Project 911S

Part 9: Phase II
The engine—head-to-head

by Mitchell Sam Rossi

PHOTOS BY THE AUTHOR

From the first day the Project 911S hit the race track in its modified street form, it ran flawlessly—not a stutter, blip or cough. The 2.2-liter boxer gave tenor performances every time it put a rubber paw to the tarmac. But, of course, the engine had been rebuilt just...well, just 20 years before. Twenty years and a 100,000 or so miles.

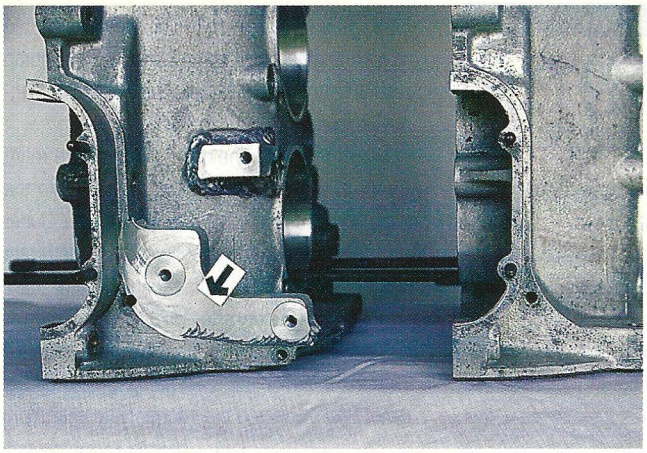
At the start of the project, the engine leakdown and compression tests gave the powerplant gold stars. But now the car was being driven more on the track than off, and every shift was casting the shadow of the tachometer needle over the red zone. Along with the normal race regimen of checking brakes, tires and the ice chest, the 2.2-liter was kept in top form by routinely changing the oil after every event. Whether the S ran a 1-day slalom or a 2-day time trial, 10 quarts of Valvoline 20w50 racing oil were drained and replenished. Next to operating at moderate temperatures, nothing is as gratifying to a 911 engine as fresh oil.

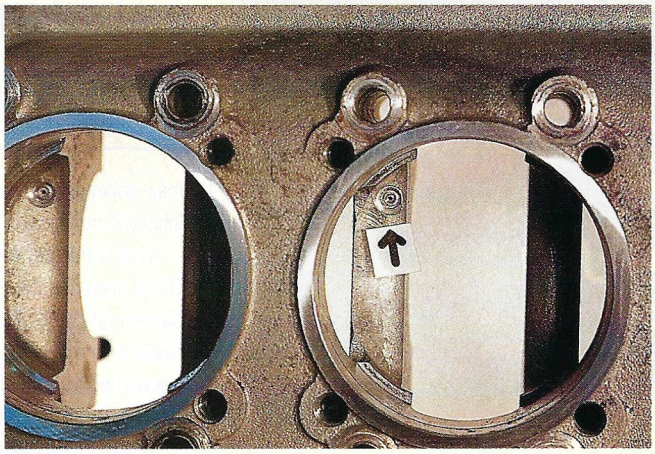
Checking the engine's health was done by slicing open the oil filter and inspecting its pleated filter paper. Examining the ensnared particles revealed whether or not the internal components were nearing the end of their usefulness. The paper, of course, always sparkled like the bottom of a lucky gold miner's pan, but not every metallic shaving was a messenger of doom.

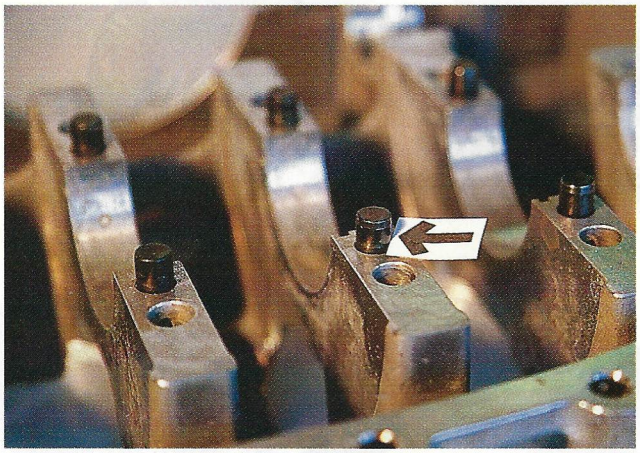
By the brutal nature of high-powered machinery, there is always a degree of discard from bearings and gears. Concern comes from the type and amount. Like reading tea leaves, the trapped shavings tell their own story. An abundance of shiny silver aluminum pieces points to serious problems with the intermediate gear. Glistening copper fragments are the most worrisome indicator, as they are the telltale signs the rod bearings are nearing certain meltdown.

