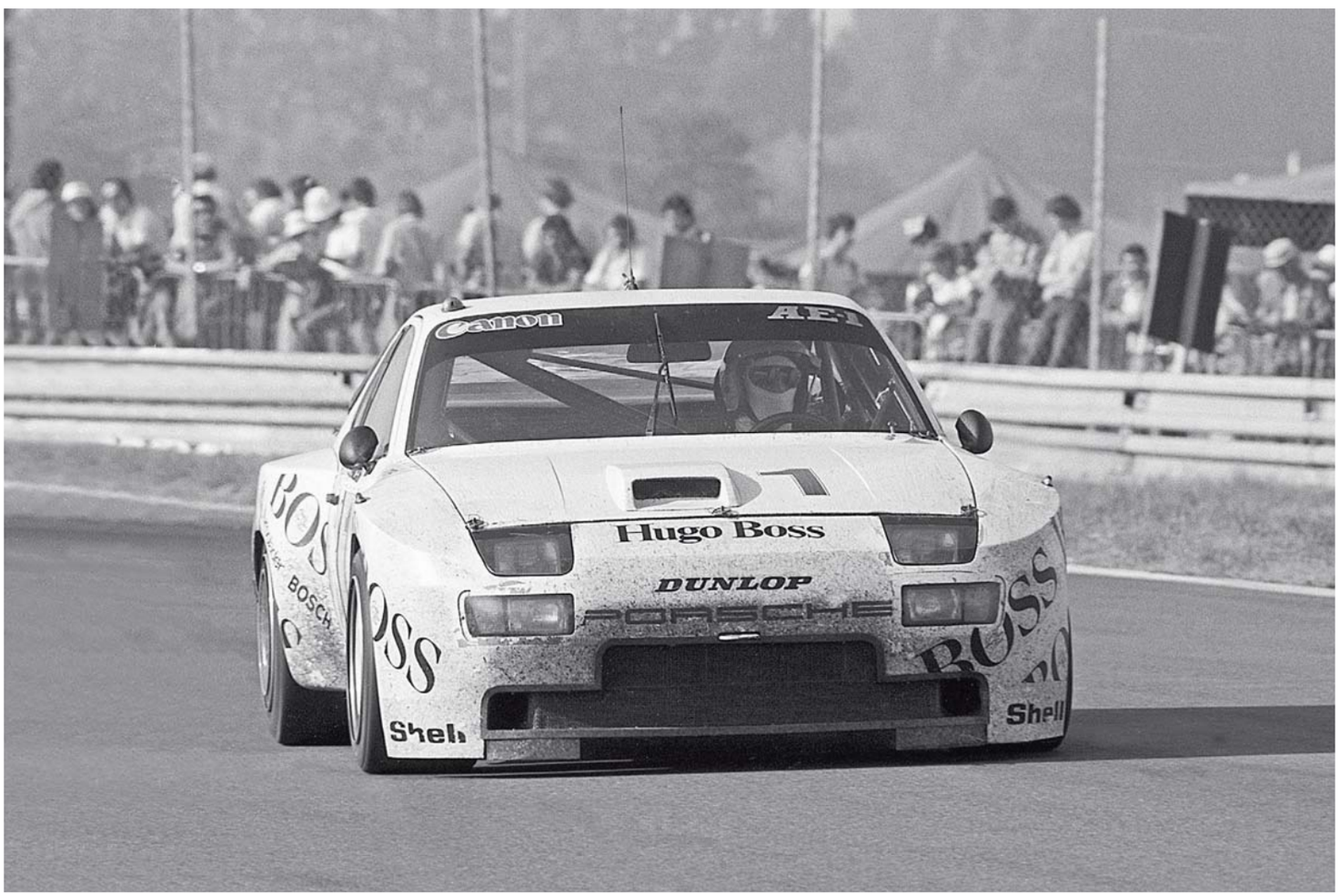
1982–1983 924 CARRERA GTR/944GTP

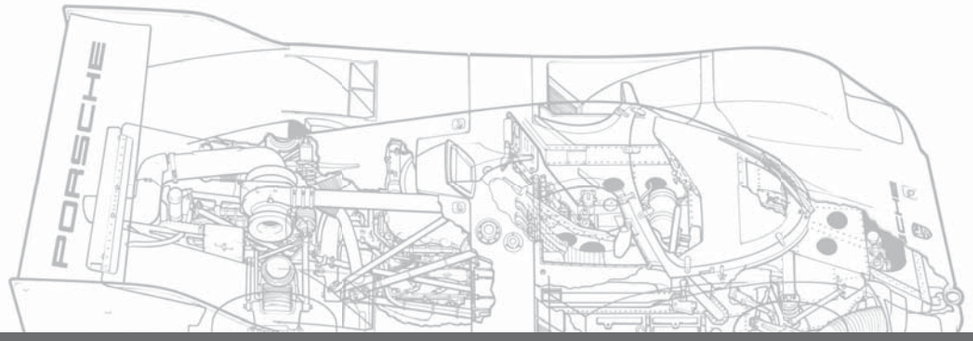
Porsche's closed-wheel racing efforts proved more satisfying and less frustrating than its open-wheel program in America had been. Weissach furthered development of its 924 with GTP versions for Le Mans. One of the three ran a prototype 2,479cc inline four-cylinder with twin-cam, four-valve heads and a massive KKK turbo. It is better known as the 944GTP, a prototype of the next-generation road car. It introduced Bosch's electronic fuel-injection system, and the Typ 944/06 engine developed 410 horsepower at 6,500 rpm. The body, chassis, and suspension were further refinements of the 924 GTPs, and this car and its backup twin weighed just 2,108 pounds each. With Jürgen Barth and Walter Röhrl sharing driving duties at Le Mans, the car finished seventh overall.

The other two entries that weekend, both 924GTP models updated from 1980, had less success. One managed an eleventh overall after suffering gearbox problems, while those same troubles sidelined the third car completely and it did not finish. (Transmission problems had plagued the 1981 Monte Carlo Rally entry, and Barth and Kussmaul retired about 400 miles before the finish line in Monaco.)

A month before Le Mans, Röhrl drove a rally-prepared 924GTS to first place at the Hessen Rally, part of the 1981 WRC season. He went on to win two more rallies but finished behind a competitive field of Renault 5 Turbos, Talbot-Sunbeam-Lotuses, Ford Escorts, Audi Quattros, and a few Japanese entries. With a new WRC-regulated class arriving in 1982, Group B, Porsche invested little effort into rally prep for the 924s, though the cars' swan song was the 1982 Monte Carlo Rally. There, Barth and Kussmaul brought their 924GTS across the line in tenth overall. The final Le Mans appearance of 924 turbocharged race cars was a trio of GTR variants in 1982, the most successful of which wore B. F. Goodrich tire-manufacturer colors and competed on the company's street radials. Entered in the IMSA/GTO class (for displacement greater than 2 liters), Americans Jim Busby and Doc Bundy won their class and finished sixteenth overall.

Porsche's priorities had changed. The FIA issued new regulations effective for 1982, exchanging competition group numbers for letters, B and C, for example. Helmuth Bott had unleashed his engineers to work on cars to meet these new classifications. In addition, with much needed outside participation, Porsche returned to open-wheel racing, this time in Formula One. For series-production customers, the 944GTP had given them a glimpse at the new entry-level 944 front-engine coupe that arrived in 1982. From its conception, engineers and product planners knew there was a 944 Turbo coming as well.





Chapter Eight

NEW **REGULATIONS**, MORE OPPORTUNITIES

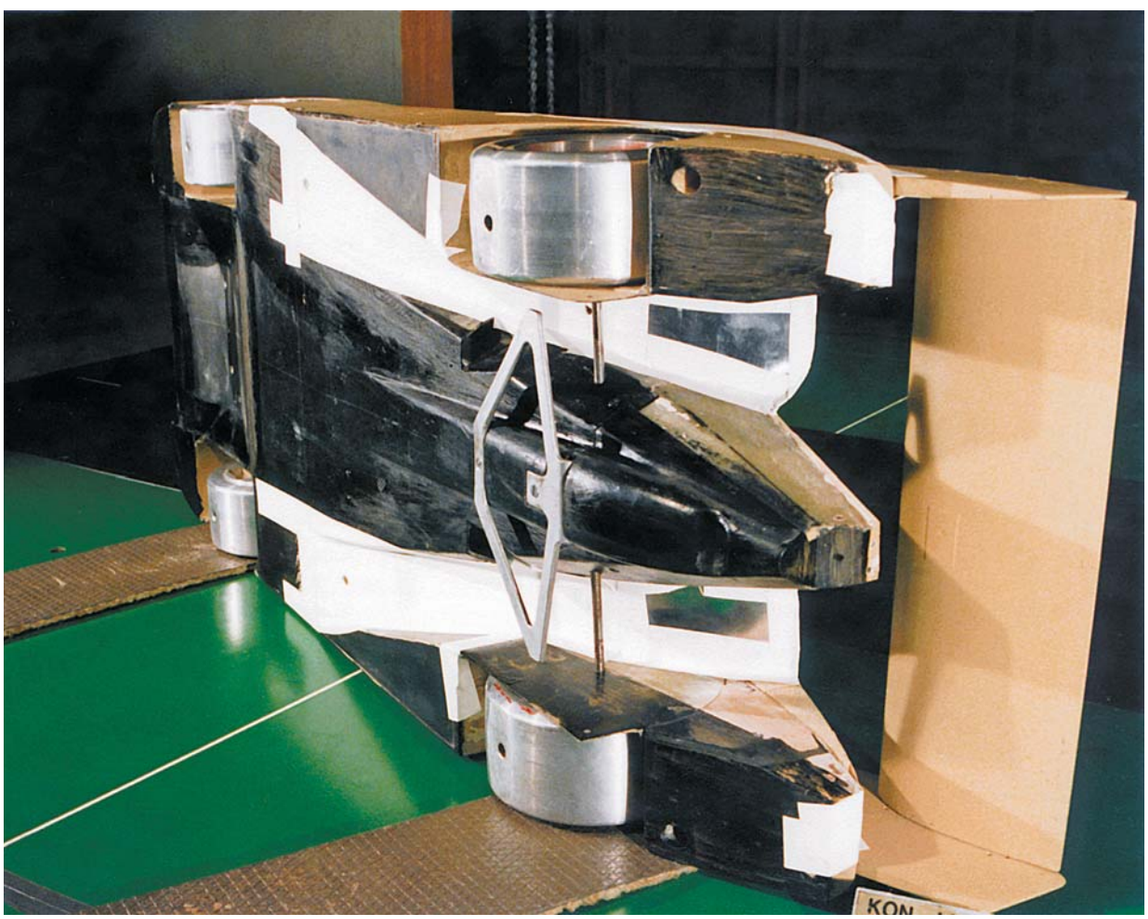
Porsche's Typ 956-001 prototype underwent extensive testing on the Weissach circuit as engineers worked out details. As Jürgen Barth reported, it was the first time he or colleague Roland Kussmaul had experienced the handling capabilities of ground-effects cars. *Porsche Archive*

1982–1988 GRUPPE C 956/962

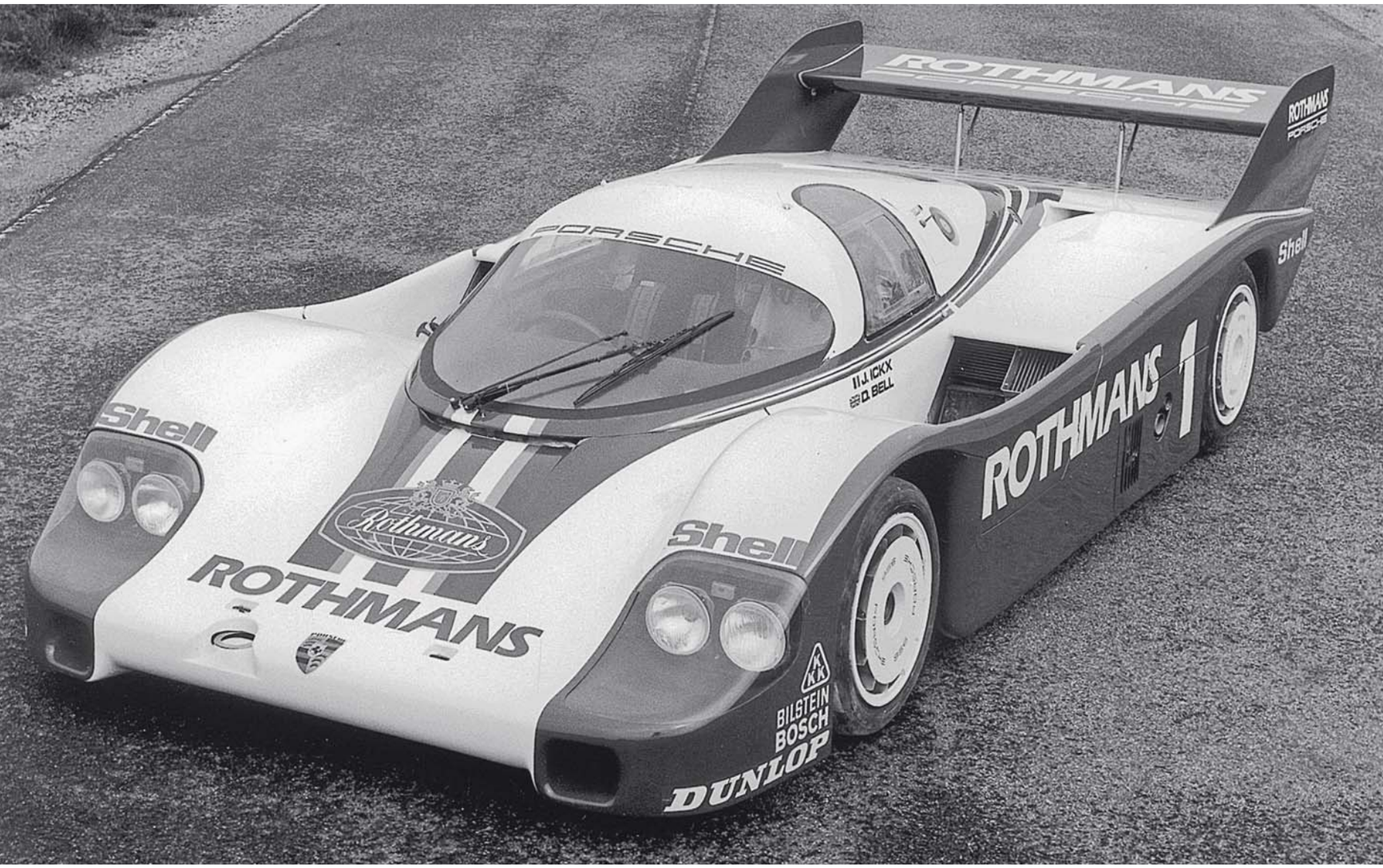
Porsche's Typ 935/72 engine—the 2,649cc powerplant perfected for Indianapolis—did not disappear. Even as the American open-wheel racing series tore itself apart and reorganized into other things, the FIA had effected a more orderly transition. Group C replaced Group 5 and 6, effective for the 1982 season. Regulations did not limit engine displacement, but they set a minimum weight at 1,764 pounds. Countless other specifications defined height, width, length, and other elements of these new cars. But the greatest challenge the FIA gave manufacturers was fuel efficiency. Rules limited entrants to 158 gallons for races of 1,000 kilometers and 687 gallons for Le Mans.

Racing engineers Norbert Singer, Peter Falk, Hans Mezger, and Valentin Schäffer had worked hard developing the alcohol-fueled engine for Indy. Converting it back to gasoline was less involved, and its 92.3-by-66 -millimeter configuration suggested the kind of efficiency Group C demanded.

Porsche already had tested the engine and the concept at Le Mans in 1981 in a surprise effort that Porsche's new CEO initiated. After Fuhrmann retired, Ferry Porsche hired Peter Schutz, telling him, "We're looking for someone who can get this whole organization unified and working together," as Schutz recalled. Porsche cars had won Le Mans in 1979 and 1980, but these were private entries. Zuffenhausen offered up racing 924 Turbos as factory representatives.



As Norbert Singer worked on this scale model in the wind tunnel, he repeated, redesigned, and reconfigured the angles and dimensions of the undercarriage tunnels. His biggest discovery was a venturi effect caused by a small underside extension just ahead of the front. It became known as the Singer Bubble. *Porsche Archive*

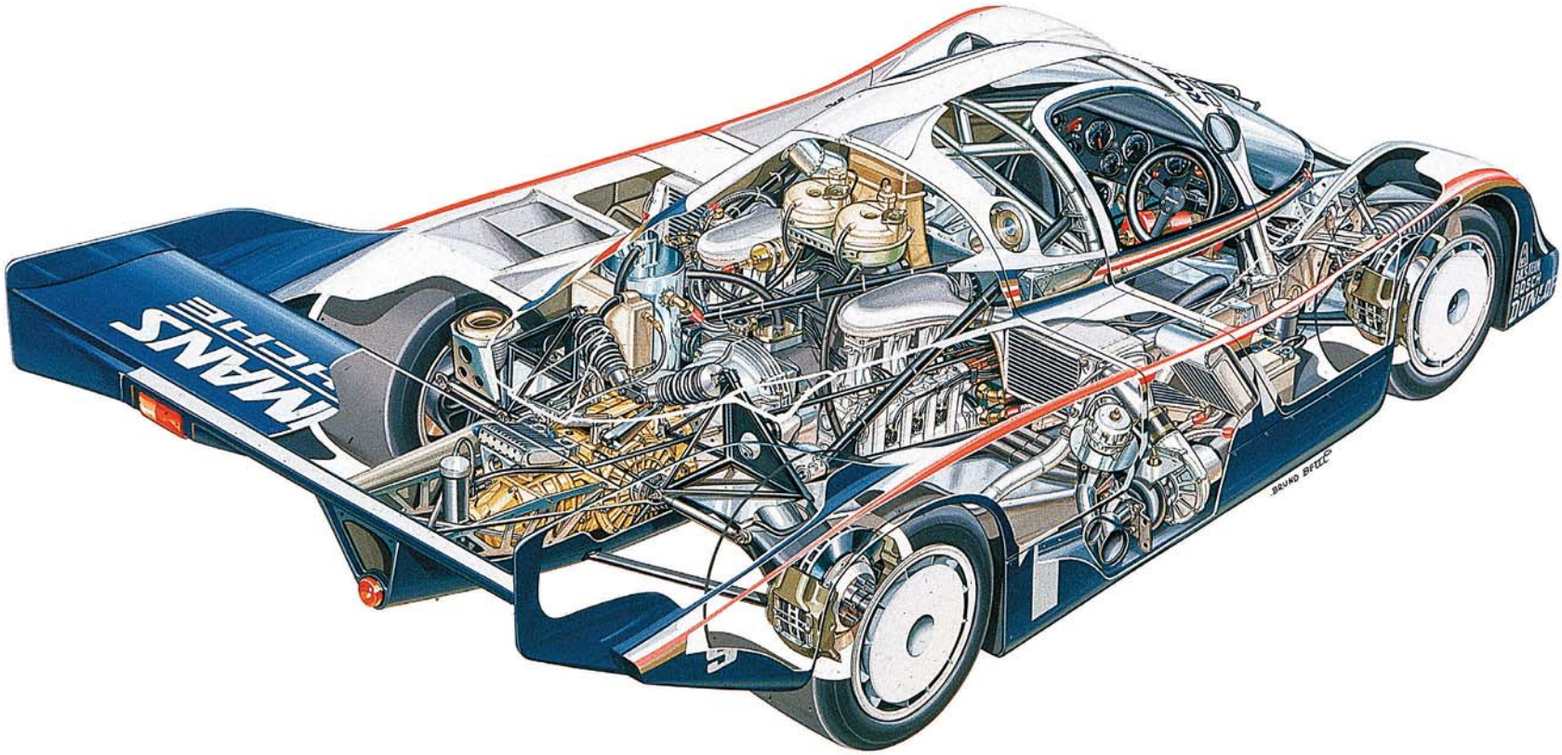


For Schutz, this seemed wrong: "I just challenged these people. They told me they were going to Le Mans, racing with a 924 Turbo. 'Well, what are your chances of winning with that thing?' 'A modified production car has no chance against racing prototypes,' they said."

"Okay. As long as I'm in charge of this organization," he announced, "we will never go to any race without the objective of winning." He ordered them back the next morning to present their ideas. That day, engineers proposed pulling the 936 from their museum and installing a reworked Indy engine using the water-cooled four-valve technology. Five months later, when the checkered flag fell in Le Mans, the four-year-old museum car—with an engine destined for next year's Group C efforts—won the race.

Singer, chassis designer Horst Reitter, and their colleagues started work on the Group C Typ 956 right after the 1981 Le Mans. The new version of the opposed six-cylinder 2,649cc Typ 935/76 engine used dual overhead camshafts to operate twin intake and exhaust valves in water-cooled cylinder heads welded to the crankcase cylinders to eliminate risk of head-gasket failure. Valentin Schäffer completely reworked the Indy engine to meet Group C performance and fuel efficiency needs. He stuck with two turbochargers with dedicated air-to-air intercoolers, one per bank, mounted beside each cylinder head. He combined this initially with Bosch mechanical fuel injection, although in late 1982, Bosch introduced its Motronic digital system. At 2.2 bar race boost, the engine developed 620 horsepower at 8,200 rpm and delivered 456 pounds-feet of torque at 5,400 rpm. To transmit this power to the ground, Porsche updated its five-speed, fully synchronized transmission inside a newly designed magnesium case.

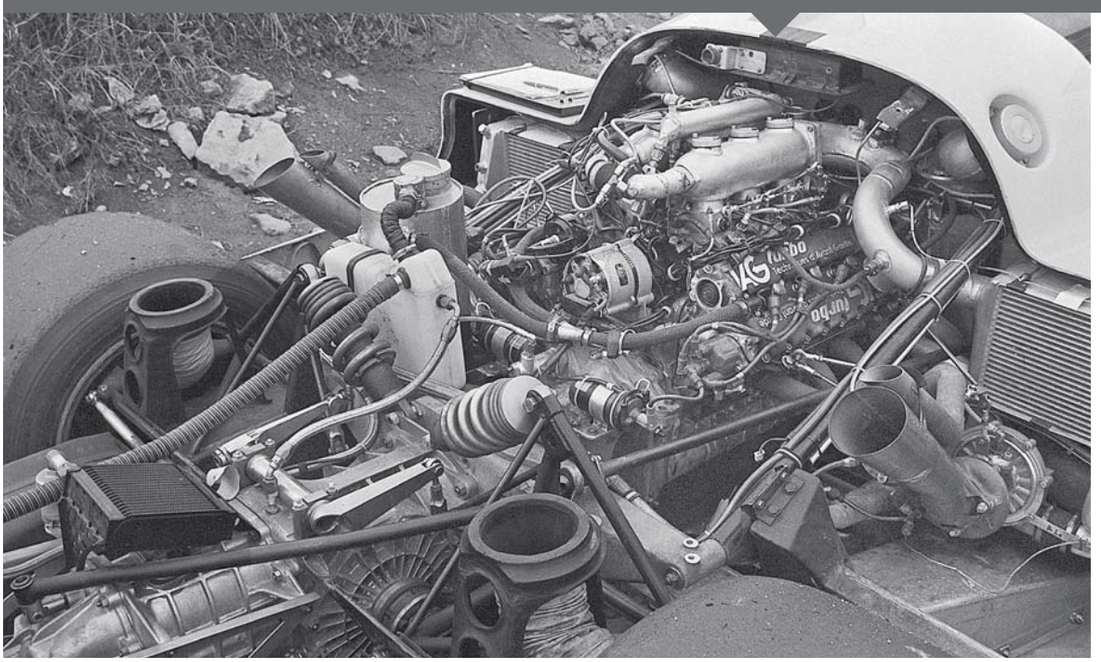
Singer, Reitter, and body engineer Eugen Kolb collaborated on a new approach to Porsche's race-car chassis and body, forsaking the long-standing preference for tube-frame design. In their days spent in the wind tunnel, they discovered that the tube-frame 936 Spyders were considerably less stiff than the sheet-metal bodywork forming the basis of the 935. They concluded that an aluminum monocoque offered potential. They positioned the fuel tank behind the driver in a safe and central location, causing the least effect on balance as the tank emptied. This enabled them to keep the monocoque narrow. They bolted Schäffer's

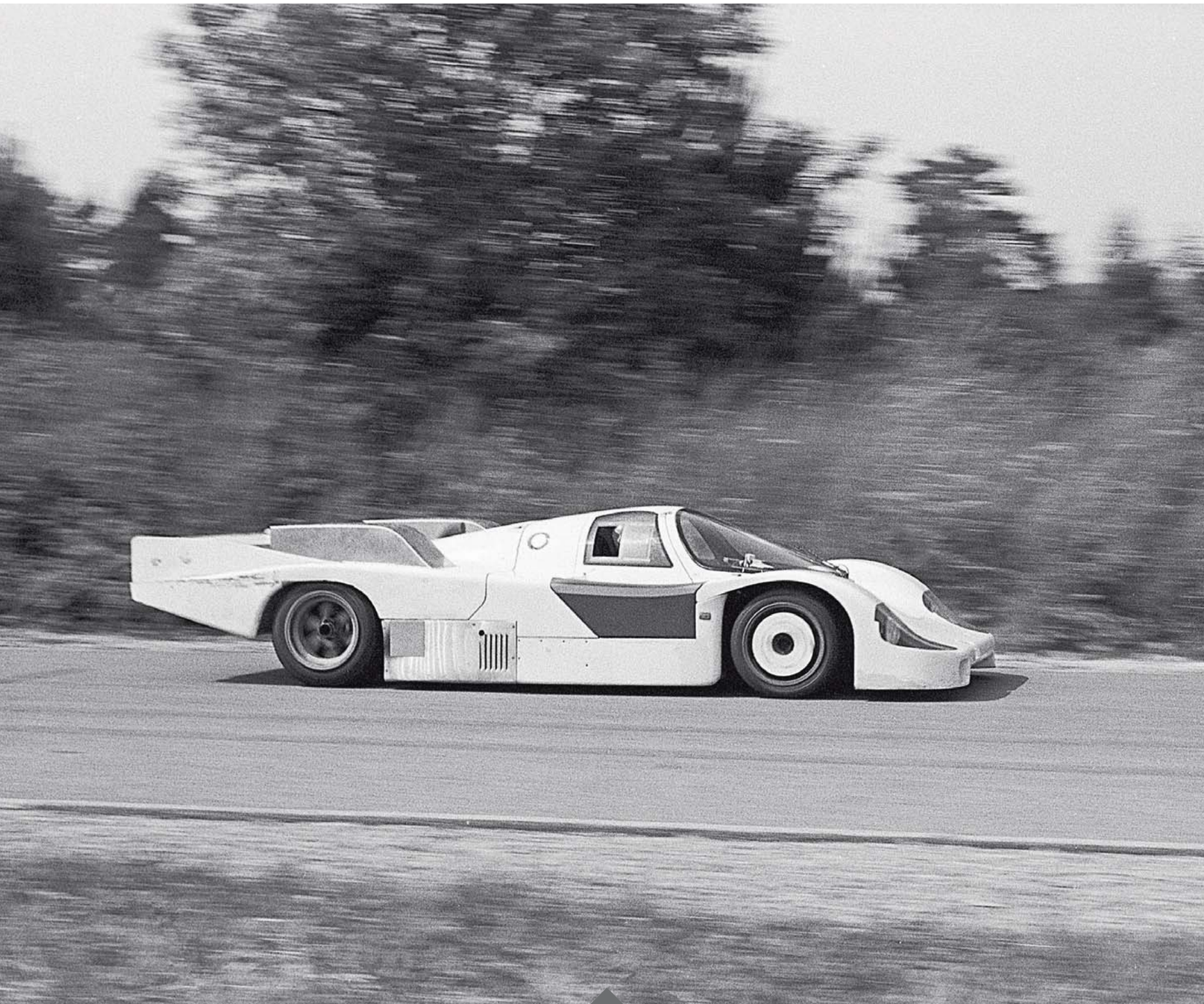


Following tests in Weissach and at Paul Ricard, Porsche felt confident enough to compete at Silverstone. There, on the debut of the 956, Jacky Ickx and Derek Bell finished second overall. *Porsche Archive*

Aerodynamic engineer Eugen Kolb designed long- and short-tail back ends of the 956. The difference—in centimeters—was not as dramatic as with the racers in the late 1960s and the 917s of the early 1970s, as this short tail might suggest. *Porsche Archive*

Following the effort and expense of designing and developing the Typ 2623 V-6 engine for Formula One, Hans Mezger and sponsor Mansour Ojjeh looked for other uses for the engine. The 1,499cc engine fit easily in the larger endurance racer, though exhaust pipes rose from the twin turbos like missile launchers. *Porsche Archive*





With a minimum of 600 horsepower available, the Formula One engine suggested a good fit for the 956. However, its narrow power band, achieved at high engine speeds, limited its usefulness. Metal boxes above the rear wheels shrouded the exhaust. *Porsche Archive*

Porsche's 962C models achieved success in Europe and North America. Here, the combination of Derek Bell, Bob Wollek, and John Andretti won the 24 Hours of Daytona, an event stopped in the night by impenetrable fog. When the race resumed, it was a sprint. *Porsche Archive*

engine to the back of the fuel tank and inserted a 15.75-inch spacer between engine and transaxle for rear-axle alignment and balance. This left them plenty of room to improve the underside of the car. Regulations required that a 31.5-by-39.4-inch portion of the undercarriage between front and rear wheels had to be flat and parallel to the road surface. The engineers determined where they could insert underbody tunnels to improve road holding through aerodynamic downforce. Singer added a small hump below the front axle, enhancing the Venturi effect they intended. Engineers nicknamed this structure the "Singer bubble." The driving effects of this chassis and aerodynamic engineering, however, were unknown at Porsche. The potential became clear only after test drivers Jürgen Barth and Roland Kussmaul put on miles. Barth was first to drive the car on Weissach's test track.

"No one had driven ground-effects sports cars before," Barth recalled. "And the cornering forces were simply incredible. I went out and did something like five laps. When I came in to check fluids, Dr. Bott saw the back of the car and accused me of going off the road!" Bott saw dust in the tunnels. "We figured out the tunnels under the car had vacuumed the track," Barth said.

Jacky Ickx and Derek Bell loved the car, praising its predictability and its consistent feedback. In short-race trim, it weighed 1,808 pounds, which put it at a disadvantage to the 1,411-pound Lancia LC1 Spyders. At the competition debut of the 956, Ickx and Bell finished three laps behind the Italian lightweight. At Le Mans, however, Porsche's competition learned what the 956 represented. Racing manager Peter Falk had set a rigid schedule: pit stops every 57 minutes and fuel consumption at 28.3 gallons per hour was their calculation to win. Ickx qualified on the pole running 1.2 bar of boost, his engine developing 615 horsepower. To go the distance with the fuel allocation, Porsche dialed boost back to 1.1 bar and the engines ran an effortless 580 horsepower around the clock.

As Quentin Spurring wrote in *Le Mans: The Official History of the World's Greatest Motor Race 1980–1989*, "The spectacle of the works team mounting a formation finish with all its cars impressed the public and demoralized all rivals." The cars finished first, second, and third. This set the pace for the season and the coming years. Porsche won the World Endurance Championship (WEC), and Ickx claimed the first ever World Sports Car Drivers Championship.

Barth summarized the evolution that followed: "From 1982 through 1985, there was really no change to the power output of the 956 and then the 962, yet the cars just went faster. Tires helped, but so did driver familiarity."

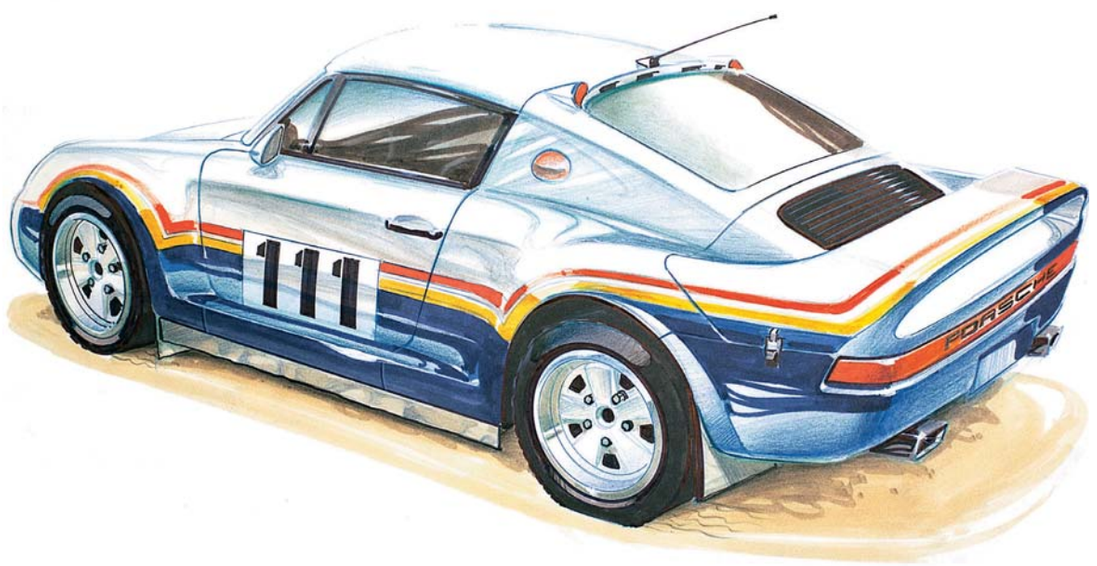
1983 AND BEYOND

Through the 1982 season, Singer and his colleagues learned hundreds of lessons and made countless changes to the 956s. Because Group C was really designated a "consumption" class, Valentin Schäffer made numerous improvements, from increasing compression to switching from single injector nozzles in each cylinder to two smaller, more precise ones. Porsche tested transmissions, evaluating a heavy but fast double-clutch system against a "dog-clutch" gearbox offering the benefits of fast shifting at the expense of faster wear if there was slippage. The carmaker began customer deliveries of 956s in 1983, and by season end in 1984, Weissach had satisfied eighteen customer requests. While it delivered the cars with the 2,649cc engines, Porsche offered kits to increase displacement to 2,826cc, 2,994cc, or 3,164cc. The company began to see its customers in winners' circles. Reinhold Jöst's 956B won Le Mans in 1984, although the factory had withdrawn its entries in protest over a last-minute rule change; seventeen 956s started, and the first seven finishers were private 956s. Through that year, however, Singer and his staff were creating the new version of the 956—the 962, developed in response to IMSA.

IMSA refused to adopt FIA Group C regulations and developed its own instead. As Barth explained in *The Porsche Book*, "According to insiders, these were precisely designed to keep the favored 956 out of the series." These included different body shapes and layout of aerodynamics, different safety requirements, no fuel-consumption limit, and different engine configuration. For any other maker in Porsche's situation, this would have meant elimination. For Singer, this was Fuhrmann's 935/2 *Baby* all over again.

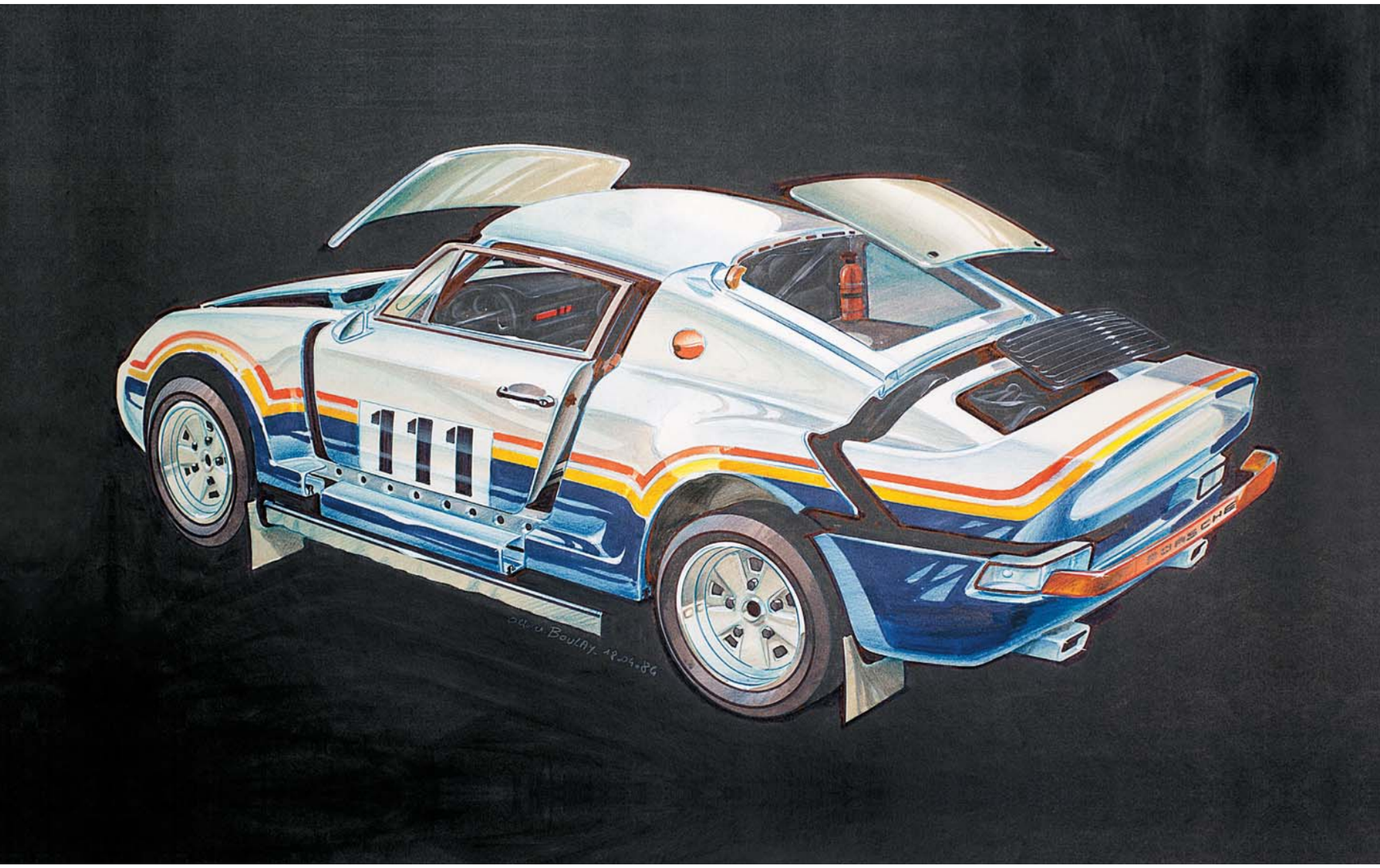
His biggest challenge was IMSA's rule that drivers' feet could not pass the line of the front axle. This required repositioning the axle, which stretched the wheelbase that still had to fit within the existing body. This upset and recalibrated all the front-end aerodynamics. To meet IMSA's engine regulations, Schäffer replaced the water-cooled head engines with

A second paint-scheme concept from Porsche stylist Olivier Boulay provided a kind of exploded view of the 959 body. The colors came from sponsor Rothmans. *Porsche Archive*



Porsche stylist Olivier Boulay spent mid-April 1986 developing color schemes for the Paris-Dakar 959 entries. *Porsche Archive*

In response to contradictory regulations between FIA and IMSA, Porsche went back to the drawing board, the parts bins, and the wind tunnel to create a car in which, for safety reasons, drivers' feet were behind the line of the front axle. Porsche then created an IMSA version (shown here) and an international Group C version Typ 962C of this updated car. *Porsche Archive*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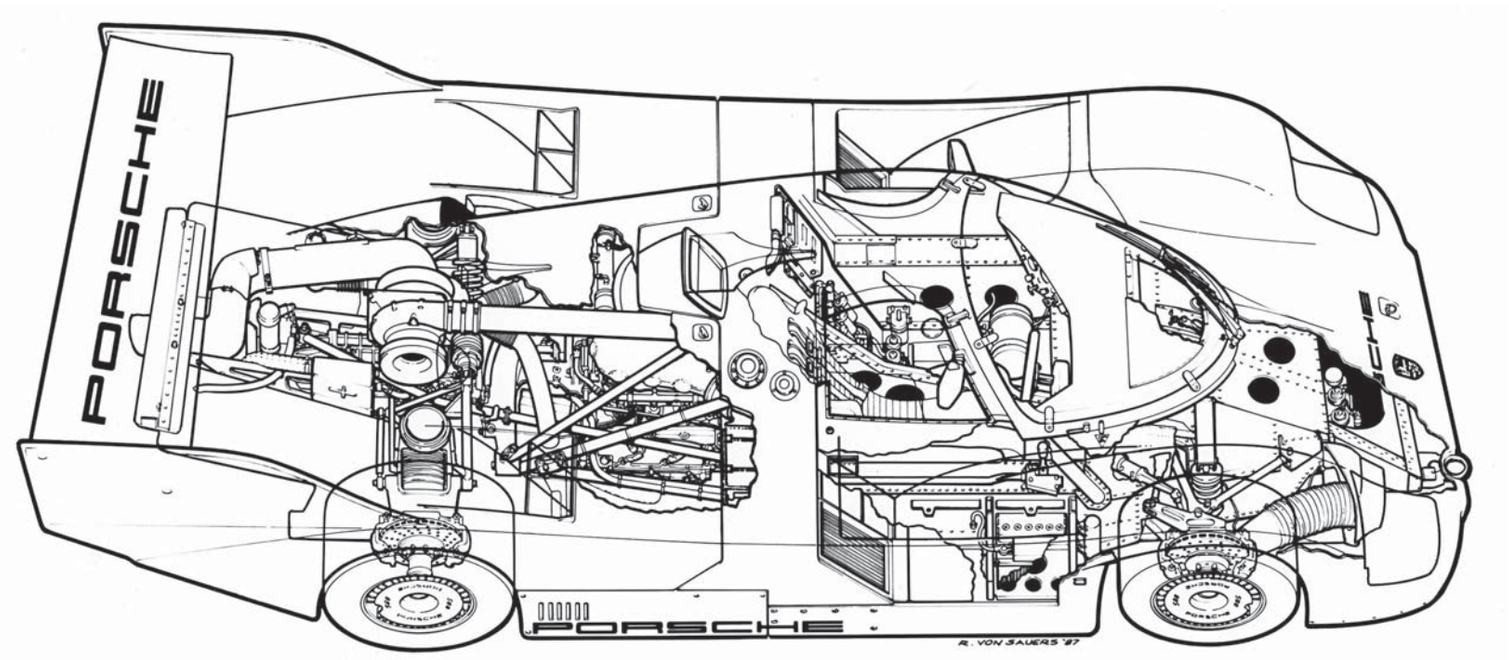
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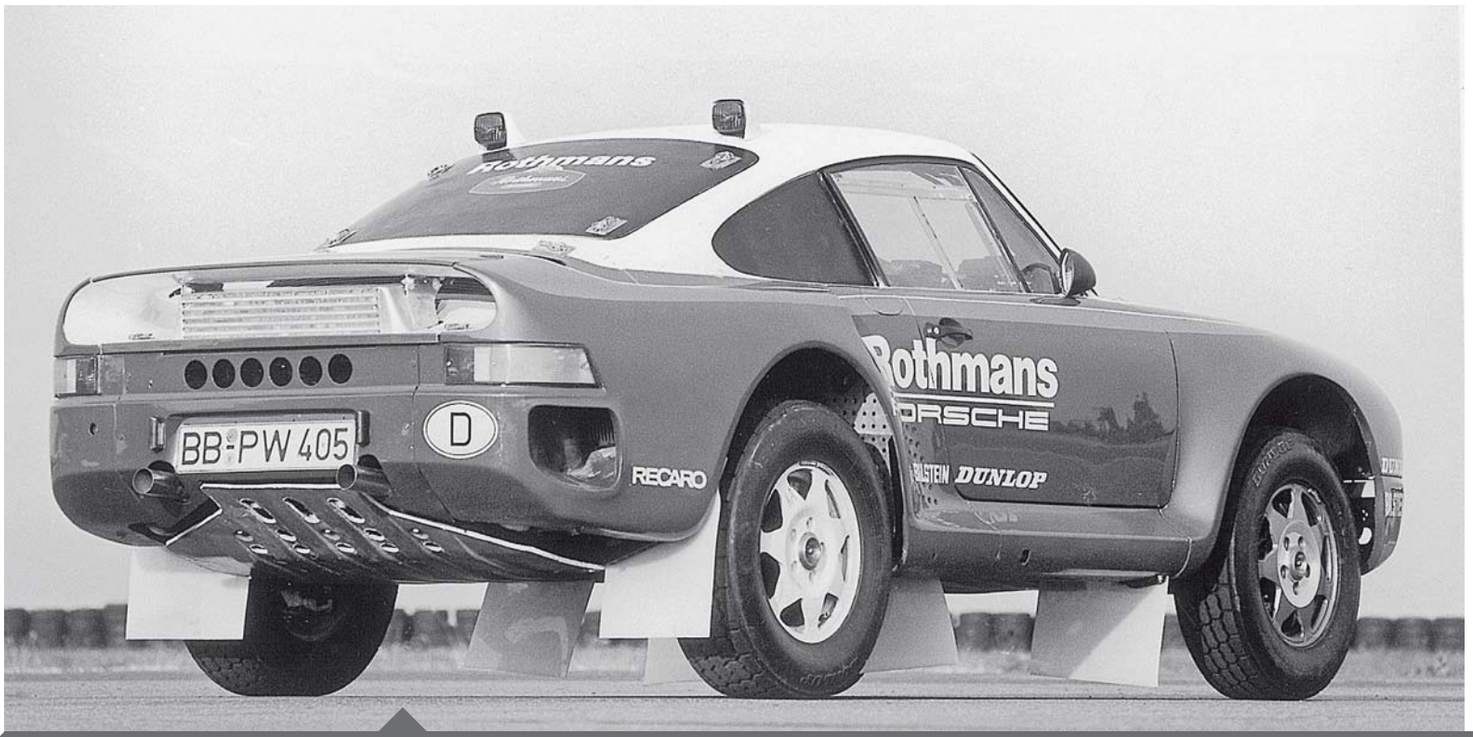


Engineer Roland Kussmaul not only developed the 1986 team cars but also drove the third entry, no. 187, to sixth overall finish. Kussmaul not only supervised car maintenance but also coordinated driver and crew nutrition and vitamin supplements! *Porsche Archive*

For pre-event publicity photos, the Paris-Dakar entries had an extra set of mud/rock flaps between the axles. The cars required road registration for the highway transit stages before the African desert. *Porsche Archive*

air-cooled two-valve powerplants from the 935, modified with Bosch's latest Motronic black box. Because he had to provide engines for those competing exclusively in the US IMSA series *and* for those meaning to race the newest cars in Group C, he developed two versions. The Typ 956/62 was the 2,869cc flat six for the 962C. It developed 680 horsepower at 8,200 rpm and 477 pounds-feet of torque at 5,800 rpm. For IMSA's typical three-hour sprints with no fuel limitations, the Typ 962/71 displaced 3,164cc and produced 720 horsepower at 7,300 rpm while developing 637 pounds-feet of torque at 4,500 rpm.

In 1985, Porsche began race-testing its double-clutch transmission: the Porsche Doppelkupplungsgetriebe, or PDK gearbox (though not yet for events such as Le Mans). The factory returned that year with four 962s, joined by another eleven customers. The Porsches competed against four turbo V-8 Ferrari-powered Lancias and five V-12 Jaguar XJRs. Reinhold Jöst repeated his perfectly managed race from 1984, winning again in 1985 using the same car. His drivers qualified with a Typ 935/79 engine of 2,986cc developing 750 horsepower at 8,200 rpm, but they won with the more fuel-efficient 620-horsepower 2,649cc Typ 935/76. Jöst's own shop assembled the engines.

Racing season 1986 brought the victories back in house. A 962GTP won at Daytona, and a pair of Weissach 962Cs took first and second at Le Mans. Porsche brought the same four chassis it used in 1985 but with a much better result. Race year 1986 also saw the first PDK victories, at Monza and in Hockenheim. In typical Porsche fashion, they repeated this performance in 1987, winning Daytona and taking first at Le Mans. The newly developed 2,994cc Typ 935/82 engine ran at 2.4 bar boost and produced 700 horsepower at 8,000 rpm, running on mandatory pump fuel. Entries from Jaguar and Sauber-Mercedes provided stiff competition, and lessons these teams learned in 1987 paid off when Jaguar's XJR-9LM narrowly defeated the 962s in 1988. The factory ran no WCS events in 1988, leaving all entries to privateers, determining only to defend its Le Mans record.

For that year, Porsche significantly revised the engine, resulting in the Typ 935/83. New cylinder heads realigned the injectors, and the engine worked with an updated Motronic MP 1.7 engine control unit. This helped do away with distributors by incorporating three ignition coils to fire the twin spark plugs twice in each four-stroke cycle. The compression ratio rose from 9 to 9.5:1, and the 2,994cc engine developed 720 horsepower at 8,200 rpm with 463 pounds-feet of torque at 5,400 rpm.