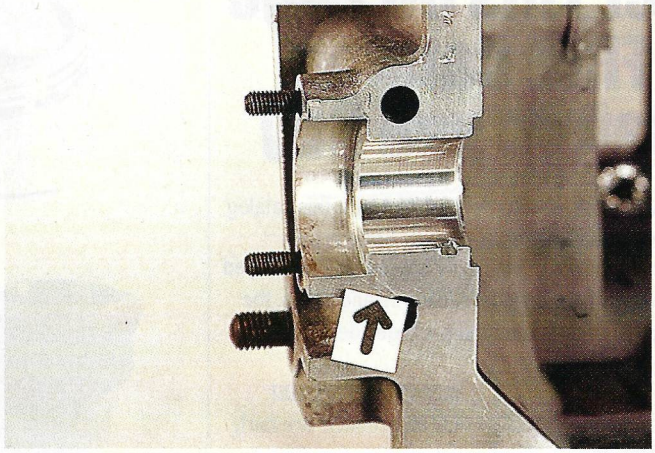
It was near the end of the car's second season when the filter paper began to shimmer. In the Valvoline syrup, I couldn't tell if it was bearings, gears or nutmeg. It did not matter; it was the beginning of the end for the 2.2-liter.

Admittedly, while the 911S will never return to its original form, there is value in the car's matching numbers, the VIN corresponding to the engine case. Given the fact that I was already inflicted with racer's itch, the unex-









Clockwise: 1. Comparing two aluminum engine cases (left to right) with and without fuel injection pump bracket modification. **2.** Comparing two aluminum engine cases (left to right) with and without fuel injection pump bracket modification. **3.** Aluminum case upgrade for accepting intermediate shaft bearings. **4.** Shuffle pin modification.

plainable urge to chase lower lap times, the only solution was to build an entirely new powerplant.

But which motor? By dismissing the original from service, there was no need to base the new motor on the 2.2-liter's magnesium case. Suddenly, I could have horsepower. Real horsepower. And torque. I wasn't even sure what torque was. While the S came alive at 4500 rpm and screamed to 7200, the car's weak point was its lack of low-end punch.

Nearly any aircooled 911 engine could be tucked under the rear deck, but some of them added risks which were best not taken. A monster 3.6-liter would certainly stress the 901 transmission, overpower the tires—whose width was currently limited by the narrow fenders—and, ultimately, turn the car into a lightning bolt with brakes too small to stop it.

The simplest increase in displacement would have been to the 2.4 liter. This would give the S a bit more spunk than the 2.2, but no one was looking for spunk. If a new motor was to be had, it would be one that would turn my knuckles white and yank expletives from the back of my throat.

Luckily, a review of the competition rules for both the Porsche Owners Club and Porsche Club of America kept my adolescent need for raw horsepower in check. Most racing clubs keep cars competitive by classifying them with a point system. Each group is allowed to "spend" points to improve various components, such as suspension, brakes, wheels, aerodynamics and, of course, the engine. Spend too many points, and the car is relegated to a higher class.

As the S was scheduled for several other enhancements, there were only so many points for increasing the displacement above the original 2200cc. Ultimately, a 2.7 -liter was deemed the wisest choice.

Topped with the Bosch mechanical fuel injection (MFI) system, a 2.7-liter seemed the proper powerplant on which to build a lightweight racecar. It also stayed true to the 911S's historical evolution. In theory, assembled with mechanical finesse, the engine could possibly match the output of a 3.0-liter motor with a Bosch K-Jetronic Continuous Injection System (CIS).