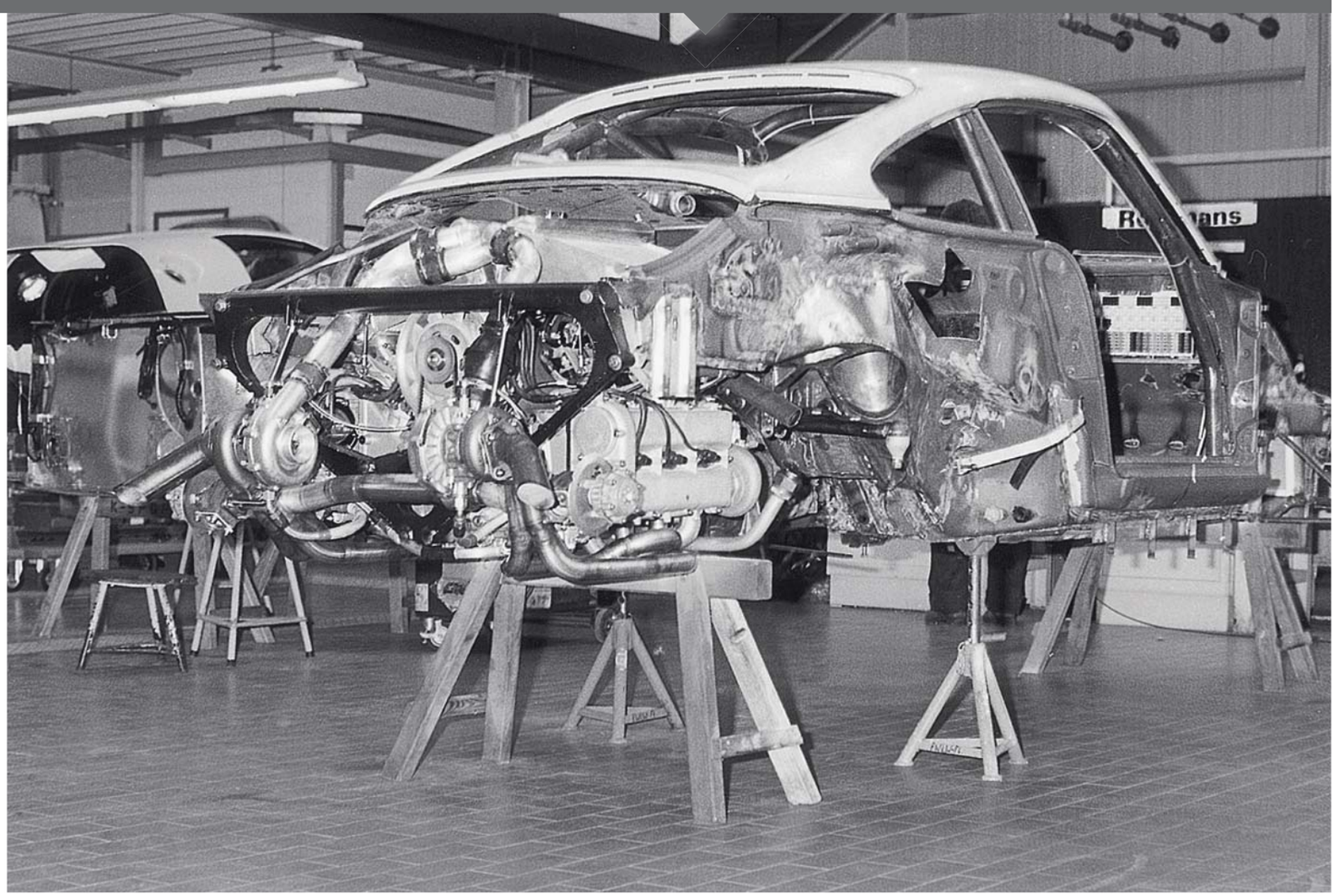
The 962C racing efforts remained in the hands of privateers exclusively in 1989 and 1990, when Weissach signed an agreement with Reinhold Jöst for mutual research, testing, and event support. By this time, however, the 962 was a relatively old car and Mercedes-Benz and Jaguar had improved their much younger ones. The combined Jöst-Weissach efforts in 1990 brought no wins, a result made more painful by FIA rule changes for 1991 that raised minimum weights on Group C cars so greatly as to retire 962s from WSC races. They continued in IMSA and Interserie events, and a Jöst 962 won Daytona one more time in 1991. In the European Interserie, 962s from Jöst in 1991 and Kremer brothers in 1992 and 1993 claimed the titles. By this time, as Barth recorded in *The Porsche Book*, Porsche had assembled eighty-six complete cars and twenty-two replacement monocoques.

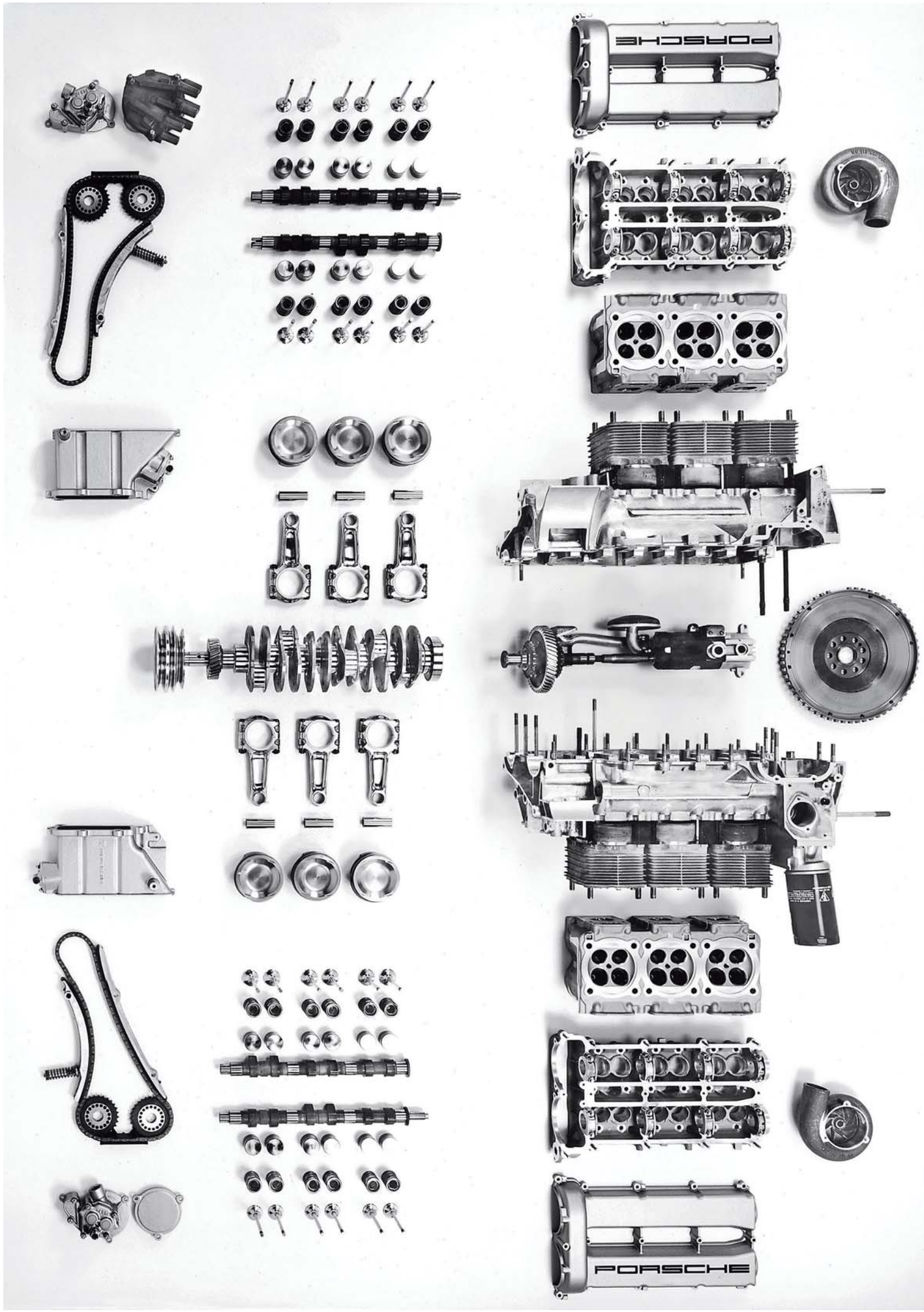
1982–1986 GRUPPE B PARIS/DAKAR, LE MANS TYP 961

At the same time the FIA announced Group C, it also introduced Group B (to replace Group 4 for modified grand touring cars and Group 5 for touring prototypes.) Homologation required two hundred identical units, and rules encouraged high technology in electronics and materials. On top of that, turbo boost was unrestricted. But that wasn't all. Back in 1979, the FIA's regulatory arm, the Fédération Internationale du Sport Automobile (FISA), authorized use of four-wheel-drive technology for the World Rally Championship (WRC). The prominent entrants—Fiat, Ford, Lancia—rejected it as too costly to develop and too heavy for the cars to remain competitive. But Ferdinand Piëch felt differently. While at Porsche, he had acquired a British Jensen Interceptor sports car to investigate four-wheel drive for

The missing intercooler rested on the upper horizontal sub frame member. The plastic and metal bodywork was completely removable for installation or major repair. *Porsche Archive*

The Typ 959/50 engine displaced 2,849cc and developed 400 horsepower at 6,500 rpm for the desert race. Engineers reduced the compression ratio to 8:1 to accommodate uncertain fuel in northern Africa. *Porsche Archive*

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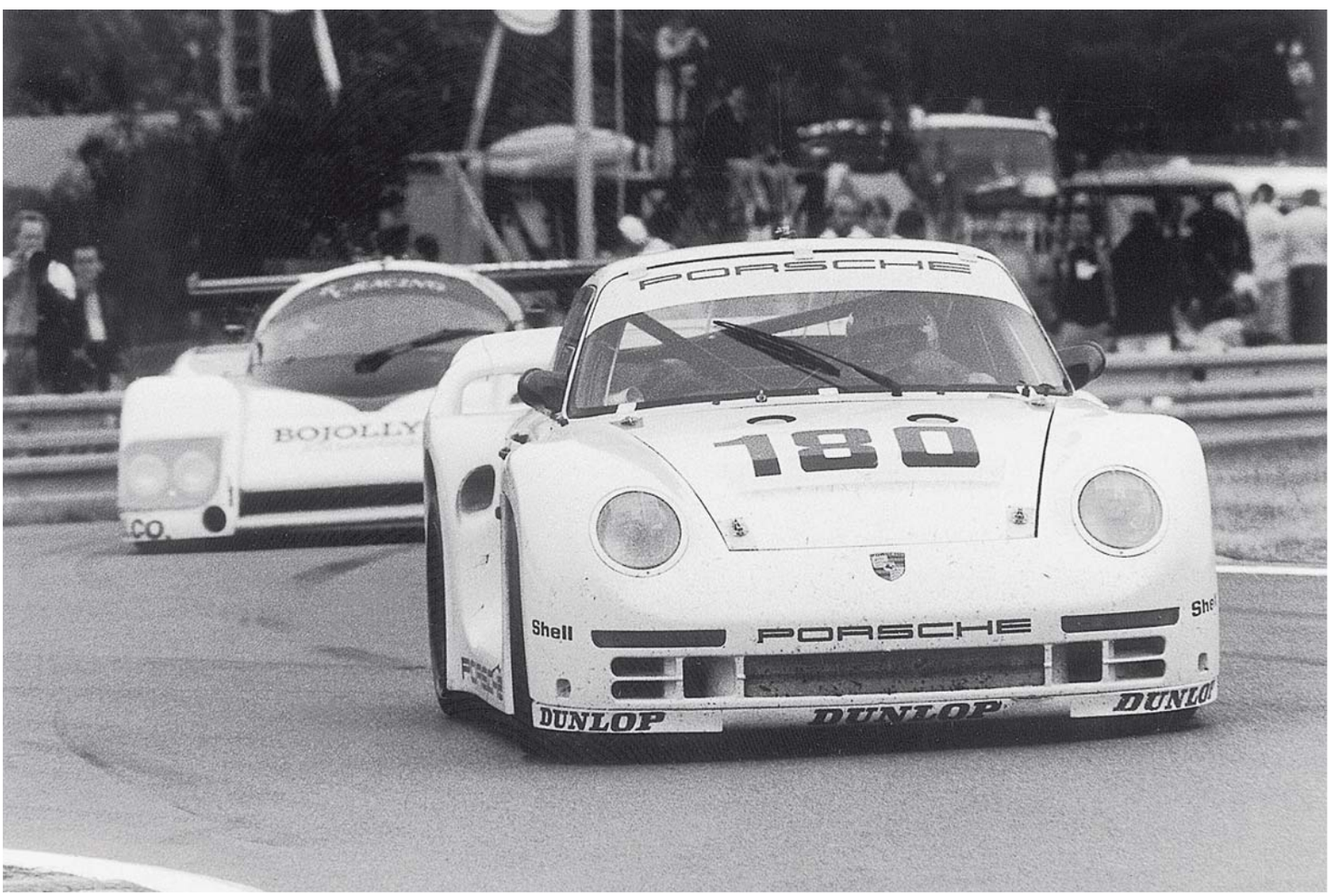
With its more aerodynamic bodywork the Le Mans Typ 961 appeared bigger and heavier than the desert 959. In fact at 2,535 pounds, the Le Mans car was 243 pounds lighter than the 2,778-pound Paris-Dakar entrants. Its race number, 180, hinted at its status as the sole IMSA GTX—experimental—entry. It was the first four-wheel-drive car to enter Le Mans since World War II, and this aerodynamic body reached 205 miles per hour along the Mulsanne straight. *Porsche Archive*

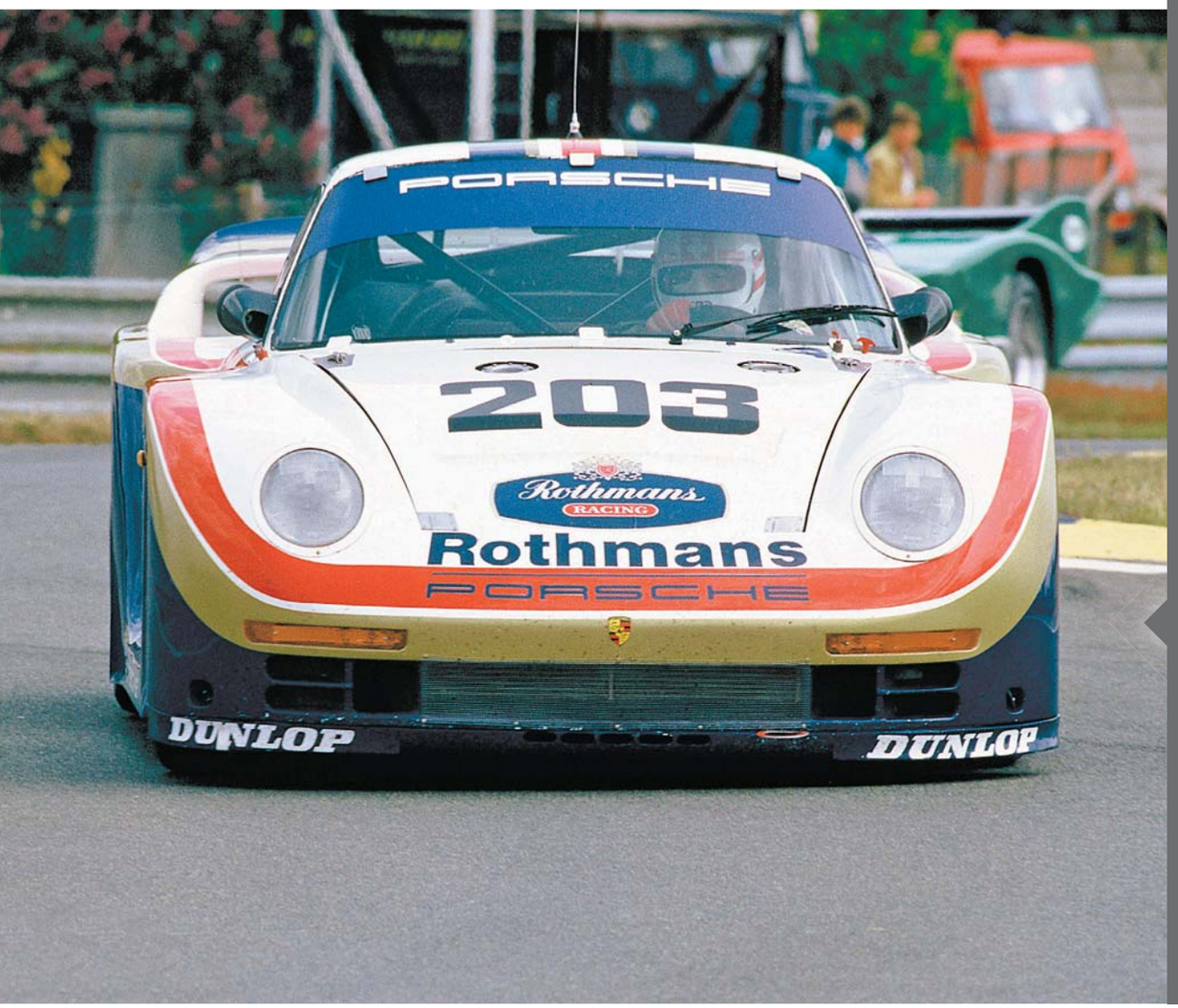
the 911. He joined Audi in 1971 with those impressions in his mind. In 1980, Audi entered a turbocharged all-wheel-drive Quattro in Portugal's Algarve Rally. Audi based the Quattro on its Model 80 front-wheel-drive coupe and succeeded in getting it classified as an "opening" car—one that makes the final sweep before the competition cars head out, doing so at race pace, as opposed to the inspection run done at legal road speeds. When the organizers totaled the Quattro's combined run time for all stages, they discovered that it covered the distance in *30 minutes* less time than the winner. Suddenly performance considerations outstripped costs and weight. Helmuth Bott was enthralled.

"Our concept with the 911," he said in an interview in 1991, "has always been that it's an all-around car. With very few changes, you can drive a rally and then go to the racetrack at Le Mans." Bott and CEO Peter Schutz had emphasized that versatility at the 1981 Frankfurt Auto Show when they displayed an all-wheel-drive, turbocharged 911 cabriolet.

In 1983, Le Mans winner Jacky Ickx won the fifth Paris-Dakar Rally in an all-wheel-drive Mercedes-Benz sport utility vehicle. He approached Bott, wondering if Porsche could conquer Paris-Dakar in an all-wheel-drive 911. Weissach's first efforts sent normally aspirated 911 Carrera 3.2 coupes, designated Typ 953, which were heavily modified and fitted with all-wheel drive. Incredibly, Porsche won the rally in 1984 in one of these vehicles. For 1985, the company returned with a sophisticated all-wheel-drive system. A normally aspirated Typ 935/85 engine of 3,164cc developed 230 horsepower at 6,000 rpm and 203 pounds-feet of torque at 5,000 rpm. However, all three of these Typ 959 entries failed to finish. Under Roland Kussmaul's direction, Porsche took the next generation to the start line for 1986. These cars used 2,850cc Typ 959/50 engines with twin sequential turbochargers and intercoolers. They developed 400 horsepower at 6,500 rpm and 289 pounds-feet of torque at 4,500 rpm. As Barth explained, "The two turbochargers carried out their tasks—at first individually—and then together. At low engine revs, only one turbocharger was in operation. Driven by the collected exhaust gas pressure of all six cylinders, it spun up to speed faster than a conventional twin-turbo system. Once the desired pressure was available, the so-called compressor cut-in valve activated the second turbocharger."

A computerized drive system distributed power and braking to any one or all of the wheels, locking front and rear axles as needed. Despite the complexities, the systems performed perfectly and gave the 959s first, second, and sixth overall in the 1986 desert raid. This performance satisfied Bott and Ickx, answering all their questions about the potential of four-wheel drive. Porsche retired from desert raids.





Porsche had assembled enough series production 959s to homologate the racer, and for 1987, the car ran in IMSA GTP category. The car climbed as high as tenth overall before an accident and fire ended its run. *Porsche Archive*

The Typ 961 engine developed 640 horsepower at 7,800 horsepower for the 1987 entry. Porsche quoted torque at 456 pounds-feet at 5,000 rpm. *Porsche Archive*

"We went to the desert because it was the only race at the time where all the regulations were free, unlimited," Bott explained. Porsche was satisfied with 959 performance. But that had been in the desert. As Bott had said, "With very few changes, you can drive a rally and then go to the racetrack at Le Mans." And that was the Typ 961.

Group B required two hundred examples of a car for FIA homologation. Porsche's supervisory board had committed to manufacturing more than two hundred copies of the 959 for the road as sport and luxury models, but that barely had begun. Coincidentally, the FIA revised its Group B regulations, rendering the cars less viable as road racers. Porsche then rewrote its assembly plans for the 959, stopping at some twenty or so sport versions and ending its planned racing program. Nonetheless, Porsche entered the Typ 961 in the IMSA GTX class, first introduced in 1978 as a more tolerant group for turbocharged silhouette cars defined by the FIA as Group 5. Most often these were Kremer-variation 935s, and those cars took the GTX championships from 1979 through 1982.

For the Typ 961, Porsche started with a pilot production 959, widened it 1.97 inches to meet regulations, lowered it 0.4 inches for better handling, and perforated the nose with additional holes to ventilate brakes, turbos, engine oil coolers, cylinder heads, and the intercoolers. Weight limits allowed Weissach's competition department to pare 772 pounds from the car, though it still weighed 2,535 pounds without driver or fuel despite its paper-thin fiberglass bodywork.

Under its rear deck lid, the Typ 961 engine (with water-cooled four-valve heads) displaced 2,849cc, and at 3.25 bar boost, it produced 640 horsepower at 7,800 rpm and 456 pounds-feet of torque at 5,000 rpm. Aerodynamic improvements and substantial power pushed the car to 205 miles per hour along Mulsanne. The 961 was the lone IMSA GTX entry at Le Mans; it joined a starting field of fifty cars and finished seventh overall. Porsche ran the car again at the IMSA season finale, a six-hour event at Daytona, but the banking proved too hard on the tires and the car retired.

At Le Mans in 1987, Porsche entered the 961 as an IMSA GTP car, but it was an ill-fated run; one of its drivers spun and crashed backward into the Armco. Bodywork shards clogged a turbocharger exhaust. The driver escaped, but the car caught fire and was destroyed. This was the last of the all-wheel-drive entries at Le Mans or in the WEC until the arrival of the hybrids in the 2010s.

Chapter Nine

OTHER **OPTIONS**, OPEN WHEELS

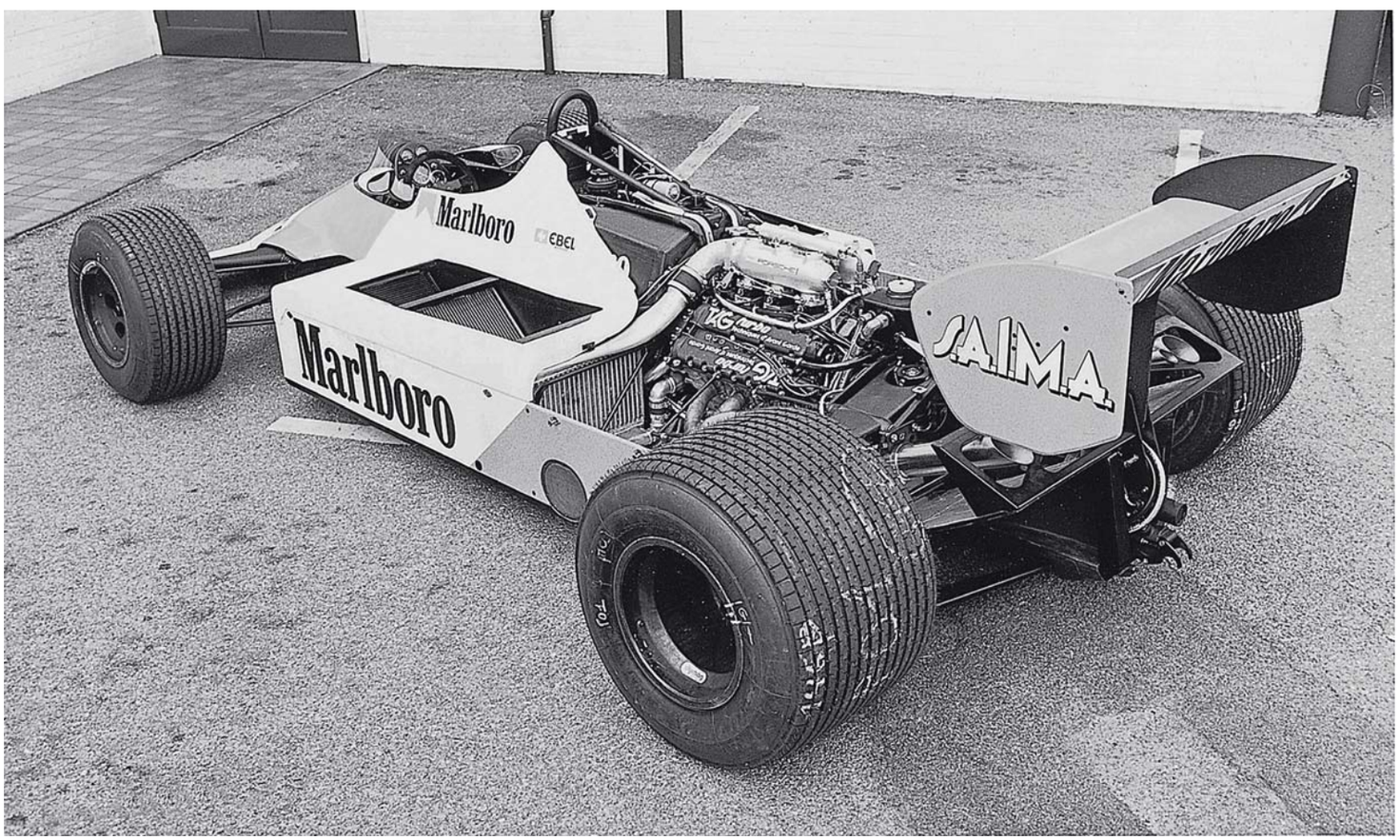
During February 1984 testing, driver Alain Prost had about 750 horsepower at his disposal at 12,000 rpm using 3.2 bar of boost. He and teammate Niki Lauda won twelve of the sixteen Formula One races that year. *Porsche Archive*

1983–1988 McLAREN TAG TTE-PO1 (INTERNAL PROJECT NUMBER 2623)

In Formula One, Renault drew first blood in 1977 with its turbocharged RS01. By midseason 1979, the carmaker's engineers had extracted more than 600 horsepower at 11,000 rpm from 1.5 liters at 3 bar boost. This provided Renault drivers a substantial margin over what the 3-liter normally aspirated engines were producing. Every F1 team began turbo development programs.

The teams running the normally aspirated DOHC four-valve V-8 Cosworth DFV engines saved the weight of the turbocharging hardware and kept their cars close to the 1,190-pound weight minimum. But after Renault replaced its heavy cast-iron block with a new aluminum one in the RE40 for 1983, it had the weight at the limit and turbocharging was no longer an advantage but a necessity. Ferrari had embraced turbos in 1982 and Brabham introduced turbocharged BMW inline fours the same year. The world championship went to a Cosworth in 1981, but Ferrari's 1.5-liter turbo V-6 won in 1982.

McLaren managing director Ron Dennis and chief designer John Barnard had introduced their carbon-fiber monocoque MP4/1 chassis with a Cosworth V-8 for the 1981 season. They approached Porsche in August that year to learn whether the company had or could make an engine that would win Formula One races. That September, Mezger answered them with a V-6 proposal needing a six-month design window.



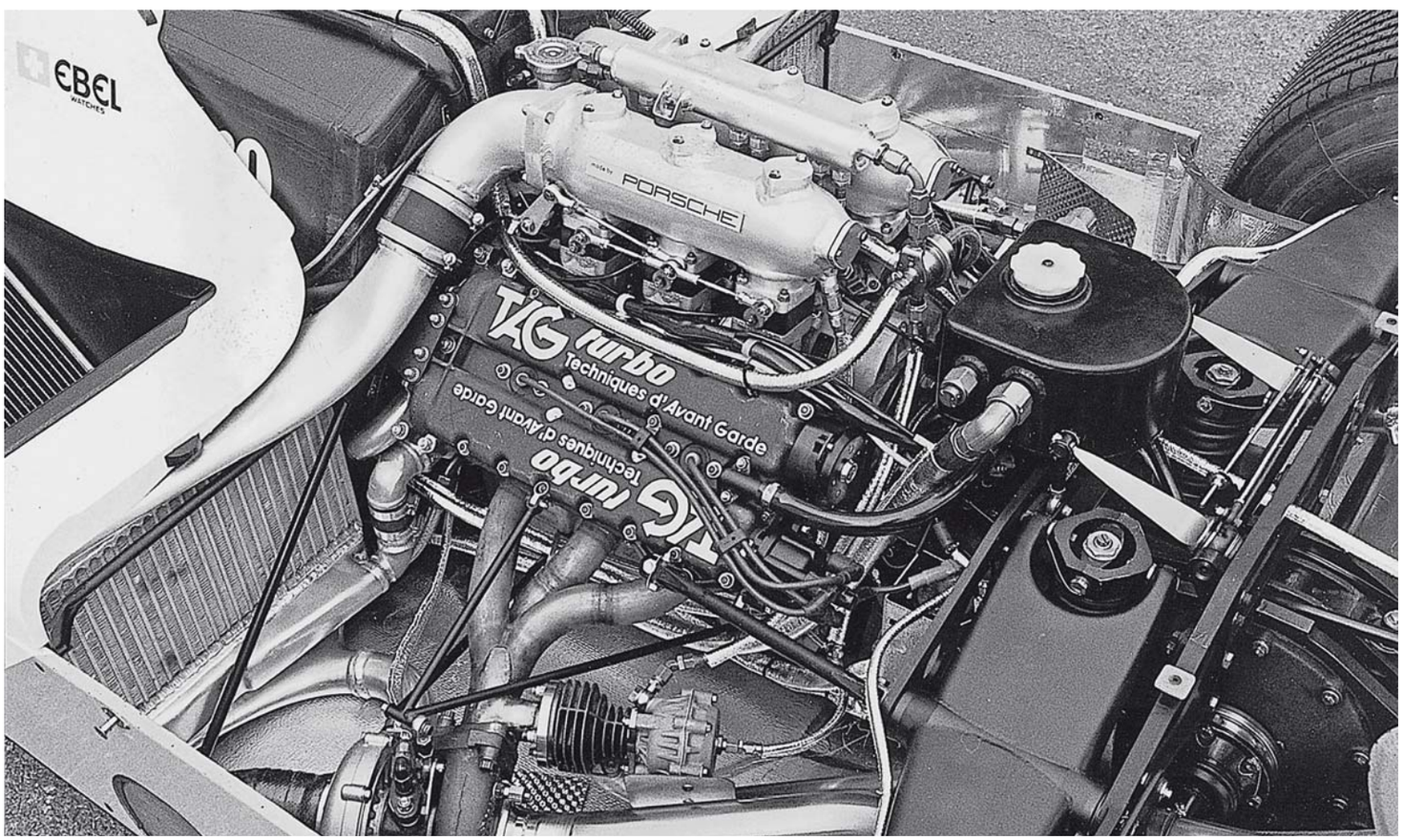
Following rigorous testing in June and July 1983 at Weissach and Silverstone in England, the McLaren car configuration was well enough set for this photo opportunity. A month later the car debuted at Zandvoort in the Netherlands with about 630 horsepower available. *Porsche Archive*

McLaren wanted it sooner for testing, and they also proposed Porsche absorb half the project costs in exchange for putting its name on the engine. Porsche's supervisory board demurred; board members were happy for Weissach to undertake the project, but McLaren had to pay.

At that point, Mansour Ojjeh, CEO of Techniques d'Avant Garde (TAG) who sponsored Frank Williams' F1 team, joined McLaren as a 60 percent partner. Within days, McLaren announced it had contracted Porsche to develop a 1,500cc turbocharged V-6 engine, expected to run in late 1982 and begin racing in the 1983 season. (According to F1 historian Alan Henry, Ojjeh offered the engine to Williams' team as well. "But Frank and [his chief designer] Patrick Head knew as well as Dennis that an exclusive turbo engine deal would become an absolute top priority over the next few years," Henry wrote in his book *The Turbo Years*. Williams went to Honda.)

With Valentin Schäffer working with Norbert Singer on the Group C 956s, Mezger and his design and engineering teams started on the F1 engine. Barnard had very clear ideas about it and how it fit into his ground-effects chassis. Mezger designed an 80-degree V-6 whose block and cylinder heads fit within a 2-foot cube. They secured the Nikasil (nickel-silicon) wet cylinder liners into cylinder walls with a flange at the top, sealed with metal rings. Aluminum heads incorporated two overhead camshafts that opened twin intake and exhaust valves at inclined angles. A Bosch Motronic MP1.2 system (as Schäffer used on the 956 engine) handled all engine management. The engine displaced 1,499cc. Development hurried through 1982, and the first engine ran on Weissach dynamometers in October that year. A completely dressed engine (with two KKK turbos, intercoolers, and all other ancillary pieces) ran December 18, and Mezger and Bott were pleased that it reached the target they had set of 600 horsepower. But that just was the starting point, and when the car debuted at the Dutch Grand Prix in late August 1983, its qualifying output at 2.5 bar boost was about 630 horsepower at 11,500 rpm. This put the burden back on Barnard; his MP4/1E interim chassis was configured for the Cosworth, which produced about 535 horsepower, so the car ran faster than its aerodynamics could handle, and in the race it ran out of brakes. By the season end at Kyalami, every part of the car had advanced and the Porsche TAG engine was producing 700 horsepower at 12,000 rpm on 3 bar of boost. For McLaren and Porsche, the 1984 racing season looked promising.

According to racing historian Ian Bamsey in his book *A History of the Turbo Charged Racing Car*, Porsche started the 1984 season using doctored avgas. "Running 3.2 bar absolute," he wrote," the race power of the Porsche engine had increased to a quoted 750 horsepower at 12,000 rpm with a maximum torque of 466 Nm (344 lb-ft)." The FIA had instigated a crippling fuel limitation: 58.1 gallons for a race with no fuel stops. It challenged every team to push peak efficiency, running, as Bamsey explained, "right on the verge of detonation without actually suffering piston crown or turbine wheel meltdown." At the season's end, the Porsche engine was a success in the hands of drivers Niki Lauda and Alain Prost. The McLaren team won twelve of the sixteen F1 races in 1984.

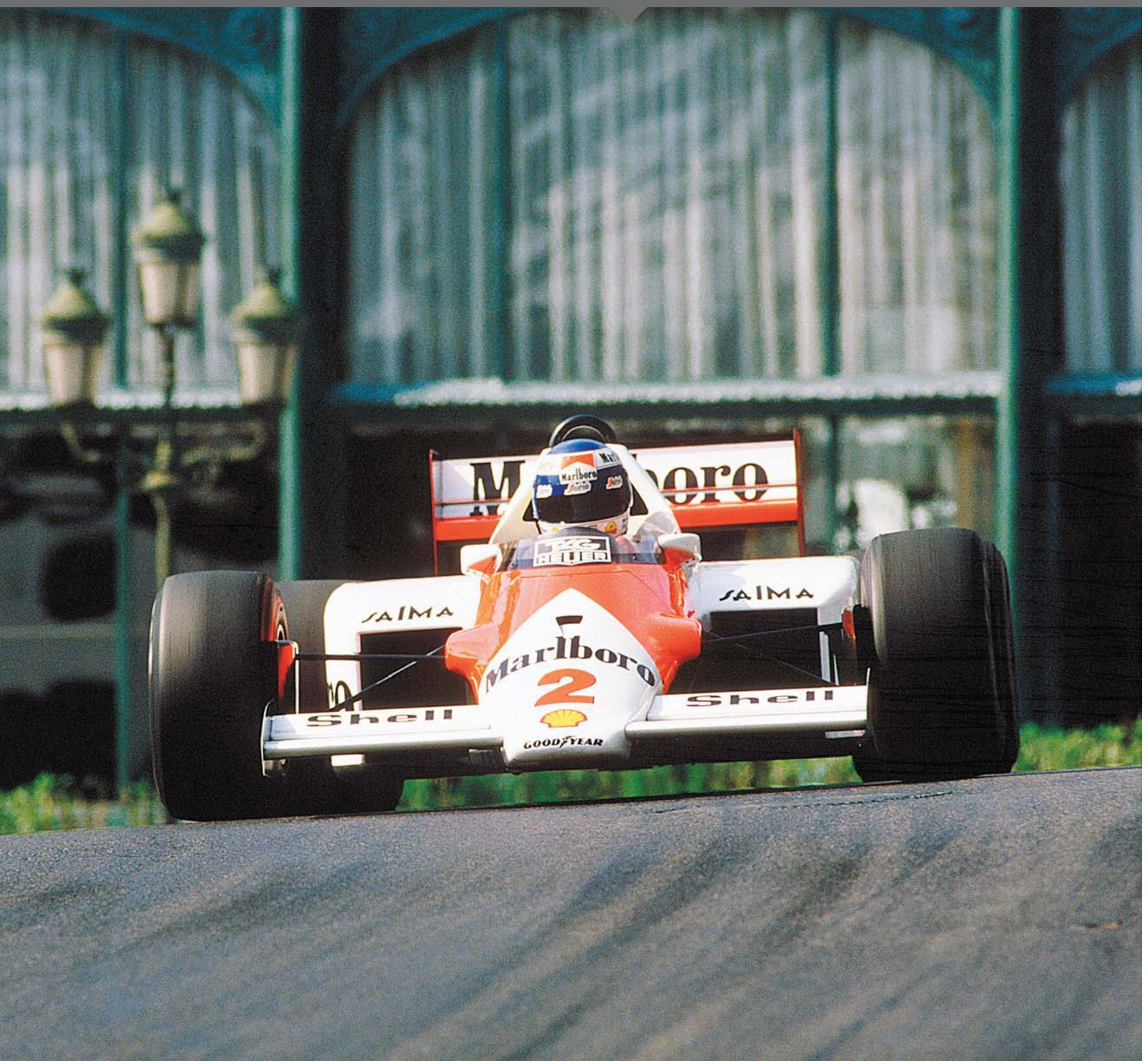


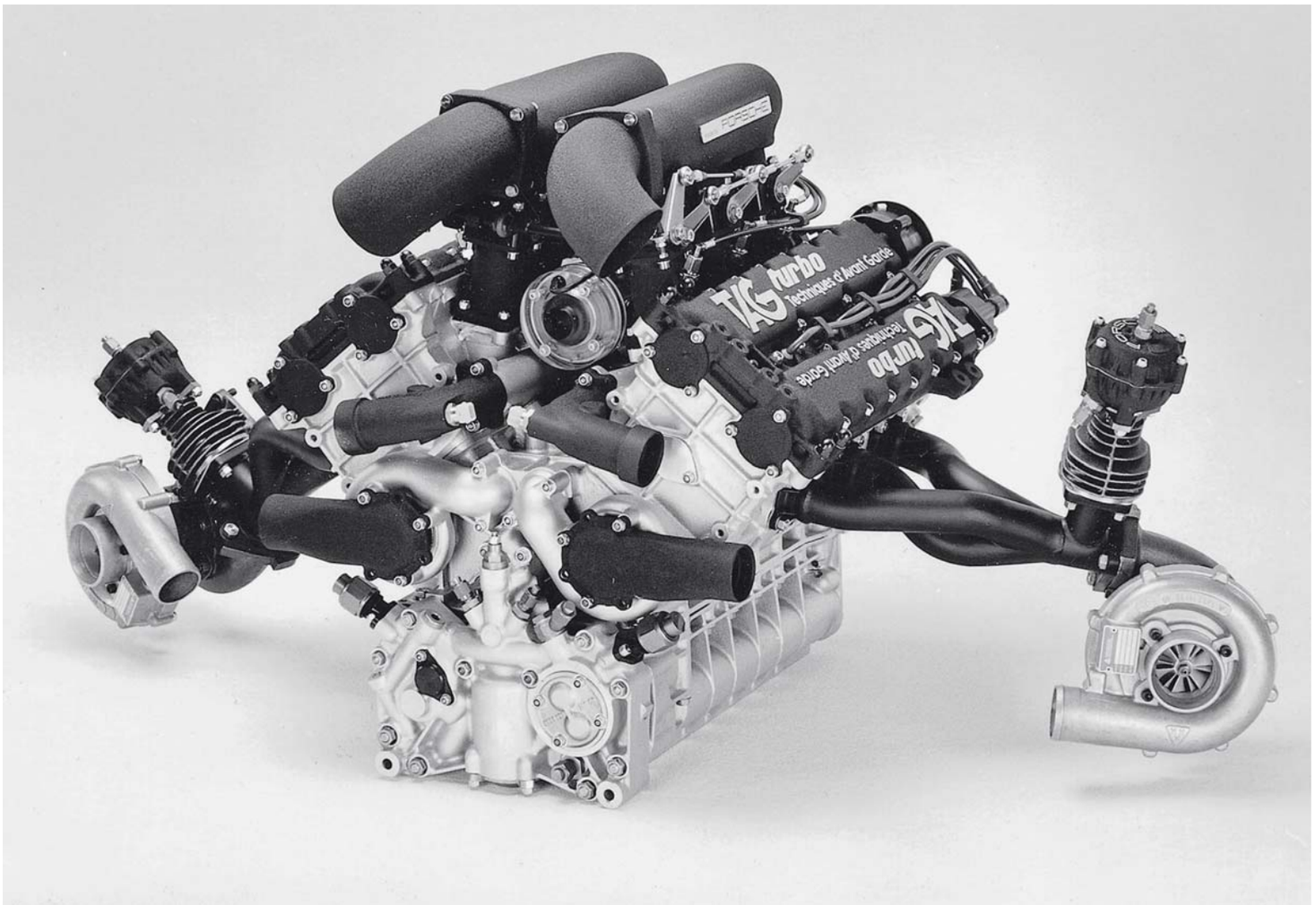
The *Techniques d'Avant Garde* twin-turbo engine P01 displaced 1,499cc, with bore and stroke of 82 x 47.3 millimeters. In this July 1983 configuration, it developed around 630 horsepower at 11,500 rpm. *Porsche Archive*

The French Grand Prix at Dijon-Prenois on May 20, 1984, saw Niki Lauda start ninth on the grid. By the end of the seventy-nine-lap race, he had won. *Porsche Archive*

Driver Keke Rosberg teamed with Alain Prost for McLaren's 1986 season but experienced more frustration. His best finish was second place at Monaco. By this time, the TTE P01 developed more than 850 horsepower at racing boost of 3.3 bar. *Porsche Archive*

Fully assembled, the engine weighed just 330 pounds (without turbos). Air cooled the aluminum/magnesium alloy crankcase, however, designer Hans Mezger relied on water cooling for his four-valve aluminum alloy cylinder heads. *Porsche Archive*





For 1985, KKK produced pairs of "mirror image" turbos that simplified engine manifolds, improved fuel flow to the right side of the engine, and narrowed the overall width of the engine package. This allowed for improved aerodynamics as well. While McLaren started the year using its 1984 blend of 40 percent avgas/60 percent pump fuel, in mid-1985 Shell introduced a more sophisticated, denser toluene-based fuel and the Porsche engine increased output to 800 horsepower at 3.3 bar for races and as much as 890 for qualifying bursts. McLaren and Prost claimed the championship titles in 1985.

The 1986 season saw output at 850 horsepower at 12,800 rpm using 3.3 bar boost. But this no longer was enough. BMW's inline four was the power leader during 1986, and with no limits on boost, reports surfaced of its engines topping 1,000 horsepower for qualifying. The nickname for these engines was "grenades," not only because they only were good for the duration of a qualifying session but also because their power band ran between 8,500 and 11,000 rpm with, as Bamsey reported, "its output virtually tripling from 6,500 rpm!" At Monza, he continued, engineers "saw a 5.5 bar flash reading—[Swiss engine developer Heini] Mader estimated that was worth over 1,300 horsepower."

Frank Williams' decision to go with Honda was proving a good idea, and its twin-turbo V-6 was second in power output for the entire season behind BMW. At season end, the Hondas had won nine of the sixteen races while Porsche had claimed only four. McLaren's Alain Prost narrowly held onto his world driving championship, giving the Porsche-powered cars a title by association.

The 1987 racing year began to see the TAG/Porsche engine's success unraveling. John Barnard left McLaren to join Ferrari, and new FIA regulations limited turbo boost to 4 bar, enforced by the addition of an Indianapolis-style pop-off valve that bled off excess boost beyond the limit. Mezger's engine ran 8:1 compression, and at 13,000 rpm (and 3.5 bar boost for races), output reached 900 horsepower. A dynamometer test performed in mid-February 1987 recorded peak output at 1,025 horsepower at 11,750 rpm with 3.3 bar boost. In order to withstand the higher compression, Mezger went to slightly heavier pistons, connecting rods, and pins.

As a coda to the story, Horst Marchart, former board member for research and development at Weissach, recalled in an interview in June 2012 that as Ron Dennis sought to recoup McLaren's and Mansour Ojjeh's investment in the engine, Dennis proposed using it in other Porsche vehicles. Racing engineers tested one in a 956. While its total power output

Porsche unveiled its future Indy car racer at the Frankfurt Auto Show in September 1987. At this point, the sponsorship with Quaker State Oil was not signed yet. *Porsche Archive*

In the racing shop, engineers and body assemblers began test fitting components to a full-scale wood model in late 1985. This allowed them time to plan placement and routing of hundreds of elements of the race car. *Porsche Archive*

compared favorably with the 935-derived engine they were using, the 1.5-liter GP engine reached its peaks in a narrow band of very high engine speeds, making it impractical for endurance racing with occasional hairpin turns. Porsche also tested the engine in some G-series prototypes. "One-point-five liter in that time was not possible," Marchart explained. "You have no torque. You need a ten-speed gearbox to make the engine work. Not possible. If you have to have a turbocharger *and* a compressor, you can drive. But at the time nobody had the idea to take both in one car."

1987–1990 TYP 2708 (INDY PROGRAM NUMBER 2708)

Cosworth was the exclusive engine provider for all of CART's Indy car teams. That relaxed in the mid-1980s. Honda arrived, and then Mario Illien, formerly with Cosworth, teamed with Paul Morgan to form Ilmor Engineering with the goal of producing a new Indy engine. Their backer, Roger Penske, brought in General Motors, and the Ilmor became the Chevrolet Indy V-8. There also was an engine from John Judd, and then Porsche initiated its own Indy Car engine program.

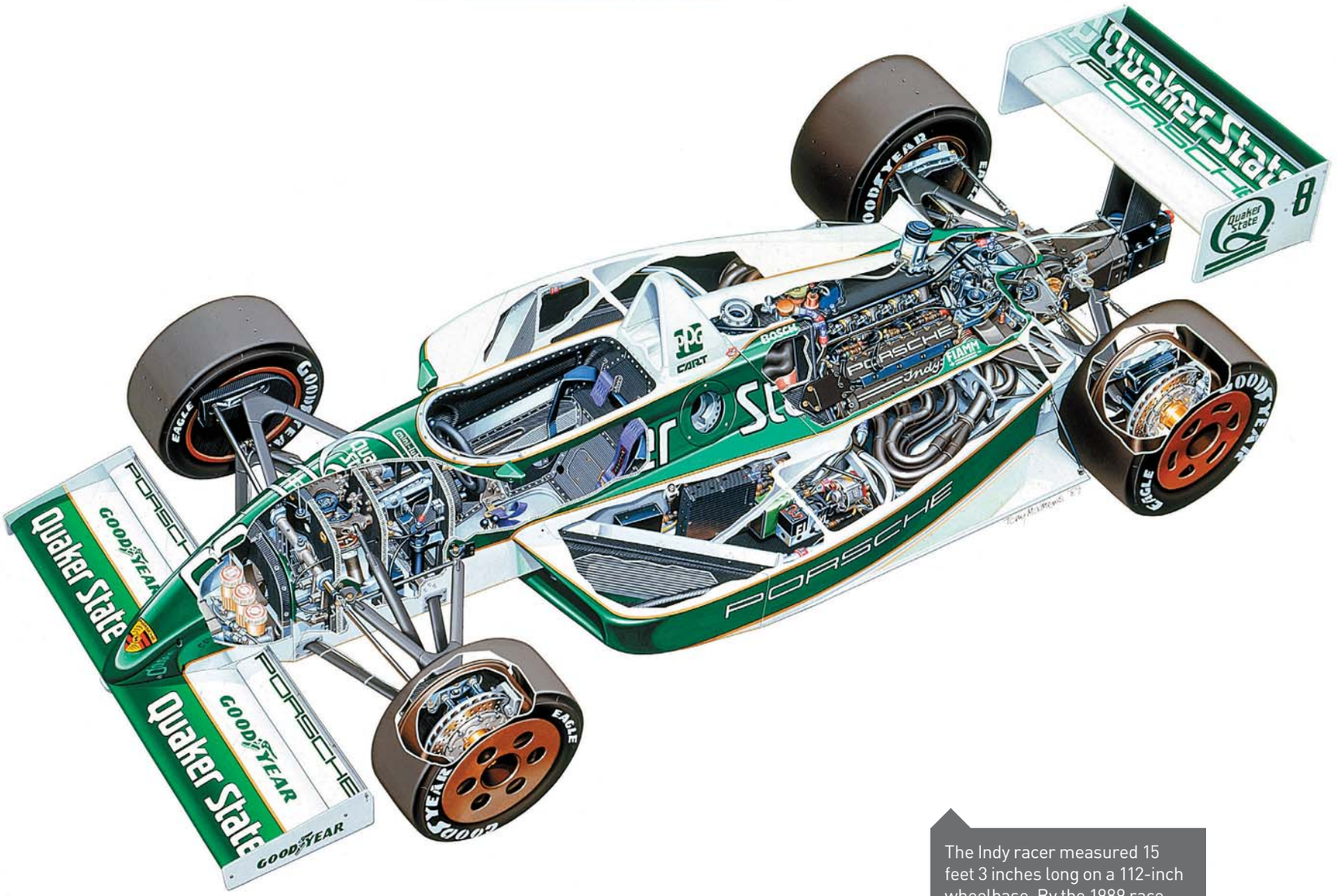
With Porsche feeling secure in F1 and Group C development nearing an end, CEO Peter Schutz proposed Porsche enter the American series. Bott named Norbert Singer project manager of program 2708, launched in November 1985. In December 1986, Hans Mezger fired up the first of the single turbo 2,649cc water-cooled cylinder head dual overhead camshaft, four-valve V-8s. The engine developed around 733 horsepower at 11,000 rpm with 336 pounds-feet torque at 9,000 rpm.

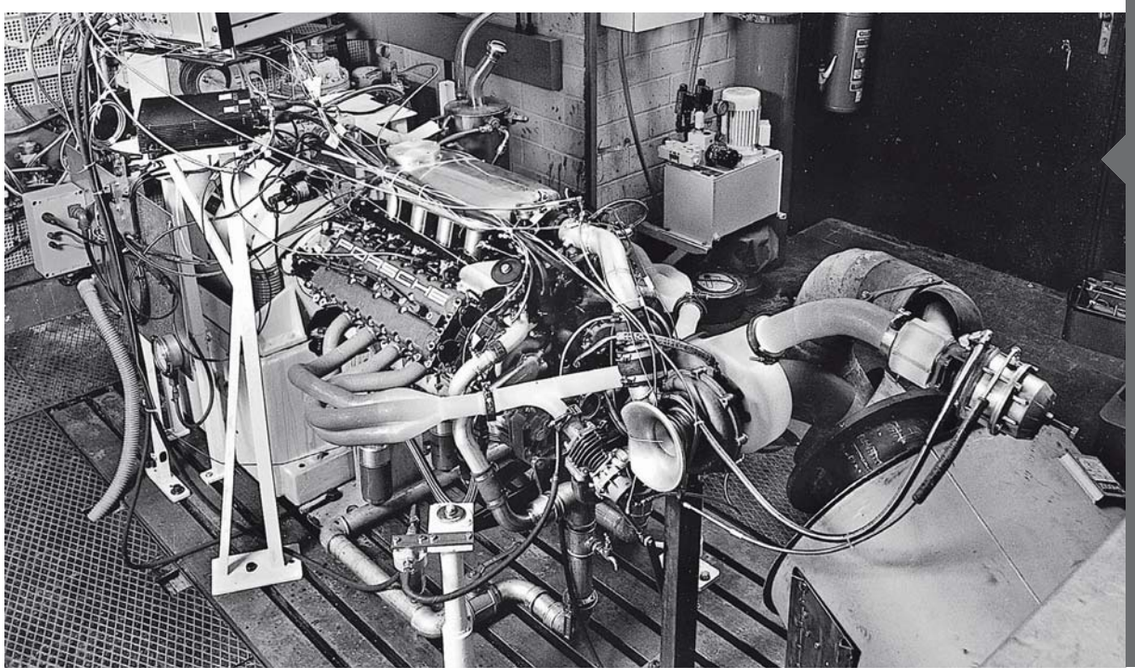
Eight months later, in August 1987, Singer's first monocoque chassis arrived at Weissach from MBB, their outside supplier in Munich. By this time Mezger's staff had 750 horsepower from the V-8. Singer and Eugen Kolb created two versions of the body, one for oval circuits, the other for road courses.