Unlike tossing together a Chevy motor, Porsche engines are more akin to building the Space Shuttle. Or, at least, so it seems. For a proper racing motor, I turned to Jeff Erickson of Randall Aase Motors. It was not only Erickson's reputation that drew me to his works but the fact that his shop cared for a stable of Porsche racers, many of whom entered the same events I was hoping to compete. Not only was Erickson's work tested in competition, he and his crew were track side for support.

Bits and Pieces

The original engine case for the 1970 911S was a cast magnesium unit. While light of weight, it is not as strong as the sand-cast aluminum crankcases of earlier 911s. To endow the 2.7-liter with as much longevity as possible, Erickson opted to build the engine from a 1967 motor. The case, however, needed several upgrades to make it compatible with its new assignment.

For the critical machining work, the engine pieces were sent to George Boley and Ike Arriola of Ollie's Automotive Machining in Santa Ana. In business since 1965, the shop specializes in modifying Porsche motors, specifically the aircooled versions.

As pre-1969 911s were carbureted, the first upgrade was to outfit the aluminum case with the proper mounting brackets for the Bosch MFI pump. Inside, small pinhole-sized oil spigots were machined into the main bearing web. Introduced in production motors in 1971, the oil squirters are fed by the

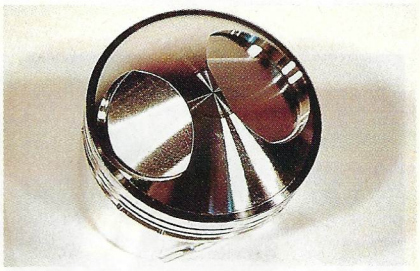
Project 911S

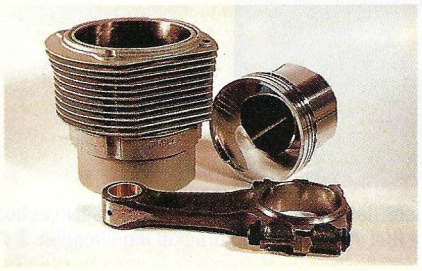
main galley and aid in piston cooling by delivering lubricant into the back of the crowns.

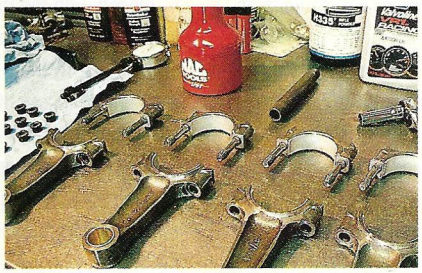
As oil is the life blood of the aircooled engines, Ollie's upgraded the case to accept a late-model Carrera oil pump. This pump not only produces higher oil pressure but also uses a larger scavenging section to draw the oil out of the crankcase and return it to the oil tank. Another benefit to this later unit is its aluminum casing. When subjected to high engine temperatures, the Carrera pump retains its tolerances better than the earlier magnesium pumps.

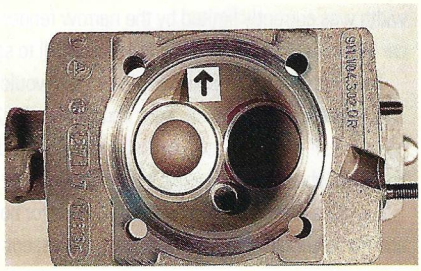
Ollie's modified one of the oil pressure relief valves to allow excess oil to flow back into the pump instead of the bottom of the sump. Under extreme conditions, this oil build-up can interfere with the crank throws. This change became standard from the factory after 1976.

The original aluminum engines were designed with the intermediate shaft riding directly on the case. Ollie's adapted the intermediate shaft bore









Left to right, in decending order: 1 & 2. 2.7-liter piston, JE Pistons. 3 & 4.Power combination: 2.7-liter piston; 90mm cylinder, EBS; lightened and balanced connecting rod, Aasco Performance; and 911S cylinder head with piston and cylinder. 5. Connecting rods readied for assembly. 6. Lightened and balance connecting rod (left to right) compared to a stock connecting rod. 7. 2.7-liter piston with lightened and balanced connecting rod. 8. Beveled combustion chamber, Aasco Performance.

to accept front and rear bearings. This improvement was done by the factory in stages. The rear cradle carried a bearing in the 1969 magnesium case; a forward bearing was introduced in 1970.

To keep the case halves from shifting under high stress conditions, it was shuffle-pinned. Small, steel dowels are installed along the main bearing cradles, which help to lock the crankcase together. For the crankshaft, Erickson chose a 70.4 stroke standard unit. Once its dimensions were determined to be within Porsche's tight tolerances, the crank was magna-flux inspected and its bearing surfaces were micro-polished. Stock connecting rods, lightened and balanced by Ollie's, were carefully matched and clamped to the crank with high-quality connecting rod bolts from ARP.

Choosing the optimal piston for the motor was one of the most critical decisions. Erickson favored the custom forged pistons from JE Pistons. Filling the cylinders of winning NASCAR engines, the high-performance piston makers are also earning a strong reputation with Porsche racing mechanics. Ordering a custom set of pistons for the 2.7-liter, Erickson was able to maintain the car's original compression ratio, an important detail under the competition rules. Polished to a near mirror surface, JE's pistons look more like modern sculptures than hard-working fists of metal ready to take unimaginable abuse.

The pistons were combined with 90mm reconditioned cylinders from Engine Builders Supply. EBS, which also incorporated JE pistons in its piston/cylinder sets, refurbishes the cylinders to factory specifications by replating them with Nikasil, a thin coating of nickel-silicon carbide that was first used on the 917's racing motors.

To firmly attach the cylinders to the case, the latest Dilavar head studs were acquired from Tweeks, an Illinois-based aftermarket parts and accessories supplier. With a thermal expansion rate similar to aluminum, the Dilavar studs have less tendency to pull the threads from the engine case, as is the problem with steel cylinder-head studs.

To further adhere to the racing rules, stock S heads topped off the cylinders. Luckily, no competition points had to be spent to open the ports, as they were already at 36mm for the intake and 35mm for the exhaust, the same dimensions as the factory's 2.7 RS motor. The only machining the heads had to endure was a slight beveling to the bottom edge of the combustion chamber to accept the piston's broader crown.

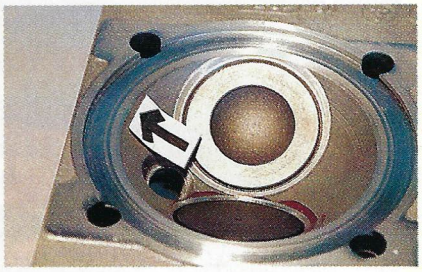
While the valves were kept stock, a key improvement to the valve assembly was the use of Aasco Performance's competition valve springs. Aasco has a long and well-respected standing in professional motor racing and current-

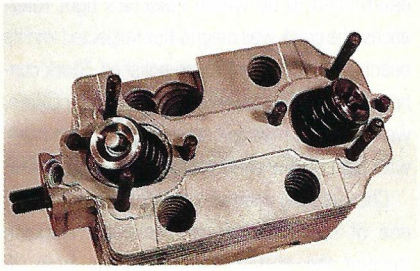
Project 911S

ly supports EMC5's GT3R Porsche in the Grand-Am GT series. Aasco's high-performance springs have been used successfully on every type of racing Porsche since 1977, from 935s to the 962, and all the way up to the 993-based RSRs.

As the engine pushes toward the higher rpm, the springs have a tendency to vibrate at their own natural frequency. This vibration not only damages the valve seat but also lowers its holding pressure against the retainer leaving the valve to "float" in the combustion chamber.

To combat this, Aasco valve springs combine two differing coils with dissimilar frequencies. At peak engine revolutions, the coils slightly interfere with each other, canceling out their detrimental harmon-

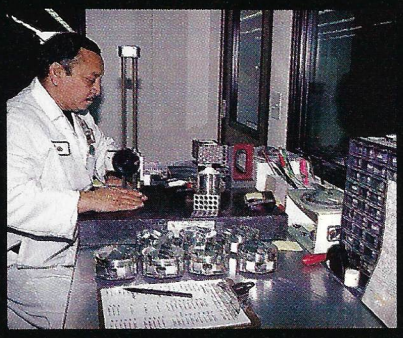




Left to right, in decending order: 1. A close up of the beveled combustion chamber. 2. S cylinder heads with titanium valve retainers and competition valve springs, Norris Performance Products and Aasco Performance. 3. Close-up of titanium valve retainer and competition valve spring. 4. The competition valve springs.