CART rules limited fuel capacity to 40 gallons of methanol. With lower volatility than gasoline, methanol was less fuel efficient; its consumption over a given distance was about twice as high as gasoline. CART's regulations ensured pit stops during a race that provided for spectator excitement not only in the pits but also by causing lead changes, unlike F1's nonstop sprints.

Porsche inaugurated the race car in the final two venues of the 1987 season. With insufficient testing before its first truncated season, the car finished neither outing. Through the winter, Singer and his engineers reworked everything from front to rear. To benchmark their testing, he acquired a March 87C chassis and installed a Porsche engine in it, on the suggestion of North American team manager Al Holbert. But then events and personalities far from Singer's control began to affect the program. As the value of the dollar rose against the deutsch mark, sales fell and the supervisory board released Peter Schutz from his contract. Former finance director Heinrich Branitzki stepped in, and the costs of a racing program in a distant market received closer scrutiny.

In the United States, Holbert's organization convinced Bott to go with the March chassis and put aside its own efforts, although Singer continued parallel development. But after a single day of a testing, Holbert unilaterally dismissed the Weissach chassis and sent the Porsche-engined March to the first race





The Indy racer measured 15 feet 3 inches long on a 112-inch wheelbase. By the 1989 race season, the 2708/81 engine developed 733 horsepower at 11,000 rpm. The car weighed 1,552 pounds. *Porsche Archive*

The 2,649cc 90-degree Typ 2708/81 V-8 first fired on the dynamometer on December 11, 1986. It immediately achieved its expected 700 horsepower using the mandatory maximum boost of 0.6 bar permitted by the sanctioning body Championship Auto Racing Teams (CART). *Porsche Archive*

Porsche team driver Teo Fabi qualified at 215.56 miles per hour, putting him on the inside of the fifth row for the start of the Indianapolis 500 on May 28, 1989. On the twenty-second lap of the race, a valve spring failed, retiring the car. *Porsche Archive*

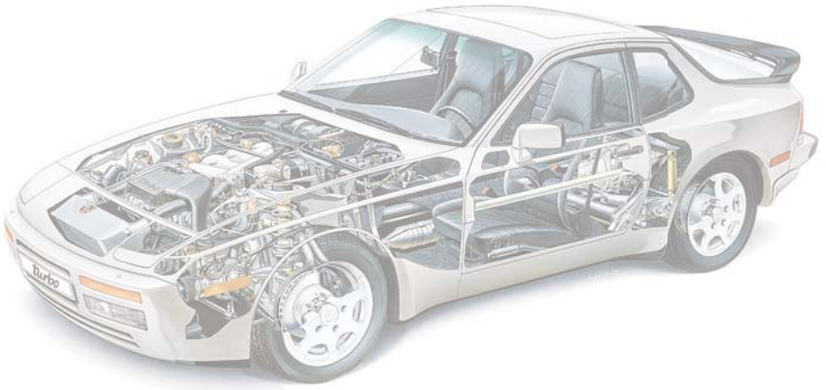
and every one thereafter. Holbert recruited Derrick Walker to run the program, and the 2708 struggled through the season. The team's best result in 1988 was a fourth in Pennsylvania; six times it failed to finish. In some ways, this was a typical development season. But then, in September 1988, Al Holbert died in a light airplane crash. A month later, Helmuth Bott took early retirement.

On one level, the choice of the March made sense. As Singer learned in his wind-tunnel tests, it had the strongest downforce. His Porsche chassis was next, and the other competitor Lola was third. But, according to Singer, March and Porsche downforce was strongest at the front and rear wings, where the Lola exhibited the best stick below its center of gravity. This made the Lola more stable, a point Singer tried to make to others.

"The March was developed in England, the racing team was in America, and engine work was done here in Weissach," he explained in an interview in 2005. "Coordinating these activities was very, *very* difficult. "In fact, I think it was the major problem that nobody understood." The Lola chassis won the constructors championship in 1988.

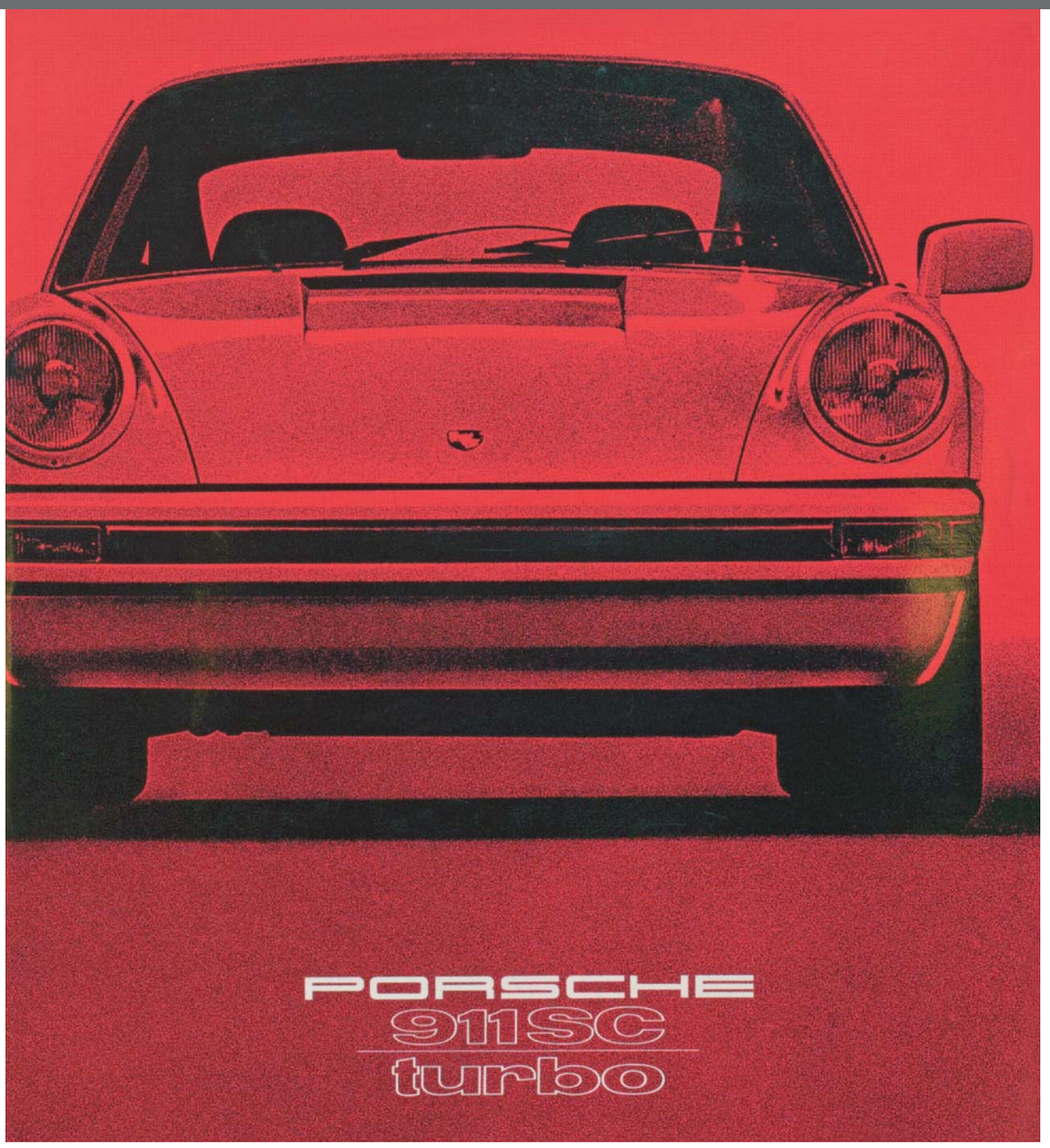
Yet the overall performance in 1989 improved greatly. The North American team won the twelfth round outright, came second twice, notched up a third place, and had five fourth place finishes to finish fourth in the annual standings. It reinvigorated efforts for the next year.

With Derrick Walker in charge, the team ran two cars for 1990. Hope in Weissach, in Zuffenhausen, and on the supervisory board was for an even better year and a victory at the Indy 500—the point of this entire exercise. Instead, the March 90P chassis proved more difficult to handle and the two entries did not even finish at Indy. The best overall performance of the season was a third place, which sealed its fate. Ulrich Bez had returned to Porsche in late 1988 to fill Helmuth Bott's role as head of Weissach. Bez reenergized the Group C efforts by providing support for Reinhold Jöst with 962C models. Then, he made it clear that if Porsche went open-wheel racing, it was better done on its home continent. He ended the turbocharged Indy Car program at the middle of the 1990 season, letting the cars run to the last painful finishes.



Chapter Ten

ROAD-GOING **INNOVATION:**
THE LATE 1970s TO LATE 1980s



911 TURBOS AND SPECIAL WISHES

In 1980, Ernst Fuhrmann told Ferry Porsche that with 924 and 928 models in steady production and the 911 scheduled to end manufacture in 1982, he felt it was time to develop a new model. He had turned sixty-one the previous October and he did not want to stay past a possible retirement date to complete a new car, but he also didn't feel it was sensible to launch a project, step away, and let his successor pick up a work in progress. He told Ferry he would leave when the company had found his successor.

That man was Peter Schutz, who arrived and reversed the 911's fate. He reallocated budgets toward the car and, in a dramatic unveiling of Porsche's plans for it, the automaker exhibited an all-wheel-drive, turbocharged cabriolet at the September 1981 Frankfurt Auto Show. As described in Chapter 4, the turbo hardware on the show car was just wooden mock-up pieces painted to look like metal. But it reignited excitement among 911 enthusiasts.

For the 1978, production engine chief Paul Hensler's team of engineers had increased turbo engine displacement from 2,993cc to 3,299cc. Horsepower rose from 260 to 300 at 5,500 rpm for European models and 255 horsepower for US versions. Torque increased from 254 pounds-feet to 304 at 4,000 rpm. Specifications did not change through 1982, although strict emissions regulations forced Porsche to discontinue 930 Turbo sales in US and Canadian markets starting in the 1981 model year.

With an all-red sales brochure cover, it was hard to discern the subtle styling changes for 1979. 911SC models received body-color headlight trim rings and Turbo models gained green-tinted glass all around as standard equipment. *Porsche Archive*

Peter Schutz's arrival as Porsche chairman re-energized the 911. To emphasize company plans to continue the model, they created this concept car, or *Studie*, that introduced an all-wheel-drive cabriolet on a Turbo chassis. *Randy Leffingwell*

This inspired outside shops to modify nonlegal European performance cars to meet US emissions and crash-safety standards. This "gray market," so nicknamed for its ability to blend otherwise black-and-white regulations, first appeared in Europe in 1977. It appealed to North American customers who knew the European Turbos delivered more power than Americans and Canadians got because of US unleaded fuels, catalytic converters, air pumps, and exhaust-gas recirculation systems. Porsche met these standards in normally aspirated 911s; the 930 variations simply couldn't cope. However, dozens of aftermarket converters claimed they could do the work. Some did, but others simply took the money and performed minimal and marginal work.

Inside Porsche, a program that engineer Rolf Sprenger was running already had undertaken other conversions. Sprenger had brought fuel injection to the 911 engines before taking over customer service in Werks I. Soon after he started, Ferry Porsche called him into his office just above the service bays.

"Listen, Mr. Sprenger," Ferry said to him, "I want your people to understand that whenever a Porsche customer comes to Zuffenhausen with a technical problem or a special wish, you shall help and solve the problem." It didn't take long before Sprenger heard those wishes from his customers. More ideas soon crossed his mind.

In the mid-1970s, an outside design firm applied a rainbow-like paint scheme to a silver 911 Targa. They did some engine enhancement and interior modification, and the car appeared on the covers of Germany's most popular auto magazines.

"I thought, what these guys can do with our car, we can do better at the factory," Sprenger said. "Customer service had all the workshops in those days, engine, bodywork, paint, chassis, and interior. We could *rebuild* an entire car, so we also could build one. We could take a body shell from production and an engine which we modified, and build up a unique car."

Sprenger brainstormed with his department heads, imagining what they could offer, he recalled. "We called it [the] Special Wishes Programme," he said. With no budget, they had no brochure, just a few typed pages and a list of a couple of dozen things they could do.

The inside pages from the 911 series sales brochure emphasized the more aggressive body shape of the Turbo model over the 911SC version. Turbos kept the headlight washer "snorkels" while the SC introduced new flush-mount nozzles. *Porsche Archive*

Red again was the brochure cover color of choice. The cross-grid background with the section lines blended into the photo enforced the impression that these were technical cars. *Porsche Archive*

Porsche 911 SC: der erfolgreiche Sportwagen-Klassiker

Nach einer erneuten Leistungssteigerung präsentiert sich der Porsche 911 SC heute mit 150 kW (204 PS) aus drei Litern (2994 cm³) Hubraum.

Mit dieser Leistung beschleunigt der Wagen aus dem Stand in nur 6,8 Sekunden auf 100 km/h und läuft 235 km/h Höchstgeschwindigkeit. Doch nicht allein der absoluten Spitzendaten willen erreicht der 911 SC derart imponierende Fahrleistungen; sie sind eigentlich nur »Zugabe«, Nebenprodukt des angestrebten Komfort-Ziels: mehr Elastizität, mehr Durchzugsvermögen aus niedrigen und mittleren Drehzahlen für müheloses, unangestrengtes Einfädeln und Überholen.

In den breiten hinteren Kotflügeln übertragen Hochgeschwindigkeitsreifen der Dimension 215/60 VR 15 die jeweils eingesetzte Leistung sicher auf den Boden, vorn rollt der 911 SC serienmäßig auf 185/70 VR 15-Reifen.

Auf Wunsch sind auch die superbreiten Serie-50-Reifen des 911 Turbo für den 911 SC erhältlich: vorn 205/55 VR 16, hinten 225/50 VR 16 auf geschmiedeten 6- bzw. 7 x 16 Zoll großen Leichtmetallfelgen.

Sicherheitsstoßstangen, die sich je nach Ausführung über leicht austauschbare Deformationselemente oder hydraulische Prallämpfer an den Fahrzeuglängsträgern abstützen, fügen sich mit einer Faltenbalg-Abdeckung harmonisch in die Fahrzeugkontur ein und verhindern bei Kollisionen bis 8 km/h Schäden an der Karosserie.

Porsche 911 Turbo: vielfacher Markenweltmeister in Straßen-Version

Im 911 Turbo realisiert sich die höchste heute erreichbare Stufe des Sportwagenfahrens. Als direktes Pendant zum Porsche 935, dem auf der Piste so erfolgreichen mehrmaligen Markenweltmeister, bietet der Turbo die exzellente Kombination aus kultivierter, straßentauglicher Rennwagentechnik und alltagstauglichem Komfort.

Ebenso wirksam wie im Sporteinsatz wird im Serien-Turbo die vom Abgasdruck komprimierte Ladeluft gekühlt – für einen noch besseren Zylinder-Füllungsgrad, die phantastische Leistung von 221 kW (300 PS) aus 3,3 Litern Hubraum, die besten Beschleunigungszeiten der gesamten Sportwagenelite bis 200 km/h und eine Endgeschwindigkeit von 260 km/h.

Bei derartigem Tempo kommt der aerodynamischen Gestaltung der Turbo-Karosserie fundamentale Bedeutung zu.

Die Bug-Schürze und der große Heckspoiler mit integriertem Ladeluftkühler und hochgestelltem Rand reduzieren die Auftriebskräfte um nahezu 100%.

Das Resultat: ein stabiler Geradeauslauf, verbesserte Bremsund Lenkeigenschaften sowie tadelloses Kurven- und Seitenwindverhalten vermitteln das Sportwagen-Erlebnis in reinster Form.


911 SC · 911 Turbo
PORSCHE

PORSCHE Sonderwunschprogramm

From humble beginnings with its options typed on a simple sheet of Porsche stationery, Special Wishes graduated to a full-color brochure promoting its offerings by 1985. The full *Flachbau*, or flat body kit, illustrated here added DM 77,330 (about $35,635 at the time) to the cost of the car. *Porsche Archive*

Sonderwunsch—Porsche Special Wishes department introduced the flat nose option in 1983, which also provided these air intakes on the rear fenders. Special Wishes offered them for 930 Turbo models and for normally aspirated 3.2 Carreras. *Porsche Archive*

"We had very grateful customers," he said. "And they told others about us. Our first motive was to help the customer and these people wanted something unique. They were patient—cars took four, six, even twelve weeks longer, and the options were costly. Yet, the customers told them, "That's all right, don't worry. Because now I'll get the car I want,'" Sprenger added.

Special Wishes arrived about the same time the first Turbos appeared on the market, but Sprenger remembers that perhaps only 30 to 40 percent of customers owned Turbo cars. Through all this, Porsche's Special Wishes accommodated ever more inventive requests. Then came a pivotal challenge.

In early 1982, while Turbos still were unavailable for US buyers, the market worldwide was growing. Special clients ordered cars that pushed and excited Sprenger's staff. Racing sponsor Mansour Ojjeh, who had funded most of the development costs of the Porsche TAG Formula One engine and racing efforts, asked for a 935.

"This was not possible to do because it was not legalized for the road in Germany," Sprenger explained. "He wanted to have this car registered in France. We decided if we cannot get a real 935 and modify it for the road, we better take a production Turbo and modify it as much as possible to be a 935. And while the car we did for Mr. Ojjeh was much more than just putting a slant nose on a Turbo, we realized right away that other customers may want to get this shape too."

The Special Wishes option list had graduated to a color brochure with fifty or more options, including a new M505 slant-nose option for the Turbo. Tony Lapine was no fan, accusing Sprenger's department of ruining the lines of the simple 911, and with his animosity to the group's bodywork modifications, Lapine offered Sprenger and his team no official help in designing the Ojjeh flat nose. "So it was mostly done by us, my assistant Elmar Willrett, and the supervisor of the body shop, and the head of body trim. We just tried it. Then when it came out, we looked at it and realized we had to modify it, improve it," Sprenger said.

The Special Wishes department was well-known for its leather craftsmen. Leather was available in any color imaginable. *Porsche Archive*

Not every one of Rolf Sprenger's customers wanted or needed the turbocharged power. His department assembled a significant number of normally aspirated "Turbolook" coupes and cabriolets. *Porsche Archive*

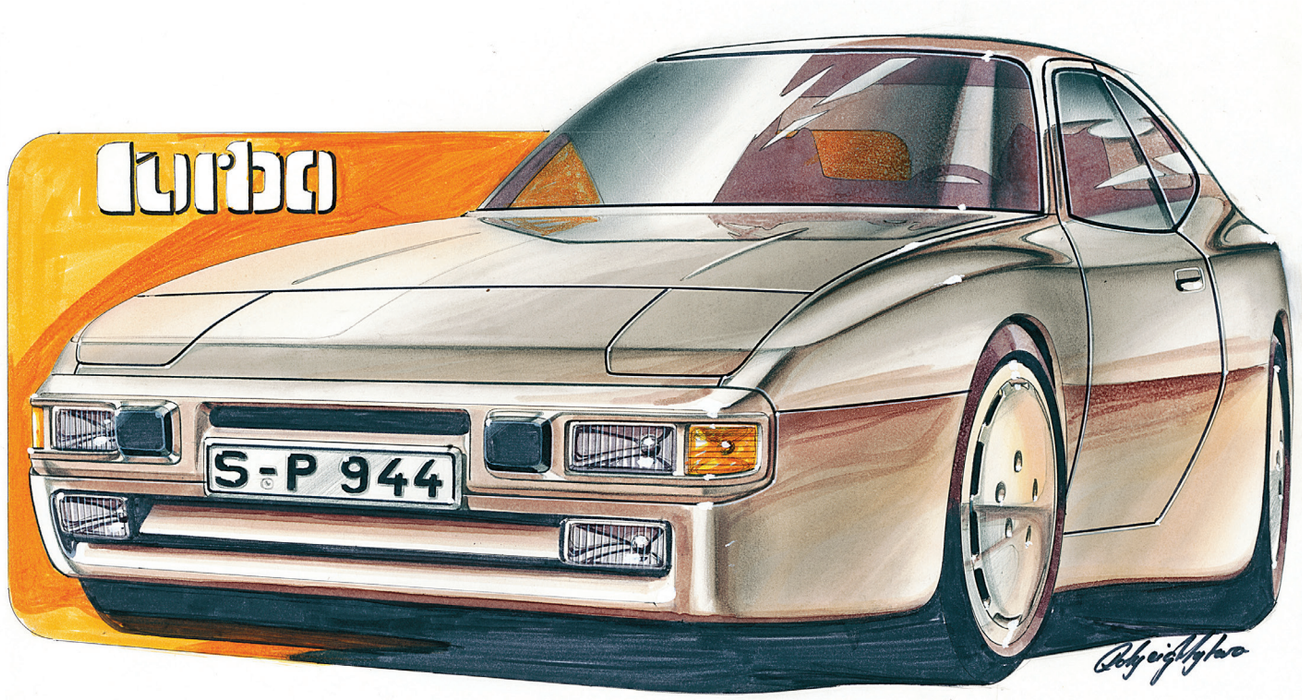
At the time *Techniques d'Avant Garde* was sponsoring the McLaren Formula One engine development, TAG co-founder Mansour Ojjeh asked Special Wishes for a road-going 935 race car. To meet Germany's road-use laws, Rolf Sprenger's staff massively upgraded a series production Typ 930 coupe. *Porsche Archive*

Their first version mounted pairs of rectangular headlights below the front bumper of the steel bodywork, straddling a large oil cooler. But they did very few of those before customers complained that the low lights didn't project far enough and also vibrated badly over rough roads. The series-production 944 was ready for introduction and Special Wishes mounted these pop-up lights higher in the bodywork.

Notwithstanding Lapine's reluctance, Sprenger did get help later from stylist Roland Heiler and model maker Peter Reisinger. Norbert Singer put the M505 in the wind tunnel and emerged with a list of recommendations. In the end, quality improved. Still, the modifications to make a flat nose were only skin deep.

"The frame was always the same," Sprenger explained. "We didn't touch this. We only modified the skin. Remember, the slant nose—and all our major projects—had to pass the US Department of Transportation crash test." Ojjeh's car emerged in early 1983; many European orders followed.

Regular production Turbos for 1983 received a few Bosch K-Jetronic upgrades, and Paul Hensler's engineers rerouted the boost bypass system through a single small silencer. These and a few other subtle changes substantially improved fuel economy (from 15.2 to 19.9 miles per gallon at a steady 75 miles per hour) and increased torque from 304 to 317 pounds-feet at 4,000 rpm. Sprenger's Special Wishes introduced a Turbo performance kit that raised horsepower from 300 to 330 by using a larger KKK turbo, making improvements to the intercooler, and adopting a new four-pipe exhaust. One benefit of the slant nose was a higher top speed for the


turbo
S-P 944


MPH
PORSCHE
Quarz-Zeit
SC

turbo—171 miles per hour compared with 168 for the standard body car. The complete M505 option included a front spoiler with oil cooler, side skirts below the left and right doors, air intakes in the rear fenders, air louvers on top of the front fenders, and the 330-horsepower performance kit.

These upgrades inspired more ideas and more inquiries. Among those were normally aspirated engine customers who wanted the wider wheels and the aggressive look of the Turbo body but did not need the power. For 1984, along with a new 3.2-liter atmospheric engine, customers could order a Turbo-Look body for their 911 Carrera. They gained the Turbo's suspension, superior brakes with four-piston calipers and cross-drilled rotors, and 16-inch forged wheels with lower-profile tires. But it didn't stop there.

"Customers asked if we could do an open Turbo," Sprenger said. "No! We had to tell them the chassis was not strong enough. 'Well, I would pay whatever additional amount of money because I want to buy my wife a nice cabriolet with all the chic features, with all the trim, and of course with a powerful Turbo engine . . .'" Sprenger went to his friends in Weissach and they began a strenuous reinforcement regimen. Ironically, Special Wishes delivered the Turbo- Look Targas and cabriolets for normally aspirated engines starting in 1985, before it was available for the Turbos.

This early 944 Turbo concept carried over much of the normally aspirated front end while opening up more engine air intakes. Series production models introduced in January 1985 picked up much of the horizontal air treatment. *Porsche Archive*

A simple order placed in 1988 became one of Special Wishes' most complex projects, resulting in its distinction as the very last G-series Turbo assembled in 1990. The finished list of options ran more than two dozen pages, including leather-faced gauges, reflecting the potential of the massively modified engine with variable boost. *Randy Leffingwell*

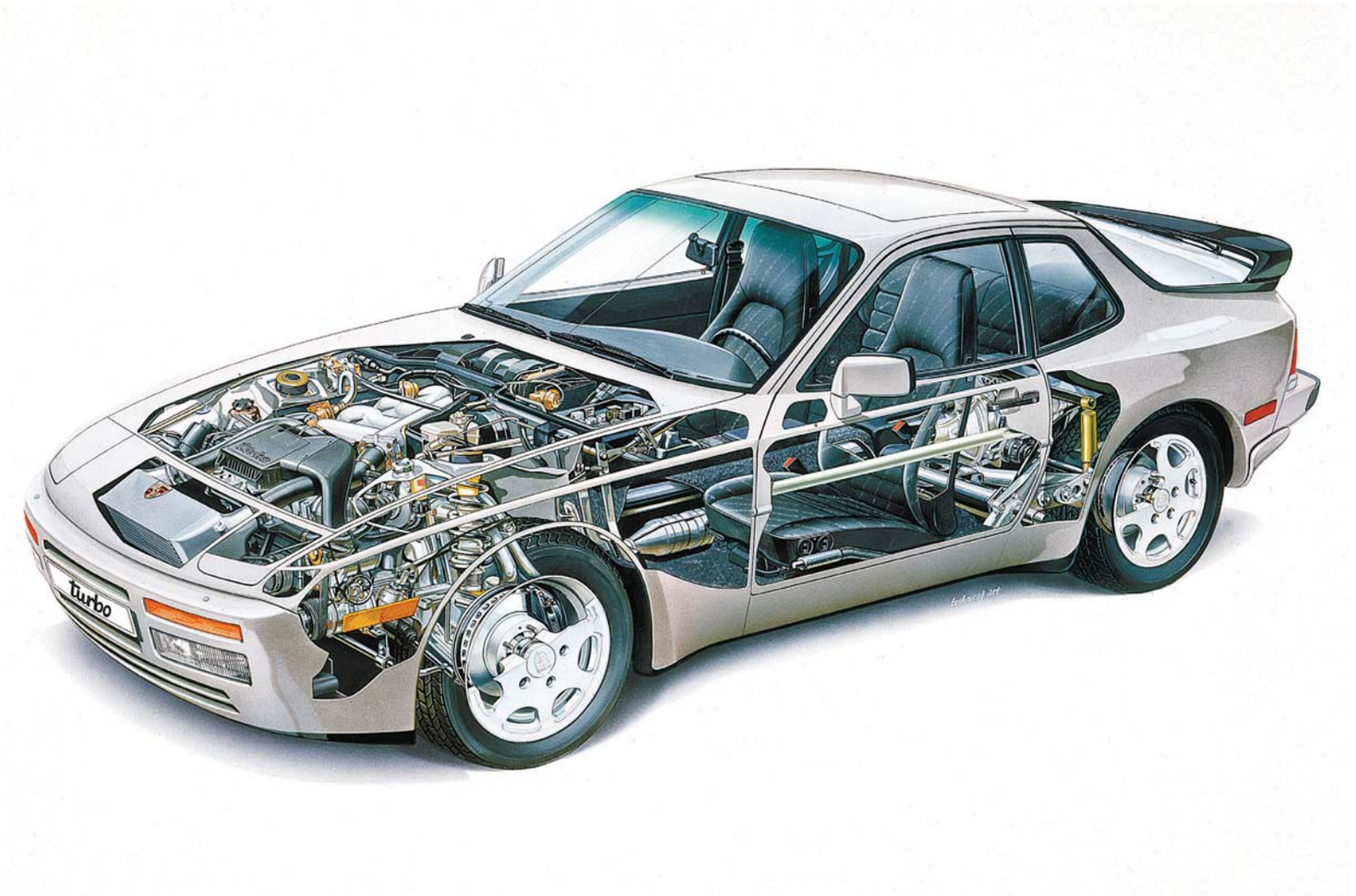
Model year 1986 brought many happy customers back to Porsche's Turbos. Weissach engineers had mastered the catalytic converter to meet US emissions. Other necessary engine hardware reduced engine output to 282 horsepower, but the joy—and ease—of getting a Turbo with a factory warranty doomed the gray-market modifiers. Zuffenhausen accompanied this with introductions of flat-nose variations in the United States as well.

"I was in the States with Peter Schutz and Rudi Noppen, the production director. We released the slant nose. There was a dealer meeting, I think it was in L.A., and I had to explain and show the Turbo slant nose," Sprenger recalled. "Quite a few dealers were very excited. Some of them ordered a couple of these cars right away because they were so different from the production version." In spring 1987, Porsche introduced the Turbo Targa and Cabriolet (which came standard with a power-operated top mechanism).

For 1988, the Turbo remained unchanged, while 1989, the final year of the so-called G-series bodies, brought Turbo owners the long-awaited five-speed transmission and hydraulic clutch on new models. The series drew to a close at the end of 1989 with the introduction of the normally aspirated all-wheel-drive Typ 964 Carrera 4.

According to Porsche historian Marc Bongers, between 1978 and 1989, Turbo production reached 15,852 coupes, of which 948 were slant nose bodies, 297 were Turbo Targas, and 1,642 were cabriolets. Sprenger's *Sonderwunsch* department grew increasingly busy with clientele coming from far beyond Zuffenhausen. This fact presented them with one more consideration.

"After a while," Sprenger admitted with a smile, "we found out that 'Special Wishes,' 'Sonderwunsch'—the word was not good for the global market. Together with sales and marketing people, we said we need a name that everybody worldwide can understand. And so Exclusive was born in 1986."



944 TURBOS

Porsche introduced the 944 in September 1981 to succeed the 924. Its normally aspirated 2,479cc inline Typ M440/01 four-cylinder engine developed 163 horsepower at 5,800 rpm and produced 151 pounds-feet of torque at 3,000 rpm. With a top speed of 137 miles per hour, it reached 62 miles per hour from a standstill in 8.4 seconds. Then in February 1985 the company unveiled the 944 Turbo coupe, improving performance considerably. This was known internally as the Typ 951, with right-hand-drive versions designated Typ 952.

The turbo M44/51 engine, with the same total displacement, delivered 220 horsepower at 5,800 rpm and 243 pounds-feet torque at 3,500 rpm. Acceleration from 0 to 62 miles per hour dropped to 6.3 seconds while top speed rose to 152 miles per hour. The need for more air resulted in more intake slots as part of subtle styling changes. Both normally aspirated and Turbo models rode on a new cast-aluminum suspension; the Turbo improved handling by using a 24-millimeter front and 22-millimeter rear anti-roll bar. Weissach engineers upgraded the atmospheric car's 15-inch wheels and tires to 7Jx16 front cast aluminum-alloy wheels and 8Jx16 rears using 205/55VR16 front and 225/50VR16 rear tires. For 1985/1986, the 944 and 944 Turbo received new interiors, distancing themselves from the 924 heritage.

Little changed for the 1986 model year. All 944 models for 1987 offered optional anti-lock braking systems (ABS), and Porsche introduced standard driver and passenger front airbags on US turbo models. For 1988, Porsche brought out the 944 Turbo S derived from the 944 Turbo Cup customer racing program. At 0.7 bar boost, this M44/52 engine increased output to 250 horsepower at 6,000 rpm and torque to 258 pounds-feet at 4,000 rpm, by way of a larger turbocharger. A stronger clutch connected the five-speed manual transmission with its own cooler to a 40 percent lock limited-slip differential. Wheel size grew to 9-inch rims at the rear, and standard Goodyear Eagle tires were 225/50VR16 front and 245/45VR16 rear. Brakes came from big-brother 928S4 models and ABS became standard. The car reached 62 miles per hour in 5.9 seconds and topped out at 162 miles per hour. Porsche limited production of the 944 Turbo S to 1,000 examples in a single color choice: Silver Rose Metallic. It restricted options as well, installing nearly everything desirable as standard equipment.

Porsche dropped the S designation from the Turbo for 1989 and broadened the color spectrum but changed no other specifications on this 250-horsepower model. Two new options appeared: heated front seats and a sound system with built-in CD player.

The coupe used the Typ M44/52 inline four-cylinder 2,479cc engine developing 250 horsepower at 6,000 rpm. Currency devaluation recalibrated prices, and Porsche introduced the car at DM 93,500, or roughly $49,468, at the factory. *Porsche Archive*

For the 1986 model year, the Typ M44/05 inline four-cylinder 2,479cc engine produced 220 horsepower at 5,800 rpm and 243 pounds-feet of torque at 3,500 rpm. Porsche sold the car for DM 50,950, or $23,480, before Value Added Taxes (VAT). *Porsche Archive*

ONS Oberste Nationale Sportkommission für den Automobilsport in Deutschland GmbH

Homologation Nr.
GTN - 1

Gruppe
Group **GTN**

ausgestellt durch: **ONS Oberste Nationale Sportkommission für den Automobilsport in Deutschland**
decided by

Homologation gültig ab 01.01.1989
Homologation valid as from

für die ONS-Gruppe GTN

Foto A
Photo A

Foto B
Photo B

ONS

1. Definitionen
Definitions

101. Hersteller: Dr.Ing.h.c.F.Porsche AG
Manufacturer

102. Handelsbezeichnung — Typ und Modell: Porsche 944 Turbo S
Commercial name(s) — Type and model

103. Gesamthubraum: 2479 x 1,7 = 4214,3 ccm
Cylinder capacity

104. Art der Konstruktion
Type of car construction

☐ getrennt, Material des Chassis
Separate, material of chassis

☒ selbsttragend, Material der Karosserie: Stahl
Unitary construction

105. Anzahl der Volumina: 2
Number of volumes

106. Anzahl der Sitzplätze: 2 + 2
Number of places

Unterschrift und Stempel der Nationalen Sportbehörde
Signature and stamp of national sporting authority

ONS

1

Nothing changed on 1990 model year 944 Turbos. For 1991, the final year for 944 models, Porsche produced a turbocharged version of the 944 cabriolet it first had offered with normal aspiration for 1989. Its power-lift top mechanism required manual lockdown at the windshield header. The Neckarsulm plant that Audi had leased to Porsche for 944 production assembled 528 Turbo Cabriolets.

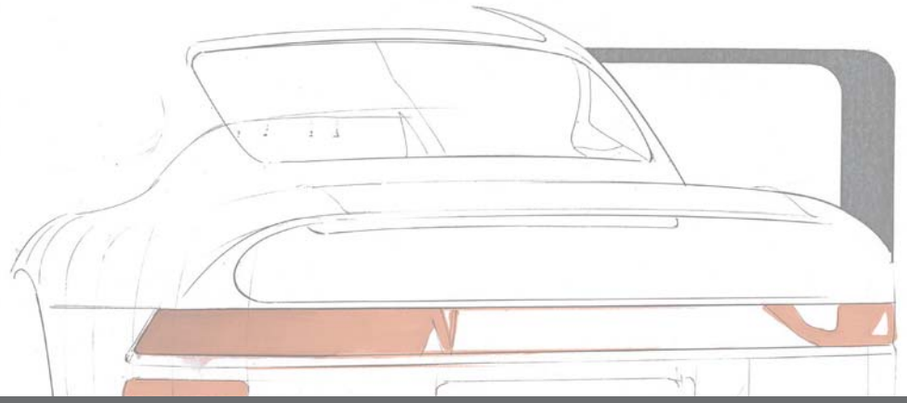
1986–1987 PORSCHE 944 TURBO CUP

Porsche inaugurated a single-marque professional and amateur racing series in 1986 using competition-prepared Typ 951s. Some thirty participants contested this seven-race series in conjunction with the Allgemeiner Deutscher Automobil-Club (ADAC) Supercup races. Entrants had to run unleaded gasoline and compete with catalytic converters and the standard series-production exhaust system. Weissach engineers reinforced the suspensions and Porsche sealed the Motronic brains, the knock sensor, and the turbo boost pressure wastegate. The cars developed 220 horsepower and prerace and postrace scrutiny was intense. The extremely close races generated tremendous fan and media interest.

That was enough to renew the series for 1987. For that year, Porsche expanded it and ran five events in Germany and one each in the Netherlands, Belgium, Austria, Hungary, and Italy. The new cars produced 250 horsepower and ran with ABS. Porsche's Paris distributor, SonAuto, inaugurated a French 944 Turbo Cup series in 1987, but, because of inconsistencies in unleaded fuel in the country, these cars ran without catalyst and with open exhausts. Porsche assembled ninety-nine of the Turbo Cup cars.

Porsche typically files homologation documents on any car it might race. This packet, dated January 1, 1989, explained in words and photos differences between the normal turbo model and this new S. The second series 944 starting in 1989 used this engine. *Porsche Archive*

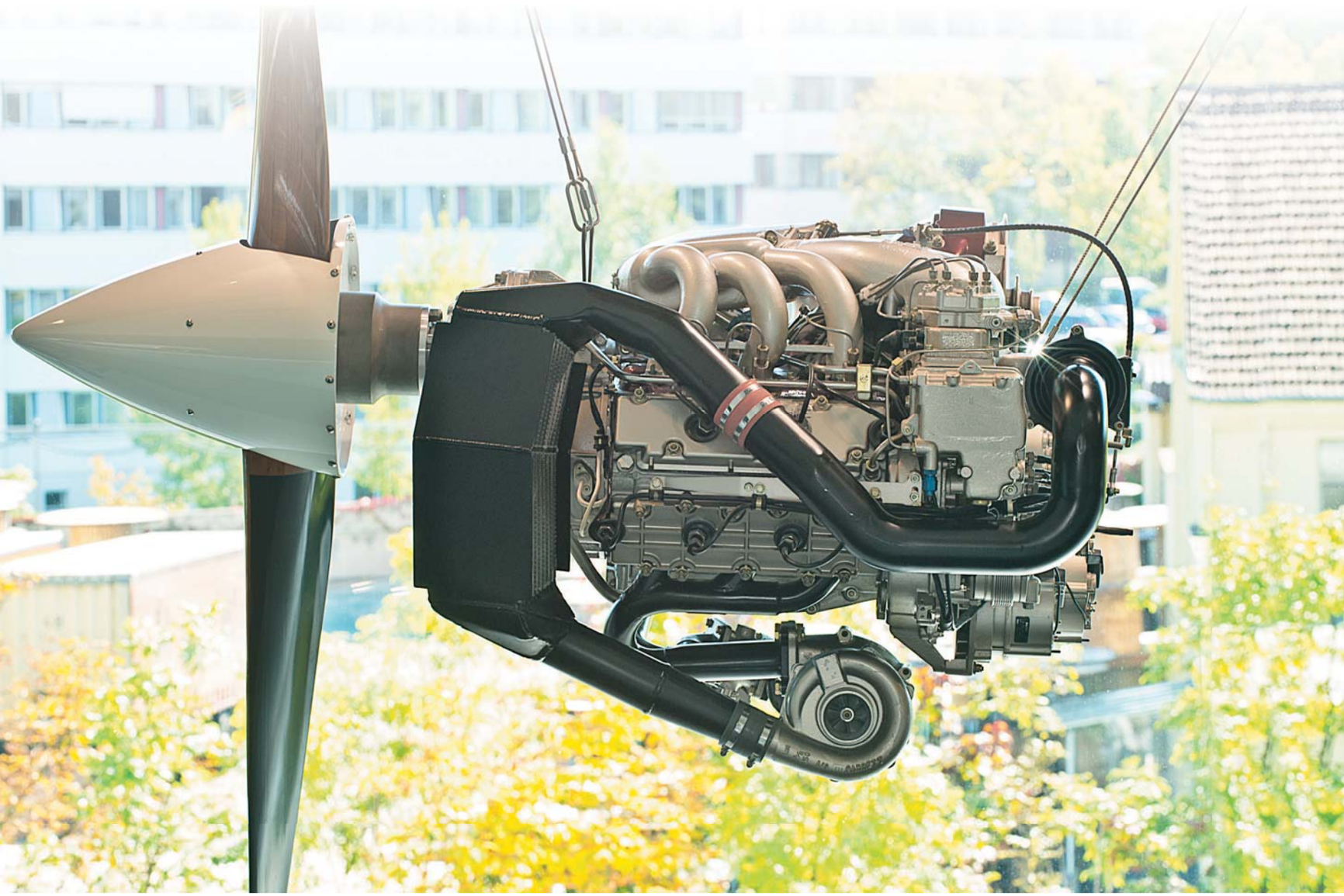
At the Nürburgring on September 21, 1986, the start lap saw racers careening through the esses three abreast. This was typical excitement throughout the series that showcased some of Germany's top racing talent. *Porsche Archive*



Chapter Eleven

TAKING THE LONG LINE TO SOME INTERESTING **CONCLUSIONS**

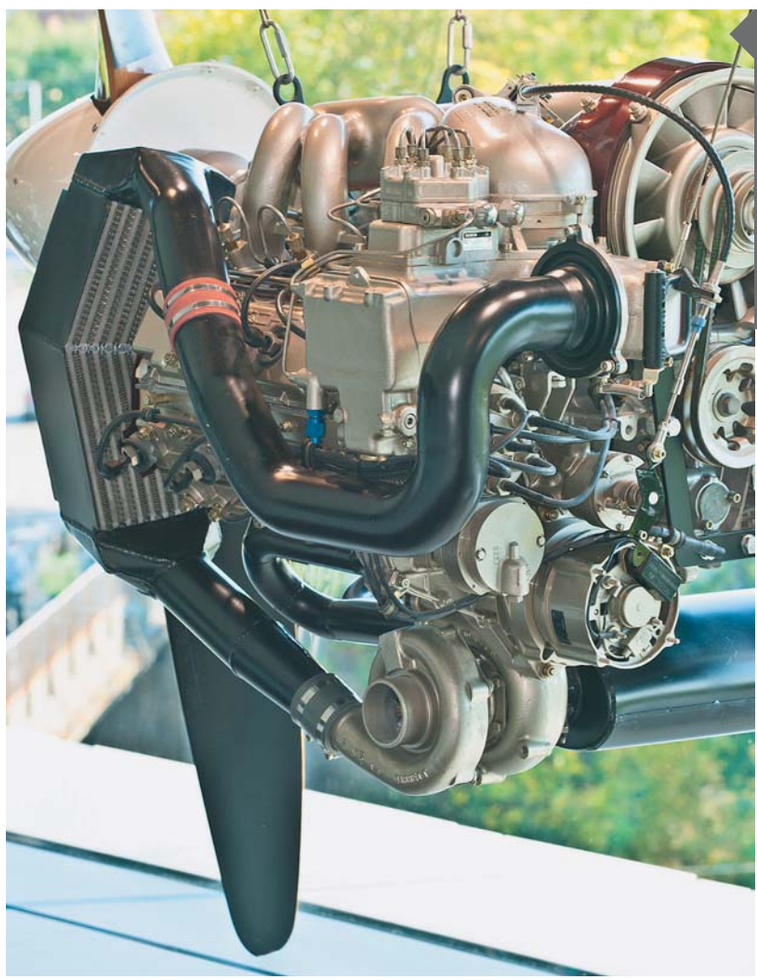
At chairman Peter Schutz's instigation, chief engineer Helmuth Bott started a couple of his engineers developing an airplane engine derived from the current 3,164cc normally aspirated 911 Carrera. Following encouraging tests, they experimented with turbocharging the engine as well. *Randy Leffingwell*



1986–1991 PORSCHE FLUGMOTOR PFM3200 AND FLUGMOTOR TURBO

"Lots of 911 owners own and fly light airplanes," Peter Schutz said in a 2011 interview. "Some do this for business, some for fun. What would be more natural than giving them a 911 engine in the air as well?" Schutz, an enthusiastic general aviation pilot, proposed that Porsche adapt its 3.2-liter Carrera engine for aircraft use. Research suggested there were two hundred thousand light aircraft in the world with engines in the range of 180 to 230 horsepower, nearly three-quarters of which were in the United States.

Aircraft require redundant systems, so Weissach fitted the 3,164cc flat-six Typ 930/21 series-production engine with twin sparkplug heads. They replaced the chain-operated camshaft drives with gears, doubled up alternators and vacuum pumps, and repositioned all the accessory drives to the rear of the engine. Weissach staff reduced compression from 9.5:1 to 9.2, resulting in output of 217 horsepower at 5,300 rpm at sea level. Bosch K-Jetronic fuel injection controlled fuel mix and an innovative computerized management system linked throttle and propeller pitch with the fuel mix for what is known as one-lever control. Initial flight tests in a Cessna encouraged Porsche to find a more performance-oriented aircraft as a demonstrator. The company selected the Mooney M20K, a four-seater that originally ran a turbocharged Continental 210-horsepower engine.



With the single large KKK turbocharger suspended below the 3,164cc twin-plug flat six, Weissach engineers developed 256 horsepower. Currency devaluations in the late 1980s destroyed the competitiveness of this engine against other manufacturers. *Randy Leffingwell*

Porsche's engine delivered slightly higher horsepower without adding the heat of a turbo system. In 1986, the company installed one of its engines in a Mooney and completed a 62,000-air-mile round-the-world demonstration flight. After this, Bott's engineers experimentally mounted a Garrett turbocharger below the engine and fitted a large intercooler on the engine's left side. This provided 241 horsepower at takeoff, and the turbocharger raised the service ceiling to 18,000 feet by pressurizing the intake. As exchange rates between the dollar and the deutsch mark sank, the cost of Porsche's engine lost its economic advantage. Mooney Airplane Company manufactured forty low-wing, long-body M20L models with the PFM3200 and achieved US Federal Aviation Administration (FAA) type certification in late 1988. By this time, Peter Schutz had left Porsche. The company ended factory support of the engines in 2005. Very few M20Ls still fly with the PFM.