JE Pistons

For more than 50 years, JE Pistons has been manufacturing high-performance forged pistons for both professional teams and serious engine builders. Located in Huntington Beach, Calif., JE employs more than 175 machinists, technicians and quality control engineers, who work in a facility



Left: Quality control at JE Pistons. **Right:** JE Pistons' manufacturing shop

as spotless as the Jet Propulsion Laboratory and nearly as secretive as Lockheed's "skunk works."

Made from aircraft-quality alloys, JE's custom forged pistons have propelled champions in the Indy Racing League, NASCAR, off-road racing, and in nearly every class of quarter-miler, from street stock to the 6,000-plus-bhp top fuel dragsters. Last year, JE pistons generated the power

ics. Valve spring retainers also contribute to valve float. Working at extremely high rpm, their downward inertia continues to compress the valve spring after the cam lobe has rotated past its lift point and the pressure on the valve stem, via the rocker arm, has been alleviated. To decrease this problem, titanium retainers from Norris Performance were incorporated into the valve assembly. Made of 6AL-4V titanium, the retainers are both stronger and lighter than their steel counterparts.

To drive the rocker arms, Porsche has offered a wide variety of camshafts, not only differing in profiles but also in their physical design. As the 2.7-liter was set to be fed by a mechanical fuel-injection system, the left camshaft had to be one with an extension capable of accepting the square-toothed gear used to run the injection pump. As the MFI was only in production from 1969-73, these corresponding camshafts are not readily available.

Fortunately, Erickson located what the engine needed from Web-Cam, a performance camshaft design and reconditioning company in Riverside, Calif. With the correct cores on hand, Web-Cam was able to ground the camshafts to our specification. Although a stock 911S grind was all that was necessary for the motor, Web-Cam could have delivered any cam profile, from a gentle T cam to a fast-lifting, long-duration RSR cam that would have had the S burbling like a top-fuel dragster.

Another critical upgrade to ensure the new motor's longevity was replacing the original sealed-reservoir chain tensioners with pressure-

for Roock Racing's GT2 turbo Porsche during the American Le Mans Series.

As pistons are the company's only ware, success is critical. Through the quality of its products and the triumphs of the teams it supports, JE has become the dominant manufacturer of forged pistons in the U.S., supplying more race and high-performance engine builders than all of their competitors combined.

"The key to what we do is to allow a builder to order a set of lightweight, aircraft alloy pistons, which is stronger and lighter than stock pistons, and have them made to the exact compression ratio he needs," said Jerry Roche, JE's sales and technical support manager. "And, if he wants, he can have them in a custom bore size."

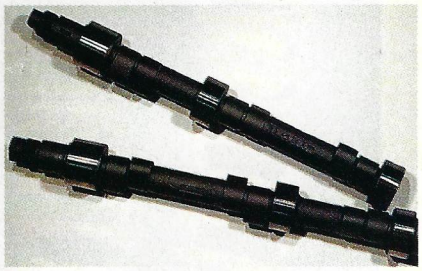
Whether it's longevity for a street motor or the creation of a monstrous 3.8-liter with a crazed compression ratio, a set of JE pistons can be an effective enhancement to Porsche's already awe-inspiring powerplants.

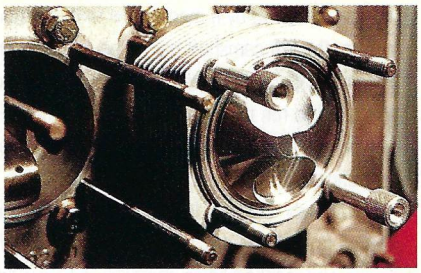
fed Carrera tensioners. The sealed units had a tendency to fail and collapse over time, while the newer devices are continuously supplied with oil pressure. For this improvement, however, the engine case had to be modified to accept the five-bolt pattern of the later Carrera aluminum chain boxes. These boxes are needed to mate with the updated covers that allow the oil to be channeled to the tensioner.