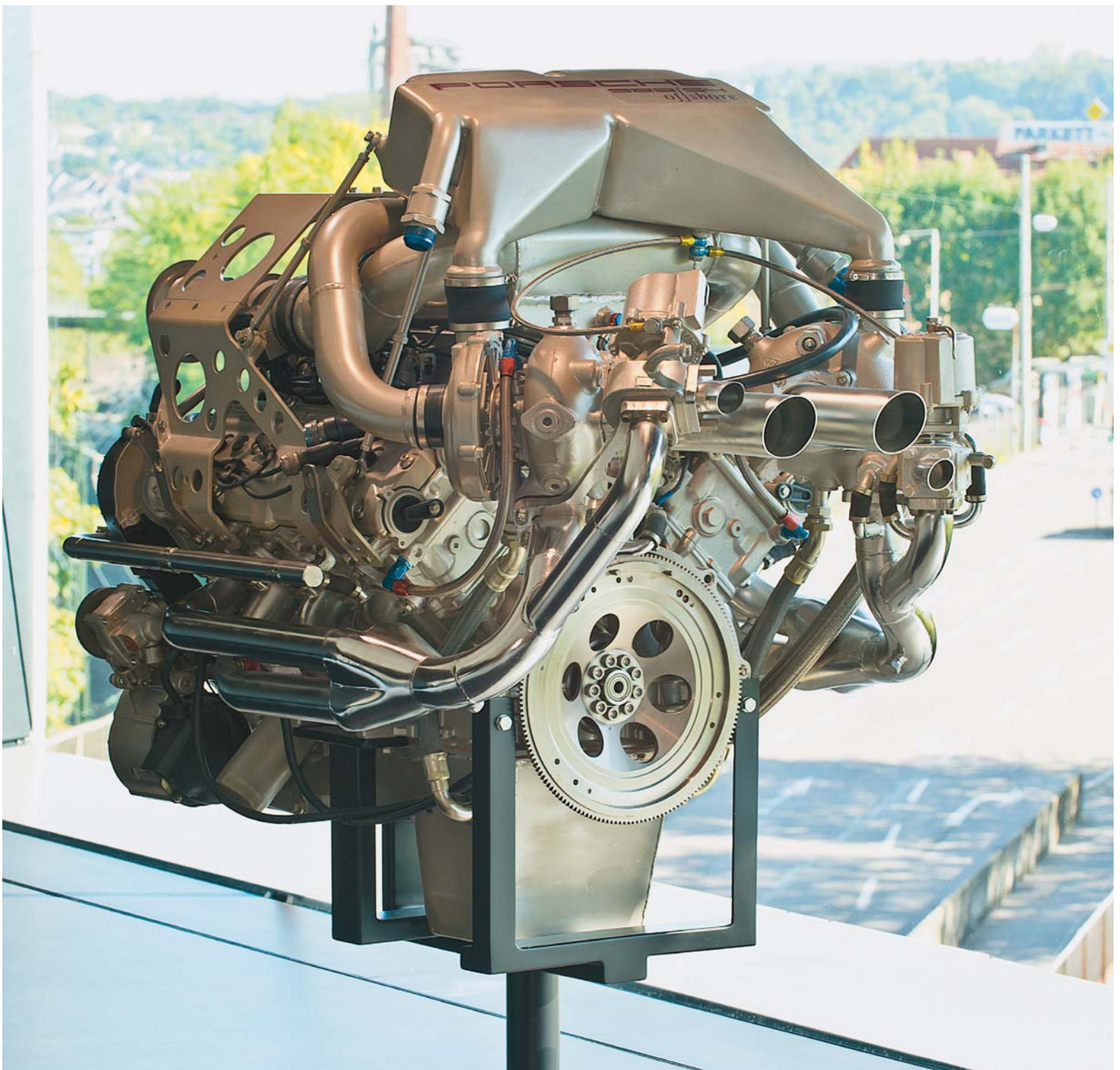
1986–1988 TYP 959 SPORT AND LUXURY

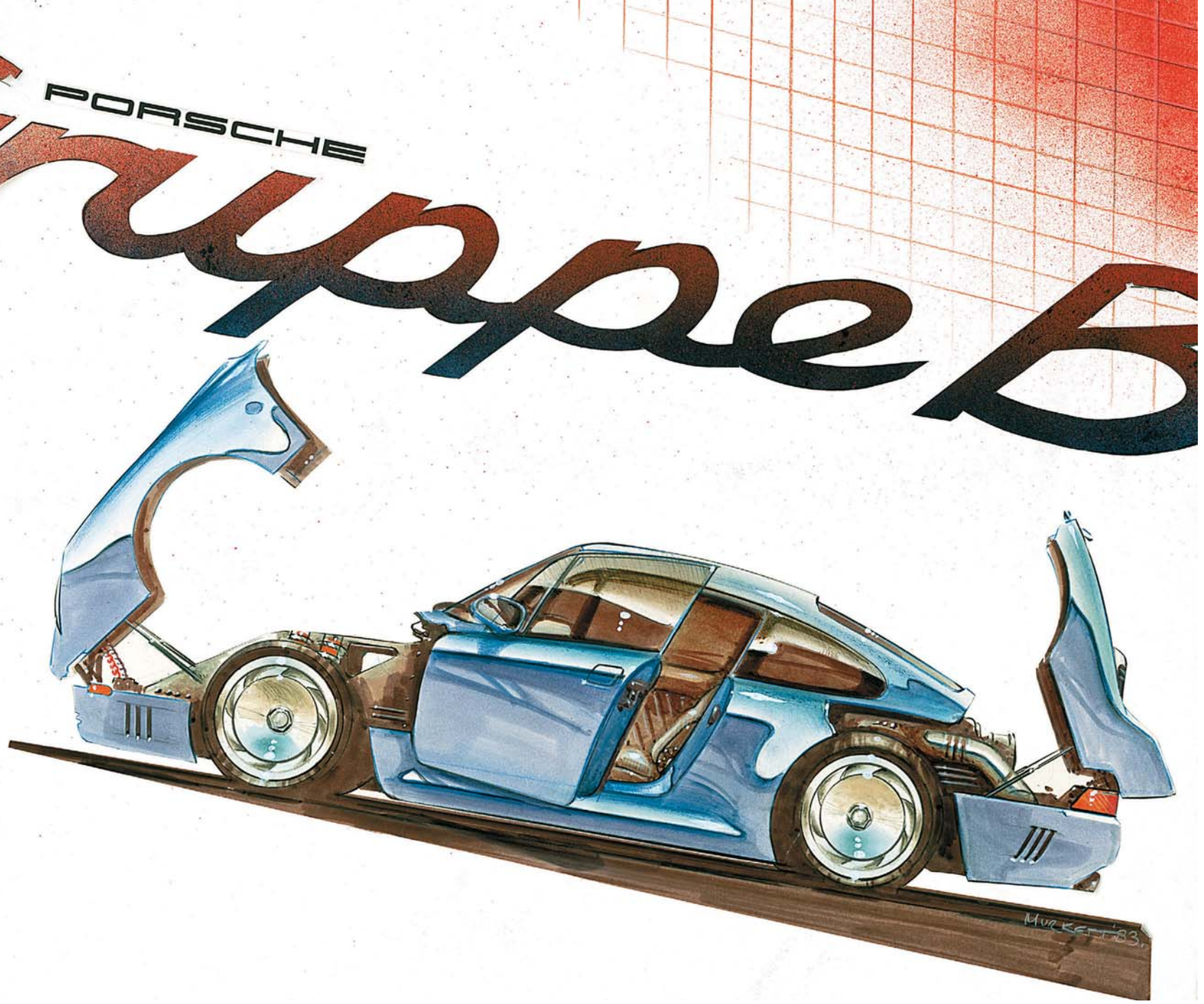
During the period of 911 engineering rebirth at Porsche in 1981, the FIA introduced its Group B category for "sports grand touring cars." The rules took effect for the 1984 competition season. When the organization legalized four-wheel-drive vehicles for competition in 1979, it took little time before World Rally Championship (WRC) competitor Audi demonstrated the benefits of additional grip on the dirt and gravel surfaces that typically made up significant portions of these contests. Porsche watched Audi prove the theories, and Helmuth Bott and Manfred Bantle made plans.

According to historian Karl Ludvigsen, this was a fairly straight-forward conversion. Each engine weighed 750 pounds and first trials on Italy's Lake Como in March 1987 proved promising. *Porsche Archive*

Large twin KKK turbos, operating at 1 bar boost pushed output up to 750 horsepower at 6,300 rpm and 634 pounds-feet of torque at 5,500 rpm. Final drives failed on the boat's two race attempts, but the idea sparked some interest from Group C racers Manfred and Erwin Kremer who briefly investigated running a 928 V-8 in their 962 CK. It proved too heavy and too costly to develop further. *Randy Leffingwell*

There are "Special Wishes" and then there are *very* special wishes. Jacky Ickx, on the verge of retiring from motorsports, asked Helmuth Bott if Weissach could develop a pair of engines for him to use with a partner in powerboat racing. Bott agreed and engineer Hans-Joachim Esch converted two four-valve 928S4 V-8 engines for the purpose. *Randy Leffingwell*


PORSCHE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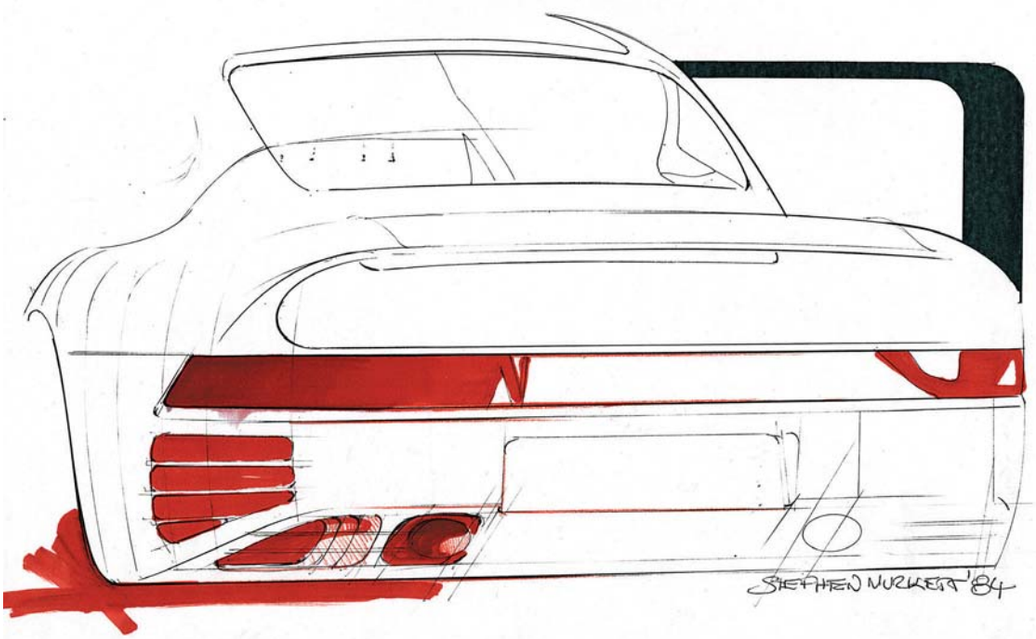
Turbo


STEPHEN NURKIEWICZ '84

FIA regulations required manufacturers to assemble two hundred identical cars before their competition versions were legal for racing. There were those in the competition department who pushed Bott to authorize a midengine car for these rallies, but he pushed back, arguing there was more to learn in developing the resurrected 911. No one had examined its potential in the latter Fuhrmann years.

Within weeks of Bott's decision, Bantle had his initial concept. He adapted the rigid central tunnel of 944 and 928 models to the 911 platform. Not only did this make room for a driveshaft, but the arched structure also increased chassis stiffness. The project officially started in January 1983, and in September, Porsche showed a Gruppe B Studie concept at the Frankfurt Auto Show. The company promised start of limited production in 1984.

To accelerate development and prove its concepts for the new model, Porsche created all-wheel-drive prototypes on the 3.2 Carrera platform, known internally as the Typ 953. Stylists worked on the car body—designated the Typ 959—and engineers developed a new powerplant. For its basis, they chose the 2,849cc flat six with water-cooled cylinder heads, dual overhead camshafts, and four valves per cylinder. This was technology (but not displacement) taken from the immensely powerful Typ 935/78 engine used for *Moby Dick*. Bantle and engineer Roland Kussmaul fitted two KKK K26 turbochargers in series, not in parallel, so at lower engine speeds, exhaust had to spool up only one of the turbos, getting it to specified boost much faster than divided exhaust could accomplish for both. As the first

Stephen Murkett reversed the typical opening panels of a 911 as he imagined what might become the Group B model. *Porsche Archive*

Stephen Murkett worked through possibilities for a rear wing and engine and intercooler heat extraction on this sketch made sometime in 1984. *Porsche Archive*

Olivier Boulay had worked before with the idea of making a solid body panel where the rear side window was, on this early April 1984 rendering. His concept sketches for Paris–Dakar desert racers explored a similar idea. *Porsche Archive*

turbo approached its boost limits, valves opened in the complex tubing, and exhaust pressure began spinning the second turbo. This engine, the Typ 959/50, developed 450 horsepower at 6,500 rpm and 362 pounds-feet torque at 5,500 rpm.

Tony Lapine's manager for exterior body design, Dick Soderberg, supervised the appearance of the 959. Lapine had hoped for a budget that gave his staff a clean slate, but costly structures such as the roof and floorpan had to carry over—a sensible decision in view of the projected manufacture of just two hundred series-production cars.

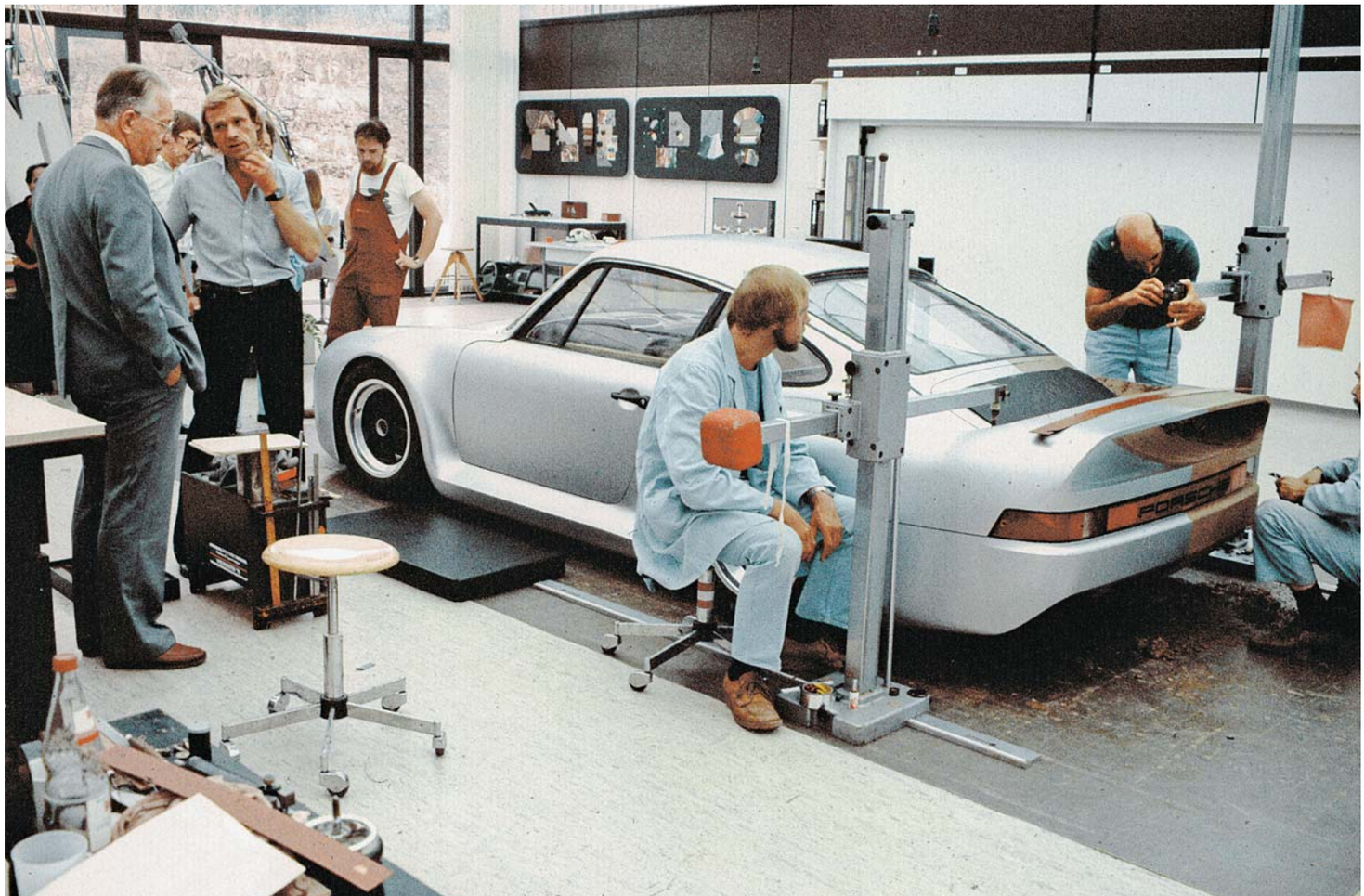
Porsche brought the production version to Frankfurt in September 1985, but it already had been taking orders based on its proposed performance of 0 to 62 miles per hour in 3.7 seconds (with a top speed in excess of 195). The car incorporated so many sophisticated systems that designing, testing, developing, and proving them delayed assembly start until late 1986 when the first twenty-one pilot production prototypes emerged. Porsche had announced a price of DM 420,000 for the car, about $164,700 in 1983 dollars. The company delivered 113 cars in 1987. By this time, the dollar had fallen further, and while the company had held the deutsch mark price steady, its exchange rate took the car up to around $235,000. Porsche delivered another 179 cars in 1988 plus a final eight in 1992, assembled from remaining parts and sold to improve cash flow in a worldwide recession.

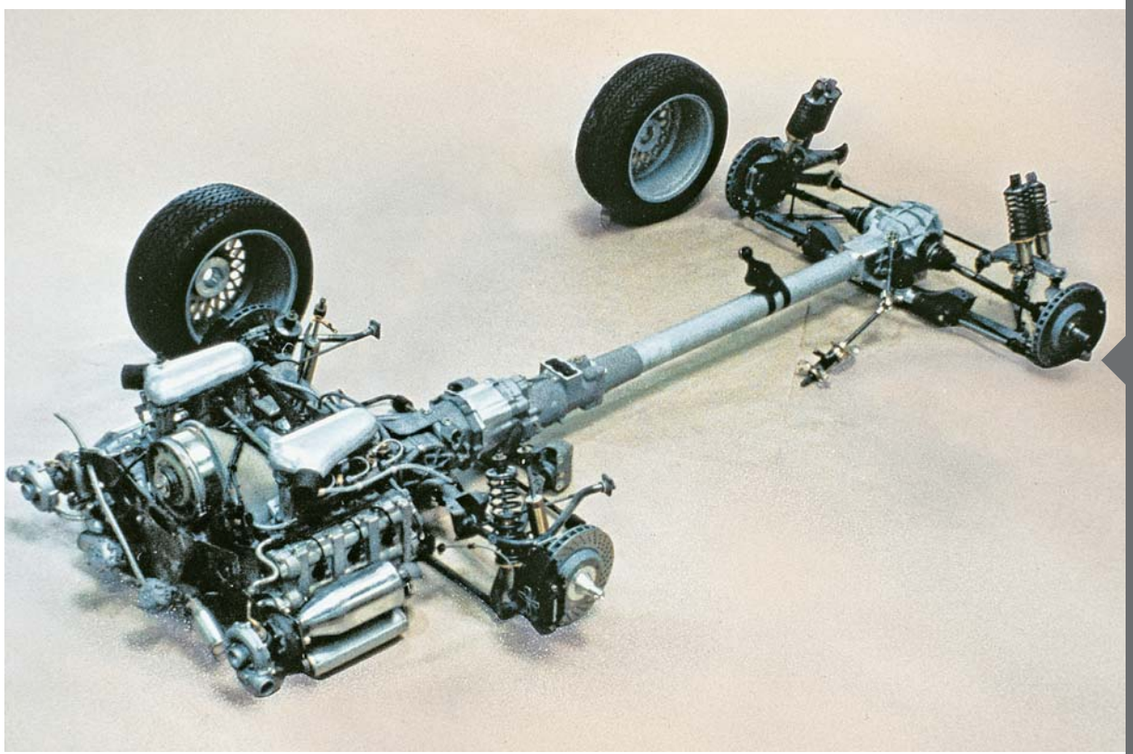
This first full-scale model of the Group B car established most of the general characteristics and the finer details of the 1986 series production model 959. Exterior styling chief Dick Soderberg supervised development of the design. *Porsche Archive*

Engineer Dieter Röscheisen performed cold tests in Sweden in April 1987. With so many new systems on a single car, engineers accumulated hundreds of thousands of miles, shaking down the technology they were introducing. *Porsche Archive*

While modelers chart reference points on this styling prototype, it was easy to see where the current series production 911 grew new bulges and surfaces. Weissach director Helmuth Bott (in dark grey suit at far left) watches the work. *Porsche Archive*


BB PW 525





The engine compartment exhibited a designed formality with its symmetrical intake runners rising from the hidden turbos. Series production models had covers over left and right rear fender compartments. *Porsche Archive*

This Typ 959 bare chassis suggests a simple concept that certainly was a difficult execution. The Typ 959/50 engine displaced 2,849cc and developed 450 horsepower at 6,500 rpm. *Porsche Archive*

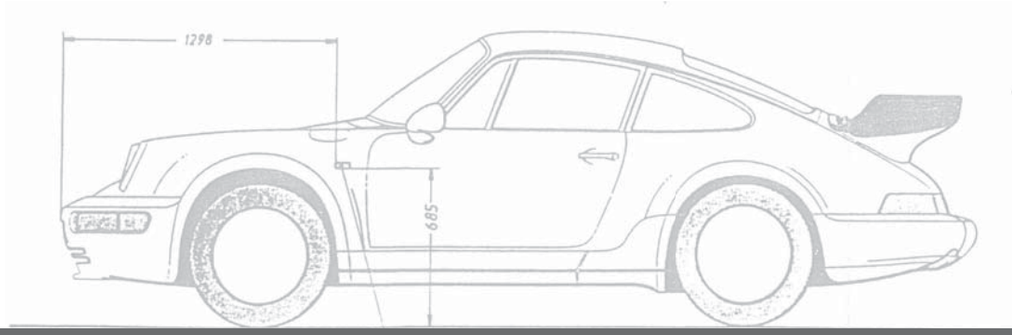
The all-wheel-drive system coupled and uncoupled electronically. Porsche introduced the model 959 in 1986 for DM 420,000 ($193,550 at the time, though subsequent currency devaluation increased the dollar equivalent to $223,400). *Porsche Archive*

At first, Porsche encouraged US customers, and fifty individuals ordered cars. Porsche dealer and racer Al Holbert had contracted with the newly formed Porsche Cars North America to import thirty of them. But a classification snafu caught the attention of US customs officials, who turned back the first eight cars and blocked all deliveries except one to a California collector's museum.

However, Porsche's supervisory board had the last word. Although Weissach had crash-tested the car (and scored the highest safety rating Weissach had yet recorded), Porsche had encountered several legal proceedings in the United States that went against the carmaker. The board pulled the orders. Bott explained, "If we were going to bring the 959 to the United States and anybody would drive at 320 top speed [199 miles per hour] and have an accident. . . . That was the thinking behind the decision."

Where was Rolf Sprenger's Sonderwunsch program in all this? Porsche knew its 959 buyers already were distinctive individualists, and it surprised no one that several of the buyers had special requests. Berlin Philharmonic Orchestra conductor Herbert von Karajan was a longtime loyal customer—of Porsche and of Special Wishes. His red 959, one of the first delivered, carried a spare wheel and tire because von Karajan used the car every day. Classical pianist Justus Frantz ordered his 959 with twenty-four audio speakers. A European king who had received assassination threats had a spring-loaded holster for his revolver mounted in the center console. A Qatari sheik ordered seven 959s, each in a different color, and in place of the Porsche crest on the front deck lid, shift lever, and steering wheel, Sonderwunsch mounted his gold family crests. (Sprenger had to gain supervisory board permission for that special wish.)

Finally, for those drivers for whom 450 horsepower was inadequate, Sprenger confided, "We had an enhancement kit at the end that boosted output to 500 horsepower. This was undercover. Not so well known."



Chapter Twelve

TURBOS FOR **EVERYONE:** THE 1990s

By the time Porsche management pulled the plug on the Typ 965, Weissach engineers had assembled at least seven prototypes. Conceived as the turbocharged sibling to the Typ 964, this model offered a distinctive body that carried over some cues from the 959 while inventing others that later appeared in the Typ 993. *Randy Leffingwell*

1988 TYP 965, 1991 964 TURBO II 3.3, 1992 TURBO S, AND 1993 TURBO 3.6

Even as Porsche commenced hand assembly of sixteen engineering prototype 959s in late 1985, Peter Schutz, Helmuth Bott, and Tony Lapine knew they had to develop a successor to the long-lived G series of 911s. In the Typ registry, two numbers came up next: the normally aspirated car became Typ 964, and the Turbo concept was 965. Bott's experiments with 953 and 959 prototypes cars convinced him that all-wheel drive was beneficial to regular customers in routine driving conditions. So Weissach developed all-wheel- and rear-wheel-drive versions of the 964. Hans Mezger and his engine designers created the Typ M64/01, a 3,600cc flat six that adopted the twin-plug ignition system perfected for the PFM3200 airplane engine. In styling, exterior body chief Dick Soderberg selected Benjamin Dimson's concepts to become the 964 car body, and Dimson, with Wolfgang Möbius, began the long process of making this idea production ready.

Bott and Schutz, however, had other ideas for the successor to the 3.3-liter Turbo. The 959 Frankfurt show car in 1985 startled visitors into accepting that Porsche's wild Gruppe B Studie was going into production. Soderberg assigned recent hire Tony Hatter to sketch ideas of next-generation concepts based on its striking body forms. Bott's engineers began devising what might power such a car. The 450-horsepower, 2,850cc, partially water-cooled flat six from the 959 was a starting point, though engineering backed down from such high output to protect the exclusivity of the 959 models. Still, 350 or even 380 horsepower seemed effortless. Through 1986 and 1987, the designers and engineers worked on the next-generation Turbo.

Olivier Boulay, who had spent extensive time rendering variations of 959 road and desert rally cars, next went to work on next-generation series production turbos. There was a strong feeling in Porsche's styling department at the time that form language developed for the 959 should carry on. *Porsche Archive*

At the end of 1987, the plummeting exchange rate led Peter Schutz and Helmuth Bott out the door. Porsche needed a new engineering boss, and it hired Ulrich Bez to rejoin the company. Styling chief Tony Lapine, who had suffered a heart attack, was recuperating at home. When he heard of all the changes, he chose to stay there, and Bez brought in his former BMW colleague Harm Lagaaij.

"When I arrived in 1988," Lagaaij recalled in November 2014, "Mr. Bez and I looked around and we saw this 965 and we immediately canceled it." This was neither engineering nor a styling judgment but purely an economic decision. There were engineering problems; attempts with a street version of the 2.85-liter turbocharged V-8 Indy engine had proven unsatisfactory, and then adopting a normally aspirated V-8 from Audi suggested that the 965 no longer was a turbocharged anything. Amortizing all these development expenses had sent the proposed 965's price point above DM 200,000, roughly $115,000, an unacceptable level for its launch date in 1989 or 1990. Canceling the 965 meant there was no Turbo at all. This decision sent Bez's engineers and Lagaaij's designers scrambling.

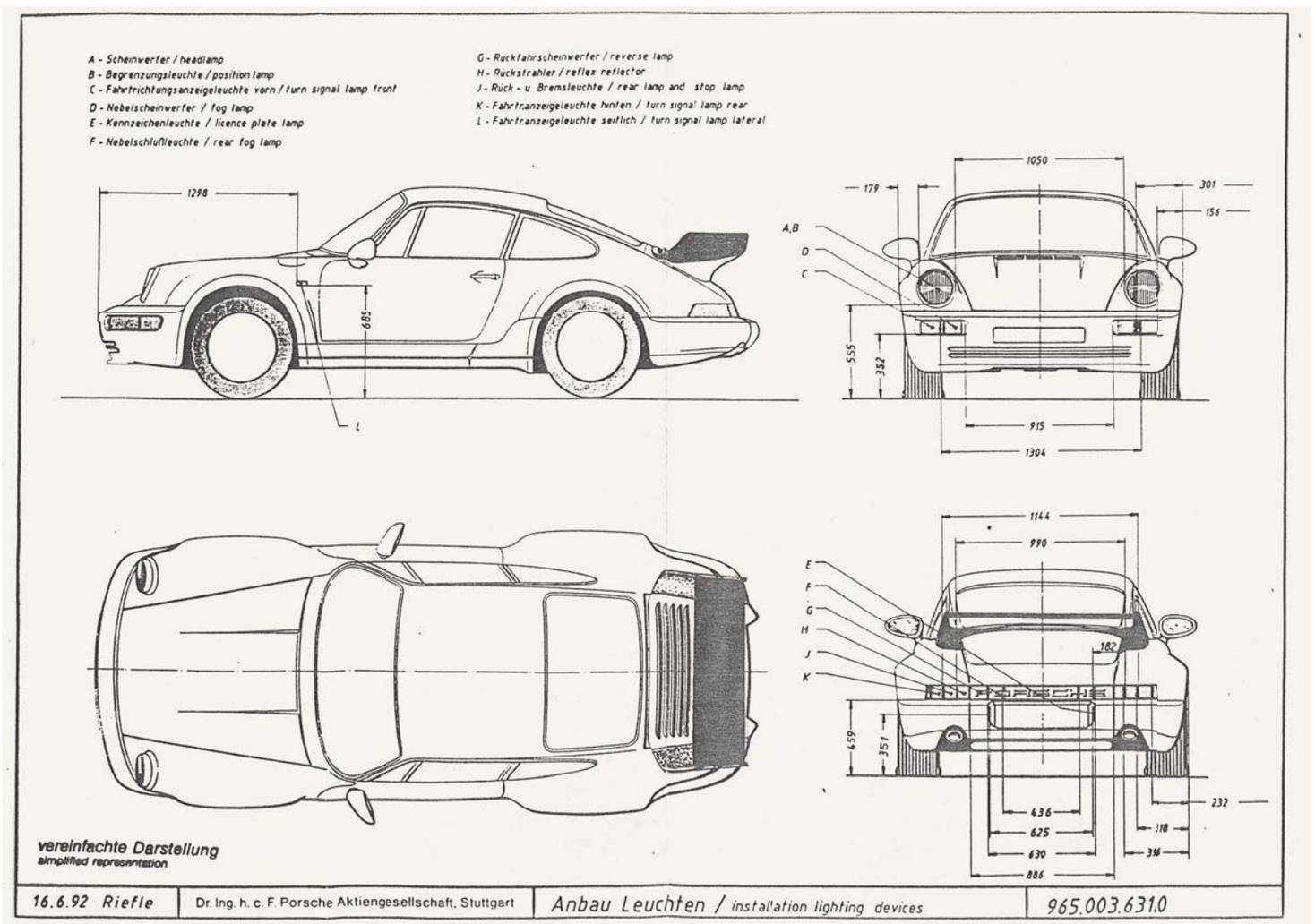
Weissach went to work revising and enhancing the 3.3-liter Turbo engine. Lagaaij set chief modeler Peter Reisinger and his team to work, adding on the obligatory wide-flared fenders and big rear spoiler. Marketing and sales named the car Turbo II.

The G-series Turbo had provided European buyers with 300 horsepower; the new Turbo II delivered 320 at 5,750 rpm. Engineers broadened the torque band so that it produced 295 pounds-feet of torque at 2,500 rpm and rose to 332 pounds-feet at 4,500 rpm by using a larger turbo, a 50 percent bigger intercooler, and revised ignition programming.

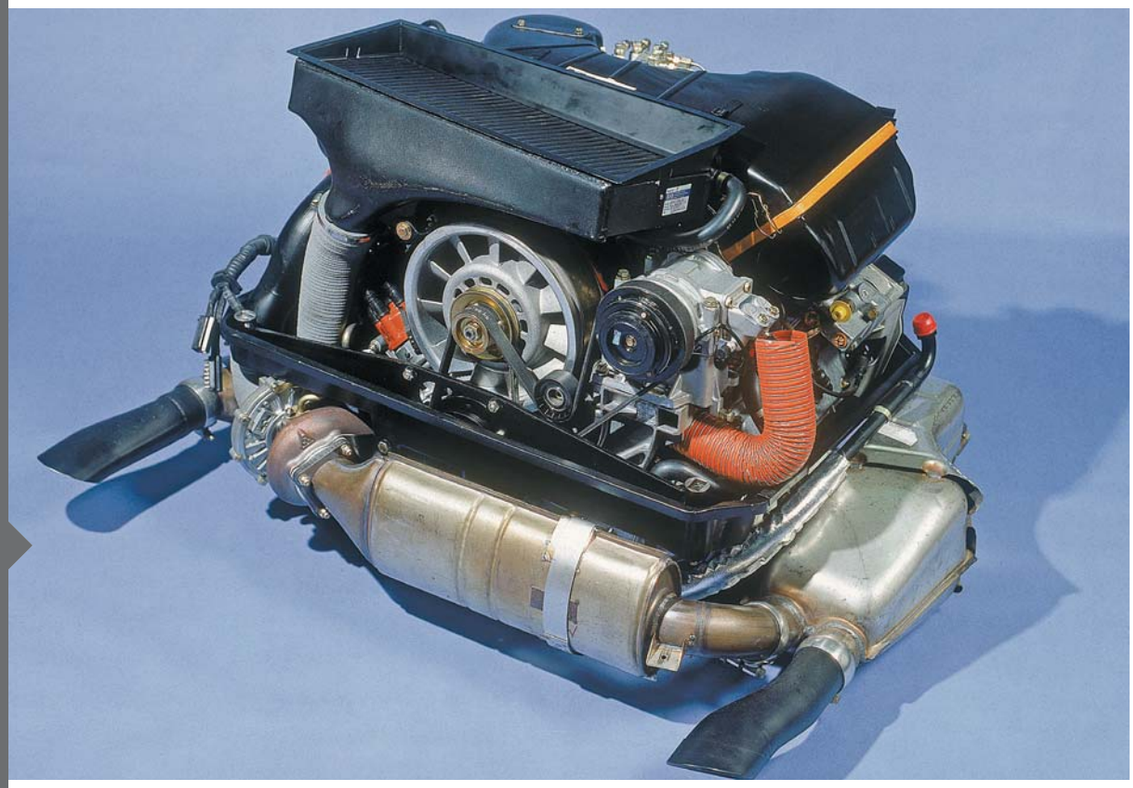
"And then the lightweight was *our* car," Rolf Sprenger explained. "The 1992 Turbo S 911. Seventy-eight cars. We created it. We sold it. Porsche cars during these years got heavier and heavier. And some of our customers asked us, 'Why can't you make lightweights?'

"We knew there were customers who did not need fifteen electric motors for functions. They didn't need a comfort seat. So we started asking, 'What can we take out? What more can we take out?'"

Sprenger and his staff removed 397 pounds of sound insulation, rear seats, and undercoating. They replaced the steel doors, front deck



While front and rear ends changed from the G-series to the Typ 964 series, the "added-on" fender extensions barely evolved. Much of this final design work took place as the change in currency exchange rates significantly decreased Porsche's earnings. *Porsche Archive*



Even though the Typ 965 officially had been cancelled by June 1992, engineers continued to use the designation for 964-based Turbo updates. This drawing specified precise location for all car body light fixtures. *Porsche Archive*

The 3,299cc displacement engine started life as the Typ 930/60 in 1978 model 930 cars. Countless updates, improvements, and upgrades increased output from 300 horsepower at 5,500 rpm in 1978 to 320 horsepower at 5,750 in 1991. *Porsche Archive*

At the request of a few Special Wishes customers to devise a "lightweight" car like the RS Carrera of 1973, Rolf Sprenger's engineers created the Turbo S. Its Typ M30/69SL engine with no change in displacement developed 381 horsepower at 5,750 rpm. *Porsche Archive*

By gutting the interior and replacing some panels with lightweight fiberglass, the Turbo S weighed in at 2,844 pounds compared to the series production Turbo at 3,240 pounds. Special Wishes had changed its name to Porsche Exclusive by this time in an effort to be more universally known. *Porsche Archive*

The vibrant exterior paint color resulted from a collaboration between Sprenger and new design chief Harm Lagaaij, who called this "Speed Yellow." Special Wishes sold just eighty-six of these cars for DM 295,000 (approximately $177,700 at the factory before VAT). *Porsche Archive*

lid, and rear spoiler with carbon-composite-reinforced fiberglass. They installed thinner-gauge side and rear glass. They replaced multifunction electric front seats with ultra lightweight buckets. Total weight came in at 2,844 pounds.

Under that carbon-composite rear deck lid and spoiler, Sprenger's engine men reworked fuel-intake runners, enhanced cam timing, retuned the electronic fuel injection and ignition system, and cranked up the boost by a modest 0.1 bar. This increased output from the stock 320 to 381 horsepower at 6,000 rpm and raised torque from 332 pounds-feet to 361 at 4,800 rpm. Acceleration time from 0 to 62 miles per hour fell to 4.7 seconds and the top speed rose to 180 miles per hour.

Chassis and suspension improvements transferred almost directly from the car's highly successful IMSA Supercar entries in the United States, in which Hurley Haywood won the championship in 1991 and 1992.

"For a while, a year or so, it was the fastest Porsche, in acceleration, in everything," Sprenger said. "We introduced it at the Geneva Motor Show. I remember when we created the color, Harm Lagaaij and me. When I showed him the car, he asked how light and how fast and how . . . and how . . . and how . . . I said we need a special color.

"And he said, 'Yellow.'

"I said, 'Mr. Lagaaij, yellow is not a traditional Porsche color . . .'

"'This is speed yellow,' he said. And there it was. The color and the name for this color were born." Sprenger's department assembled seventy-eight of these cars.

Throughout this time, Hans Mezger's engine designers were hardly sitting still. Increasing compression on the 1992 normally aspirated M30/69 engine from 7:1 to 7.5 and remapping the electronic fuel-injection system had a profound effect on Turbo engine torque. The 1993 peak output rose from 322 pounds-feet at 4,500 rpm to 384 pounds-feet at 4,200 rpm. More impressively, the engine reached the 332 figure at 2,500 rpm and held steady to 5,500 rpm. By comparison, this torque production exceeded what Porsche had derived from its 5.4-liter V-8 in the contemporary 928 GTS. Horsepower rose to 360 at 5,500 rpm, and between these two improvements, acceleration time from 0 to 62 miles per hour dropped to 4.8 seconds and top speed rose to 174 miles per hour.

Rolf Sprenger's Exclusive creators weren't done with the Typ 964 Turbo just yet. Customers had believed the G-series Turbos had been the last ever to offer the slant-nose modification. It took time, and Sprenger's loyal and inventive customers definitely inspired it, and so for 1993–1994, Exclusive offered a slant-nose option on the 964 Turbo coupes. Some seventy-six patrons took advantage. This slant nose incorporated pop-up headlights from the Typ 968 and added a dedicated front spoiler ducted for

an oil cooler and front brake cooling. Rear fenders resembled those from the ill-fated 965 with vents for rear brakes. Exclusive used a larger turbo, ported the cylinder heads, improved intake manifolds, and created more aggressive camshaft profiles, all of which resulted in 385 horsepower at 5,750 rpm and 384 pounds-feet peak torque at 5,000 rpm. Exclusive retained more of the typical Turbo luxuries than on its severe S the year before; the slant-nose matched the weight of regular production Turbos at 3,243 pounds.

VARIOCAM AND VARIORAM

As Weissach's engineers worked on improvements to their engines, they called on a collaborator since 1984, Hydraulik-Ring GmbH. As Karl Ludvigsen reported in *Excellence Was Expected*, Hydraulik-Ring had worked with Weissach on a variety of hydraulic tensioners.

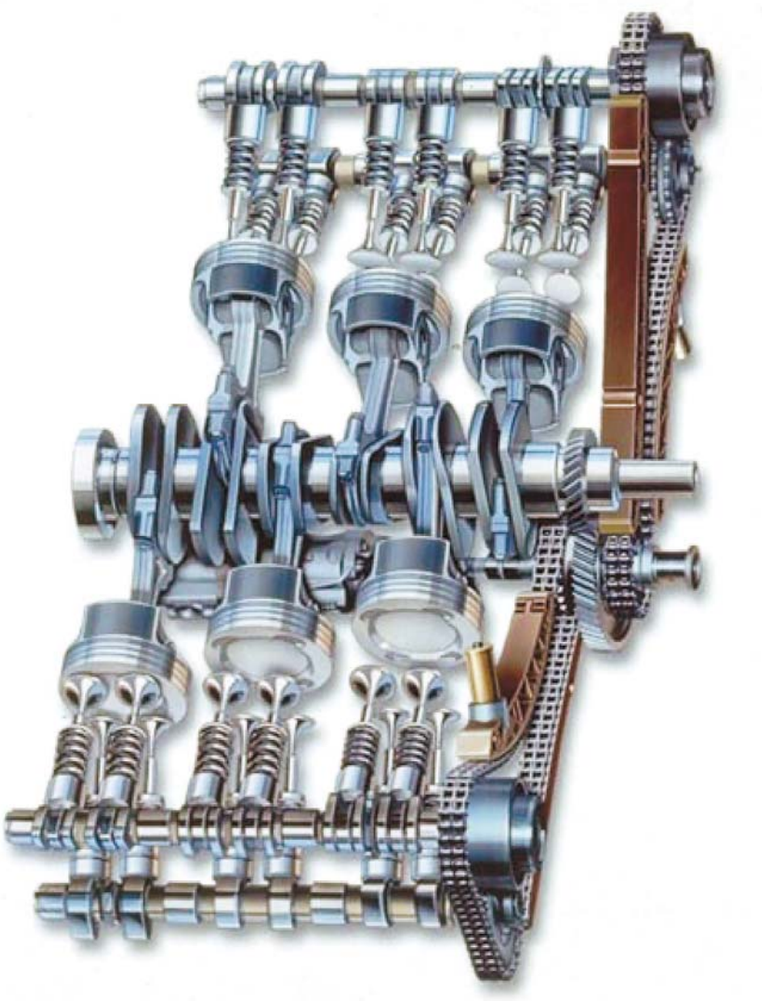
"At the beginning of 1989, Hydraulik-Ring was drawn into Porsche development work," Ludvigsen wrote, "when the idea arose of using this cam-drive chain to vary the inlet-valve timing." The intricate system they created moved cam chain tensioners minute amounts (not quite a quarter inch) to advance intake cam timing. As the engine's Bosch Motronic management system sensed throttle increase, "it signaled a solenoid to move a shuttle valve which told engine oil pressure to force down the . . . shoe on the tensioned side of the chain. . . . The shoe on the slack side of the single-roller chain gave way by a similar amount," Ludvigsen added. "This advanced the inlet camshaft with respect to the exhaust cam by 7.5 degrees, the equivalent of 15 degrees at the crankshaft." While the Motronic kept the system in normal overlap at slower speeds and lighter throttle loads, it advanced the intake cam timing between 1,500 and 5,500 rpm. "Of the 14 trade names that Porsche considered for the system," Ludvigsen continued, "VarioCam, Ventronic, and Cam Vario were at the top of the list. The final choice fell to VarioCam." Porsche introduced this on the M44/43 normally aspirated engine for the 1992 Typ 968.

The next significant advance came with the 1994 Typ 993 Carrera RS. This employed a normally aspirated 3,746cc engine that paralleled development of the 1994 Carrera Cup cars. For the RS, Porsche engineers went a step further, taking further advantage of the sophisticated capabilities of the Bosch Motronic.

"Individual ram pipes to each cylinder from an upper plenum chamber gave a pipe length of 18.7 inches to emphasize mid-range torque, at speeds up to 5,000 rpm," Ludvigsen wrote. "Above that, connecting sleeves slid back 1.3 inches to expose shorter ram-tube lengths of 9.4 inches that suited higher engine revs better. Then above 5,800 rpm a cross tube in the manifolding opened to vary the system's resonance further. A progressive-opening dual throttle was part of the pneumatically operated system, which was designed to heighten both torque and responsiveness at medium engine speeds. As this new VarioRam system applied to the RS engine, Typ M64/20, it helped develop a maximum of 300 horsepower" at 6,500 rpm with peak torque of 262 pounds-feet at 5,400 rpm.

What was rarer than a 968 Turbo S? One of the three of these Turbo RS models, with 350 horsepower (without intake restrictor) in an ultra-light 2,645-pound body. *Porsche Archive*

Porsche introduced the 968 Turbo as a 1993 model, using the Typ M44/60 water-cooled inline four-cylinder 2,990cc engine. It developed 305 horsepower at 5,400 rpm and sold at the factory for DM 175,000—$105,420 at the time. Porsche delivered just ten examples.



1993 968 TURBO S, TURBO RS

Porsche's Typ 968 succeeded the 944, and this line evolved from the base production coupe introduced in 1992 to a Club Sport (CS) variation for 1993. Engineers lowered the suspension, removed 110 pounds of insulation and other content, and offered an optional limited-slip differential. Porsche introduced the Turbo S near the same time, utilizing the CS suspension and beefed-up ABS. The Typ M44/60 engine used a two-valve cylinder head unlike the four-valve CS. This 2,990cc engine developed 305 horsepower at 5,400 rpm and 369 pounds-feet of torque at 3,000 rpm. Zuffenhausen assembled only fourteen of these cars in 1993 and 1994.

The 968 Turbo RS competition version prepared for Le Mans and ADAC Cup races was rarer still. Gutted as much as possible, the endurance-tuned versions weighed 2,645 pounds and the 3-liter turbocharged/intercooled engines developed nearly 350 horsepower. As Jürgen Barth pointed out in *The Porsche Book*, "Because the [normally aspirated] 911 RSR 3.8 was being offered at the same time, only three [968 Turbo RS] cars were sold."

1996–1999 993 TWIN TURBO

In spring 1995, Porsche introduced the 993 Turbo. Regulations in Europe and throughout the United States made it increasingly apparent that water-cooling the entire 911 engine, not only its cylinder heads, was necessary to meet emissions and noise standards.

Water-cooling jackets absorbed internal engine sounds and eliminated the need for high-velocity air fans; they also reduced the cylinder temperature peaks that generate nitrogen oxides. (Catalytic converters already dealt with hydrocarbons and carbon monoxide.) What's more, future crash and safety regulations mandated airbag passive restraints, and this called for new platforms. On top of that, few of the new guard appreciated the 964's styling adherence to the quarter-century-old form that Gerhard Schröder and Heinrich Klie had done as the 901 for F. A. Porsche. But there was little money available for these enormous changes.

During this time, another former Porsche employee returned to the company. Wendelin Wiedeking, who had been in production and materials management in the mid-1980s, came back to head production in 1991. He streamlined manufacturing procedures and inventory controls, axed the unprofitable 928 and 968 models, and set about to make Porsche strong and keep it independent. Wiedeking recognized the customer loyalty for and great profitability of the 911, and he directed efforts to preserving the car.

The 993's version of the 911 engine (M64/05) started with the 3,600cc case and dimensions of the 964 series, but internal changes were extensive. The company introduced the coupe in fall 1993 as a 1994 model and followed it six months later with a cabrio. Stylist Tony Hatter, who had done the lion's share of work on the 965, found new uses for many of his design elements, and he, Peter Reisinger, and the styling-department modelers created the car bodies. Six months after the cabrio appeared, the company unveiled the all-wheel-drive coupe and cabrio Carrera 4 versions as 1995 models. Then another six months passed before the 993 Turbo appeared at the Geneva International Motor Show (accompanying two competition-oriented versions, the Carrera RS and the 911 GT2).

Weissach engineers introduced this complex variable valve timing system on the series production 968 3-liter engines. By providing greater or lesser valve opening at certain crankshaft rotating speeds, this allowed the engine to develop more torque lower in the engine range while maintaining high horsepower output in the upper limits. *Porsche Archive*

With certain elements resembling 959 and others reflecting stylist work on the 965 prototype, this concept sketch looked ahead toward what Porsche revealed as the 1995 Typ 993 Turbo. *Porsche Archive*

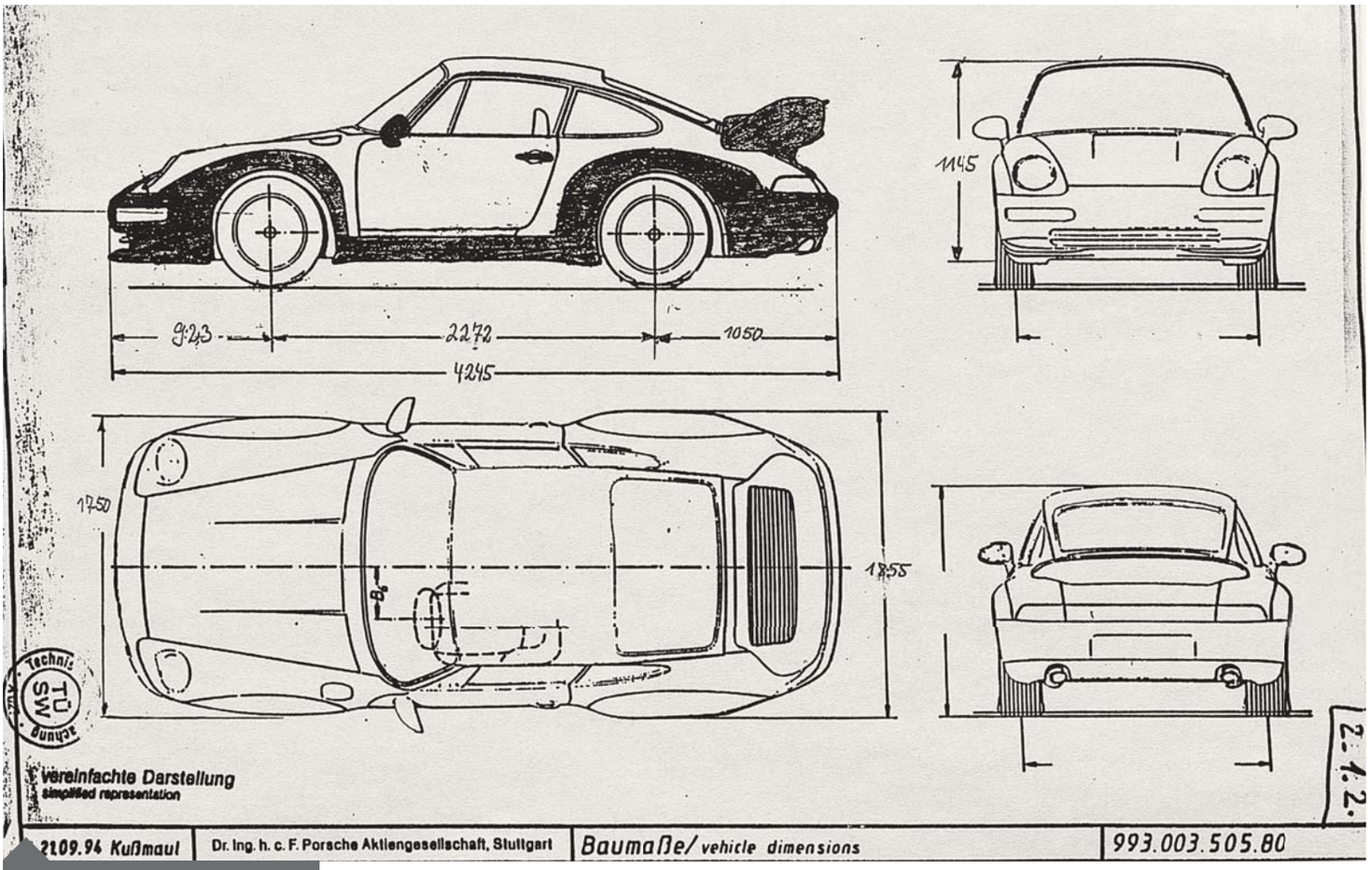
The new Turbo carried over the 3.6-liter displacement, and this M64/60 engine used two KKK turbochargers (slightly smaller model K-16 units) with a pair of intercoolers. The two smaller oil-cooled turbos sped up quickly, providing drivers better throttle response and reduced turbo lag. The Bosch Motronic M5.2 managed engine functions. The engine produced 408 horsepower at 5,750 rpm, and it developed 398 pounds-feet of torque at 4,500 rpm. This reduced acceleration time from 0 to 62 miles per hour to 4.5 seconds yet still provided a top speed of 180 miles per hour.

"This was a lot of horsepower in a sports car at that time," Erhard Mössle explained. Mössle worked in concept and pre-development engineering at Weissach. "That's when we had four-wheel drive for the first time. The idea was to say that so much horsepower on the rear wheels alone was not so easy to control. There were not stability controls at that time. Traction control was just starting, so we decided it was better for the customer to have a more stable driving behavior. We adopted the viscous clutch system for the 993. We developed it to feel more like a rear-drive car," he said. The car used a new Typ G64/51 six-speed manual transmission.

"They thought they wanted to follow the 959 look," Tony Hatter recalled in November 2014. "So this integrated bodywork business was already going on." The faired-in fenders and wing of the 959 set the patterns for Turbos from there on. "I don't think anybody really believed that the 911 could carry on as it was," Hatter said. "So nobody thought [the 993] was going to be a real important car. 'Oh, just facelift the 911 again. And oh, by the way, you've got to do a Turbo version of it too.'"

While Hatter and a team of modelers got on with "the facelift," the supervisory board replaced Bez with Horst Marchart. Marchart soon devised the brilliant but hugely challenging concept that yielded an entry-level roadster and the next-generation 911 complete with water-cooled engines. On top of that, Lagaaij accepted a management challenge to produce a show car demonstrating that Porsche was still alive. The resulting Panamericana engaged another designer and modeling team.

"We were kind of left to get on in the corner," Hatter remembered. "It was so far over in the corner that I couldn't even really get a proper modeling concentration on it." Largely ignored because of the more economically significant projects commanding better space in the studios,



In preparation for the German TÜV vehicle certification, engineer Roland Kussmaul developed a sheet of verified dimensions for the inspectors. This sheet, dated September 21, 1994, specifically addressed body changes to the 993 Turbo. *Porsche Archive*

By now, in the repeated evolution of series production models, buyers could expect an S variant of the turbocharged model that was going to appear in the final year or two of the series. The 993 was no exception and Porsche assembled 345 of these Turbo S coupes. *Randy Leffingwell*

The Turbo S used Porsche Typ M64/60 S engine of 3,600cc displacement from bore and stroke of 100x by 76.4 millimeters. It developed 450 horsepower at 6,000 rpm and 431 pounds-feet of torque at 4,500 rpm. *Randy Leffingwell*

The Turbo S was a luxury automobile whose purchasers frequently ordered special interior treatments or exterior colors through Exclusive. The car sold for DM 304,650, around $175,000, at the factory before VAT. *Randy Leffingwell*

Porsche quoted acceleration from 0 to 100 kilometers per hour in 4.1 seconds and all-wheel drive helped make that horsepower useful. Top speed was 180 miles per hour. *Randy Leffingwell*

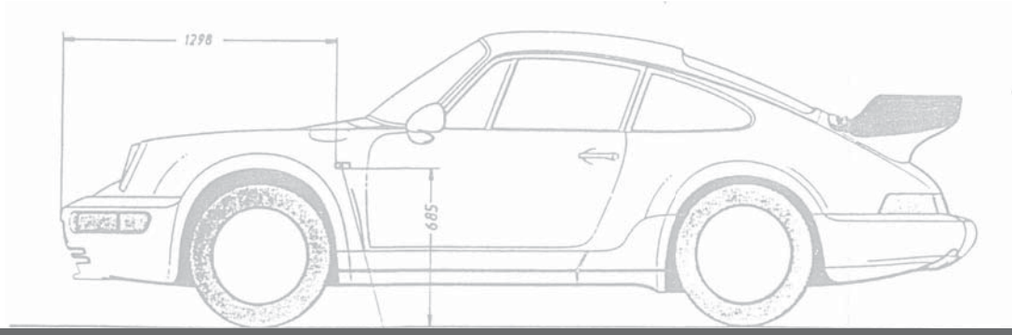
their work progressed with little interference. "Our modelers work surfaces to perfection," Hatter said, speaking of the final forms of the 993.

"Porsche has a special form language," retired chief modeler Peter Reisinger explained. "*Stil Frage*, the question of style. No sharp lines. Everything is round. This came from the 356. The body has different proportion, different surfaces, and they are cut between light and shadow with highlights," he said. "Since the 993, we have cleaned up these little add-on pieces. And since that time, it's a feature of the Turbo." Porsche began delivering 993 Turbos in April 1995, calling them 1996 models.

Rolf Sprenger's Exclusive department quietly converted fourteen narrow-body, rear-drive cabriolets to Turbos for good customers, incorporating a fixed rear wing and a five-speed manual gearbox. Exclusive also offered performance kits for the Turbo coupes in European markets only. These boosted engine output to 430 or even 450 horsepower at 6,000 rpm using engine modifications from the race-bred GT2 model M64/60R and M64/60RS engines.

The 993 GT2s were homologation models that Porsche offered customers in order to meet production requirements for racing classes. Motorsports engineers widened the series-production Turbo front and rear track from 55.6 and 59.2 inches, respectively, to 58 and 61 inches, and this widened the body (from 70.7 inches to 73) through added-on wheel arches. From introduction in February 1995 through end of 993 production at the start of the 1998 model year, the company assembled 172 of the 430-horsepower versions. An additional 21 emerged through 1998, with the higher-output 450-horsepower M64/60 S engine modifications.

Near the end of 993 model life, a series-production Turbo S emerged from Exclusive. This was the proverbial wolf in sheep's clothing, using the same M64/60S engine and providing almost identical performance to the GT2 while equipped with production Turbo accoutrements. Porsche claimed 0-to-62-mile-per-hour acceleration for the GT2 and this Turbo S in 4.1 seconds with top speeds of 186 miles per hour. Externally, the Turbo S incorporated an aero-kit front spoiler, a subtle C scoop between the door and the rear wheel arch for additional intercooler ventilation, and a gentrified 959-type basket-handle rear wing slightly elevated above the rear deck lid. Exclusive assembled 345 of these cars.



Chapter Thirteen

RACING IN THE 1990s

In advance of the 24 Hours of Le Mans, Porsche ran tests on the new GT at Paul Ricard. The run of eighty-six from Exclusive had provided a homologation level as a Grand Touring class entry. *Porsche Archive*

1993 964 TURBO S LM 3.3-LITER

Porsche has created special cars for Le Mans since 1951. These vehicles have served as proving grounds for engineering ideas and publicity generators drawing new customers to the company. One such effort arrived in 1993, when the World Sportscar Championship (WSC) had disappeared and a new series was to begin the next year. For the first time in several years, Le Mans organizers welcomed production-derived GT cars to the grid.

Into this mix, Porsche inserted the nearly unique 911 Turbo S Le Mans GT. The competition department assembled one car for the race and another as a test and development model. Hans Mezger's engineers tweaked the 3,164cc twin-turbo Typ M30/69SL to develop 474 horsepower at 7,500 rpm and to create 406 pounds-feet of torque at 5,200 rpm. The car weighed 2,328 pounds.

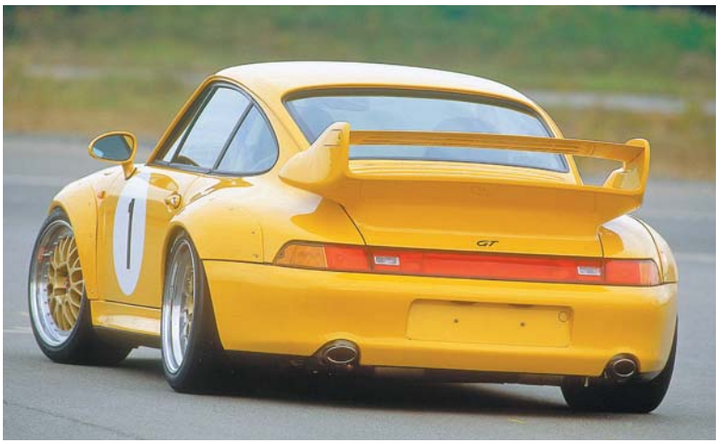
It debuted in March 1993 at Sebring, where it won GT class and finished seventh overall. At Le Mans, it qualified as the fastest GT car and hopes were high. Then a few minutes after 10:00 p.m. on the car's seventy-ninth lap, a 2-liter prototype spinning out of control collided with team driver Walter Röhrl. The impact split the oil cooler and ruined the engine before he reached the pits.

Before the season ended, Porsche sold the car to privateer Jack Lecomte. At Daytona in February 1994, despite a qualifying session incident that adversely affected handling, the car finished second overall. It took first in a four-hour race at Paul Ricard, repeated at Jarama in Spain and again at Suzuka in Japan, finishing the season with a win at Zuhaï, China.

The 3,164cc twin-turbocharged flat six developed 474 horsepower at 6,900 rpm. Sadly, co-driver Walter Röhrl collided with a spinning prototype six hours into the 24 at Le Mans and the car retired. *Porsche Archive*

1993 964 3.6-LITER IMSA SUPERCAR

Starting in 1991, Porsche drivers contested IMSA's Bridgestone Supercar Championship in 911 models. By 1993, Brumos Racing in Jacksonville, Florida, ran the factory-supported effort. All entries ran identical Bridgestone street tires. Porsche's competition department engineers and Brumos' racing team pulled 450 horsepower from the 3,600cc M64/69SL twin-turbo engine at 6,000 rpm; it developed 395 pounds-feet of torque at 4,800. Vehicle weight was tied to engine displacement, and the supercar raced at 3,155 pounds, carrying 220 pounds of ballast to meet the minimum, but placed exactly where Norbert Singer and his engineering staff had calculated to enhance handling. In 1993, with American Hurley Haywood and German Hans Stuck sharing driving duties, the Brumos team took the season championship and Stuck claimed the driver's title.



The GT America pulled out of the Daytona pits for practice. It used the Typ M30/69 flat six. This Brumos entry retired after 467 laps with a broken fan belt. *Porsche Archive*

The Typ 993 GT2 used Porsche's 3,600cc twin-turbocharged M64/81 that developed 450 horsepower at 5,700 rpm. Weissach motorsports department assembled forty-three of the cars that weighed 2,425 pounds. *Porsche Archive*

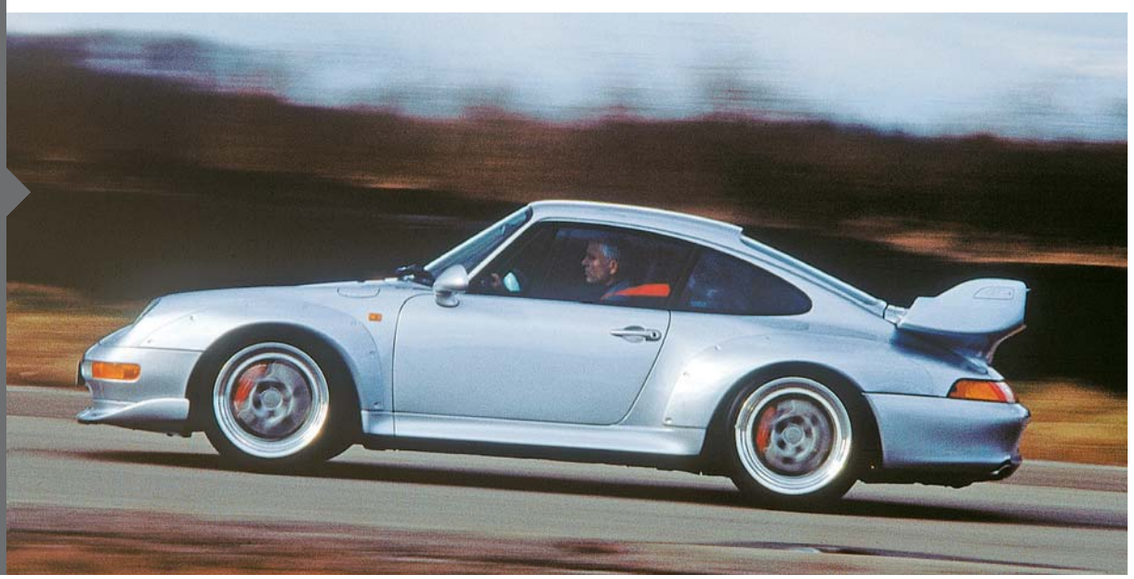
Following development and testing at Weissach in February 1992, Porsche shipped the car to Brumos Porsche in Jacksonville, Florida. Hurley Haywood drove it to the season championship. *Porsche Archive*


BILSTEIN
Kendall
Brumos
Porsche
59
Brumos
Porsche
BOSCH
BRIDGESTONE
EXXON


911 GT
S LZ 4088

The interior of the street version was understated. Doors and front deck lid were aluminum. *Porsche Archive*

Weissach assembled 172 of these street versions and at introduction sold them for DM 288,000 ($201,400 at the factory before VAT). The obviously added-on fender extensions were part of the homologation package. *Porsche Archive*



The street version GT2 ran with the Typ M64/60 R engine developing 430 horsepower at 5,750 rpm. The company quoted acceleration from 0 to 62 kilometers per hour in 4.4 seconds and a top speed of 172 miles per hour. *Porsche Archive*

1995–999 911 GT2

The BPR endurance races started in 1994. By late 1995, the four GT classes narrowed to just two groups. While the GT1 classification represented engine, drivetrain, chassis, and body technology at a level corresponding to Gruppe C 962s, the GT2 class encouraged Porsche to develop its road-going 993 Turbo model into a competition vehicle to succeed the normally aspirated Typ 964-derived Carrera RS and RSR 3.8-liter models.

BPR rules called for a minimum of one hundred cars for class approval, and Weissach kicked into action. Add-on fender flares, 1.2 inches wide at rear and 1.6 inches at front, wrapped around the racing tires. Additional vents cooled the front brakes while another set sliced into the rear wing, feeding air to the intercooler.

The motorsports department gutted the series-production interiors and welded in a roll cage, mounted an air-jack system, installed a fire-suppression system, and mounted a single racing seat. Doors and the front lid were aluminum, and side and rear glass panels were thinned to half of production specifications. Adjustable shock absorbers and springs replaced production versions on the otherwise production-stock suspension.

The Typ M64/81 twin-turbo engine displaced 3,600cc. Fitted with inlet restrictor plates to constrain horsepower according to specific regulations, the engine developed 450 horsepower at 5,750 rpm and 398 pounds-feet of torque at 4,500 rpm. A strengthened, production-derived Typ G50/54 six-speed transmission gained additional lubrication and oil cooling, along with an asymmetric limited-slip differential that delivered 40 percent lockup on acceleration and 65 percent on coasting. GT rules specifically did not allow all-wheel drive. Ready to race but lacking the driver, the GT2 weighed 2,535 pounds.

One 1996 rule let Porsche engineers revise the front spoiler, and another permitted competition engineer Roland Kussmaul to introduce an evolutionary—or EVO—version of the GT2 intended to compete in GT1 class. Porsche had offered a GT1-equipment option for the 1995 model; it delivered 550 horsepower from its 3,849cc twin-turbo engine. The 1996 EVO used the 3,600cc Typ M64/83 engine, incorporating changes to camshafts, intercoolers, turbochargers, Motronic engine management, and oil cooling and tanking. The modifications boosted engine output to 600 horsepower at 7,000 rpm and raised torque to 479 pounds-feet between 4,000 and 6,500 rpm.

For those not contesting GT1, Porsche offered the 911 GT2 versions (1996/2) in midyear, adopting parts from EVO versions. Kussmaul's improvements elevated horsepower from 450 to 465 at 5,750 rpm but left torque unchanged. Very subtle changes differentiated the 1997 GT2 race cars from those 1996/2 versions. Kussmaul offered conversion kits for 1996/2s, including the larger K24 turbos and EVO body modifications. The 1997 cars introduced ceramic brake pads.

Bigger changes arrived for 1998. The M64/82 engine (still 3,600cc displacement) went to twin-plug ignition, and with a few other improvements, output increased from 465 to 485 horsepower at 5,750 rpm and torque from 479 pounds-feet to 490 at 5,000 rpm. Singer's aerodynamicists improved the front spoiler.

The ultimate Typ 993 model 911 GT2 arrived in 1999 when the competition department introduced the M64/84 conversion kit that enlarged the 3,600cc displacement to 3,800cc by increasing bore from 100 millimeters to 102. (Stroke remained 76.4 millimeters.) Horsepower rose from 485 to 535 while torque increased from 490 pounds-feet to 503. Another upgrade included next-generation shock absorbers, front camber plates, and front and rear brakes with six-piston calipers. In the BPR GT2 class, these cars often competed against many—sometimes dozens—of identical Porsche GT2s.

1996–1997 993 GT1 AND 1998 996 GT1

Back in 1993, as he was preparing concepts for the coming BPR series launch in 1994, Singer and racing-chassis designer Horst Reitter began brainstorming how a Porsche-engined car could compete successfully against the endurance-race-prepared McLaren F1. "Horst Reitter and I already believed we could make a midengine 911 if we turned the engine around and put it right behind the driver," Singer recalled in 2005.

"We knew a longer wheelbase would improve high-speed stability. We had to keep the car's basic steel monocoque, but we decided to put a wall behind the driver, put the engine behind that, and put the gearbox behind that."

The EVO competition car interior was a far cry from the comfort of the GT2 road car. This car was strictly about performance and driver safety. *Porsche Archive*

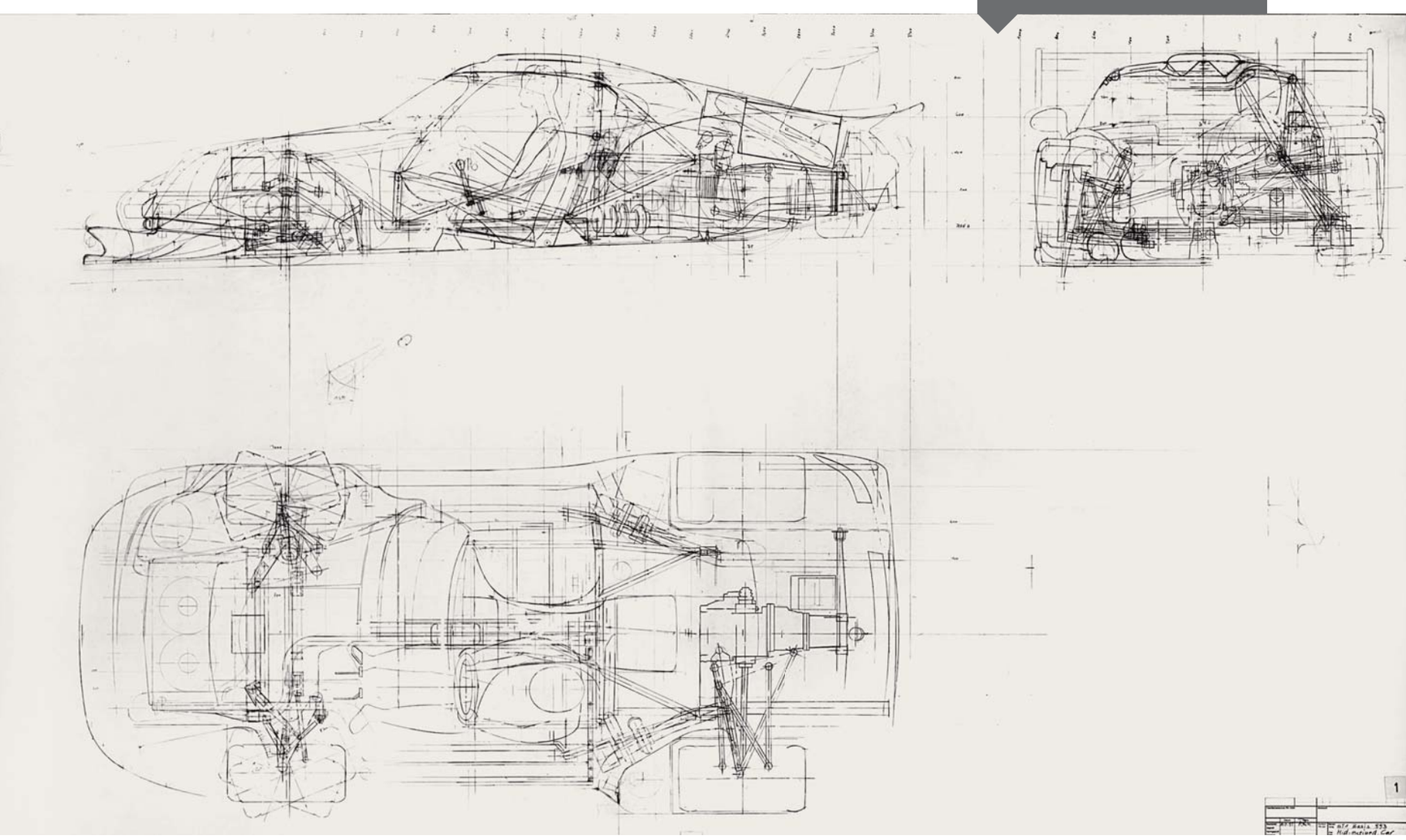
Motorsports offered an upgrade package to run the GT2 in GT1 class. This fitted larger turbochargers, a more aggressive Motronic engine management program, separate turbo wastegates, and resulted power output up to 550 horsepower at 6,250 rpm. *Porsche Archive*

BPR regulations allowed annual updates for already homologated cars as evolutionary models, or EVO. With a number of subtle changes, engine output rose to 600 horsepower at 7,000 rpm. This serious race car sold for DM 570,000, roughly $382,000, at Weissach without VAT. *Porsche Archive*

It is hard to refer to this as production when each of these twenty-one homologation models was so explicitly hand assembled. Because BPR regulations required GT1 cars had to be based on production models and had to be offered to the public, Porsche priced these cars at DM 1,550,000, approximately $1,033,000, at the race shops without VAT. *Porsche Archive*

The cars stretched 15 feet 5 inches long, 6 feet 6 inches wide, and 3 feet 10 inches tall. Porsche quoted acceleration from 0 to 62 kilometers per hour in 3.7 seconds and a top speed of 192 miles per hour. *Porsche Archive*

In mid-September 1995, Porsche issued this technical dimensions drawing labeled "GT1, Basis 993 Mid-Engined Car." Because it grew from the series production Typ 993, the car's stylist Tony Hatter worked closely with racing manager Norbert Singer. *Porsche Archive*



Following the 1994 Le Mans weekend, where only three Porsche 911s were among the fifteen finishers—and where twelve Porsche cars had failed to qualify—competition director Herbert Ampferer asked Singer to develop his midengine concept for GT1. "We had to bear in mind," Singer wrote in his book *24:16*, "that even if the engine was in a different place, this still was a production car, a 911, not a prototype where [we] would have a free hand."

Style Porsche had had little to do with race car design since the early 1970s. Dick Soderberg and his team worked on the 908, and Tony Lapine's stylists created the many paint schemes for the 917s. They did only graphics for factory 935s, 956s, and 962s. But the GT1 brought them back in.

"The directive was to make the GT1 as near to a road car as possible," Tony Hatter explained. He had designed the exterior of the 993 and that was the basis for this new racer. "I made a model in the very early stages of computer-aided styling on the screen, from the package I got from the racing department. And we milled it and that was the first GT1.

"We went into the wind tunnel," he recalled. "And this is when I first got to know Singer. He came in and said, 'It's rubbish. Typical styling exercise; it's rubbish. It'll change.' And the thing did change quite radically, but we were using this computer-aided styling system. And he was a hands-on guy. So we'd do stuff in the wind tunnel and measure it, primitively, marking points. And these points and sections I'd put back into the computer and do it on the screen." That represented a big change in race car design.

"We went into the wind tunnel with a scale model in September 1995," Singer continued in his book, "and then, in parallel, we made a full-size clay model in October. We had to make a road car first—that was the rule. We got the first body parts in March 1996."

As Singer had expected, the GT1 changed. The wheelbase grew from the standard 993 length of 89.4 inches to 98.4. Production car height was 51.2 inches while the GT1 hunkered down to 43.3. The race car measured 77.2 inches wide compared to the series car's 68.3-inch width. Overall, the 993 grew from 167.1 inches to 184.4. Body panels of a Kevlar/carbon fiber/epoxy resin compound surrounded the sheet-steel unibody, and the roll cage provided reinforcement. It weighed 2,205 pounds.

The engine evolved from the GT2 EVO 1996/2 twin-turbo crankcase and some of its internals. New water-cooled cylinders and cylinder heads incorporated dual overhead camshafts and four valves per cylinder. This Typ M96/82 engine displaced 3,164cc. With 35.7-millimeter intake restrictor plates, it developed 600 horsepower at 7,200 rpm and 479 pounds-feet torque at 5,500 rpm using twin KKK model K27.2 turbochargers and intercoolers. The fully synchronized six-speed transmission had a dedicated lubricating pump and an oil-intercooler to maintain proper temperatures.

As Jürgen Barth pointed out in an interview in 2011, "the GT1 development period was crazy, just two hundred and thirty-four days from approval to the start of Le Mans on June 15, 1996. And the two GT1 entries won their class!"

Porsche's GT1 did not appear again until a four-hour race at Spa in late September, when one took first overall ahead of two McLarens. This was followed by success at Zuhaï in early November, when two factory cars finished first and fifth.

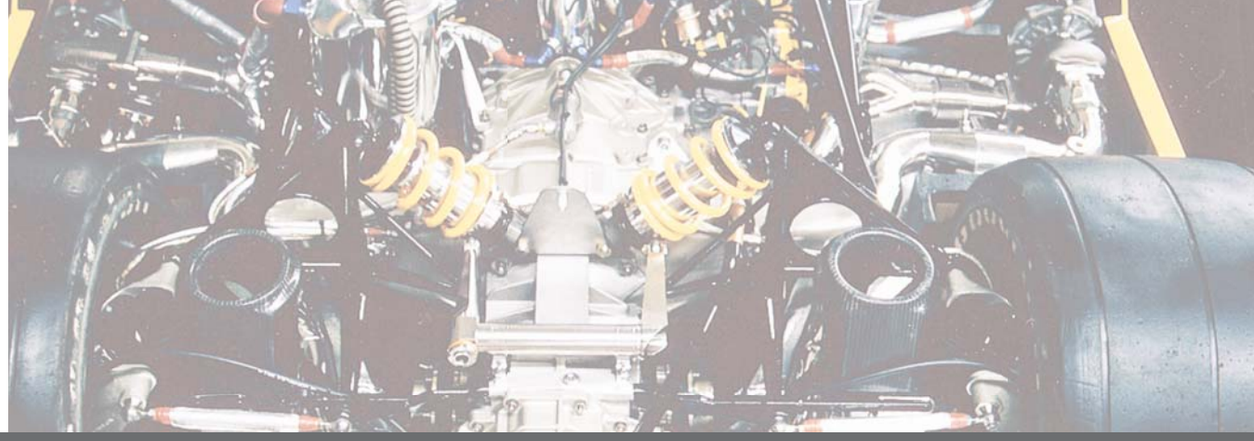
For the 1997 season, Singer, Reitter, and Hatter updated the car and its appearance using the distinctive headlights from the new Typ 996 series-production model. Called the 911 GT1 EVO, the new front end accommodated a new front suspension. The annual racing series changed names, becoming the FIA GT Championship. Porsche delivered five customer racers as well as new factory team racers. Where 1996 rules had required completion of just a single street car to homologate a GT1 for competition, the 1997 rules called for twenty-five. Competition from a not-quite-rules-compliant Mercedes-Benz CLK GTR model (Mercedes assembled just twenty, with a number of features unsuitable for road use) compelled Porsche to vigorously support its customers and take on more races than originally planned. By season end, Mercedes had taken the team championship, followed by BMW-McLaren. Porsche fared no better than fourth.

Following such a season, it took all of Ampferer's persuasive power to convince Horst Marchart to renew support for GT1 for 1998. Porsche had learned from Mercedes and McLaren, and Singer knew the company needed a pure racing car underneath a familiar badge. A hurriedly finished GT1-98 road car earned Technischer Überwachungsverein (TÜV) approval while Horst Reitter developed a new carbon-fiber monocoque and Singer and Hatter perfected the body and its aerodynamics. Porsche carried over its engine, but Singer knew it was severely stressed and significantly overmatched by Mercedes with its 5-liter V-8 and two small turbos.

Le Mans divided a disastrous season, and the twenty-four-hour race pitted Porsche against many serious challengers and challenges. At the end, it finished first and second overall. Racing historian Jànos Wimpffen summarized the contest in his *Time and Two Seats*: "Porsche team manager Herbert Ampferer and his crew cried tears of relief. Beginning with the 1996 race Porsche had designated the 911 GT1 to be their standard bearer and after three long years they could finally celebrate its victory."

For Le Mans, Norbert Singer and aerodynamics designer Eugen Kolb created a "long-tail" version of the GT1 that was 16 feet 2 inches long, just 9 inches longer than the customer street versions or race cars. Allan McNish, Laurent Aïello, and Stéphane Ortelli co-drove the car to overall victory. *Porsche Archive*

The Typ M96/83 water-cooled 3,164cc flat-six twin-turbocharged engine developed 544 horsepower at 7,200 rpm and 443 pounds-feet of torque at 4,250 rpm. It weighed 2,469 pounds. *Porsche Archive*



Chapter Fourteen

PORSCHES BY **ANOTHER** NAME

Former racing team owner and driver Jochen Dauer unveiled his wild idea for a Porsche Typ 962 converted to street use at the Frankfurt Auto Show in September 1993. He anticipated obtaining a one-model exemption from the German government and he set a price of DM 1,725,000 (about $1,040,000 without VAT). *Porsche Archive*

1993–1994 DAUER 962 LE MANS GT

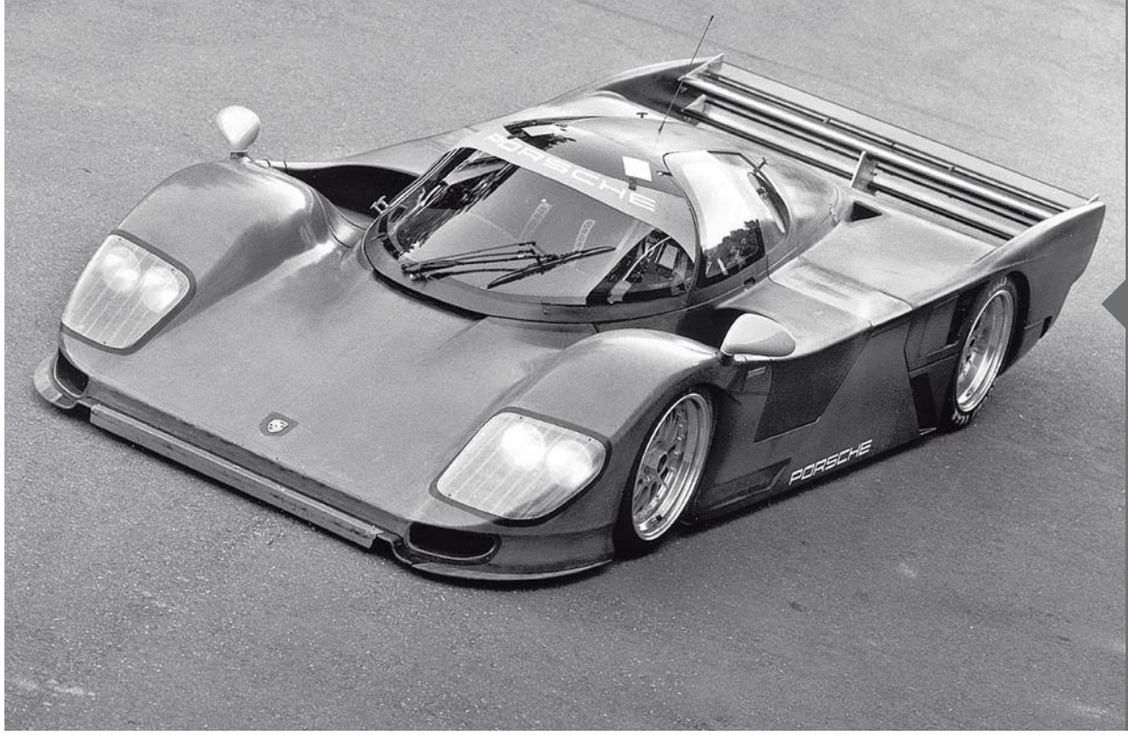
Porsche has experienced numerous instances when an outsider has taken one of its products and modified it, often attaching their own name to the creation. In series production, engineers and designers such as Alois Ruf, Techart Automobildesign, b+b, DP, Uwe Gemballa, and 9FF have revised and altered road-going models since the 1970s. In racing, the practice goes back to the 1950s with Walter Glöckler and includes such great successes as Manfred and Erwin Kremer, Reinhold Jöst, and Gruppe C racer and team owner Jochen Dauer.

Dauer startled 1993 Frankfurt Auto Show visitors with a road-going Porsche 962. Norbert Singer noticed the car and liked what he saw, but he recognized it needed serious work to meet Germany's stringent road regulations.

Dauer's adaptation ignored racing regulations. With twin KKK turbochargers, his version of the 2,994cc flat-six 962 engine offered 730 horsepower at 7,400 rpm and 517 pounds-feet of torque at 5,000 rpm, sufficient to take the 2,381-pound coupe from 0 to 62 miles per hour in 3.6 seconds and on to a theoretical top speed of 241 miles per hour through its five-speed transmission. He displayed a price of DM 1,725,000, or roughly $1 million.

As the world's economy contracted during the recession years of 1990 to 1993, Le Mans felt a similar contraction. In 1990, forty-nine cars started the race; that number dropped to thirty-eight for 1991 and twenty-eight for 1992. New racing categories hamstrung the Porsche 962 and its best finishers in 1992 went to tenth-place privateers. FIA rules aimed at the 962's extinction while letting the World Sportscar Championship (WSC) die in 1992. Prudently, France's Automobile Club de l'Ouest (ACO), the

Even with rear brake light turn signals and reversing lamps, along with substantial twin mufflers, he wasn't able to interest anyone in his car except Norbert Singer. Singer understood that as a road car, this 962 was eligible to compete as a GT1 class racer at Le Mans. *Porsche Archive*



Engineering chief Horst Marchart had little enthusiasm for the project but gave Singer guarded approval to proceed with three spare 962s still at Weissach. BPR's inspectors had even less enthusiasm, having thought they'd seen the last of any 962 in racing. *Porsche Archive*

With Porsche's Typ 935/85 engine installed, Dauer claimed 745 horsepower out of the 2,994cc engine at 6,000 rpm. *Porsche Archive*

sanctioning and operating body at the twenty-four-hour race, adopted a new grand-touring-car-based sports-car series. This BPR Global GT Series came together through the efforts of French organizers Patrick Peter and Stephane Ratel and Porsche customer racing manager Jürgen Barth. For 1993, forty-seven cars started Le Mans, some of them updated 962s while thirteen were 911 RSR or Cup models.

BPR called that a trial year, and the series launched officially for 1994 with four classes, GT1 through GT4. Where the WSC demanded specially constructed racing cars, BPR called for production-derived automobiles that teams modified into racing versions. BPR's loosely written regulations did not specify a minimum production number and Norbert Singer, ever the sharp-eyed reader of rules, saw Dauer's "road car" as the production car basis on which to resurrect and race the 962 one more time.

Singer set out to homologate Dauer's car. This meant meeting the demanding TÜV technical and safety inspection required for every motor vehicle in Germany. With Horst Marchart's guarded blessing, Singer began work. Some modifications were structural changes, including widening the cockpit to meet field-of-view specifications for street-legal automobiles. This allowed a second seat for a passenger. He replaced the ground-effects tunnel underbody with a flat sheet on a carbon-fiber chassis and installed a hydraulic suspension to elevate the car's ground clearance to meet national laws. His engineers found a space suitable for a small piece of luggage and they muffled the engine. Singer devised an electric windscreen heater to defrost the front glass in the required 10 minutes. The Dauer 962 GT obtained its TÜV approval. But a tougher challenge remained: he needed approval from the ACO in the person of race director Alain Bertaut.

"He was far from pleased," Singer recalled in his autobiography. "This is not in the spirit of the regulations," Bertaut told him. "A GT car should be derived from a road car. This is a racing car that already has won Le Mans many times!" Reluctantly, Bertaut accepted two cars, promising to rewrite the 1995 rules so no 962 ever would appear again.

Hurley Haywood remembered his 1994 winning drive during an interview in 2011: "It was like driving a 936. The flat bottom meant it had no ground effects and the rules made us use narrower tires. I could slide it through the corners and use the throttle to control it, not like a ground-effects car. And we had fantastic carbon-composite brakes, so nobody could catch us going into corners."

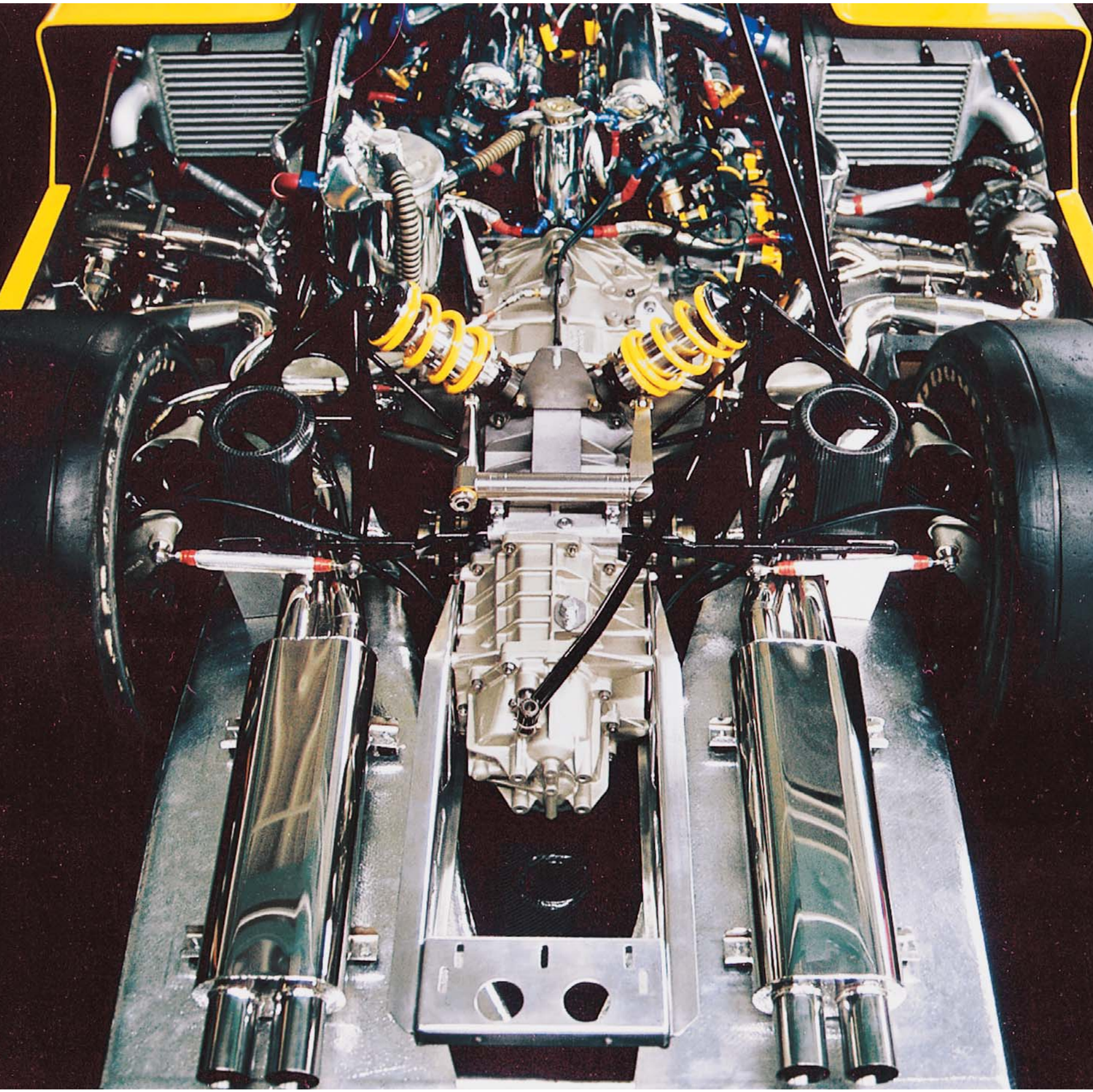
While it was not an easy race—driveshafts failed and other typical Le Mans gremlins plagued the teams—the work Singer and his engineers and drivers accomplished paid off, as the Dauer Porsches finished first and third overall, the winners covering 2,927.8 miles at an average of 121.9 miles per hour.

1995–1998 KREMER K8

Erwin and Manfred Kremer in Cologne breathed life in to the aging 962 Group C coupes by adapting their perfectionist technology to a series of racing spyders they developed on either carbon-fiber or aluminum monocoques. The Kremers first tried this idea with their CK7 Spyder in 1992. This was an open car with Typ 962 Group C running gear that competed in the ongoing and evolving Interserie races. They carried over the 3.2-liter flat-six twin-turbocharged engines. Running a single CK7 in 1992, they captured the series championship.

With the arrival of BPR regulations at Le Mans and a similar mindset affecting the IMSA GT series in the United States, the Kremers created the K8. Unlike Interserie rules, BPR regulations wanted a two-seat configuration, and the brothers again drew on their 962 CK6 platform. The K8 used a Kremer-modified 2,994cc engine derived from Porsche's 935s. Back in 1994, the low, sleek spyder, dressed in Gulf livery, qualified third fastest for the twenty-four-hour race. At the end, a pair of equally hybridized 962s—the brain child of parents Jochen Dauer and Norbert Singer—finished first and third, while the one and only spyder entered in the race, the K8, contented itself with sixth overall.

The regulations at Daytona's twenty-four-hour event seemed inviting. The K8 qualified seventeenth out of seventy-four starters, but because of last-minute rule changes, further constricting air/fuel intake, they came in first! At Le Mans, with a second K8 in the stable, Kremers finished sixth overall against stiff competition from the Porsche-powered Courage



The mysterious Spyder, which should be raced in the States but for some reason never made it to a race. *Porsche Archive*

While factory racer Hans-Joachim Stuck did the test and development driving, he also led the team driving at Le Mans. After 24 hours, the Porsche–Dauer–Singer long shot took first overall. New rules for 1995 banned 962s for all time. *Porsche Archive*

The redoubtable Reinhold Jöst entered and won Le Mans with this same car in 1996 and 1997. Not only that, but the same car, with the same driver, Michele Alboreto, qualified on the pole each year as well. *Porsche Archive*

C34 and the McLaren F1. Following Le Mans, the Kremers contested the Interserie again. Through 1996, 1997, 1998, and 1999, the cars competed, but competitors passed them by, literally.

1995–1998 WSC LE MANS

Where Jochen Dauer's 962 LM-GT at least had started life as a Porsche, the TWR-Porsche WCS cars began their existence as Group C Jaguar XJR-14 prototype coupes. These had fine provenance, having won the World Sportscar Championship in 1991. Tom Walkinshaw Racing (TWR) had assembled these cars and run them with normally aspirated 3.5-liter Cosworth V-8s. The three XJR-14s fought heavy competition from a new Peugeot prototype, and at the end of 1991, Jaguar withdrew from FIA Group C, migrating like many others to the 1992 IMSA Camel GTP series in the States. There, however, it continued to struggle behind Nissan and Toyota entries, and at the end of 1992, Jaguar withdrew altogether. TWR found other uses for the chassis and produced five similar versions that enticed Mazda to enter IMSA.

Following Porsche's 1994 Le Mans victory with the Dauer cars, Norbert Singer looked into the IMSA championship and the new World Sports Car (WSC) class for 1995. Porsche racing manager Max Welti and competition engines chief Herbert Ampferer met with TWR to develop two TWR-Porsche WSC95 Spyders. Time was insufficient to prepare the cars to Porsche standards, and when they arrived at Daytona for testing, they were so far from competitive that Daytona officials accused Porsche of sandbagging, intentionally going slow to mislead competitors. Race officials punished them by raising the car's minimum weight by 100 pounds and reducing inlet restrictor diameters from 34.5 to 32 millimeters. This, according to Singer, "effectively reduced the power by 13.9 percent." He withdrew the cars, and when the Kremer K8 won using the same engine, Daytona officials felt vindicated in their decision.

Within a month, Porsche severed its arrangement with TWR and brought the two Spyders and all the spare parts to Weissach. At year end, Reinhold Jöst proposed using the cars for Le Mans in 1996. Porsche, having lost Le Mans to McLaren in 1995 (but having confidence in Jöst), agreed, and in December 1995, Reinhold's team began working on them. Jöst installed the twin-turbo 2,994cc Typ 935/85 engine, and with 34.5-millimeter restrictor plates and 2 bar of boost, it produced 540 horsepower at 7,700 rpm and 443 pounds-feet of torque at 4,500 rpm. The car weighed 1,953 pounds. Because Singer was intensely involved in the company's efforts for the GT1 category, Porsche encouraged Jöst to use the two prototypes to go for overall victory. Singer and Ampferer continued to advise and consult with Jöst, and Reinhold's team took first overall in the TWR-Jöst-Porsche WSC95, while Singer's new twin-turbo GT1 factory effort followed just behind in second and third overall, taking first and second in GT1.

Jöst's twin-turbocharged Spyders repeated again in 1997, winning Le Mans while the factory GT1 entries did not finish. Results reversed for 1998, when the GT1s claimed first and second overall, and Jöst's two Le Mans Prototype Spyders failed to complete the twenty-four hours.

Chapter Fifteen

TURBOS ON AND **OFF-ROAD**: THE 2000s

The "face" of the 996 Turbo resulted from hard work from engine designers, aerodynamics engineers, and designers who blended everyone's requirements to make an elegant front end. Then the US Department of Transportation questioned the result of Porsche's front-end impact tests and demanded— for 2001 only—the bumperettes. *Porsche Archive*

2001–2005 TYP 996 TURBO

In the early 1990s, Porsche's marketing department saved the 911 Turbo—by killing it.

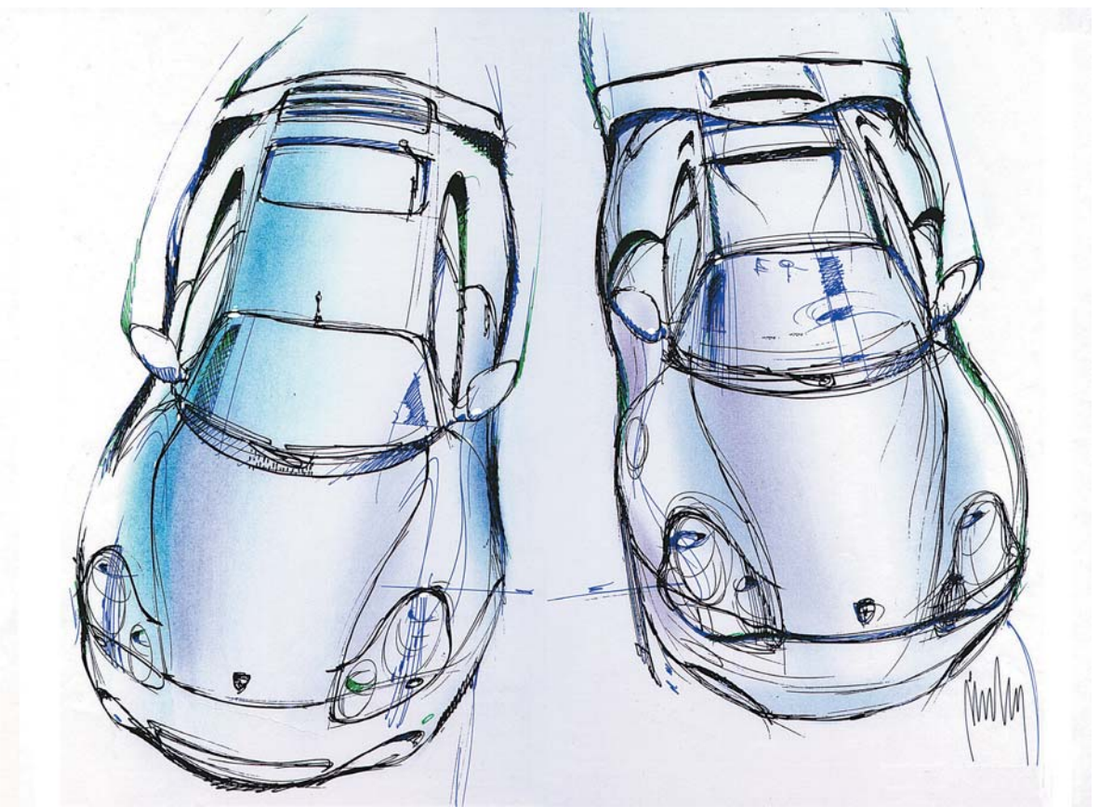
"Marketing said we didn't need a Turbo model for the 996," Thomas Krickelberg explained in November 2014. "And the board of directors believed them. The 911 project manager, Fritz Bezner, went to our board four times to convince them that we should build a Turbo."

"So they looked for a cheap way to do it," he continued, "not from the parts cost, but for the development cost. They determined it was cheaper to take the old Hans Mezger crankcase and do some water-cooled liners and water-cooled cylinder heads—it was cheaper to do it that way than to use this new crankcase and develop a turbo from there.

"So it was *not* an engineering reason to do that. It was just because it took a long time to convince the marketing people to build a Turbo. Then they calculated the possible market volume. They decided they can sell 1,500 units per year."

Marketing's actions saved 996 Turbo buyers from the hardships that followed the introduction of the troubled 3,387cc flat-six M96/01 engine for the 996 Carrera coupes.

As for the challenges of water-cooling the existing air-cooled engine, "it wasn't really hard to do," Krickelberg said. "It was nearly carryover. They had to develop the water-cooled liners . . . separate wet liners . . . Nikasil-coated liners. The cylinder head was designed for our VarioCam Plus system because we thought this was the most intelligent solution for valve lift systems."