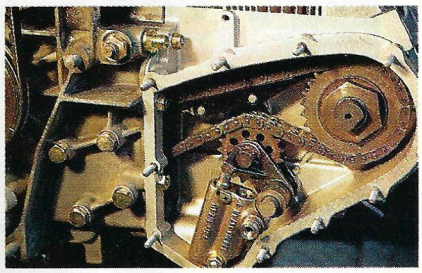
While the 1967 core motor was acquired for its aluminum case and other miscellaneous components, it could have also been pilfered for a variety of other nuts and bolts. Yet, at this stage, it seemed frivolous to economize on anything that might have been subjected to excessive wear.

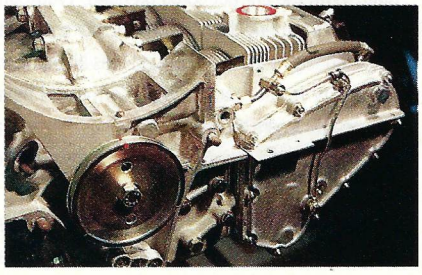
Thus, new rocker arms, rocker shafts and all the accompanying hardware were purchased from Tweeks, as were new timing chains and ramps. The hardware that was reused was refurbished by being cleaned and gold zinc-coated.

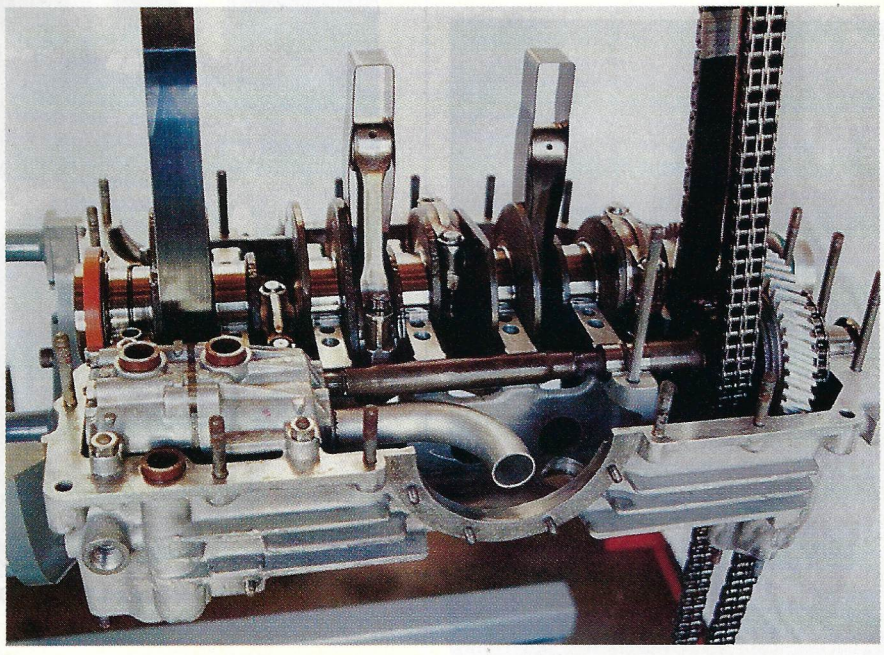
It was almost a shame to watch the polished











Left to right, in decending order: 1. S camshafts with extension for mechanical fuel injection gear (arrow). 2. Assembling the 2.7-liter engine. 3. Camshaft timing chain housings. Note the updated hydraulic chain tensioner. 4. 2.7-liter engine assembled head-to-head. 5. Assembling the 2.7-liter engine. Note the large aluminum Carrera oil pump.

piston crowns disappear beneath the cylinder heads, but it was time to focus on feeding the beast we had created. With the new engine now complete from head-to-head, the next phase of Project 911S will highlight the mysterious Bosch mechanical fuel-injection system and the importance of a properly designed and -prepared exhaust system.

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