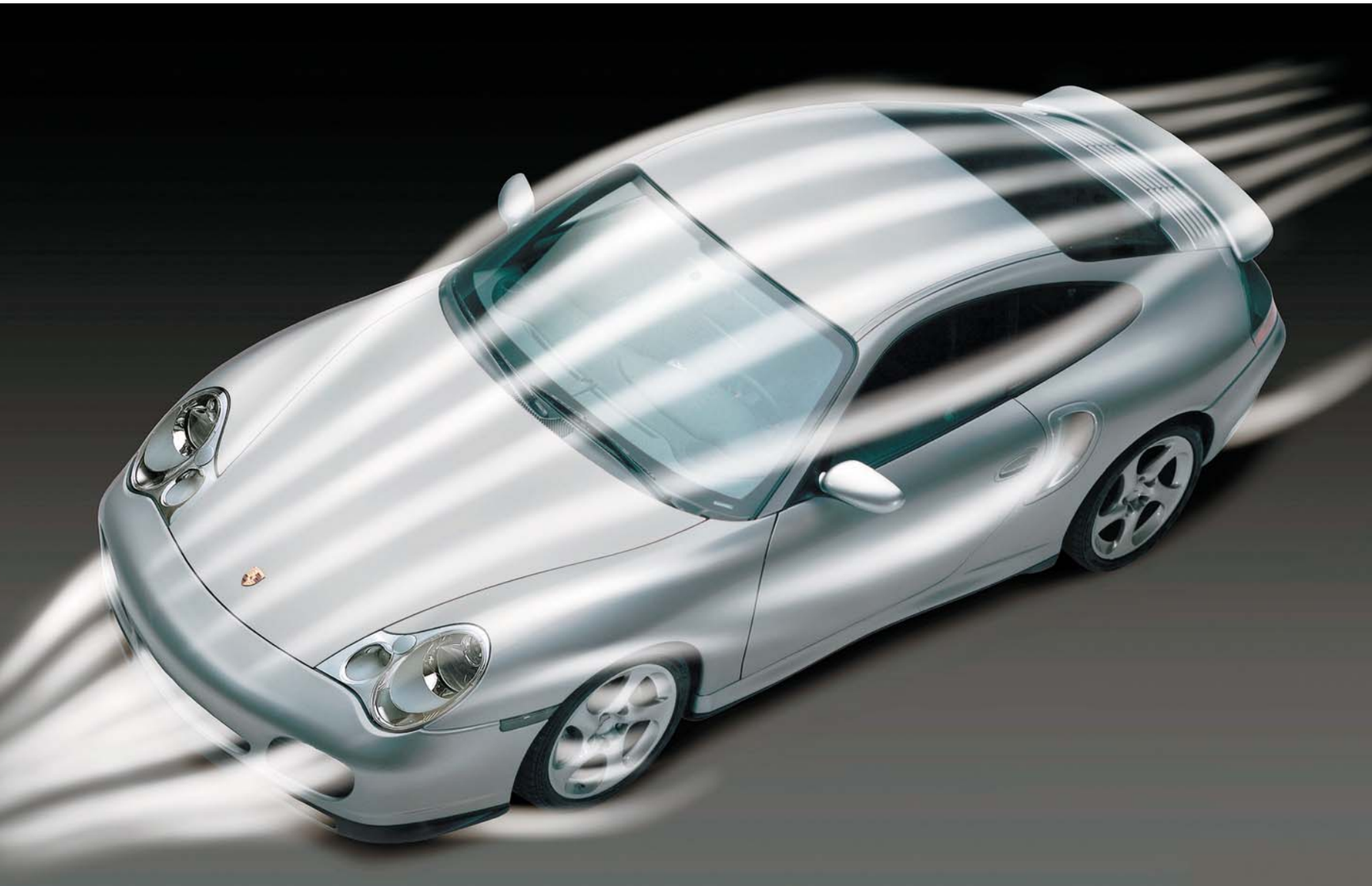
Concept sketches Pinky Lai made for the 996 Turbo strongly emphasized the "coke bottle" taper that resulted from much more subtle integration of flared wheel fenders. *Porsche Archive*

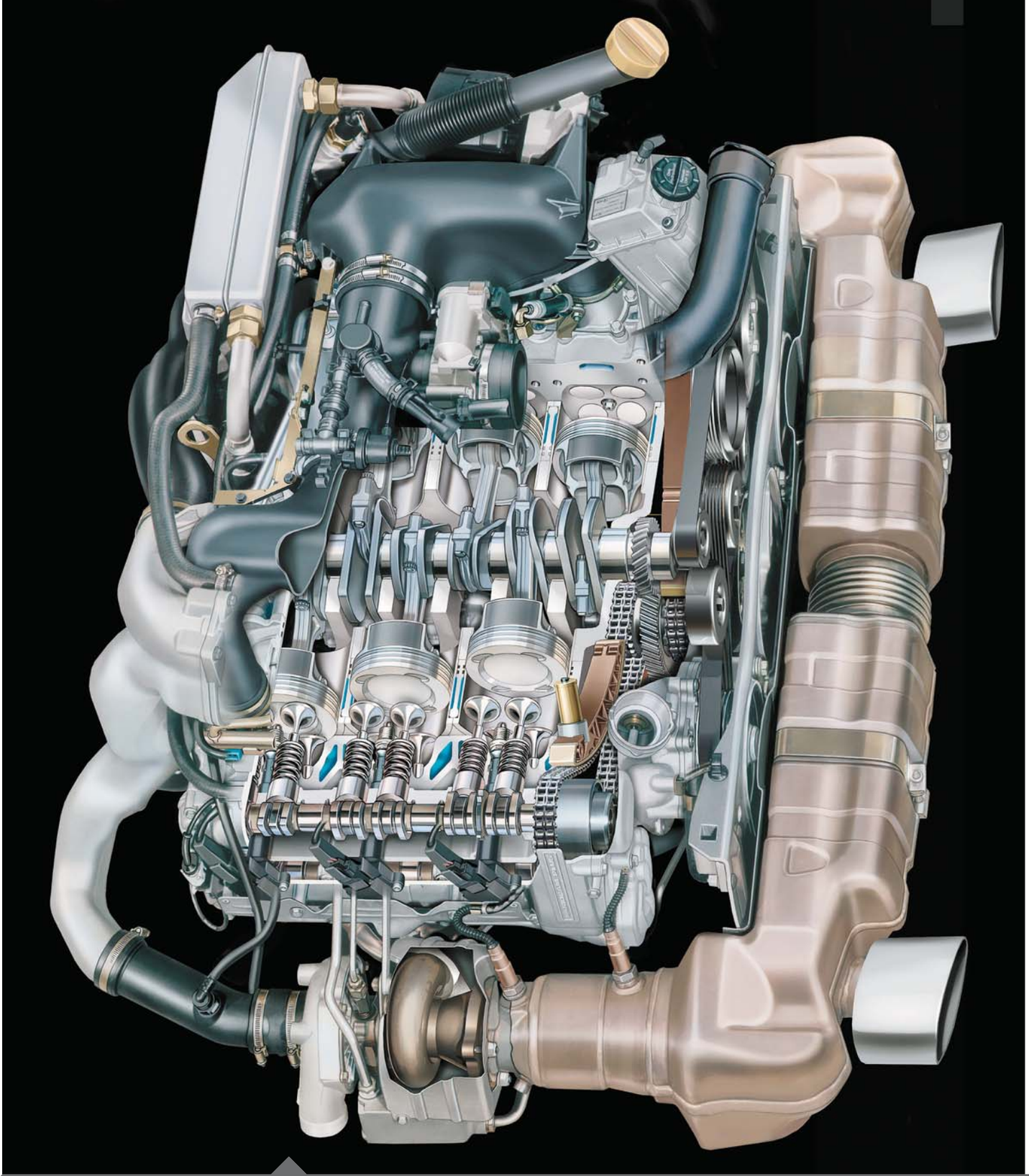
The model year 2000 Typ 996 Turbo was the first of Porsche's 911 turbos to benefit from this VarioCam/VarioRam technology. This twin-turbocharged, water-cooled Typ M96/70 inherited a system developed for and introduced on the water-cooled 996 GT3. But the Turbo's system went further. The complexity and capability of the normally aspirated GT3 was startling. To quoting Karl Ludvigsen in *Excellence Was Expected*, "A hydraulic [cam angle] variator on the drive end of each inlet camshaft was capable of delaying the inlet-valve timing by 30 crankshaft degrees from the advanced timing that was optimum for high horsepower. The enhanced system, led by Weissach engineers Claus Brüstle and Dietmar Schwartzenthal, varied valve *lift* as well as timing." Named VarioCam Plus, this system essentially provided each intake valve with two tappets in one. "A small 11mm tappet, in contact with the valve stem, slid in a hole in the center of the main tappet, which was of normal size," Ludvigsen explained. One cam lobe contacted this center tappet and provided a 3-millimeter lift. A pair of cams on either side of this lower lobe touched the full-size tappet, lifting it 10 millimeters. The camshaft angle variator adjusted timing for early opening for increased power or late opening for low engine loads and reduced emissions.

"VarioCam Plus offered combinations of early and late timing with high and low lift, all under the control of electro-hydraulic switching valves operated by the specially adapted Motronic," Ludvigsen continued. "Low lift and late timing were just the ticket for stable operation and low emissions at low speeds and loads." But it was a tricky balance that took testing to make the system drivable. Ludvigsen quoted Peter Zickwolf, development chief for the 996 turbo engine: "Initially . . . oil pressure was too low below 2,000 rpm to operate the system with the result that 'torque used to leap up by as much as 120 lb-ft with the change to the high-lift cams.'"

The 3,600cc Typ M96/70 engine for the Turbo was a further development of those Hans Mezger and his engineering staff had created for endurance racing. Its only similarities to the new 3,387cc M96/01 water-cooled engine designed for the series-production Carreras were that both were opposed-six cylinder configurations and were water-cooled. As Weissach engineers converted air cooling to liquid cooling, they carried over the steel connecting rods from the Typ 993 Turbo Typ M64/60 engine, which were parts that engineers determined were adequate for its 6,750 rpm redline. Water-cooling the cylinder heads also allowed engineers to incorporate two exhaust and two intake valves per cylinder, finally achieving a longtime goal.

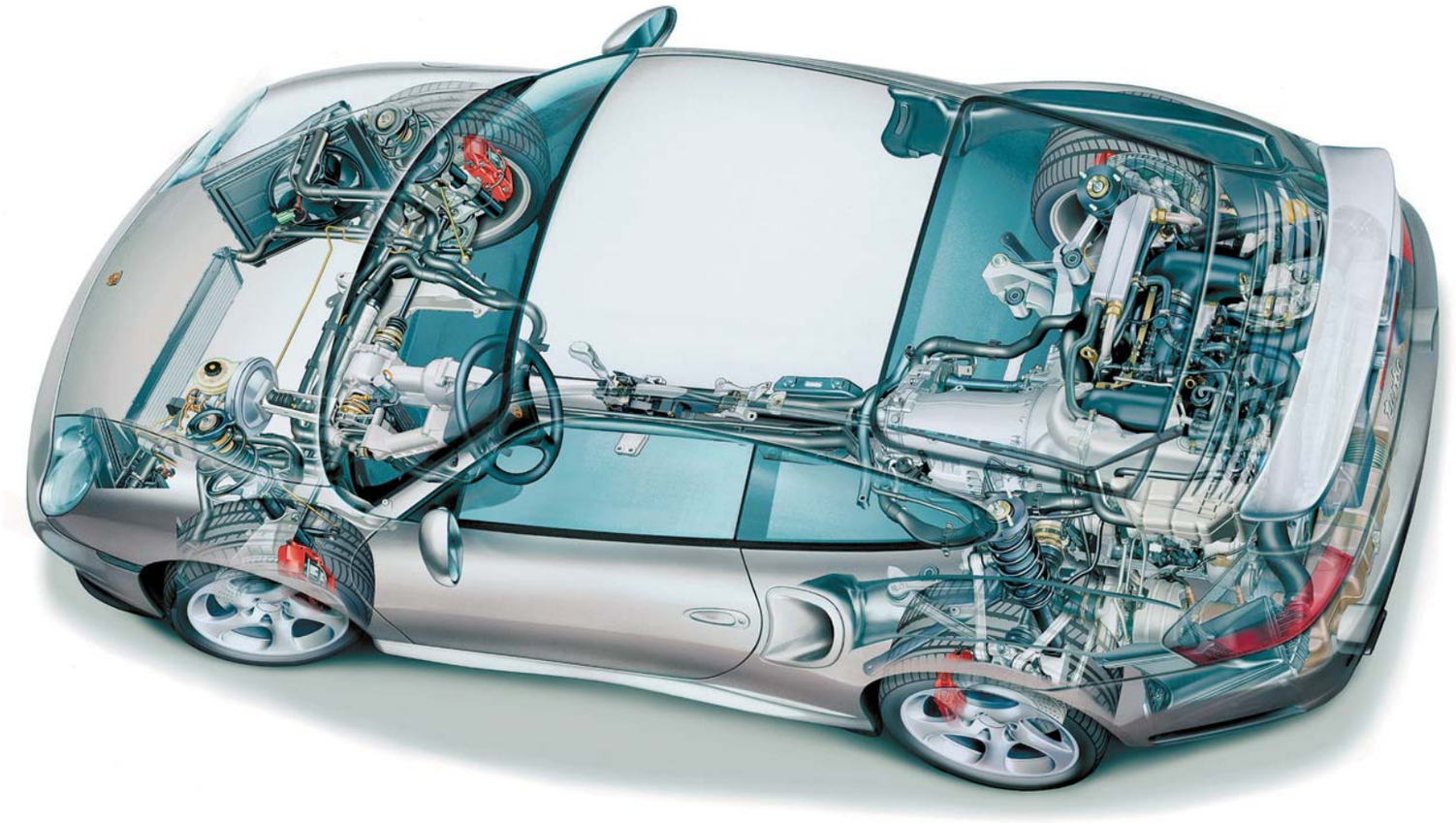
These twin-turbocharged engines with their twin intercoolers demanded greater cooling than the normally aspirated Carreras. Porsche engineers added a third radiator at the front of the car in the process creating what became known as the Turbo face. As Paul Frère described in *Porsche 911 Story* , "The twin turbochargers with incorporated wastegate differ from those used in the 993-series Turbo only by the flange and are

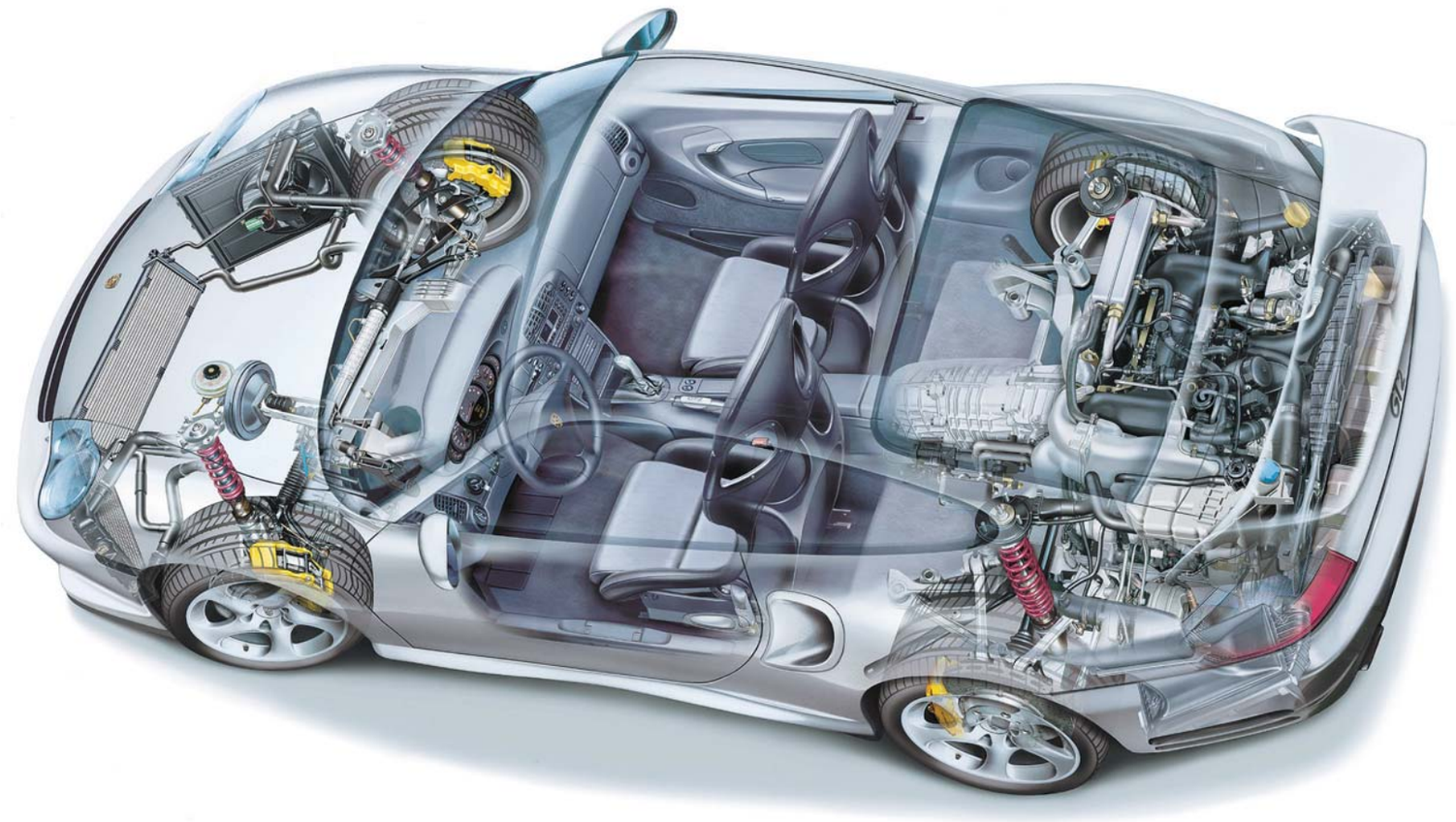




Turbo 911 design priorities changed demonstrably when Porsche introduced water-cooled engines. The "face" of the 911s not only had to look familiar but it had to accommodate—and even dramatize— the presence of radiators to cool the powerful engines. *Porsche Archive*

Porsche's M96/70 was a carryover from several previous generations onto which engineers added water jackets for engine and cylinder head cooling. The engine developed 420 horsepower at 6,000 rpm and produced 413 pounds-feet of torque across a broad range from 2,700 up to 4,600 rpm. *Porsche Archive*





located close to the exhaust ports to benefit as much as possible from the heat and kinetic energy of the exhaust gases. Their response time is so short that it passes unnoticed under most driving conditions. At 0.85 bar boost, the engine developed 420 horsepower at 6,000 rpm and created 413 lb-ft torque over a range from 2,700 to 4,600 rpm." The turbos operated in parallel, each three-cylinder bank spooling up its own turbine for maximum effect. Fuel economy, an increasing priority in Porsche's high-performance automobiles, improved significantly over that of the 993 Turbo. Frère attributed this to the 996's higher compression ratio—9.4:1 compared to the 993's 8:1, an increase that water cooling, four-valve cylinder heads and the VarioCam Plus made possible. Porsche quoted acceleration from 0 to 62 miles per hour at 4.2 seconds (times aided by all-wheel-drive traction) and top speed at 190 miles per hour with the six-speed manual or 185 with the optional Tiptronic S. After twenty-five years with only manual gearboxes, Porsche now had an automatic for its highest-performance and highest-visibility models. Porsche delivered the first cars four months after their debut at the September 1999 Frankfurt Auto Show.

Turbo styling had steadily evolved from the 1980's G-series models to the 964. Modelers smoothed and softened the contours of the necessary flared fenders, though the large rear wing still appeared appended and designers emphasized its juncture with the rear deck lid using a black seam. Still, the front of the 964 Turbos looked little different from the base Carrera 2 and Carrera 4 models; designers and modelers worked at understating the distinctions. All engine breathing and intercooler air intake happened through the grille on the black rubber-rimmed rear spoiler—still in rubber because pedestrian safety laws in Germany mandated soft-impact edges in case distracted walkers bumped into a parked Turbo.

Porsche introduced the all-wheel-drive Typ 996 Turbo in January 2000 as a 2001 model. In Germany, it sold for DM 234,900 on introduction (about $123,800 at the factory before VAT). *Porsche Archive*

The twin-turbocharged model without all-wheel drive was the race-bred GT2 model, also introduced as a 2001 model year product. Its Typ M96/70 S engine, with the same 3,600cc displacement as the Turbo but with other tweaks, tunes, and modifications, yielded 462 horsepower at 5,700 rpm. *Porsche Archive*

With the 993, the designers and modelers directed intense effort into integrating wheel arches and flares into widened bodywork. Their goal for these to no longer be appendages but to become elements molded into a single form. This impetus came not only from the designers' eyes but also from customer input."If you go back in history," Grant Larson said in an interview in mid-November 2014, "the 993 had the RS and the GT2, and you have a tendency to go ahead with this kind of 'maximus' approach. But our customers, through surveys, let us know that they think of the Turbo as more of a gentleman's car. I don't want to say luxurious, but, with appointments like full leather, a little more decent looking. Without too much wing and too much aggressiveness. It had to be a car for the opera."

Engineering complications of front-wheel drive on the turbocharged model left the 993 design team little choice but to open up the front fascia to air. Instead of the narrow horizontal slits suitable for the 964, the 993 displayed three openings to accommodate front brake cooling and more efficient engine oil cooling. When the 430- to 450-horsepower Turbo S arrived, they sliced subtle gills into the rear fenders between the door handle and the rear wheel arch to ventilate the intercoolers.

Water cooling changed everything. As Jürgen Barth put it, "The front valance now bore only a remote resemblance to that of the 911 Carrera. For efficient airflow through the radiator, air inlets, radiator housing, as well as air ducts were newly developed and tuned." And, he might have said, considerably enlarged over the previous 993 Turbo models.

The GT2 weighed 3,175 pounds while the 996 Turbo coupe came in at 3,395 pounds. That 220 pound difference, plus the extra 42 horsepower and the lack of front-wheel-drive stability made the GT2 a more exciting and challenging car to drive.
Porsche Archive

Porsche introduced the GT2 at DM 339,000—$178,700 at the factory. By the time production stopped in 2002, the European currency had changed to the Euro and the price for either GT2 or GT2 Clubsport had readjusted to €175,044, or $158,140. That advantage did not last long.
Porsche Archive

"That's a big challenge," Grant Larson explained. "All our sports cars have no radiator in the middle. They're out on the side. Take, for example, an early 911 or even current 911s. They have a blank-out piece, but they have two big side intakes. It's our typical sports-car identity out of function."

With early Turbos, fenders expanded to accommodate the wider wheels and the increased tire track that engineers introduced to manage the handling. There were functional reasons to extend the front and rear fenders, but increasing the car's width through the passenger compartment was unnecessary. This left the 911s with the "Coke bottle" taper. The introduction of water cooling meant that hoses, pipes, and tubing had to run from the engine to the nose of the car, where engineers put the radiators into the airstream. And the formerly slender midbody fleshed out more to make room for enhanced plumbing. In ways, this was the subtlest Turbo yet.

"Customers of course see this differently," Larson said. "They want to see the car and instantly recognize it as the Turbo. And that's a bit trickier to do if there are no changes necessary for technical reasons." The 996 Turbo established the instant recognition through the car's face, its center oil-cooling radiator below the license plate flanked by two large openings for engine-cooling radiators. It initiated a new Turbo form language.

At the rear of the car, the Turbo spoiler achieved its best integration yet by nestling into the bodywork at low speeds and rising when road speed triggered it. To differentiate the Turbo from the GT2, Porsche fixed an elevated wing.

"Every time we do a new Turbo," Tony Hatter said, "we try and integrate the spoiler. Even the terminology has changed. When it's down, it's a spoiler because it trips the air up. When it's up, the air actually goes underneath it and it has an inverted aerofoil section so it works like a wing. It changes its function."

Porsche expanded the Turbo lineup starting in summer 2003 with a 2004 model year 996 Turbo Cabriolet. This model was never even part of the delayed-start plan. Porsche had done these and a Targa on the 930 G-series platform from 1987 through 1989. Sales in the first year—eighty-two cabriolets and just twenty-seven Targas (all to the United States)—suggested it may not have much longer life.

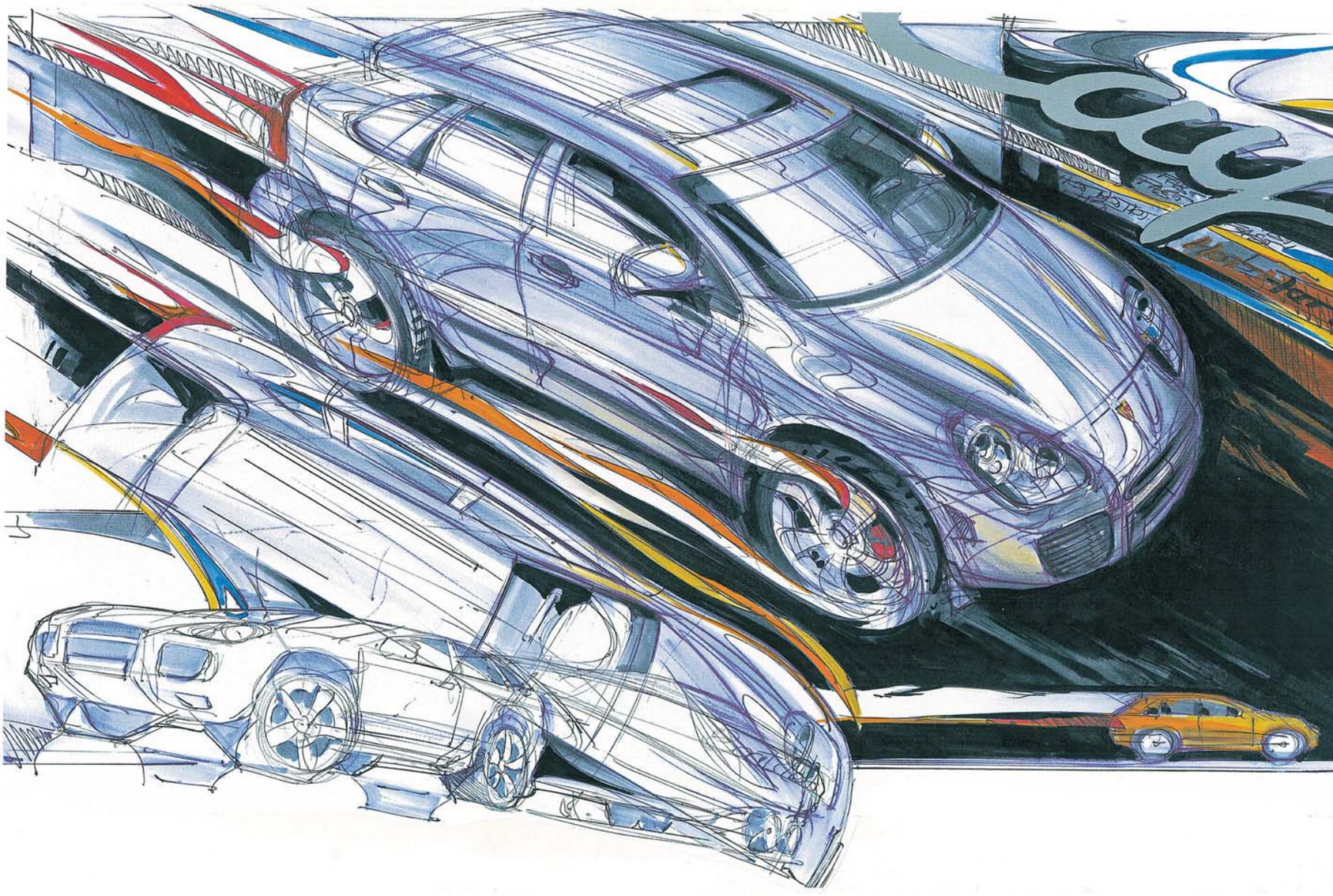
"We had a new board member at that time," remembered Erhard Mössle, general manager for product-line 911 Turbo and all-wheel-drive models since 2001. "He came from BMW and immediately let us know they had planned an open two-seater, the Z8. Mr. Marchart called in the engineers and asked if it was possible to take the 996 Turbo coupe body and make it a convertible. We made a long run on the test track with a car built

up in the workshops. We saw it was possible to reinforce it in places like the side doorsills, the B-pillar, and it turned out that with just a handful of parts we could make a convertible out of the coupe body. That was the when we decided to make the Turbo convertible an official offering in the 996 model range." Power came from the same M96/70 engine, and the 65 pounds of added weight slowed acceleration to 62 miles per hour by 0.1 second, from 4.2 to 4.3, with the six-speed manual. However, non-US customers had access to a Porsche Exclusive X50 Performance Kit that boosted output from the stock 420 horsepower to 450 at 5,700 rpm and raised torque from 413 to 457 pounds-feet between 3,500 and 4,500 rpm.

Porsche finished out 996 Turbo manufacture with a Turbo S coupe or cabriolet for model year 2005. These versions also were unplanned at the start. "We used it to help end the 996 lifecycle," Mössle explained. "More power is always good for the customers. They always want more than we can offer. For them, there is never enough." Essentially, this made the X50 Performance Kit a regular option, delivering the same 450 horsepower and 457 pounds-feet torque, with carbon composite PCCB brakes as standard equipment. From model year 2000 through end of 996 production in 2005, Zuffenhausen assembled 11,248 Turbo coupes and cabriolets.

With Porsche vehicles whose front and rear track changes very little with the introduction of turbocharging, the engineering and design philosophy is to do nothing unless there is a purpose, a need. Turbocharged engines require more air, and those who pay the additional price also want some visible indication of the additional power they have purchased. *Porsche Archive*

Porsche already had learned the wisdom of managing new model releases, especially to maintain series interest because customers also had learned that the company—since the 964—made model changes on a more regular basis. The 996 Turbo Cabriolet arrived as a 2004 model year offering and carried over through 2005 even as the company introduced its new Typ 997 series. *Porsche Archive*



2002–2005 911 GT2 AND GT2 CLUBSPORT

Weissach's motorsports department developed the 996 GT2 "as a sister model to the 911 GT3," Paul Frère wrote in *Porsche 911 Story*. "In contrast to the GT3, which from the beginning was intended to be a limited-production model, the GT2 was launched as an addition to the regular 911 range. Although it would lend itself perfectly to be developed for racing in the international GT2 class along the same lines as the GT3," Frère explained, "Porsche does not offer an RS version of the GT2." Instead the company simultaneously introduced a Clubsport version, complete with all the FIA-required racing equipment.

Working from the series-production 996 Turbo body, engineers removed the front-wheel-drive hardware, replaced power-assisted front seats with lightweight buckets, and deleted the rear seats, the spare wheel, and the PSM stability-control system. They replaced steel brake rotors with the Porsche Ceramic Composite Brake (PCCB) system. This removed 232 pounds of content from the series car, reducing weight to 3,086 pounds.

Just because it has more power doesn't mean it's no longer extremely capable. But engineers need camouflage to disguise changes and improvement before the company publicly unveils their real work. *Porsche Archive*

The dual-overhead camshaft, four-valve-per-cylinder V-8 Typ M48/50 engine displaced 4,511cc and developed 450 horsepower at 6,000 rpm. More impressively—and more usefully off-road—the engine produced 457 pounds-feet of torque between 2,250 and 4,750 rpm. *Porsche Archive*

Engine modifications improved the performance in concert with the weight saving. GT2 models used the Typ M96/70S engine with two turbochargers, each slightly larger than on the 996 Turbo, and boost raised to 0.95 bar instead of 0.85. These and other minor changes increased output from 420 to 462 horsepower at 5,700 rpm (at which point the sophisticated Bosch ME 7.8 Motronic allowed boost to reach 1 bar up to the red line at 6,200 rpm). Torque held steady at 457 pounds-feet from 3,500 to 4,500 rpm. Porsche quoted acceleration of 0 to 62 miles per hour in 4.1 seconds and to 100 miles per hour in 8.5 seconds, and top speed of 196 miles per hour. Introduced as 2002 models, Jürgen Barth reports that combined 2002–2003 production totaled 522 examples.

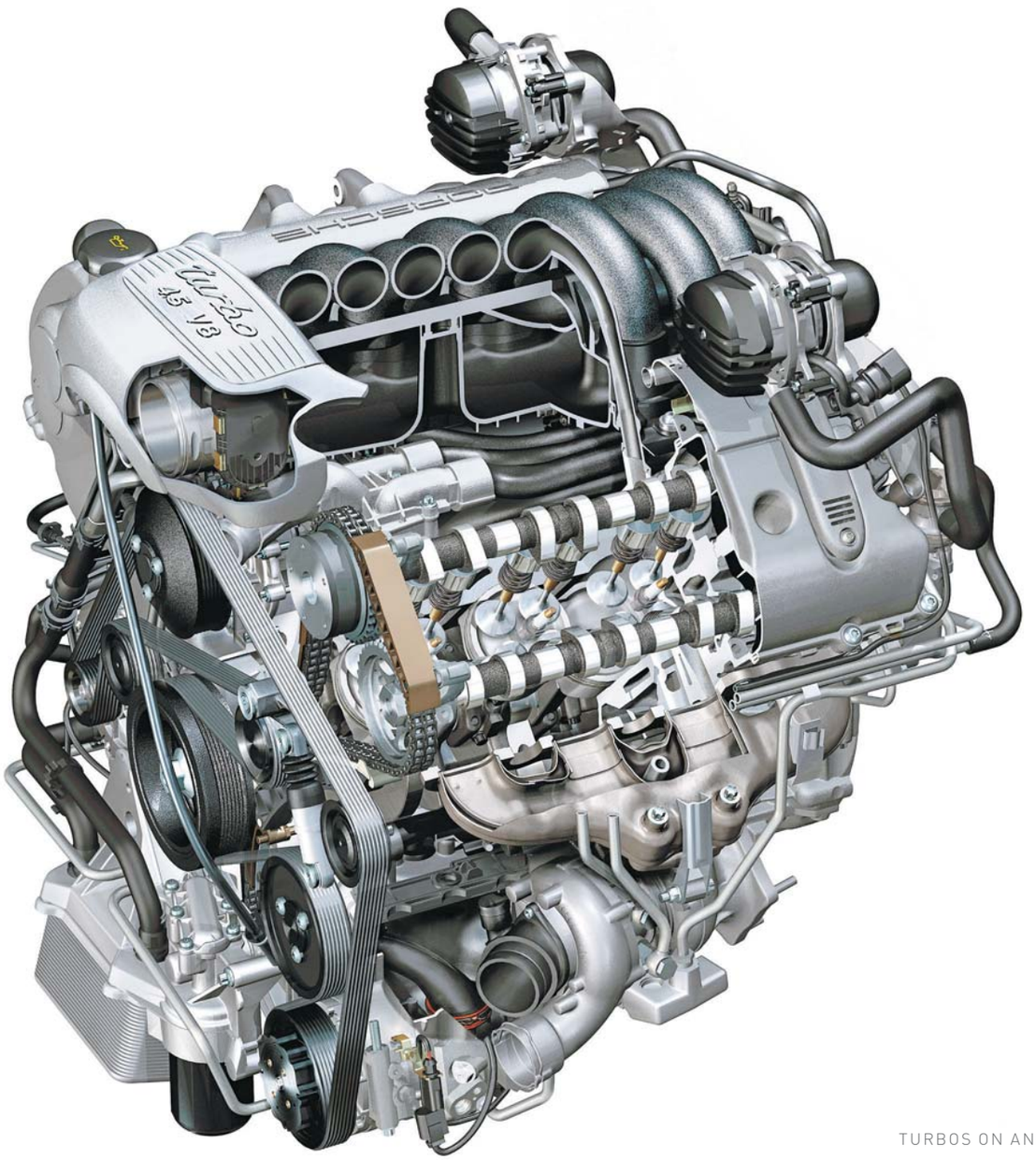
For the 2004 model year, Weissach's engineers updated GT2 power with the revised M96/70SL variation, introducing new pistons, strengthened cylinders, and more efficient intercoolers. These changes and some engine management tweaks improved horsepower output to 483 at 5,700 rpm and torque to 472 pounds-feet across the same range. The car's appearance did not change.

2002–2005 CAYENNE TURBO

While Porsche's introduction of the Cayenne, designated internally as E1, startled sports-car loyalists, turbocharging it stunned its competitors.

Land Rover, Toyota's Land Cruiser, and even America's Jeep might boast of their off-road capabilities. Range Rover and Mercedes-Benz's ML models might offer class consciousness. Daimler also appeased performance addicts with its model year 2000 ML55, offering 347 horsepower at 5,500 rpm and acceleration from 0 to 60 miles per hour in 5.9 seconds; only this ML matched the Cayenne top speed of 150 miles per hour with the V-8 engine. Yet that ML was less satisfying off road. However, Porsche already knew this performance level was not enough.

Because nearly all Porsche body styling originates on the Weissach campus, it is understandable that its Turbo face is the single most distinctive visual feature of the turbocharged Cayenne. A style that appeared with the inaugural 996 Turbo—large symmetric and highly functional air intakes—migrated onto the Cayenne as well.



Designer Stephen Murkett gave the Cayenne a front end that put it square in the Porsche design family. Its long, sloping nose hinted at the long-hood 911 models from early air-cooled days. Air intakes for oil and water radiators on the SUV echoed Pinky Lai's base 996 and Turbo as well as Grant Larson's 986 Boxster, each reinterpreting Porsche's organic form language. But as one expects of any vehicle that Porsche turbocharges, not only was more cooling required but also some hint of aggressive performance potential had to be expressed.

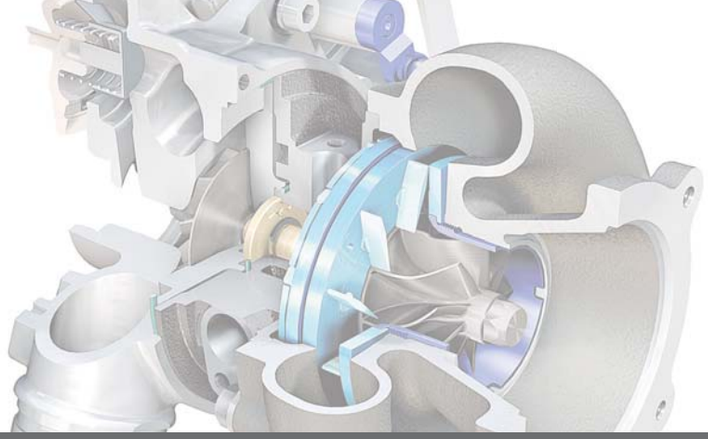
Porsche's engineering staff, working under Cayenne project manager Klaus-Gerhard Wolpert, started with the 4,511cc Typ M48/00 base V-8 engine to develop the M48/50 twin-turbocharged version. They upgraded cylinder heads to a heat-resistant aluminum alloy, modified intake ports to handle the increased (and highly pressurized) air/fuel flow, installed double valve springs to ensure that the exhaust valves closed completely, and replaced the cast pistons with oil-cooled forged ones. Engineers developed what Jürgen Barth called "'mixed-flow turbines' with low rotational inertia [that] provided good throttle response." One served each bank of the V-8. The intercoolers for each side were mounted ahead of each front wheel and increased fuel-air density while cooling the mix to improve engine inside-component life expectancy. The turbos reached peak boost of 1.6 bar at just 2,300 rpm and the engine-management system reduced this incrementally to 1.5 bar as engine speed reached power peak. At this level, the engine produced 450 horsepower at 6,000 rpm while torque of 457 pounds-feet ranged from 2,250 rpm to 4,750. While the fully equipped Cayenne Turbo weighed 5,190 pounds, it accelerated from 0 to 62 miles per hour in 5.6 seconds and pushed the vehicle to a top speed of 165 miles per hour.

Porsche continued enhancing the Cayenne Turbo. For 2005 model year, the Tequipment program improved the brake system, suspension, and engine internals, elevating output to 500 horsepower by increasing airflow through the intercoolers and by making minor program changes to the engine-management system. Torque rose from 457 to 516 pounds-feet between 2,250 and 4,750 rpm.

Cayenne engineers established a new benchmark for 2006 when they introduced the Turbo S model. Its 521-horsepower rating at 5,500 rpm made it Porsche's most powerful vehicle at the time. The Turbo S ran 20-inch wheels and tires, and massive 380-millimeter front brake rotors mated to 358-millimeter discs in the rear. Flamboyance was avoided: front air inlets remained body color, a discrete script badge identified the model on the rear tailgate, and for those who noticed the SUV rocketing away, the Turbo S used quad tailpipes.

There is no longer any question that the Cayenne is a Porsche; the grille motifs that ventilate the engine and the intercoolers—that emphasize the healthy output of these engines—helped set a style that, by this 2006 model year, had migrated across the entire Porsche product line. *Porsche Archive*

The face says it all. No longer are wildly flared fenders the indication of turbocharged power. Instead, subtly, Porsche's designers and engineers have found that improving the breathing on these high output engines improves their first impression as well. *Porsche Archive*



Chapter Sixteen

INCREASING COMPLEXITY, **IMPROVING** PERFORMANCE

The Typ 996 Turbo was barely out and Grant Larson was already working on ideas for the successor Typ 997 Turbo. Engine cooling radiators had found a permanent home in Porsche products straddling the front oil-cooler opening. *Porsche Archive*

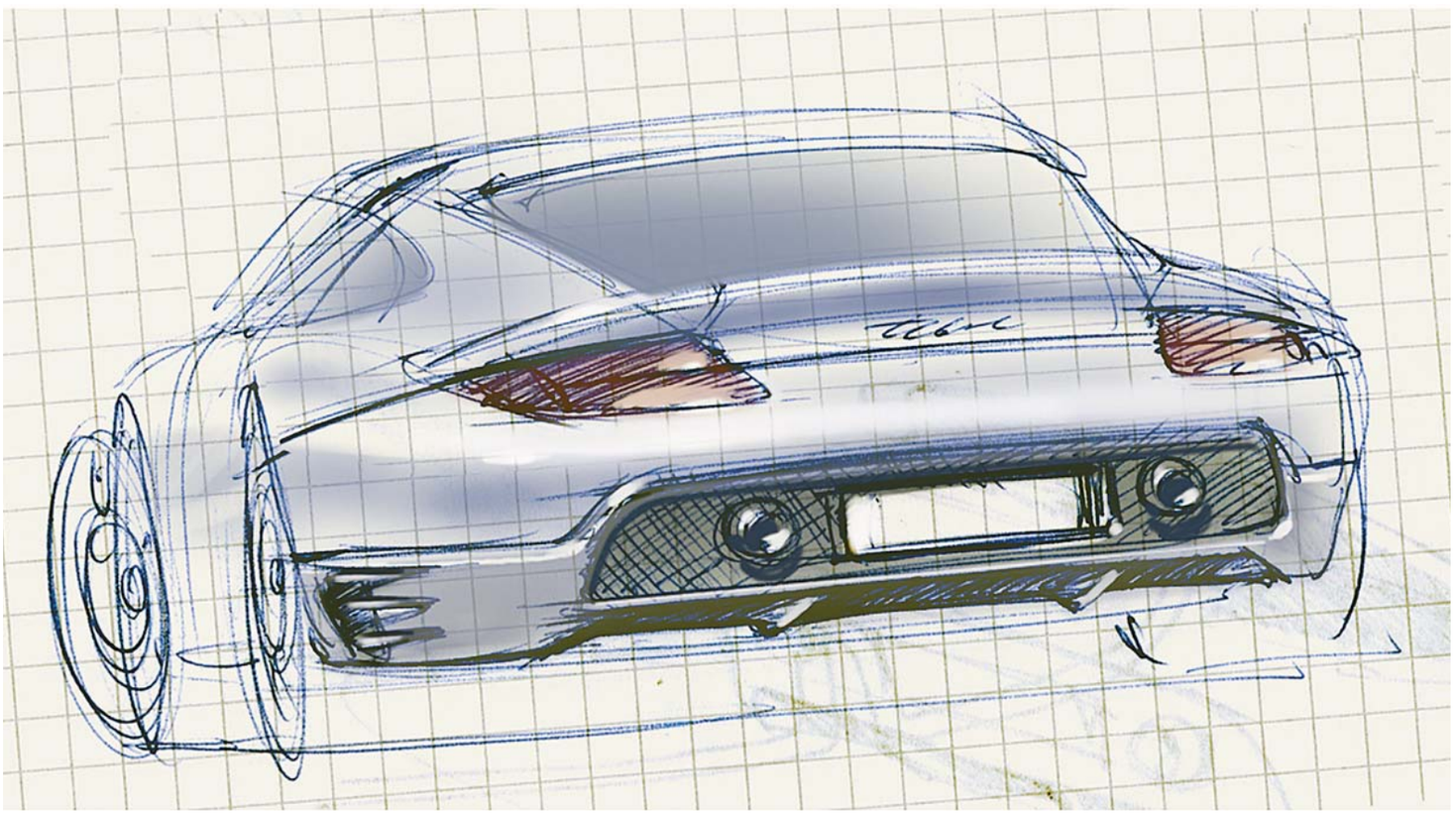
2006 997 TURBO

"When we did the 997 Turbo," Grant Larson said, "We were finding that we already had the GTs, the GT3 and GT2, and it was the tendency of the enthusiasts to force the Turbo in that direction, but a little more roadable." Larson had designed the bodies for the normally aspirated 997 Carrera and Carrera S model. He ended up doing the Turbo body as well.

While design director Harm Lagaaij recognized there were benefits to having the base cars' designer work on the Turbo because of their familiarity with the body forms, he always sought at least one additional concept. In the case of the 997, that opportunity fell to Larson's colleague and friend Mathias Kulla.

"Matthias had the job of managing and administrating, but also doing a model," Larson said. "He had to do the car that filled the catalog of requirements and it had to cost so much. And I got to do whatever I wanted. How you tackle a job like that is different for different people. I don't just go wild like a student and come up with a space ship. You do a pragmatic solution.

"I wanted to have as many new ideas as possible in the car, such as having the rear wing more integrated in the fenders. My spoiler evolved the idea from the race 911s, creating a line or a hard trailing edge around the perimeter of the rear end, a treatment similar the 996 GT1 cars. These were some of the things that lined up to create a trailing edge, which is aerodynamically good. A wraparound edge with the taillight sunk in. It was really tricky because it was all one piece, integrated with the whole rear



Larson already had integrated 997 taillights into the lower rear valence. This understated Turbo concept—suggesting perhaps a disappearing rear spoiler/wing assembly—took Turbo design another step toward subtlety and integration of engineering needs and mechanical practicalities with updated design. *Porsche Archive*

fender, which was a gigantic stamping. It became too expensive and we eventually went back to Matthias' idea."

Their merged ideas inspired an innovation. Light-emitting diodes, LEDs, were gaining attention across a number of industries. Few manufacturers had gotten them to automobile designers, and the early adopters used them for high-mounted brake lights. But, as Larson explained, "it *was* developed far enough for a blinker. So I wondered about taking these LEDs and using them as a blinker that would be a really small blade. We worked forever on this thing, to get this blade to work up front. This was in 2001, and the idea started to take hold and people were interested in it, especially the electric department. When they find a new challenge that could work well with a design, they get excited."

There was no money in the budget for these lights, and Larson learned there were a myriad of laws that delineated where front blinkers could or could not or had to be. A 30-degree front impact test, the so-called pendulum test in the United States, required the car to get smacked on the front quarter panel but still have every light function. The solution Porsche developed incorporated Larson's efforts, plus work from the electric engineers, a safety engineer, and a compliance engineer. All this netted Porsche a patent for front LED signal lights.

"And by the time we presented the car to the board of directors, this was definitely the front end that won, because it was different enough from the base model," Larson said. The unveilings that Style Porsche does for the directors takes on a special significance when the car they're seeing is a Turbo.

"The Turbo," Larson continued, "was always a *Vorstand Fahrzeug*, a board-of-directors car, a CEO's car. What I noticed doing the presentations, whether it was doing a Boxster or a 911 or a Carrera GT or a Turbo, they always look a little more closely at the Turbo because they see themselves in that car. For the Boxster, they say, 'Oh that's cute, but that's for such-and-such range and that's not us. We are going to drive Turbos."

From the first Turbo production—following those few brief weeks when engine chief Robert Pindar told engine designer Herbert Ampferer that the Turbo was only a homologation car, not needing air conditioning—the Porsche 911 Turbo has presented the pinnacle of Porsche's performance and it has been the flagship of all its car line. Ferry Porsche gave the very first production example to his sister, Louise Piëch. The 930 altered the perception enthusiasts held of the company. It recalibrated the automotive pecking order, taking Porsche's 911s from cars that had to hurry to keep up with Ferrari 308s but fell behind their 365 Boxer Berlinetta to cars that out-accelerated the Boxer and made their own startling visual statement.

It's likely no one at Porsche used the terminology in 1975, but in 2015, engineers, designers, product planners, and management universally echo the sentiments of the engineers who were part of the 997 Turbo engine development team: "For us here at Porsche, we always want to make the best-in-class engine and the best-in-class car," Larson said. That motivation

Porsche carefully schedules hot and cold weather testing of its prototypes so that lessons learned from one climate influence the next test. Camouflaging on this preproduction prototype made the point that especially in desert weather climates, engine cooling was critical. *Porsche Archive*

These 997 turbo prototypes already had advanced to the point Weissach engineers needed extreme cold weather test. Body paint outlined the headlights in ways that suggested to anyone slightly familiar with Porsche that this was just another all-wheel-drive 996 Turbo out for a winter run. *Porsche Archive*

Using the latest generation of the venerable 3,600cc water-cooled flat six with twin turbochargers and intercoolers, the Turbo developed 460 horsepower at 6,000 rpm and 460 pounds-feet of torque between 1,950 and 5,000 rpm. For the first time, Porsche quoted acceleration figures that were faster for its Tiptronic transmission than the manual, with 0 to 60 miles per hour that took 3.4 seconds with the automatic and 3.7 with the manual. *Porsche Archive*

The Typ M97/70 turbocharged engine developed 480 horsepower at 6,000 rpm from its 3.6-liter water-cooled flat six. This turned out to be the final iteration of the legendary "Hans Mezger-designed three-six," an engine that had saved Porsche considerable development costs when water cooling became necessary for the turbo engines for 996. *Porsche Archive*

led to one of the carmaker's toughest challenges. Porsche had barely introduced the water-cooled 996 Turbo and an engineering team set out to define and develop what its successor was going to be as a 997 Turbo for 2007.

Porsche's reason for carrying the Hans Mezger–designed air-cooled 3.6-liter engine on as a water-cooled turbocharged engine for the 996 led Weissach to carry over the engine for the 997 introduction. But remaining best in class with an existing engine posed a challenge. It demanded best-in-class improvement.

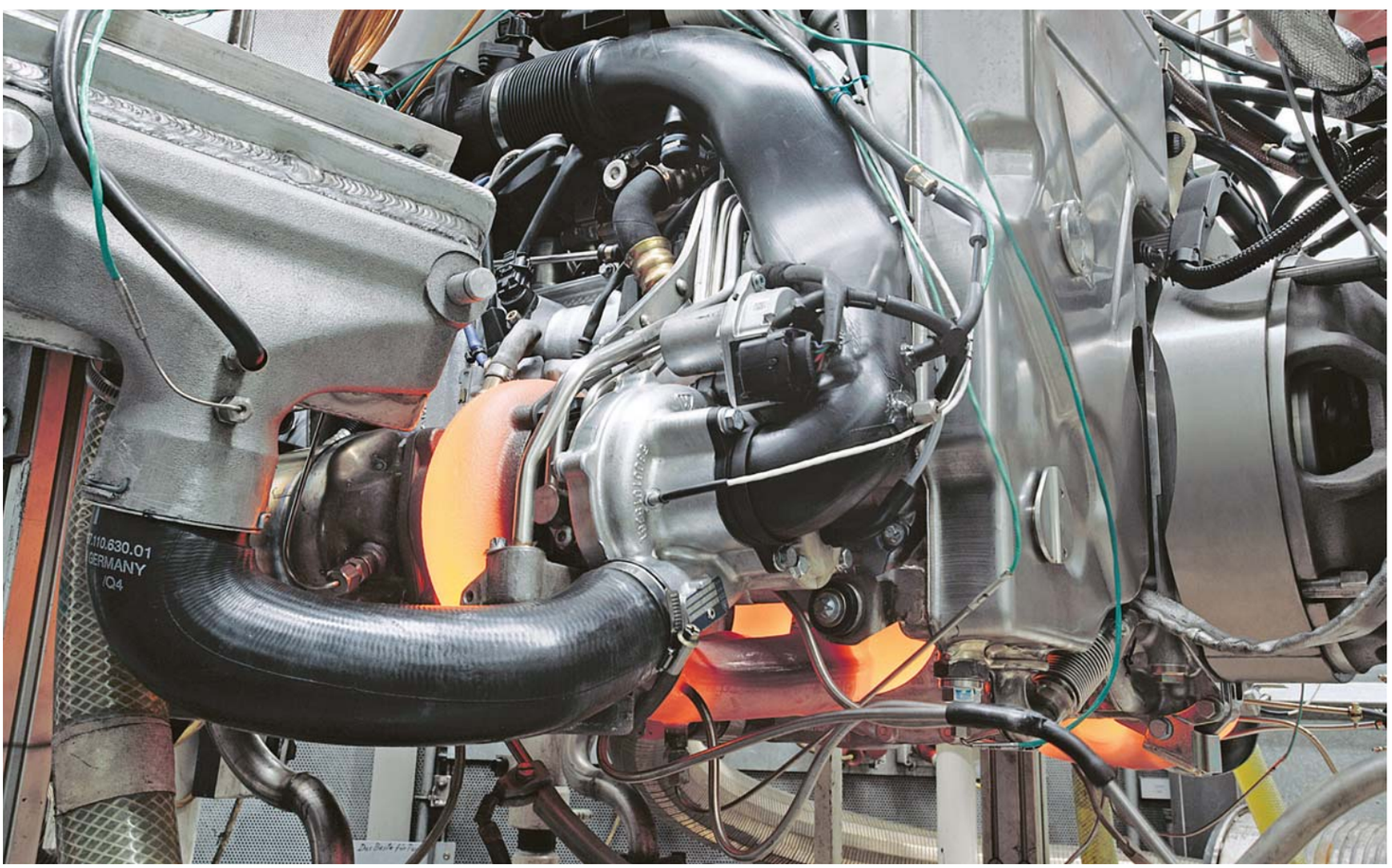
A turbocharger innovation conceived for diesel truck engines had intrigued Porsche's (and other automakers') engineers for fifteen years. Known as variable-geometry turbines (VGT) or variable-nozzle turbines (VNT), these clever apparatuses gave engineers the benefits of a small-turbine-diameter charger for low-end torque and a large one for high-end horsepower in a single device. Porsche had perfected the two-turbine sequential turbo concept with its 959, where complicated plumbing directed exhaust first to a compact turbocharger that spun up to speed very quickly. Once it reached peak efficiency, the 959's systems opened a channel in the exhaust tubing so its flow then struck a significantly larger turbo to boost pressures for higher output and speeds. The concept was complex, as was the execution—and, with two different turbos, it was very expensive.

Carroll Shelby was among the first to adapt a variable-range turbo to a passenger car. In 1989 he introduced his CSX-VNT. This stood for Carroll Shelby Experimental Variable Nozzle Turbine, and his engineers utilized 2.2-liter economy car engines that they installed in three- and five-door hatchbacks. With Garrett's turbocharger, these engines developed 175 horsepower and 205 pounds-feet of torque at 2,100 rpm. Production, limited to five hundred copies by Shelby's contract, fell below that number in reality.

The same year, Honda introduced a home-market Legend using what it called a "wing Turbo" on its single-overhead-camshaft 1,998cc C20A V-6 engine. It developed 190 horsepower, but Honda quickly pulled this version of the car from the market. At the same time, Porsche looked at VGTs and determined this was not yet a viable—or valuable—technology. It had other uses for which it had been perfected. But times change.

"When it comes to diesel engines, engines with VTG are the state of the art," Martin Stöfka explained, talking about its use of VGTs. "As we thought about making a new turbo engine, new turbo technology, it was the challenge for us to get an optimum between low-end torque and high-end power. And this you can do very well with variable-turbine technology." Doing it very well, however, did not mean doing it very easily.

Stöfka's collaborator Mathias Hofstetter explained: "We stared with a diesel turbocharger. We started the engine and put in a little load and then a higher load, and then when we wanted to go full load, there was nothing. The turbine was completely broken. It shattered. It didn't melt; it stuck."



Because the turbocharger manufacturers originally developed these VGTs for the diesel truck industry, there were immense problems adapting them to work on gasoline engines. Diesel exhaust gas exposes the turbine to temperatures up to 750 degrees Celsius—approximately 1,380 degrees Fahrenheit—whereas automobile gasoline engines produce exhaust temperatures of up to at 1,050 degrees Celsius—approximately 1,920 degrees Fahrenheit. But other problems arose right as Porsche began to reckon with the ramifications of these temperature differences.

"We looked at this system as a way to improve low-end torque," Thomas Krickelberg explained. Krickelberg—now director for powertrain, Product Line 911—was involved with the variable-geometry turbine development from the first decisions to investigate the system. Several manufacturers produced these complicated turbos. One was Garrett, whom Shelby had used. Another was Borg-Warner, who had acquired Porsche's reliable collaborator KKK in the early 2000s.

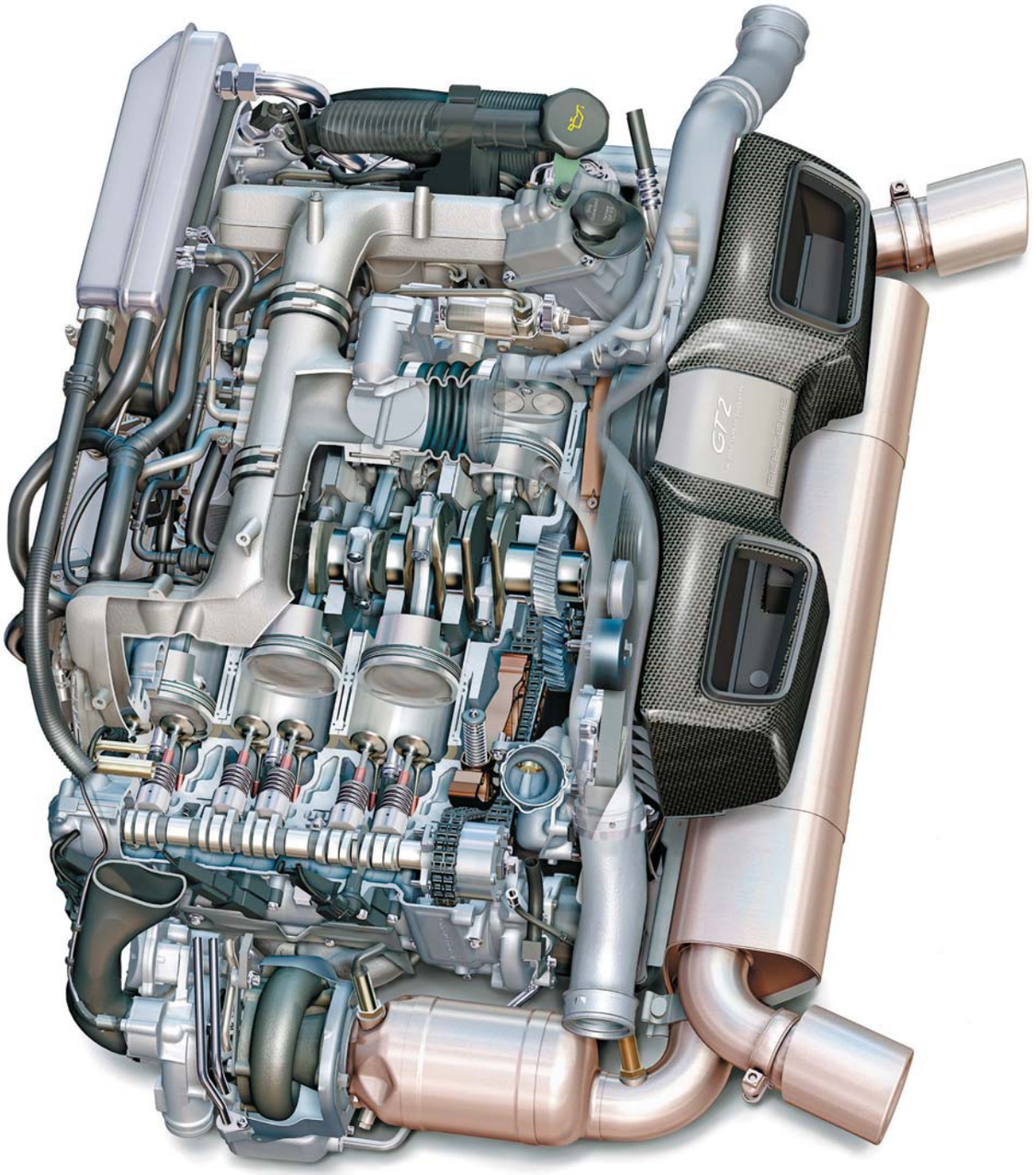
"At the time," Krickelberg explained, "Borg-Warner was the supplier of the diesel VGT for Volkswagen. They sold hundreds of thousands of them to VW. But they had used a patent from Garrett and they didn't know that. Garrett realized it and they went to German law court, and Borg-Warner lost. The legal decision was that Borg-Warner had to pay most of its profit from this VW project to Garrett as long as they used the patent. And that was the same time we did our development for our Turbo."

Borg-Warner, facing a financial disaster entered combat survival mode, putting every engineer to work devising a new system. "And so the priority of our project was suddenly number one . . . hundred," said Krickelberg. "We had to do most of the work ourselves. A lot of calculations, a lot of laboratory tests."

VGT turbos are marvels of engineering and innovation. In a typical turbocharger, exhaust gases enter the turbine chamber obliquely to the angle at which the turbine blades sit in the chamber. Their force often skips over the edges of the blade, catching these edges and steadily accelerating the turbine. VGT turbos incorporate a ring of adjustable blades, or wings, just outside the periphery of the turbine. An electronically operated variator adjusts these wings, and at low throttle demand, they flatten out around the circumference of the turbine. This deflects the exhaust force toward the edge of the turbine blades, and, in this position, the wings create a venturi effect between them that effectively accelerates the exhaust speed as it strikes and speeds up the edges of the turbine. As engine speed rises and horsepower demands start to overtake torque needs, the wings or vanes pivot outward into the exhaust "wind." At their furthest extension—their steepest angle—this provides the effect of slamming high-velocity exhaust into the already spinning turbine. Turbine designers bend over the upper edges of this spinner acutely in the direction of rotation to take the best advantage of the kinetic energy in this exhaust wind. The biggest problem

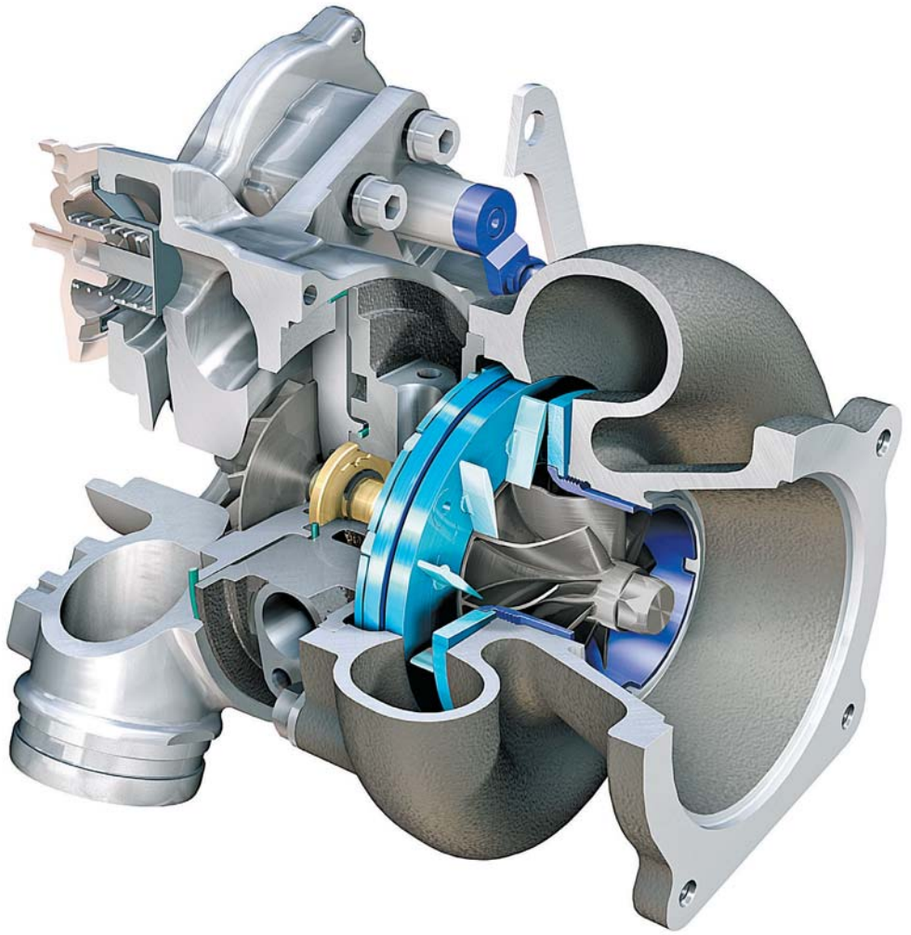
Once again, the Typ 997 model GT2 took honors for the most potent automobile in the 911 lineup. The flat-six water-cooled engine developed 530 horsepower at 6,500 rpm using 1.4 bar of boost. *Porsche Archive*

Bore and stroke remained unchanged in the 3,600cc engine, at 100 x by 76.4 millimeters. Dual overhead camshafts operated four valves per cylinder with VarioCam providing variable valve timing, which assisted in delivering 505 pounds-feet of torque across a range from 2,200 rpm up to 4,500. *Porsche Archive*



The American website Edmunds.com described the GT2 "as a track-prepped GT3 RS with a nuclear reactor in its rear end." For this thrill, customers paid $192,560 in the States. *Porsche Archive*

With this single complicated unit, turbocharger designers and Porsche engineers accomplished even more efficiently what they set out to achieve with two different size turbos in the 959 with a smaller one spinning up at lower pressure. The pivoting vanes (in pale blue) make this unit two-in-one. *Porsche Archive*



Porsche engineers faced was the difference between diesel-engine and gas-engine exhaust temperatures. They had to solve this problem alone.

"If you run such a gasoline turbo in steady-state conditions at full load," Krickelberg explained, "you have up to 1,050 degrees, diesel-engine temperatures, in the area where you have these movable wings. And they have to be movable all the time. If you change the load, if you decelerate, you get a cooler exhaust gas. There are tiny screws that hold the sleeves that mount the wings. They have—for just a few parts of a second—a higher temperature than other parts. Then these little wings seized." A gap between the parallel mounting discs—measureable only with a micrometer—expanded and contracted microscopically and in milliseconds. First, engineers had to find a material that was capable of handling these extreme temperatures and to accommodate nearly instant changes of several hundred degrees. It fell to space-age technology—a material known as Alloy 617, a metal with high nickel, chromium, and cobalt content providing exceptionally high temperature strength, developed for America's NASA and the space shuttle. Through observation and literally thousands of hours of bench and practical testing, Porsche and Borg Warner engineers discovered that if they machined the surface of these two discs by thousandths of millimeters (less than the thickness of a sheet of paper), they created "a special structure that enabled the wings to move under these critical conditions," Krickelberg said. Solving this problem led to reaching their goals. But they found other benefits that they never expected.

"You have so many possibilities with the angle of these positions," Martin Stöfka said, "to get a behavior of your car, a behavior of acceleration, a special behavior of your sound. You can use it as an exhaust flap . . ."

"You can use it to make sound or no sound," his colleague Mathias Hofstetter interjected. "You can use it to preheat the catalyst for the California market. You can use it to give you better control for your onboard diagnostic functions. And let me say here: understanding this, calculating this, testing this, it was the work of a minimum of one year."

The result was a Turbo engine that developed 480 horsepower at 6,000 rpm, exceeding the 996 Turbo engine by 60 horsepower. But more impressive was torque development, which rose quickly with the 997 VGT system to 457 pounds-feet, between 1,950 and 5,000 rpm. (This compared to torque output in the 996 of 413 pounds-feet, from 2,700 to 4,600 rpm.) Acceleration from 0 to 62 miles per hour, already impressive with the all-wheel-drive 996 at just 4.2 seconds, dropped to 3.9 seconds with the 997's six-speed manual gearbox and a startling 3.7 seconds using the optional Tiptronic S. Porsche unveiled the 911 Typ 997 Turbo on the last day of February at the 2006 Geneva International Motor Show. Sales began in Germany four months later, and US buyers started to see them in showrooms in mid-July.

In late 2007 as a 2008 model, the company introduced its Turbo Cabriolet using all the technology of the Turbo coupe. With some chassis reinforcement, a retracting top, and a rollover system, the cabrio weighed just 154 pounds more than the coupe.

2007 997 GT2

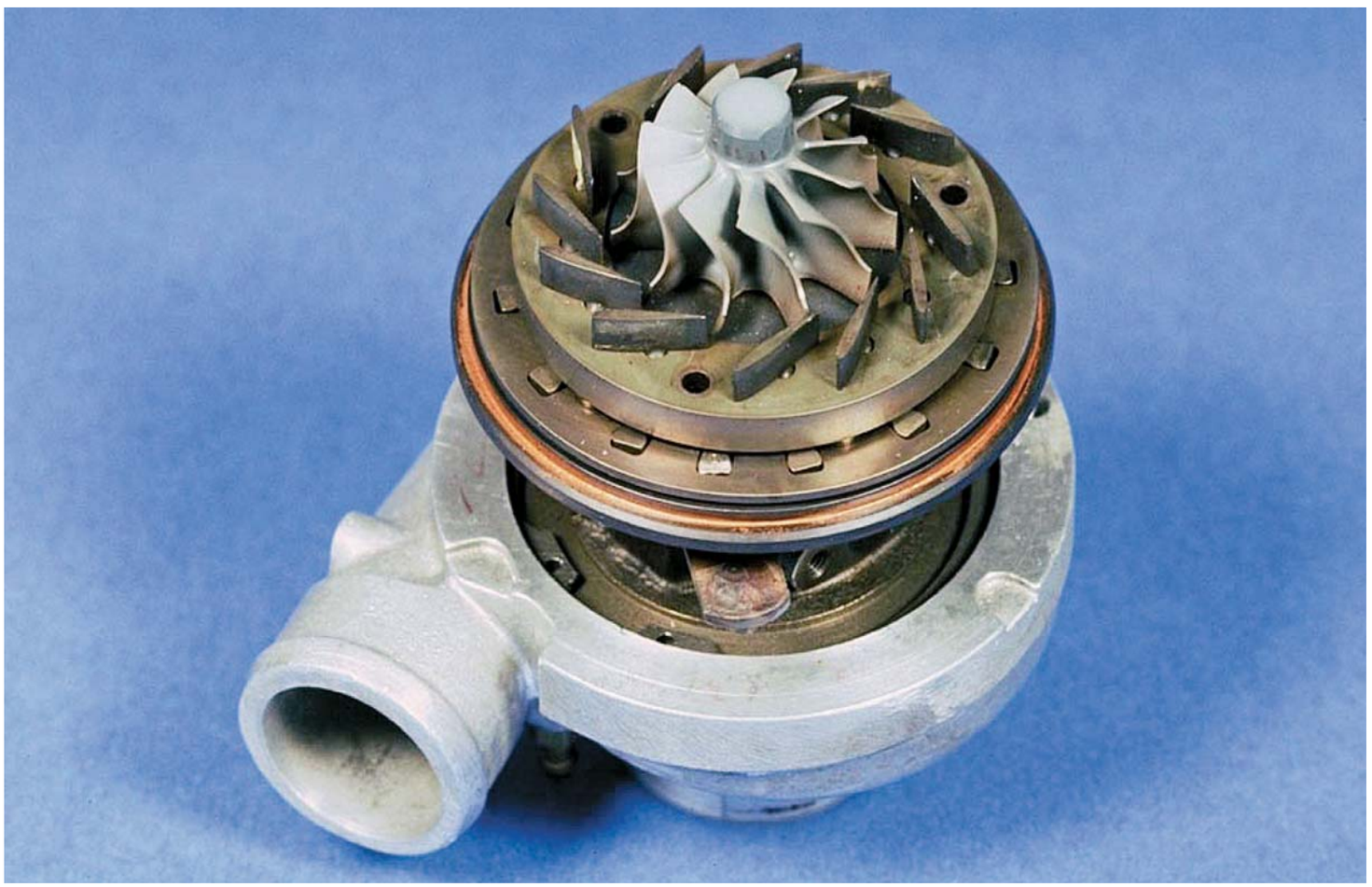
The next Porsche to benefit from variable-geometry turbines was the GT2 model that debuted at Frankfurt in September 2007. Where the Turbo had been "the gentleman" of Porsche's performance lineup, the GT2 clearly was its "maximus." While it used the same engine, the 3.6-liter flat six now developed 530 horsepower at 6,500 rpm and it produced 502 pounds-feet of torque between 2,200 and 4,500 rpm. This brute force was sufficient to launch the rear-wheel-drive manual transmission model from 0 to 62 miles per hour in 3.7 seconds, the same as the Turbo with the Tiptronic. However, in this model, the driver had to be adept and skillful.

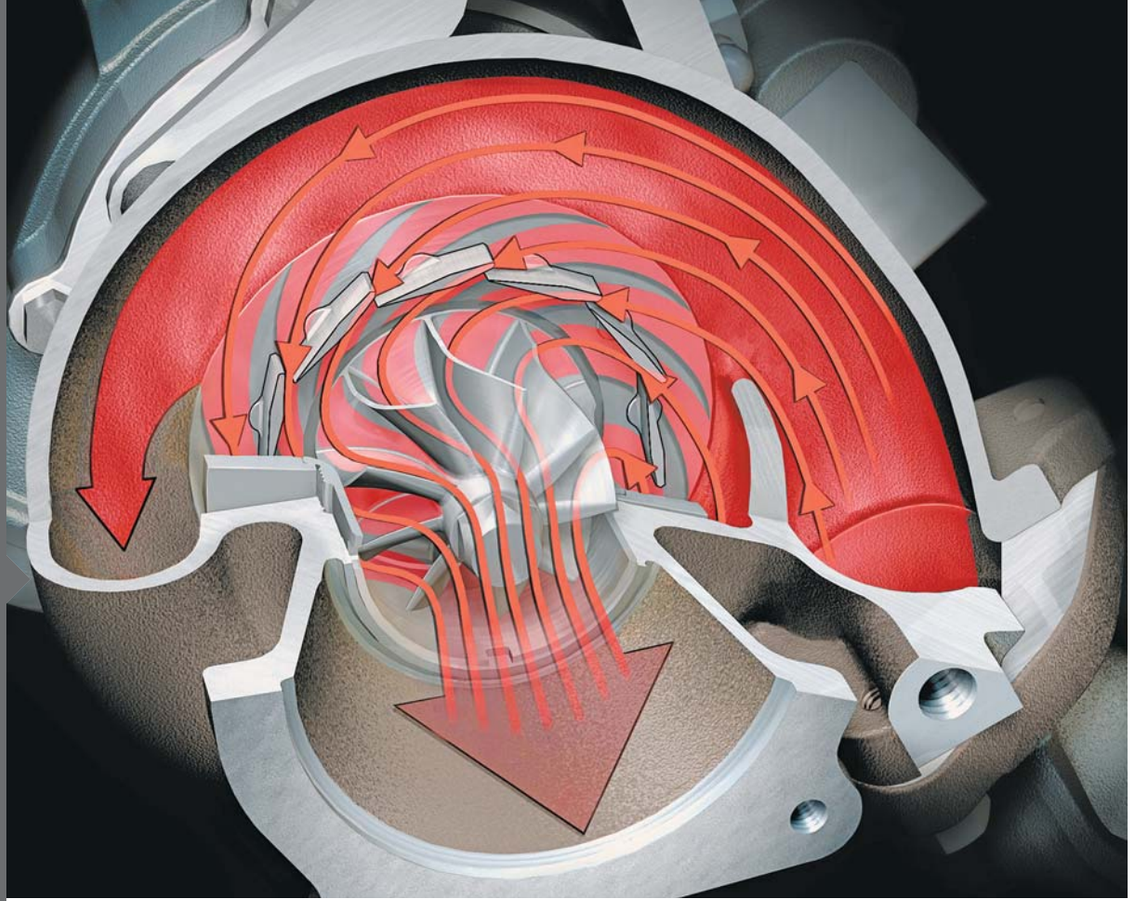
Porsche fitted the car with its carbon composite brakes, and it was the only one of its GT models to include the Porsche Stability Management, which—specifically for the GT2—provided "vehicle dynamics control with targeted brake application to stabilize the vehicle around the yaw axis [read: spinning]—and traction control to modify drive forces, as well as ABS for optimum braking," according to Jürgen Barth in *The Porsche Book*. It was clear, with such electronic control units on board, that Porsche recognized this car had performance potential to challenge even its most capable customers. And yet, within another three years, output such as this no longer measured up.

2010 997 TURBO, TURBO S

Weissach brought two significant technological improvements to the 911 in the second-generation Typ 997. Both of these represented years of research, development, and testing, and each improved performance and fuel economy. For 2009, Porsche introduced new engines for the normally aspirated Carrera and Carrera S that used direct fuel injection. The new M97/MA1 engines for the base Carreras displaced 3,614cc, growing by 18cc because the new bore and stroke dimensions, 97 millimeters by 81.5 millimeters, were 1 millimeter larger and 1.3 millimeters shorter, respectively. The 3.8-liter S engines displaced exactly 3,800cc, reduced from 3,824 by increasing bore by 3 millimeters to 102 millimeters and shortening stroke by 5.3 millimeters to 77.5 millimeters. To form the crankcases, Porsche utilized a new technique known as chill casting, in which technicians controlled the cooling in specific areas of the casting so that the metal solidified consistently. AluSil, an aluminum-silicon alloy, provided greater durability while also saving 22 pounds in casting weight. A new closed-deck design reconfigured the water jackets for more uniform cylinder cooling. This design provided much greater rigidity.

It was to this 3.8-liter DFI engine that Weissach engineers applied the twin VGT turbochargers and intercoolers. This replaced the very successful and long-lived Hans Mezger–designed 3.6-liter engine, used





This diagram shows the adjustable vanes nearly closed, their position at low engine speeds. Exhaust forced through these narrow venturi-like slots accelerates as it slips between them, strikes the turbine vanes at the outer edges for maximum mechanical advantage, and rapidly accelerates the turbine, which correspondingly increases flow on the fresh air side of the turbine. *Porsche Archive*

The adjustable vanes—nearly fully opened in this somewhat used turbo—directed exhaust flow deep into the turbine blades for maximum power. The plate on which they were mounted was a high-temperature resistant metal with high nickel, chromium, and cobalt content, known as Alloy 617. *Porsche Archive*

Porsche introduced new Typ M97/MA1 engines with 3,800cc displacement for the turbos incorporating direct fuel injection for greatly improved performance and efficiency. Combined with twin Variable Geometry Turbine turbochargers, VarioCam Plus, and many other improvements, the new engine developed 500 horsepower between 6,000 and 6,500 rpm. *Porsche Archive*


GT2RS
D
S GO 620

since 1974. The new Turbo, in coupe and cabriolet body styles, debuted at the Frankfurt Auto Show in September 2009. The models reached US dealers in late January 2010.

"You have a lot of advantages with DFI," Mathias Hofstetter said. "You have more power because you can get more fresh air into the combustion chamber. With DFI, you have no fuel in the chamber [when the intake valve opens] so you can put in much more air and then inject the fuel. When you have induction outside, you have fuel mixing in the air. And where the fuel is, there can be no air, so you get less air into the chamber. Less power.

"When you have manifold injection," he continued, "you have time to make a good mixture before it comes into the combustion chamber. With DFI you have not so much time to thoroughly mix the fuel and compressed air. And you have to be extremely precise and accurate with the amounts that go in. So you make the setting of the injector so you have the best mixture in the area of the spark plug to initiate a good thorough burn."

The secret to maximizing power output in a turbocharged DFI engine was to design the cylinder head, the intake valves and their collars, and the fuel-injector nozzle to produce the greatest tumble and swirl in the fuel and air mixing in the combustion chamber. Hofstetter and his colleagues integrated a "tumble duct" into the intake manifold just before the valve seats to accomplish this. "Swirl is like a tornado," he explained, "and tumble is like a ball doing somersaults. It is like making a controlled storm inside the cylinder."

The system injected fuel into this maelstrom at 140 bar, above 2,000 pounds per square inch at sea level. This was some 20 bar, about 290 pounds per square inch, greater pressure than in the normally aspirated engines, because the injector fought against heavily compressed air from the turbocharger. The electronic control units managed the amounts of fuel delivered per squirt and even were able to inject additional squirts.

"On catalyst warmup," Hofstetter went on, "you can inject extra fuel to make hotter exhaust. You make a late injection so the burning actually goes into the exhaust system. This you can do with the direct injection but not with the manifold injection—because with that system, the intake valve is already closed!"

With VarioCam Plus and other improvements in the new crankcase, cylinders, and oil-lubrication system, the engine developed 500 horsepower between 6,000 and 6,500 rpm and produced 480 pounds-feet of torque across a range from 1,950 to 5,000 rpm. On brief overboost, torque reached 516 pounds-feet.

Porsche unveiled the final 997-generation GT2 version, the RS, at the Moscow auto show in August 2010. The company announced production limited to five hundred examples and all sold within two months. *Porsche Archive*

High Performance Cars manager Andreas Preuninger and his engineers removed 154 pounds of "content" from the first generation 997 GT2 to get this RS version down to its 3,020 pound weight. That meant counting and reconsidering every gram that went into or came out of this car. *Porsche Archive*

With direct fuel injection, a pair of Variable Geometry turbos, intercoolers, and special tuning modifications, the racing engineers at Flacht managed to extract 620 horsepower at 6,500 rpm from this 3.8-liter engine. Torque of 516 pounds-feet started at 2,250 rpm. *Porsche Archive*

Its internal code number, 727, referred to a Nürburgring target lap time. The car sold for $245,000 in the United States. *Porsche Archive*

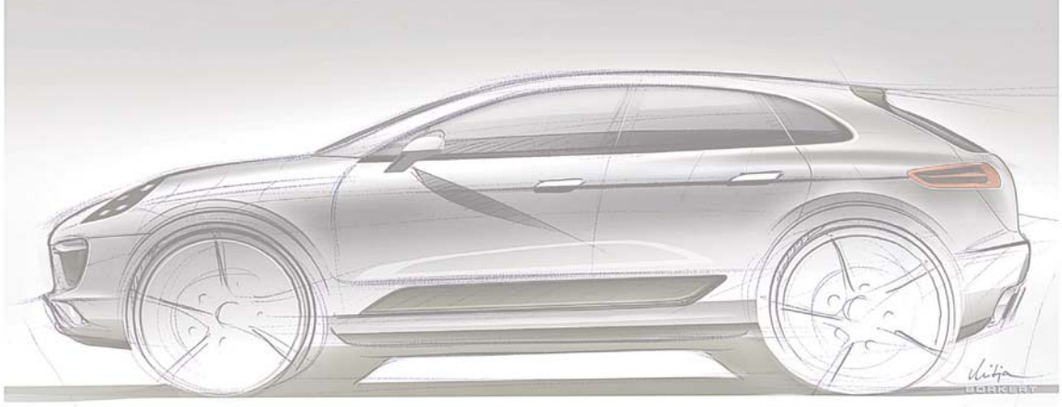
To get this power to the ground, Porsche replaced the Tiptronic S five-speed transmission with its race-developed PDK (Porsche Doppelkupplung) double-clutch transmission with seven speeds. The PDK's lightning-quick shifts made it the fastest performing Turbo combination, with coupes accelerating from 0 to 60 miles per hour in 3.2 seconds yet returning 17 miles per gallon city and 25 miles per gallon highway fuel economy.

Within days of delivering the first Turbos in the United States, Porsche unveiled the Turbo S coupe and cabriolet in Geneva. For the first time, Porsche delivered a Turbo model only with an automatic transmission, as the company discontinued the manual gearbox for this 530-horsepower model. Torque rose to 516 pounds-feet between 2,100 and 4,250 rpm, and using the Launch Control feature within the Turbo S and its standard Sport Chrono package, acceleration from 0 to 60 miles per hour required just 3.1 seconds. Porsche fitted its ceramic-composite PCCB brakes to the S coupe as standard equipment.

2010 TYP 997 GT2 RS

At the Moscow auto show in late August 2010, Porsche introduced its ultimate turbocharged coupe, the GT2 RS. Weissach engineers had removed 154 pounds from the previous-generation GT2. DFI, special tuning, and twin VGT turbos and intercoolers helped this engine develop 620 horsepower (at 6,500 rpm and 516 pounds-feet of torque starting from 2,250 rpm) in a car that weighed 3,020 pounds. Sources suggested that High Performance Cars manager Andreas Preuninger and his crew conceived the RS in 2007 to challenge other manufacturers who were flirting with these kinds of engine outputs. The RS supposedly got an internal code number, 727, that corresponded to one competitor's best lap time around the Nürburgring, 7 minutes 27 seconds. Fitted with a six-speed manual gearbox, acceleration from 0 to 60 needed 3.4 seconds, 0.3 seconds longer than the PDK-equipped Turbo S. Top speed was 205 miles per hour. Porsche limited production to five hundred units, and within two months of its debut, all had sold. By that time, Preuninger's test drivers had consistently run the 'Ring in 7:18.


GT2RS
S GO 620
GT2RS



Chapter Seventeen

WHEN ENGINEERING **TECHNOLOGY** BECOMES A PRODUCT NAME

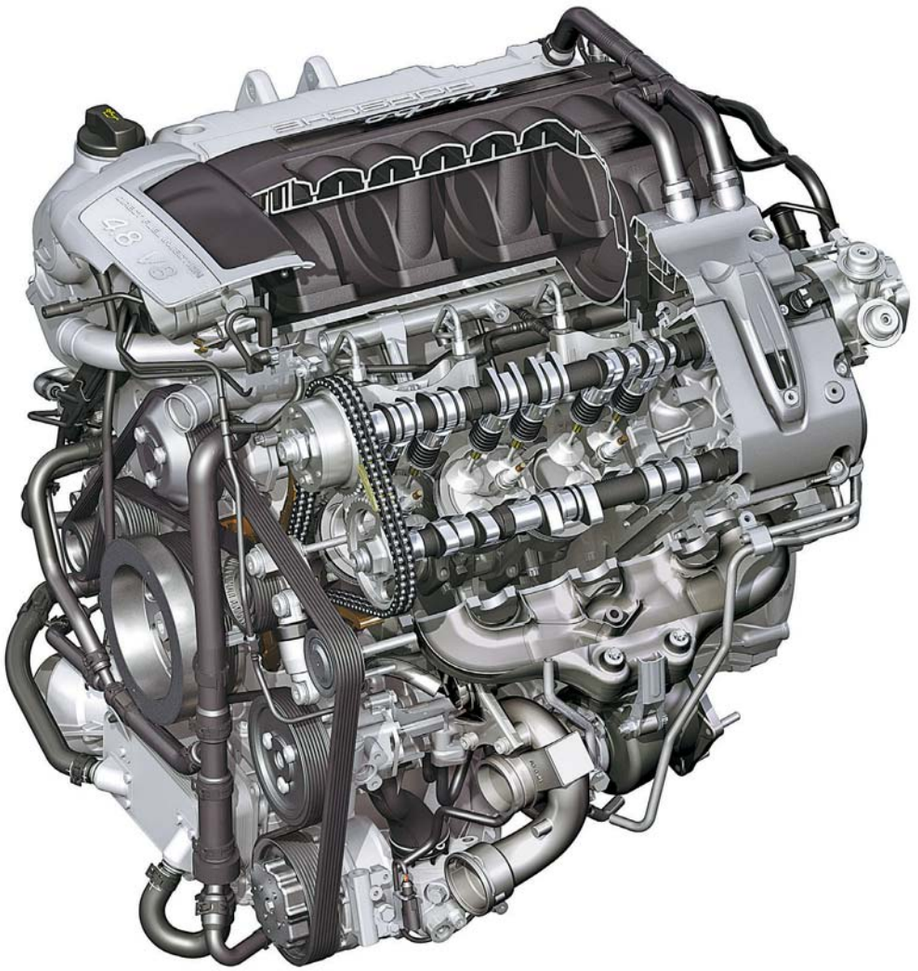
CAYENNE TURBO AND TURBO S

Porsche launched the second-generation Cayenne, E2—introducing new engines with VarioCam Plus and new bodywork—for the 2008 model year. Direct fuel injection beat the 997 second-generation engines by a year, appearing first in the 4,806cc V-8s. Conventional twin turbochargers boosted Turbo model output to 500 horsepower at 6,000 rpm and 516 pounds-feet of torque across a range from 2,250 rpm to 4,500. The six-speed Tiptronic S transmission powered all four wheels and gave the sport utility 0-to-60 acceleration in 4.9 seconds and a top speed of 171 miles per hour.

The only styling announcement of the Cayenne Turbo's greater performance potential was its larger symmetrical cooling openings. With 500 horsepower, the Cayenne accelerated from 0 to 60 miles per hour in 4.9 seconds. *Porsche Archive*

Only subtle badges and slightly different exhaust pipe treatments revealed the engine configuration of the Cayenne models. The 5,200-pound vehicle could tow as much as 7,700 pounds. *Porsche Archive*

The Turbo rode on a new air suspension system, integrated into the Porsche Active Suspension Management (PASM) technology. For the new E2 series, the PASM also offered Porsche Dynamic Chassis Control (PDCC), an active anti-roll system that constrained body lean through turns, stabilizing the handling while improving ride comfort. The Turbo provided standard 18-inch wheels, and tires with new 21-inch combinations were optional. Standard bi-xenon headlights were standard on the Turbo with a Dynamic Curve feature in which the lights swiveled with steering input. The lights made up part of the new face of the



Porsche Exclusive options were available for Cayenne models as well as the department's more traditional involvement with 911 models. Porsche sold the Turbo S for $103,050 in the United States. *Porsche Archive*

With 4,806cc displacement, dual overhead cams, four valves per cylinder, and twin turbochargers, the Cayenne Turbo boasted 500 horsepower at 6,000 rpm. The engine developed 516 pounds-feet of torque between 2,250 and 4,500 rpm. *Porsche Archive*

The Turbo S carried on the family tradition within the Cayenne line up by increasing horsepower and torque without making a dramatic visual statement. Output from the new direct fuel injection (DFI) engine rose to 550 horsepower at 6,000 rpm. *Porsche Archive*

Cayenne, which, on the Turbo, emphasized the large openings necessary for engine and intercooler radiators.

Model year 2009 brought the Cayenne Turbo S model, with 4.8-liter V-8 output boosted to 550 horsepower at 6,000 rpm while torque reached 553 pounds-feet between 2,250 rpm and 4,500. Acceleration from 0 to 60 miles per hour took 4.8 seconds, and with the standard Tiptronic S and all-wheel drive, top speed was 174 miles per hour.

The same year gave Porsche's rest-of-world customers a new high-tech DOHC four-valve 2,967cc V-6 diesel adopted from Audi. With a diesel VGT turbocharger, the engine, with bore and stroke of 83 by 91.4 millimeters, produced 240 horsepower at 4,400 rpm and 406 pounds-feet of torque starting at 2,000 rpm. Five years later, Porsche offered non-US buyers its 2014 Cayenne Diesel S. This used a 4,134cc DOHC four-valve V-8 with intercooled twin VGTs that developed 380 horsepower at 3,750 rpm and 630 pounds-feet starting at 2,000 rpm.

In order to visually distinguish this most powerful Cayenne, Style Porsche rendered the air-intake grilles, headlight houses, and components of the mirrors in high-gloss black. The SUV ran on 21-inch Turbo II wheels fitted with the Porsche crest, with inner spokes painted high-gloss black as well.

PANAMERA TURBO AND TURBO S

The world's emerging automobile markets have strongly influenced Porsche's product development, and in acknowledgment of that, the company unveiled its Panamera sedan in Shanghai, China, in April 2009. Porsche's media release said at the time, "With four doors, four seats, eight cylinders, seven gears and numerous innovative design and technical features, the Panamera is a true four-door sports car—and truly unlike anything else on the road."

Wolfgang Dürheimer, Porsche's board member for research and design, explained that "the crucial task was to combine Porsche's sporting DNA with all the spaciousness and driving comfort of a luxurious sedan." It went without saying that, as there had been 911 Turbo models and Cayenne Turbos, Panamera Turbos were coming as well. This proved to be a simple adaptation, taking the twin-turbocharged and intercooled 4,806cc V-8 from the Cayenne Turbo, carrying over its 500 horsepower and 516 pounds-feet of torque. Porsche delivered this potent sedan only on an all-wheel-drive platform and used the new system-wide PDK gearbox. This configuration moved the Panamera Turbo from 0 to 60 miles per hour in 6 seconds and up to a top speed of 188 miles per hour. Ordering the optional Sport Chrono Plus system reduced acceleration time—using Launch Control—to 3.8 seconds.


S GO 1223

Porsche carried over the DFI engine and 500 horsepower output but packed it in a new body that appeared sleeker and weighed 400 pounds less than previous E1 generation Cayenne models. A slightly longer wheelbase increased rear storage and passenger comfort. The Turbo model sold for $104,800 in the United States. *Porsche Archive*

Most improvements between the 2011 E2 generation and new E22 versions were mechanical evolutions. The 4.8-liter Turbo engine delivered 520 horsepower and, with its new eight-speed Tiptronic S transmission, accelerated from 0 to 60 miles per hour in 4.2 seconds. It sold for $113,600. *Porsche Archive*

It terms of the car's appearance, its Porsche lineage was clear and its front end "is clearly recognizable as a genuine Porsche, bearing strong resemblance to its siblings," according to media materials released at the introduction. "With a low air intake instead of a traditional grille, powerfully curved front wings that rise above a low hood creating the 'topography' of a sports car and its characteristic headlights, the Panamera clearly has the face of a Porsche."

"The Panamera turbo features a different and quite unique front end," the release added. "The air intakes at the front boast a special grid feature giving the top-of-the-range model an even more powerful and dynamic look." Stylist Grant Larson developed distinctive daytime running lights, incorporating four LEDs symmetrically situated around the round headlamps. Position lights, formed with light conductors surrounding the direction indicators, give the Panamera Turbo a very aggressive look in the dark.

Taking advantage of Cayenne engine upgrades, the Panamera line introduced a Turbo S model for 2013. As with the Cayenne Turbo S, torque output was 553 pounds-feet, with the benefit of a full-throttle kick in the standard equipment Sport Chrono Plus "Sport" or "Sport Plus" setting reaching 590 pounds-feet. The additional power resulted from using new turbochargers with titanium-aluminum turbines. Panamera engineers considered using variable-geometry turbines (VGT), but packaging limitations made it impossible. The VGT units were considerably larger, and fitting a pair of them under the hood was not possible. Still, the low-mass titanium-aluminum turbines spun up to optimum boost speeds quickly. In Sport Chrono Plus and engaging Launch Control, 0-to-60 acceleration for this large four-door sedan took only 3.6 seconds.

To improve handling, the Panamera Turbo S incorporated the curve-flattening PDCC system from the Cayenne. Its interlocked hydraulics stiffened shock absorbers on the outer side of a turn, resisting body roll and improving traction and drivability. The company also brought over another system, Porsche Torque Vectoring, introduced as an option on the 2012 Typ 991 Carrera and Carrera S models. This employed an electronically controlled rear differential lock to the rear wheels. Essentially, the system

applied a braking force to the inside rear wheel in a turn, improving cornering traction, safety, and performance. Some journalists commented that this system made the four-door sedan behave like a nimble 911 with an extra row of seats.

For the 2014 model year, Porsche extended the concept of its four-door four-seater by lengthening its wheelbase from 114.96 to 120.87 inches and stretching its body from 197.44 to 203.35 inches. The height of the car grew slightly as well, from 55.83 inches to 56.1. This subtlety lengthened the interior, by the same 5.9 inches in rear seat legroom. And so the Panamera Turbo Executive and Turbo S Executive models were born. Engine outputs matched the shorter-wheelbase versions, with 520 horsepower at 6,000 for the Executive Turbo and 570 at 6,000 for the Executive Turbo S. As the media materials explained, "Porsche developed the Executive models for customers who have especially high standards for space and ambience combined with Porsche performance."

2015 MACAN S AND TURBO

Porsche unveiled its fifth model line at the 2013 Los Angeles Auto Show, bringing into production a compact sport utility vehicle as a sibling to the Cayenne and the rest of the model lineup. The company introduced the new vehicle in two versions: the Macan S and the Macan Turbo. In an interesting change of nomenclature, not only was the Turbo model fitted with a V-6 twin-turbocharged and intercooled engine, but so was the Macan S.

As release material explained, "The Macan S is powered by the new 3-liter V-6 twin turbo engine from Porsche. The engine is particularly high-revving, thanks to its 96 millimeter bore and short 69 millimeter stroke. When tuning the new engine, the engineers focused on providing uniform performance and an even torque curve. By combining two turbochargers, positioned in a compact format on the left and right which together deliver a boost pressure of 14.5 pounds per square inch, exceptional performance values have been achieved." Both the 3-liter and 3.6-liter variations use VarioCam Plus and

As with its sibling Cayenne, the Panamera sedan offered a peak-performance Turbo S package, incorporating the 4.8-liter V-8 as well. The Panamera used the seven-speed PDK transmission and active all-wheel drive. *Porsche Archive*

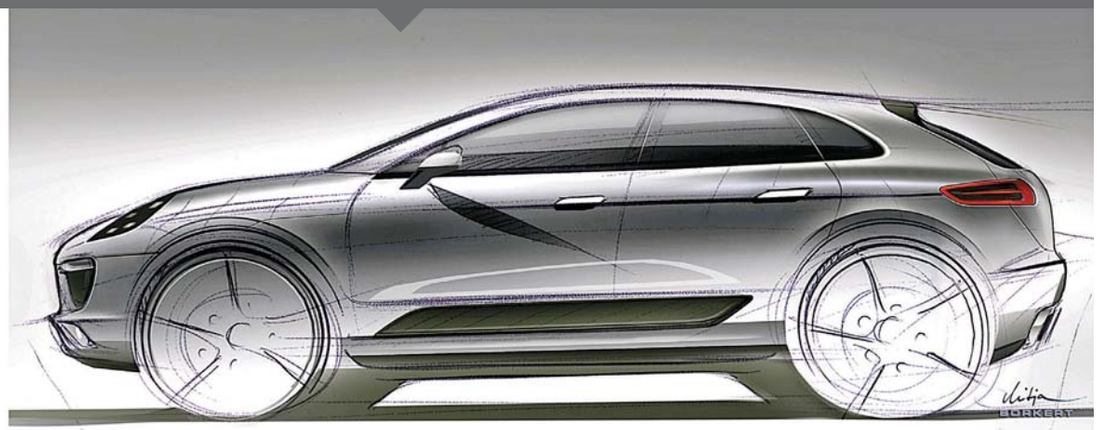
There was a strong family resemblance internally and externally. The 4,806cc aluminum block (and heads) V-8 developed 550 horsepower at 6,000 rpm and produced 553 pounds-feet torque between 2,250 and 4,500 rpm. Direct fuel injection and VarioCam Plus also carried over from the Cayenne family. *Porsche Archive*

The Turbo S provided 550 horsepower, connected to the ground through the eight-speed Tiptronic S, and active all-wheel drive traction management system. The S represented a collection of acronyms intended to improve driving and handling, including active suspension management (PASM), dynamic chassis control (PDDC), and Torque Vectoring (PTV Plus) that made the Cayenne feel agile. *Porsche Archive*

For even greater rear passenger comfort, Porsche extended the wheelbase of the sedan an extra 5.9 inches and fitted the longer versions with adaptive air suspension. With 550 horsepower available, the car sold for $200,500 in the United States. *Porsche Archive*

Porsche introduced the Macan as "the sports car of the compact SUV segment" and preferred to describe it as the 911's "big brother" rather than the Cayenne's little one. Its engine concepts reflect that, as all three V-6 power plants are twin-turbocharged. *Porsche Archive*

Engine development for the Macan series represented an effort at downsizing engines through turbocharging. With all-wheel drive in each model, and PDK seven-speed transmissions throughout, the combination suggested a sportier Cayenne as well as a more utilitarian Carrera 4. *Porsche Archive*



direct fuel injection to achieve their output, fuel efficiency, and low emissions. The seven-speed PDK gearbox mated with full-time all-wheel drive. According to Porsche, "The rear axle is always driven, while the front axle receives its drive torque from the rear axle, and the torque is dependent on the locking ratio of the electronically controlled multi-plate clutch."

The S used a new 2,997cc Porsche V-6 at 1 bar boost that developed 340 horsepower between 5,500 and 6,500 rpm, produced 339 pounds-feet of torque from 1,450 to 5,000 rpm, and bore the word *Turbo* nowhere on the vehicle. The Macan Turbo ran with a 3,604cc V-6 at 1.2 bar boost that developed 400 horsepower at 6,000 rpm and created 406 pounds-feet of torque between 1,350 and 4,500 rpm.

Porsche Torque Vectoring and Sport Chrono were offered as options on both models. A standard steel-spring chassis supported the S model while the Turbo blended steel springs with the electronic PASM (which was optional on the S). An air suspension with automatic leveling, height adjustment, and PASM was also available for either model. The Macan platform came from an Audi Q5 compact SUV.

"At the beginning of the project," Macan chassis supervising engineer Harald Schwer said, "everybody was afraid that Porsche [was] not Porsche anymore. So we all decided we must do something different. The idea struck us to use mixed tires, just as we do on our sports cars. The Macan has this 'Coke bottle' design. So what to do with the bigger space at back? Fill it with tires! We put mixed tires—larger width at the rear—on a Q5 and, at the Nürburgring, it was 5 seconds faster." Project managers made it clear to the engineers and designers that the Macan was to be a Porsche. "It makes no sense to produce a Porsche Escalade," SUV product-line vice president Hans-Jürgen Wöhler said. "The desire was to be in the sportiest position, more as a 911 big brother and less as the Cayenne's little brother." But it was the engine nomenclature that signaled a change within Porsche and its marketing efforts.

Dr. Hans-Jörg Hermanns, the Macan's engine-development manager, recognized that Porsche buyers expect different things if a vehicle is labeled "Turbo," even when, in this case, the S uses two of them. Hermanns' engineers adopted the V-8 from the Panamera, removed two cylinders, and shortened dimensions of some parts to fit the package of the Macan. Both engines used the Panamera's 96-millimeter bore; the Turbo kept its 83-millimeter stroke while the S used 69 millimeters. "The turbo housing is the same for both engines," Hermanns said, "but a few small changes for the Turbo model allow the torque to arrive at slightly lower rpm. The Turbo has to be different from the S."

2015 CAYENNE S AND CAYENNE TURBO

Porsche introduced the next-generation Cayenne, the E22—now termed a "makeover" instead of a "facelift"—near Barcelona, Spain, in September 2014. The effects of cross-pollination were on display, as the entire lineup of new models for the US market was turbocharged. The new base model is a 2,967cc DOHC four-valve-per-cylinder V-6 diesel with a single turbo that develops 240 horsepower at 4,000 rpm and 406 pounds-feet of torque at 2,500 rpm. (Porsche later introduced a normally aspirated diesel for non-US markets as well as a hybrid model that used the 3.0 as its fuel engine.)

The Cayenne S was next in the lineup. This was where cross-pollination truly emerged, as the Cayenne S uses the same four-valve DOHC 3,604cc gasoline V-6 developed as the Macan Turbo model, also offering 420 horsepower at 6,000 rpm and 406 pounds-feet of torque at 4,500 rpm. This engine configuration replaced the prior S powerplant, a 400-horsepower 4.8-liter V-8. This is the latest example of Porsche's commitment to reducing displacement and improving efficiency through turbocharging. This new engine not only delivers 20 horsepower more, but also it improves performance (nearly half a second faster from 0 to 60 miles per hour), betters fuel economy, and decreases exhaust emissions.

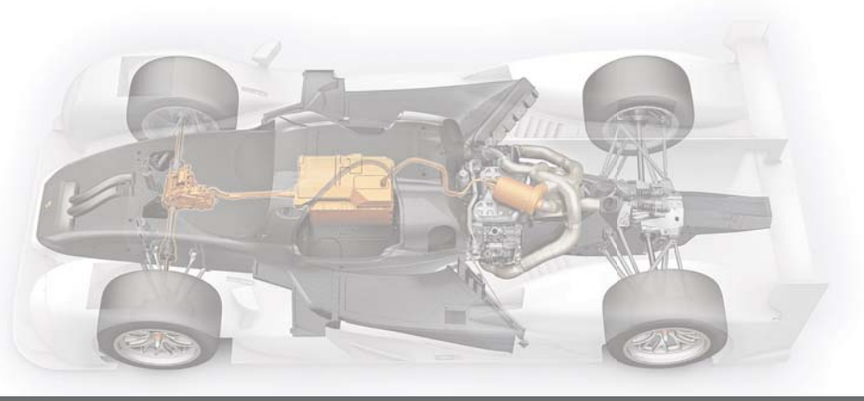
The Cayenne Turbo continued the updates on the 4,806cc V-8 that Cayenne shares with Panamera. Output is common between the two, at 520 horsepower at 6,000 rpm and torque at 553 pounds-feet at 4,000. New to each of these vehicles is Porsche's updated PDK, offering eight forward gears.

Style Porsche's designers gave the Cayenne new front fenders, new front fascia and grilles, and a new front deck lid. Blade-like LEDs that Grant Larson and his electronics colleagues labored over on the 997 second-generation Turbo now mark the front of every Porsche and have become a new element in familial identity. The Turbo got a distinctive parallelogram treatment.

At the North American International Auto Show in Detroit in January 2015, the company announced the companion Turbo S Cayenne. As expected, its specifications match those of the Panamera Turbo S models, delivering 570 horsepower at 6,000 rpm and 590 pounds-feet of torque across an engine range from 2,500 to 4,000 rpm. Acceleration, assisted by Sport Chrono's Launch Control, requires 3.8 seconds from 0 to 60 miles per hour and gets the vehicle up to a top speed of 176 miles per hour. Turbochargers, while they have assumed a role in downsizing displacement with all its benefits, continue to scale up their performance.

While this model was the Macan Turbo, the third engine in the Macan lineup was a 2,967cc V-6 diesel with a single turbocharger. At 4,000 rpm, that engine developed 258 horsepower. The use of turbochargers across the entire Macan lineup demonstrated the ability of more compact engines to provide the performance as well as fuel economy and restricted emissions the engineers sought. *Porsche Archive*

This model, labeled Turbo, used Porsche's new 3,604cc aluminum V-6. Bore and stroke were 96 millimeters by 83, and the twin-turbo engine developed 400 horsepower at 6,000 rpm. The "base" model Macan S engine displaced 2,997cc and with two turbochargers it developed 340 horsepower between 5,500 and 6,500 rpm. *Porsche Archive*



Chapter Eighteen

SPINNING OFF BOOST FOR **VOLTAGE**

By Andrew Cotton

2014 PORSCHE LMP1 TYP 919

As Formula One entered a new hybrid era, so did sports-car racing, but in a very different way. While Formula One mandated 1.6-liter V-6 engines, cars competing in the World Endurance Championship had an open engine formula. Regulations allowed both gasoline and diesel, along with a variety of energy recovery and storage systems.

Essentially, the FIA rules limited the amount of energy carried by a sports car but left open how a team reached that limit. Audi had a 4-liter V-6 diesel with one kinetic energy recovery system (KERS) from the front axle, and it stored the energy in a lightweight electromagnetic flywheel system. Toyota had a V-6 3.7-liter gasoline engine and recovered energy from the brakes front and rear, storing it in a supercapacitor that was fast to charge and discharge the energy.

Once Porsche engineers solved an early problem with an engine vibration in their new 2-liter V-4, they tested in earnest at Paul Ricard (shown here) and later at Portimão, Portugal, dialing in the complex integrated systems that characterize hybrid racing cars. The psychedelic camouflage body wrap made it difficult for competing teams to analyze body openings or aerodynamic devices. *Porsche Archive*

Porsche, which developed its own 2-liter V-4 engine, was the only one of the three manufacturers to have two different energy recovery systems. The first was a kinetic system on the front axle, similar to that used by Audi, but Porsche was the only manufacturer to perfect the MGU-H (Motor Generator Unit-Heat), a heat energy recovery system that worked with the exhaust gases. Porsche elected to store the energy in a battery, a system that in theory is slower to charge and discharge but that gave the team more options in terms of where it can deliver the power back to the wheels.

Such diversity was universally welcomed by manufacturers and the public alike, and this led to a resurgence of interest in endurance racing. The FIA calculated energy for each car and produced a regulation appendix that stipulated in which hybrid energy category the car raced, how much fuel it could carry, and how fast the fuel could be used. There was very little room for maneuvering, and the days of successful political pressure were gone. Responsibility for implementing the regulations lay with the FIA, not with the ACO, and the association was resolute in its calculations.

Porsche raced in the 6-megajoule (6 MJ) category, which meant that, at Le Mans, it could release 6 megajoules of energy back to the wheels over the course of the 13.6-kilometer lap. Figures were adjusted for each circuit of the WEC, which is one of the reasons why Porsche elected not to go for the maximum 8-megajoule category. The 2014 Le Mans regulations offer "five categories of energy," defined from 0 to 8 megajoules per lap, with 8 megajoules registering as the strictest limit. This demanded that cars perform at a 28 percent reduction in fuel use from 2011 levels. Regulations allowed cars in the 8-megajoule category only 1.17 gallons per lap—about 7.19 miles per gallon—although the most generous, 0 megajoules, still restricted them to 1.31 (roughly 6.42 miles per gallon). The 6-megajoule category allowed 1.19 per lap (approximately 7.06 miles per gallon). The 0-megajoule cars had to weigh at least 1,874 pounds while the 2-, 4-, 6-, or 8-megajoule cars shared a minimum weight of 1,918 pounds. In addition, rules limited each car to only two energy systems.

The 919 Hybrid therefore raced at Le Mans at 1,918 pounds, as did each of the hybrid cars. It carried a maximum of 18 gallons of fuel, and regulations limited maximum fuel flow to 89.5 kilograms per hour. Porsche picked drivers from its own stable, including Romain Dumas and Timo Bernhard, who were loaned to Audi pending Porsche's LMP1 program starting and who had won at Le Mans in 2010. Marc Lieb, a driver with multiple successes and an engineering degree under the watchful eye of legendary engineer Norbert Singer, also got his chance to race in the top flight. Swiss driver Neel Jani came in from the Rebellion Racing team, while New Zealander Brendan Hartley was snapped up after a stint in LMP2. The sixth driver was Australian Mark Webber, who raced at Le Mans for Mercedes in the 1990s before switching to Formula One, where he rose to partner with Sebastian Vettel at Red Bull. Webber wanted to return to Le Mans, and Porsche gave him the perfect opportunity. However, he wanted one final season of Formula One in 2013 and did not join the Porsche team officially until the tail end of the calendar year.

Porsche's program was ambitious, but the brand had the advantage of not racing in 2013, meaning its resources were entirely aimed at the car's development throughout the season. The team was also free to test, but a vibration problem with the engine meant that testing was severely limited. Nevertheless, Porsche contested the full World Endurance Championship, including Le Mans, with two cars, and it scored its first victory with the car at the final round at São Paulo in Brazil in November 2014.

That win was a welcome reward for a season of hard work that showed plenty of promise. More than 145 engineers were recruited and placed onto the 919 program at Flacht, and by midseason, work was almost complete on a new wind tunnel. Hybrid development that started on Porsche's 918 road car under Dr. Frank-Steffen Walliser continued in the 919 race car, and in fact the hybrid system was the least of Porsche's worries at the start. The V-4 engine configuration meant that the unit could be mounted low in the chassis and was a structural part of the design, yet early on a vibration issue caused the development to be stilted. LMP1 project leader Alex Hitzinger ordered an extensive revision to the engine, which took almost six months to deliver.

"We had a vibration issue caused by the engine configuration," Hitzinger confirmed. "We changed the engine configuration and reduced the vibration level a lot by changing the firing order. Changing the firing order means a new crankshaft and camshafts, and new calibration

Porsche fielded two teams for Le Mans in cars that weighed in at 1,918 pounds. Car 20 here qualified fourth fastest for the start, while teammates in car 14 secured the second fastest time. Neither car finished well. *Porsche Archive*

The days are long gone when what looks appealing to the eye is judged aerodynamically sound. Computer modeling and days of wind tunnel testing determined the appearance of the 919. *Porsche Archive*

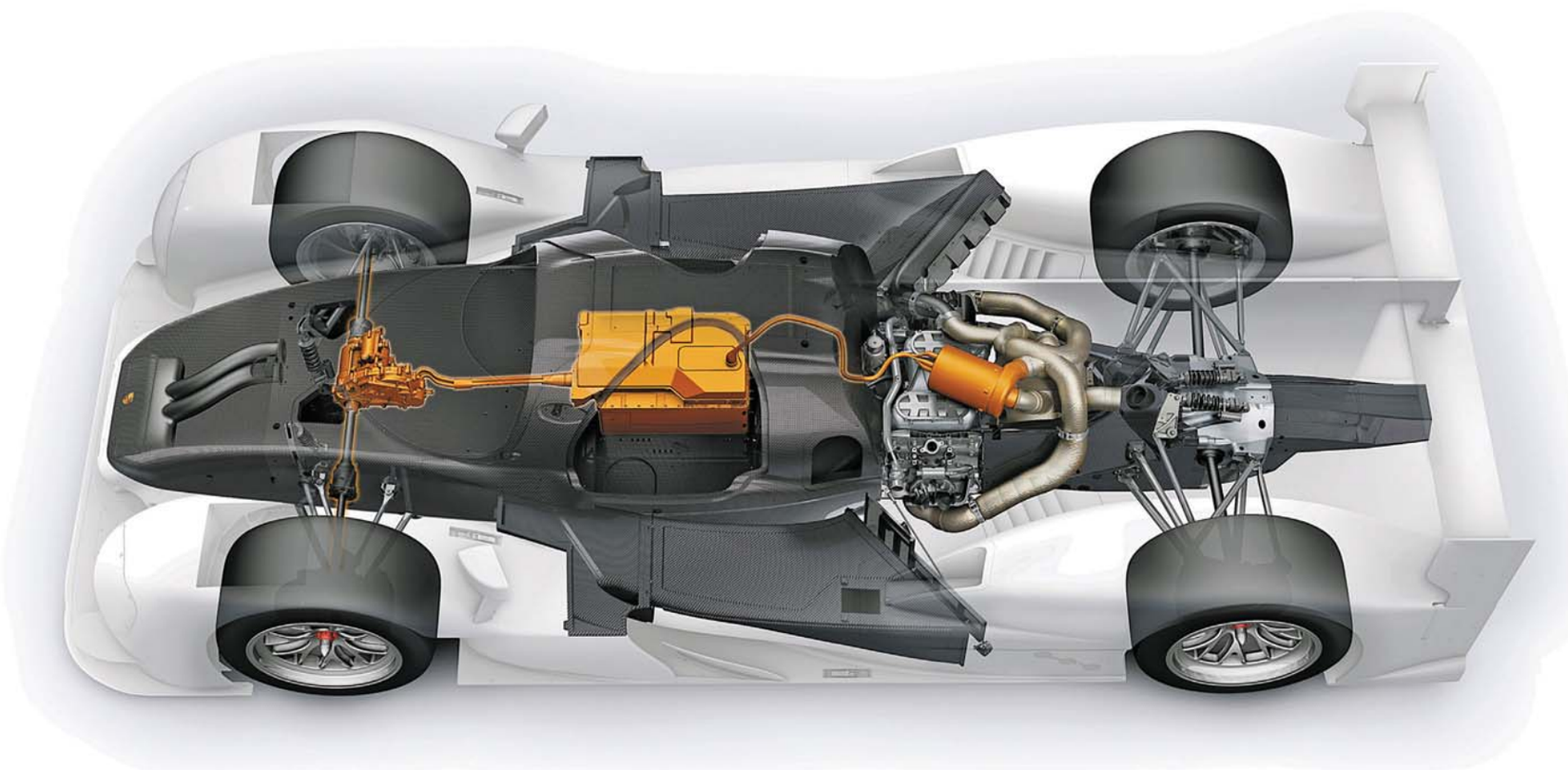
because of the gas-exchange changes. It was a big thing. We discovered the problem at the rollout. For me it was quite clear at the beginning that this was going to be a problem that would otherwise be difficult to solve. I decided very quickly because it is such a big change that it takes a long time to implement it, but if you let it drag on before you try to solve it, you could be in trouble later on. We saw the problem, and we acted decisively."

The vibration issue caused parts to fall off the car, including the rear diffuser, and it also apparently interfered with the interlinked suspension. (This system hydraulically interconnects front and rear suspension as well as left and right sides to maintain constant optimal ride height and aerodynamic balance under acceleration, braking, and cornering.) The vibration also gave false readings to the drivers, and so even though the car ran and other systems were tested, learning was limited until a new configuration was delivered in time for a test just before Christmas 2013 in Portimão, where newly signed Mark Webber was able to put more than 600 kilometers onto the car. "The feeling for the drivers was very different than what it would normally be," Hitzinger said. "We felt that there were issues on the suspension side in terms of yaw behavior and so on."

Porsche's short engine meant that the gearbox housing was almost a third of the car's length, but Porsche calculated that this was almost as strong as a longer engine. "From a thermodynamic point of view, you want a certain ratio between air and volume in the combustion chamber and that leads you towards a smaller number of cylinders at a given capacity,"

Porsche was the only one of three LMP1 manufacturers to make use of two separate energy recovery systems. The MGU-H unit atop the turbocharged internal combustion V-4 essentially was a second turbocharger, although this one connected to an electric generator. *Porsche Archive*

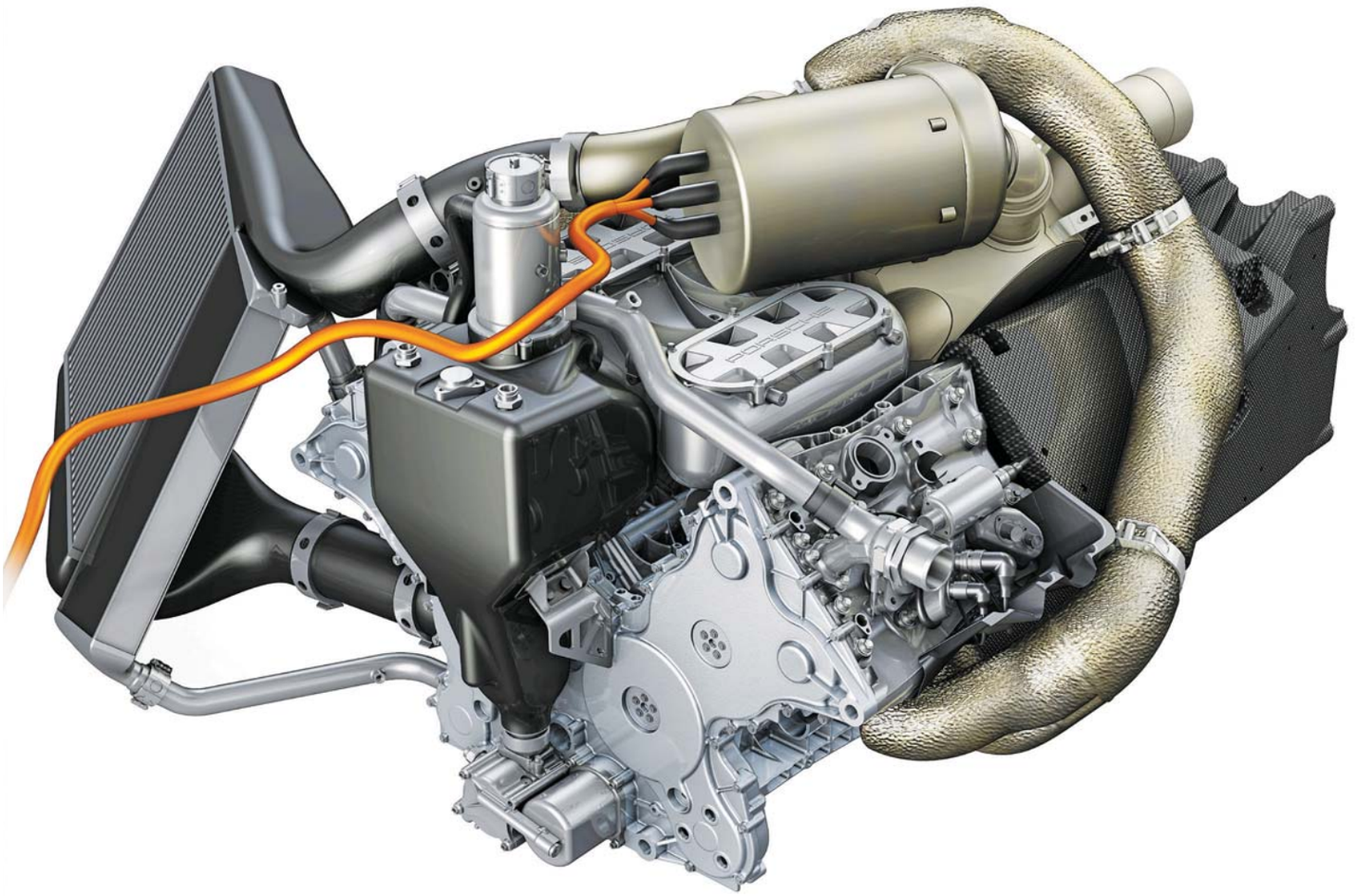
"Porsche was the only manufacturer to perfect the MGU-H [Motor Generator Unit-Heat]," Andrew Cotton wrote. This heat energy recovery system was the cylinder atop the engine in which exhaust gas spun a turbine linked to an electric generator. A second energy recovery worked off the front axles, generating as much as 250 horsepower on call. *Porsche Archive*



Hitzinger explained. "With a four-cylinder V configuration, you can nicely install it in the car as a structural component."

The decision to store the energy in batteries was a risk, according to rivals who watched with keen interest the performance of the 919 over the course of a six-hour race and a twenty-four-hour race throughout the season. The batteries were supplied by an American company, A123, and developed for race usage. "[Batteries] give the best compromise between energy and power density," Hitzinger said. "It gives you more flexibility in terms of strategy, and A123 Technology is, in my opinion, the best out there and we are lucky to have them. We are exclusive in LMP1 and it is a very good thing for us. I think it is a lighter solution than the others. You size the battery according to how much power and energy that you need, and how safe you want to be. Our investigations concluded that this would be the lightest solution for application and our assumptions."

For the rear ERS, the electric energy is not used to counter turbo lag as, Hitzinger explained, that is not as efficient as using it totally for charging the battery between braking phases. "It's another turbine that drives an electric generator, so as soon as there is more exhaust energy than required for the turbocharger, that surplus gas flows through the additional turbine," he said. "It has nothing to do with anti-lag. Flowing electric energy from the exhaust energy recovery system to the front is possible, or direct it to the battery." With a tightly packaged engine sitting low in the chassis, and an MGU-H and turbo sitting above it, cooling was clearly an issue for the team, and that is one of the reasons why it elected to go for the 6-megajoule category rather than the 8.



Cooling was a big issue, and the size of battery required to reach 8 megajoules would have compromised the design. Instead, the team looked at the whole WEC schedule and concluded that, for the majority of the season, it would not be able to recover enough energy to warrant the larger storage and use it effectively. Instead, therefore, it opted to race at 6 megajoules and at a stroke reduced the amount of cooling required while increasing the efficiency of the overall package.

The team finalized the carbon monocoque at the end of 2012 to meet with the company's schedule of rolling out the car in June, announcing the program just before Le Mans 2013. This meant that the front suspension concept was designed early, and although the team initially hinted at an unusual coil-spring suspension, in fact it was an interlinked hydraulic suspension. The car was designed with a low frontal area while still meeting the new regulations that increased visibility from the cockpit. The large blind spots that saw drivers rely more on hearing than vision to avoid collisions were reduced significantly. The 919 therefore featured a raised section in the roof, designed to give drivers more height in the cockpit. "The bubble in the roof was not an afterthought; that was the result of being very aggressive in terms of frontal area," Hitzinger said. "You have clear templates that you have to respect in terms of cockpit internal volume and visibility, and you want to wrap around these templates. It is purely aerodynamically driven."

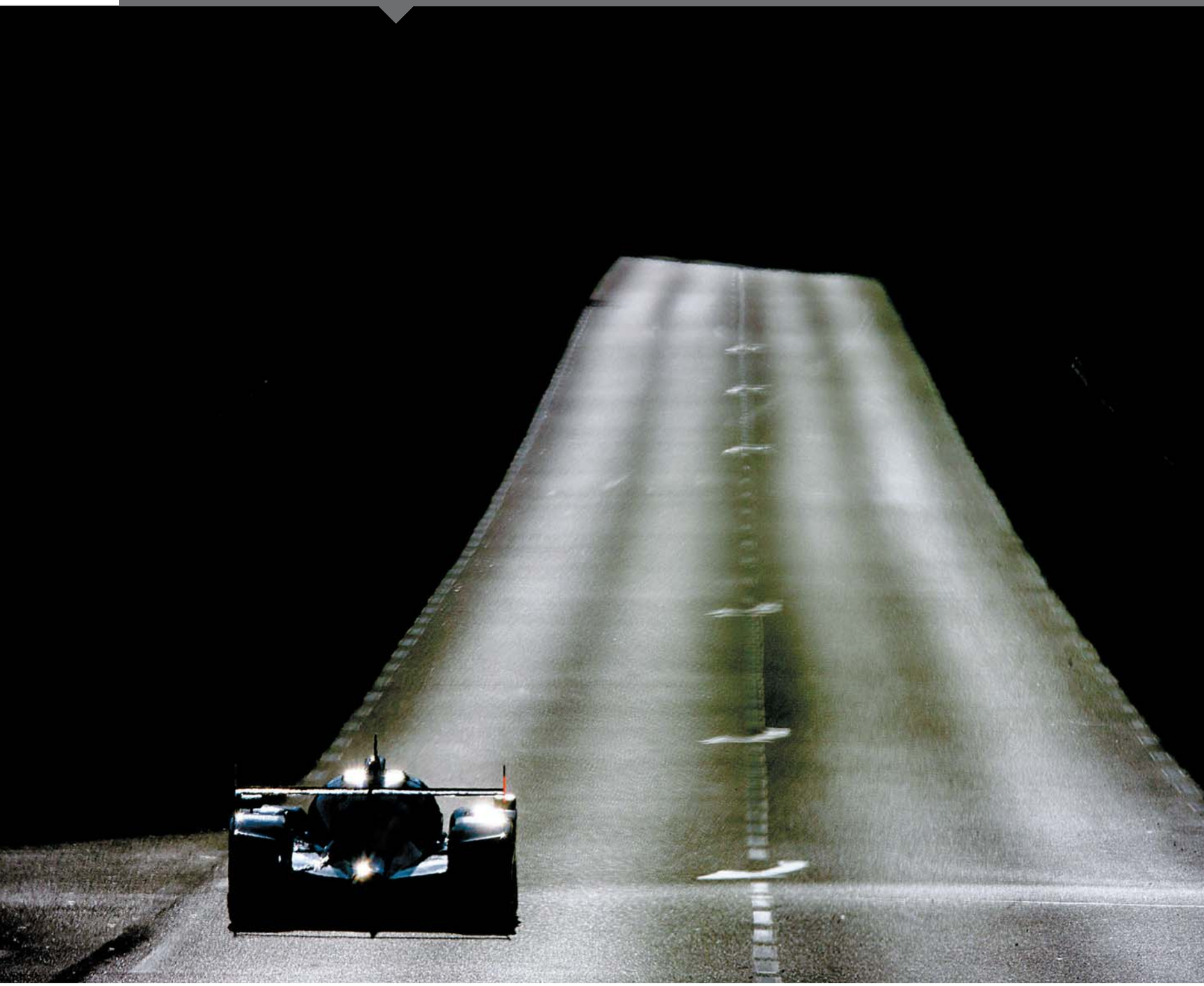
Porsche was coy about its braking, refusing to confirm that it was a brake-by-wire system, but with a large energy recovery system working on the front brakes, clearly a system is required to help the driver. If a driver has a system that recovers energy during a braking event, he will have one pressure on the pedal. Once that ERS stops recovering energy, the driver will have a different feel to his pedal, and that could lead to a problem midevent. It is possible to solve this problem mechanically, but Toyota was clear that it had an electronic solution.

While the electronic solution is allowed by the regulation, it may not do more than can be achieved with a mechanical system. At Le Mans in June, Toyota's electronic braking system was challenged, but declared legal and allowed to race. "There have been some clarifications over the course of the year in terms of the regulations that we have to react to, in terms of bodywork, aero, brakes, the skid blocks under the car," Hitzinger said of the 2015 developments. "We already have some form of brake compensation for ERS, but the regulations have changed quite a lot and opened up. [What an electronic system can do] can't be policed, so of course there is a lot more potential that we didn't use before because we thought that it was illegal, and now it is legal. It should be invisible for the driver, what the KERS does. It should have the same braking feeling, and the two systems have to compensate. If you have such an active input into the hydraulic brakes, you can use that for brake balance migration. It was clear in the regulation that this was illegal, but we can now do that."

Toyota was not the only manufacturer to be caught out seeking an advantage. Although the TS040 also featured a rear wing that rotated at

Porsche quoted its 2-liter V-4 engine as developing 500 horsepower. It relied on a sequential seven-speed transmission to provide power to the rear wheels. The Kinetic Energy Recovery braking system on the front axles (KERS) essentially made the race car all-wheel drive. *Porsche Archive*

As the sun set at Le Mans, the already challenging day continued. While car no. 14 here, with co-drivers Marc Lieb, Romain Dumas, and Neel Jani in 14 went on to record an eleventh place overall at Le Mans, they won outright at Interlagos in Brazil at the season end. *Porsche Archive*



The Typ 919, known internally as 9R9, presented orders of greater complexity than Porsche's last prototype, the 9R6 RS Spyder that raced in LMP2. The intense reliance on energy recovery systems reflected the growing responsibility auto-racing organizations had accepted to serve as vanguard for automotive efficiency and environmental consciousness. *Porsche Archive*

Porsche rolled out its next generation 919 with its new nose for testing on its Weissach circuit in mid-December 2014 before shipping it to Abu Dhabi for extensive testing and development. Work on the car there at the Yas Marina circuit began in mid-January in advance of the season-opening WEC race at Silverstone, England, in mid-April. *Porsche Archive*

speed, reducing downforce when it was not required, there were issues elsewhere on the grid, notably in the Porsche camp. At the test day, the 919 was rolled out onto the grid for the now traditional photo call, and immediately Toyota noticed that the rear engine cover flexed. This led to Porsche having to fix the center of the bodywork to the crash structure, although flexing around the rear outer sections of the bodywork meant that the 919 still had good straight-line aerodynamics. Toyota, Porsche, and Audi all received dispensation to run with flexible bodywork at the front part of the skid block to protect the carbon monocoque. "Regarding the front part of the skid block, we have observed during scrutineering that each of your cars had some flexibility in order to prevent any damaging of the underside of the cockpit in case of unwanted passage out of track or on [curbs]," the statement read from the FIA. "Formally speaking, this contravenes regulations. However, as it seems indispensable and used by all of you, we agree not to apply strictly this article for this specific part. We make it mandatory to have a stop effect and that this deflection cannot [*sic*] under no circumstances be more than 15mm."

The 919 raced in the first half of the year with low-downforce bodywork optimized for Le Mans. That meant a compromise in overall car performance in April at Silverstone and in May at Spa, where downforce was crucial. Nevertheless, Porsche scored a podium at Silverstone through Bernhard, Webber, and Hartley and led at Spa before an electronic failure meant a system reboot for French driver Romain Dumas out on the track. It showed potential, but more was expected at Le Mans before an engine failure caused one car to retire with Webber at the wheel, leading the race overall on Sunday afternoon, while a gearbox failure accounted for the second 919. The team was still encouraged by the performance of the cars. "We didn't quite have the pace in the beginning, but we had the pace at the end," said Swiss driver Neel Jani. "During the night, as it cooled, our pace got better. We knew we would have problems with reliability. Unfortunately, they came for us very early and for the sister car very late. On the other hand, all seven LMP1 factory cars had issues. It was the best time to have no problems. That is why the sister car was up there, as it had no problems. When you watch my night stint, the car started to work better and better. There is plenty to take into the next race, but mainly into next year."

"Our goal was to be in the first year competitive," said Wolfgang Hatz, Porsche board member in charge of research and development, who was a regular visitor to the Porsche pits during the 2014 WEC campaign. Porsche's goal for 2015 was greater, and its motorsports engineers essentially reinvented the car for the new season with a new platform, revised engine, improved bodywork and aerodynamics, and more ambitious 8-megajoule energy recovery. The decision to enter three cars helped ensure success.

At the end of twenty-four hours, car 19—which was co-driven by Nick Tandy, Earl Bamber, and Nico Hülkenberg and had led for 214 of the total 395 laps of the race—crossed the finish line first, with teammates Mark Webber, Brendon Hartley, and Timo Bernhard following in second place in car 17. Two Audis chased them, pursued in turn by the fifth-place 919 of Marc Leib, Romain Dumas, and Neel Jani driving car 18. The win marked Porsche's seventeenth overall victory at the 24 Hours of Le Mans.

Chapter Nineteen

REDEFINING A **CLASSIC**

The new 991–generation Turbo introduced many significant technological innovations. Active Aerodynamics not only meant the rear wing rose or fell in relation to road speed but also an air-inflatable chin spoiler appeared and enlarged as downforce needs increased. *Porsche Archive*

2014 991 TURBO AND TURBO S

This was about stability.

"We had this idea to lengthen the 911's wheelbase long ago," August Achleitner explained during the launch for the normally aspirated 911 Typ 991 in fall 2011. Achleitner was director for Carrera product line management. "We didn't exactly say 100 millimeters as it is now, but it was roughly this number in 2003. That's when we started development work on PDK, and we considered the technical requests from our chassis engineers to make the wheelbase longer." Porsche Doppelkupplung appeared in 997/2 models, and lengthening the wheelbase in a second-generation update was not practical. "The reasons for doing it now," Achleitner said, "came only out of the decisions for vehicle dynamics, to make the car more stable, more calm, more precise."

The decision was controversial, however. His chassis engineers also widened the front track, a change he called more important than the wheelbase change. "Now we [could] support more rolling forces by the struts, not only by the stabilizer. This allowed us to make the stabilizer a little bit thinner and not so stiff. Simultaneously, this avoids understeering." Onto this new chassis, the car's engine development manager Thomas Wasserbäch carried over the basic 9A1 engine and PDK from the 997/2 with modifications to increase power, torque, and fuel economy. But part of the requirement of a new generation and a new chassis was a new car body.

"I was doing my internship at Style Porsche in 2003," designer Peter Varga recalled in November 2014. "I saw Grant Larson's 997 and I thought to myself, 'It's really difficult to improve *that* car.'" After design director Michael Mauer arrived and Varga completed his degree, Mauer hired him. The project that had earned him the internship was a one-third-scale model of a 911 that, as others have characterized it, "pushed the 911 concept as far as you can push it and yet it's still a 911." This inspired him when Mauer called for ideas for the 991.

"I thought it was not useful to improve on the 997," Varga explained, "but to do it in a different way. To make it new and different. To simplify it even more. To make it more precise." For Varga, that meant introducing lines: "three lines," he said, "two roof lines and this sharp line on the back." He refined his internship idea.

Mauer, like design chiefs before him, launched a competition among his staff. They submitted eleven scale models, but as Matthias Kulla, director of sports car design management, recalled, "Michael looked at [Varga's] and said, 'This could well be the one.' We still had the competition going, but we kind of knew it would win." Everything "that makes the 991 become the 991 was part of the scale model," Varga explained. "Just what we find there we made feasible."

Active rear-wheel steering altered the direction of the rear wheels for low-speed maneuverability or high-speed ability. A byproduct of the front e-steering technology, rear steer made two-lane-road vehicle passing or city parking maneuvers considerably easier. *Porsche Archive*

The Turbo S provided exclusive two-tone interior treatments in leather. The PDK gearshift lever, center console, and door panels were finished in Carbon Look. A standard Bose audio system provided eight amplifiers and twelve speakers while the optional Burmester system provided a total of 821 watts of audio power. *Porsche Archive*

Upon joining Porsche, Mauer introduced the idea of strategic design models as an adjunct to sketches and creations that developed new themes. While Varga and his colleagues brainstormed their concepts, two proportional study models were built in full size using the packaging dimensions that engineering and planners had suggested. "These didn't look like an old 997," Kulla said, "but they also didn't look like a new one. They just looked like 'a 911.' We do these types of models to visualize technical decisions that have an influence on proportions. And this was very important because with the new 100-millimeter wheelbase increase, we found it had to have bigger wheels because otherwise it would have lost its typical 911 stance."

Varga's 991 concept went into production virtually unaltered from his first scale model. From this grew cabriolets and all-wheel-drive variations. Then Mauer asked for 991 Turbo concepts. Varga's ideas, perhaps based on his familiarity with his own design, became the car.

"The place where the 991 Turbo really breaks new ground for Porsche," Kulla continued, "is that it looks so much like a machine. This is not just the general shapes. It's all these things that happen down low."

Varga remembered putting in "so much attention on details, all the functional things, rings around tail pipes, opening for the grilles." The rear of the car was undoubtedly powerful. But in discussions about its front, "they said the features, the motifs are not actually aggressive. The proportion is aggressive—to let in the air—but the face is not brutal. It is very finely honed, friendly."

With the Turbo especially, Kulla summed up, "it is not about designing a pretty car. It's about designing authority. A journalist, I think, even nicknamed it the Boss."

A great deal of that authority comes from the chassis of the car. The longer wheelbase and wider front track improved ride and handling. The 991 chassis also introduced Porsche Dynamic Chassis Control, an electronically controlled cross-linking of left-side and right-side hydraulic shock absorbers that reduces lean almost to zero. Active aerodynamics inflated a front air dam to further improve high-speed stability and enhance front downforce. Rear-wheel steering enhanced maneuverability, giving the car a nimbleness Porsche enthusiasts expected from a 911.

Yet all these sophisticated electronic systems did not change a fundamental goal of 911 chassis engineers. "Even when every system is electronic," Ulrich Morbitzer said, "it is still very important for Porsche philosophy to have a very mechanical base. The car must still drive well without all the controls. We use those systems to get to the last percents, to make it easier to drive, more stable. We never want to have a weak mechanical base and put many systems on it to cover it." Morbitzer supervised chassis development for the Turbo and all-wheel-drive 991 product lines.

"There's a three-stage development for the chassis," he continued. "Weight/weight distribution, wheelbase, track width. Then in the second stage are axles and all the mechanical things. The third stage is all the

electronics. We are a little bit proud of the chassis. When the first two considerations are weight and weight distribution, we have 60 percent on the back. Yet we hold our own against cars that have 50–50. I often get this criticism of the Turbo chassis: 'I can't find any weaknesses . . .'

"Every year it's much more difficult to balance out. If you ask people from development what they want in the next car, they want the very best. If you ask the financial chief, he says you only get this much money. If you ask somebody from the quality department, they say we have to be first again in J. D. Power. You never find a way to get all these targets to 100 percent. So every day you have to think about how to make the best compromise."

With the 991 Turbo, it's difficult to imagine any compromise in the engine. The 3.8-liter aluminum block engines (and heads) used bore and stroke of 102 millimeters by 77.5 millimeters. Engineers optimized the twin variable-geometry turbine turbochargers by reducing the compressor diameter to improve response. The Turbo developed 520 horsepower between 6,000 and 6,500 rpm and produced 487 pounds-feet of torque from 1,950 to 5,000 rpm. The Turbo S delivered 560 horsepower at 6,500 rpm and 516 pounds-feet of torque from 2,100 up to 4,250 rpm. Porsche quoted 0-to-60 acceleration as 2.9 seconds for the S with PDK. Yet turbocharging itself represented a kind of compromise, a clever strategy to reduce engine displacement (and corresponding fuel consumption and exhaust emissions) while providing even better performance. It's an idea Erhard Mössle, general manager for Turbo and all-wheel-drive 911s, said first originated in Porsche's racing department.

"They tried to increase engine power of the 917 by using a sixteen-cylinder engine," he said. "They saw very fast that it was much better to use the turbocharged twelve than the normally aspirated sixteen with its big dimensions and heavy weight." The FIA codified this approach with its rules equating the displacement of turbocharged engines to normally aspirated ones that were 1.4 times larger.

Porsche introduced 991 Turbo and Turbo S models simultaneously, unlike past 911s, for which the models appeared a year apart. "We need such a car," Mössle said, "to win our comparison tests. When we made the 996 Turbo, I think we had maybe two or three serious competitors worldwide: BMW, Mercedes AMG, Corvette. But no Ferrari or Lamborghini. Today we have Ferrari, Lamborghini, Audi, Corvette, Aston Martin, Jaguar, Nissan, Mercedes, and BMW. It is much tougher now, and I think we haven't lost one test since the car was introduced."

All decisions at Porsche are considered very carefully. Every millimeter of dimension, every gram of weight, every penny of cost is examined. Porsche charged a premium price for its 520-horsepower Turbo and 560-horsepower Turbo S. It carefully monitored how its customers specified their cars; there is roughly one Turbo buyer for every two who order the S. Porsche was surprised to learn, when they introduced the 997 second-generation Turbo with either a manual or PDK gearbox, that 93 percent of buyers selected the PDK. In Tiptronic S days, the Turbo had been the 911 with the highest percentage of manual transmissions. But times changed. And the economy intruded.

"The reason for eliminating the manual was simple," Thomas Krickelberg explained. He was director of powertrain development across all 911 lines. "We developed the 991 Turbo in the recession of 2008, 2009. We had to look for cost reduction, especially in engineering costs. Offering two transmissions meant nearly doubling the fleet of test cars for development. All the chassis engineers do suspension work for manual and for PDK-transmission cars.

Airflow management was critical with all Porsche turbocharged engines from the first series-production models sold in 1975. Attention to packaging everything necessary for the modern water-cooled 911 twin-turbocharged and twin-intercooled engine has brought many innovations. *Porsche Archive*

Weissach engineers increased rear track width by 1.7 inches over Carrera 4 models to handle 520 horsepower in the Turbo and 560 in the S. The wide rear fender bulge is also a function of providing adequate ducting to the side-mounted intercoolers without sacrificing any performance. *Porsche Archive*

"We weighed this decision very carefully," he continued. "The performance of the PDK is much better than with a manual transmission. If you try to shift at the correct time from first to second, or second to third, you will never get the right time. That shift . . . no driver can do it perfectly. But the PDK does. From a performance aspect, there is no reason for a manual. It's only for the emotion."

No sooner did Porsche freeze body design and engineering specifications on the 991 Turbo and Turbo S than teams began considering what would come next. "Our Turbo customers," Erhard Mössle observed, "they are our 'Top Guns.' They only buy the best, the car with the most power output. I know some customers well and they always ask, 'Why doesn't this car have 600 horsepower?' The current Turbo is able to deliver every horsepower to the road without problems. That is a major consideration for anything we do in the future." These cars are Porsche's most distinctive models. They are so distinctive that they have become a brand in themselves, a brand that Porsche seems to own.

"Think about this," Mössle said. "We have Turbos in nearly every product line: Panamera, Cayenne, Macan. If we ask a customer what car he drives—if you ask a stranger what car he drives—and he says 'a Turbo' . . . what car is that? It's a 911."

This "full-LED" lighting system was standard on Turbo S models and optional on Turbo versions. The stacked tube-shaped light housings provide a two-system low-beam light (above) that uniformly illuminates the road while the lower housing reacts dynamically to steering input. The grille opening below provides air to one of the two cooling radiators. *Porsche Archive*

2016 991 CARRERA AND CARRERA S

Porsche's performance targets went beyond engineering and marketing comparison tests. Some of its more significant concerns related to average fuel economy across all its vehicles. Thomas Krickelberg explained the obligation.

"We have to meet all the legislation's requirements in terms of fleet values for fuel economy in the United States, in China, in Europe," he said. Krickelberg served as project manager for the second-generation 991. "Everywhere they have different legislation. But they all have the same objective: to reduce fuel consumption. We *had* to change from normally aspirated engines to turbo downsizing just to continue reducing fuel use." With that as Porsche's goal, the automaker unveiled the 991/2 at the Frankfurt Auto Show on September 15, 2015.

Krickelberg and his engineering team began work on the car in the fall of 2011, while his colleagues launched the first-generation models. "We need a development time of four years, and our start of production was September 2015," he said.

Porsche's accomplishments with turbocharging almost were legendary by the time this car launched. The Typ 930 from 1975 had developed 260 horsepower. The 991 Turbo developed 520, doubling output. A recent run over the modern German fuel-economy test-drive cycle revealed the 1975 car's fuel consumption was 13 miles per gallon. The 2015 Turbo delivered 24 miles per gallon on the highway (20 combined and 17 in the city). In its best performance, the new Turbo nearly doubled fuel economy. Yet displacement, from 3 liters to the current 3.8, was not even a 30 percent increase. The advances in and advantages of turbocharging were clear.

"The data really tell the story," Krickelberg said. "The base 991 Carrera 3.4-liter engine developed 350 horsepower. And we replaced that for

2016 with two engines of 3 liters displacement but with twin turbos and intercoolers. For the Carrera, this engine developed 360 horsepower. We could have done more! But we wanted to keep base horsepower at a sensible level.

"The previous S developed 400 horsepower with a 3.8-liter naturally aspirated engine. The new-generation 3-liter engine for the S delivers 420 horsepower." Krickelberg's engineers achieved the two horsepower levels with different exhaust systems and turbos.

The 3-liter Carrera and Carrera S engines shared cylinder dimensions of 99-millimeter bore and 76.4-millimeter stroke. While this overall displacement struck a chord with Porsche enthusiasts, the reason was more practical: in China, engine displacements greater than 3 liters were severely taxed.

Acceleration for the 991/2 Carrera and Carrera S dropped by 0.1 second each, while fuel consumption improved more noticeably. The 991 Carrera required 9.3 liters per 100 kilometers (25.4 miles per gallon); the new generation consumed 7.9 liters per 100 kilometers (29.7 miles per gallon). For the more potent S, previous consumption was 9.9 liters per 100 kilometers (23.7 miles per gallon), while the new engine delivered 8.3 liters per 100 kilometers (28.4 miles per gallon).

The engines were almost completely new, with very few carryover parts. They used conventional (non-VGT) turbochargers with a wastegate, but with new crankcase, cylinder heads, and everything inside. Maximum engine speeds for each version were listed as 7,500 rpm—not so high as the previous normally aspirated peak of 7,800, but a very high figure for a turbocharged engine.

"And," Krickelberg added, "while improved fuel consumption and increased horsepower were important accomplishments of these new engines, daily usability is much better because our drivers got high power at lower speeds." Torque output for the 3-liter Carrera flat six was 332 pounds-feet across a range of 1,700 rpm up to 5,000 rpm. The S engine developed 369 pounds-feet through the same range.

Styling for the new turbocharged Carreras was circumspect compared to the 991 Turbo coupe and cabriolet flagships. Matthias Kulla worked with Peter Varga again on the next-generation models and he described some of the challenges they faced.

"My goal," Kulla said, "was always to have the base-model 911 to be the purest. It always shined through whatever else you did to it, fenders and wings for the Turbo or for the GT3 and GT2.

"I think there was one area where someone could recognize the new 911 had a turbocharged engine, and it's the air *outlet* for the intercoolers. Apart from that, it's very hard to tell. I think the biggest mistake we could have made was to say that now that it has a turbo, let's make it look like one.

"What we said was, 'This still is the base-model 911.' In this case, we came up with some features that gave the car a different facial expression. Not because this is a turbo, but to make people see something really fresh. But it's funny, about a year ago one of my colleagues from the design studio, who was not really familiar with it, saw it one day and [said], 'Oh, that's a bit shy.'"

"Good, because that's exactly what we tried to do," Kulla replied.

"But you could have made something much more exciting out of it . . ." the colleague said.

"Let's leave that to the Turbo. We've tried to be fairly quiet about this one."

Kulla pointed out that, with the new 918 steering wheels, the interior still looked fresh. "This is an interior where the craftsmanship, the proportions, the detailing all came together," he said. Porsche's turbocharged 911s made for an interesting test.

The family resemblance was clear with this late concept sketch of the new second-generation turbocharged 991 Carrera. The large nostrils for the front radiators indicated greater cooling demands, yet the smoother body forms gave no hint of what had happened to the Carrera and Carrera S engines. *Porsche Archive*

The 520-horsepower Turbo sold for $148,300 in the United States while Porsche sold the 560-horsepower Turbo S for $181,100. Despite the increase in horsepower, each engine delivered 16 percent better fuel economy. *Porsche Archive*

The bidirectional engine cover louvers assist engine breathing while the dynamic wing retracts to become a spoiler integrated into the car body at slower speeds. The Turbo body is 3.3 inches wider at the rear wheels than in front. *Porsche Archive*

Turbo cabriolet models sold for $160,700 while Turbo S cabriolets were priced at $193,900. Turbo cabriolets accelerated to 60 miles per hour in 3.3 seconds (Turbo S in 3.1), reached top speeds of 195 miles per hour, and returned 17 miles per gallon in the city and 24 on the highway. *Porsche Archive*

The retractable roof on Turbo cabriolets used a magnesium frame for light weight and rigidity to maintain a coupe-like roofline when the cloth top is in place. Drivers could open or close the top while driving as fast as 30 miles per hour. *Porsche Archive*

The rear view reflected Matthias Kulla's goal of making it hard for the observer to recognize that the 991/2 is turbocharged. There were small small air outlets for the turbo intercoolers near the bottom of the rear valence, well below the taillights. Here was a turbocharged 911 that did not look like the 911 Turbo. *Porsche Archive*

"With 911, it's easy to see that one is a Turbo, the other is normal," Kulla continued. Horsepower output and acceleration and cornering loads put requirements on the Turbo chassis that were less exaggerated on the Carrera and Carrera S. The necessity to duct masses of air to huge intercoolers forced the Turbo rear fenders out and up. The Carrera and Carrera S had smaller requirements. The rears of these cars are less obvious. "Porsche says if there is no necessity from a technical reason, don't do it," Kulla added. Meanwhile, the engineers had plenty of technical reason for their efforts.

"Our goals were 180,000 kilometers of durability testing," Krickelberg explained, "and not just on roads but race tracks as well—Nardo in Italy, and the Nürburgring. We did thermal shock tests on dynamometers that lasted 100 hours where we cooled the engine to –4 degrees Fahrenheit, then started it and went directly to full-throttle max power. Then we heated up the engine and cooled it down very fast by putting cold water inside to bring it back to –4.

"We did turbo durability on a chassis dyno, taking the engine and turbos up to 198 miles per hour, down to 175 miles per hour, and back and back for 6,000 kilometers. That's what makes them reliable their whole life."

As Krickelberg prepared for the Frankfurt launch, he anticipated a question from automotive journalists and customers as well: "Now that every 911 is turbocharged, what happens to the Turbo?"

"It's still the name of that one," he answered himself. "The name of this one is Carrera."

Porsche's engine plans for the Carrera leaked out in a German magazine about a year before the Frankfurt introduction. Then in January 2015, at the North American International Auto Show in Detroit, engineering chief Wolfgang Hatz confirmed the rumors, announcing the new 991 GT3 RS introduced at Geneva in March had the new normally aspirated engine. "A version of that engine with turbos will be what's in the facelifted 911s in 2016," he said. He hinted that similar technology was headed to the Boxster and Cayman and that the endurance-racing Typ 919 LMP1 had technology to offer the 911 as well.

"If you drive here in Germany on country roads or the autobahn with our normally aspirated engines, they are fascinating," Krickelberg admitted. "Their sound is different. But all the other cars are turbocharged, they have strong diesel engines, or they are supercharged. In a normally aspirated 911, you had to push them really hard to get some distance; you had to rev your engine high to keep them away. And that's hard work. But now with these turbo engines, it's gotten much easier."

"That really is the crux of it," designer Tony Hatter said after reconsidering his work on the series-production 911 Typ 993 Turbos and the Le Mans–winning 911 GT1s. "Porsche *is* the turbo company. We were the first in road racing. Then we made a model out of it because the others couldn't get the engineering down.

"When someone says they drive 'a Turbo,' everyone knows what car they mean."

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PORSCHE TURBO

THE INSIDE STORY OF STUTTGART'S TURBOCHARGED ROAD AND RACE CARS

WHEN PORSCHE BROUGHT TURBOCHARGING to the racing world in the form of the 917, the small German company changed the face of racing. But Porsche wasn't just about racing; it believed in taking that technology to the streets. It mounted a turbocharged version of its air-cooled flat six-cylinder engine in its fabled 911 and created the 930 Turbo. From the moment the 930 appeared in the spring of 1975, it redefined the concept of the supercar. Over the years, the company has applied this groundbreaking technology to all of the vehicles it builds, from the Cayenne SUV to Porsche's latest supercar, the 887-horsepower 918 Spyder. *Porsche Turbo: The Inside Story of Stuttgart's Turbocharged Road and Race Cars* presents the entire history of the company's turbocharged cars, including the 935, 924, 944, Cayman, and Panamera.

ISBN: 978-0-7603-4758-4

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