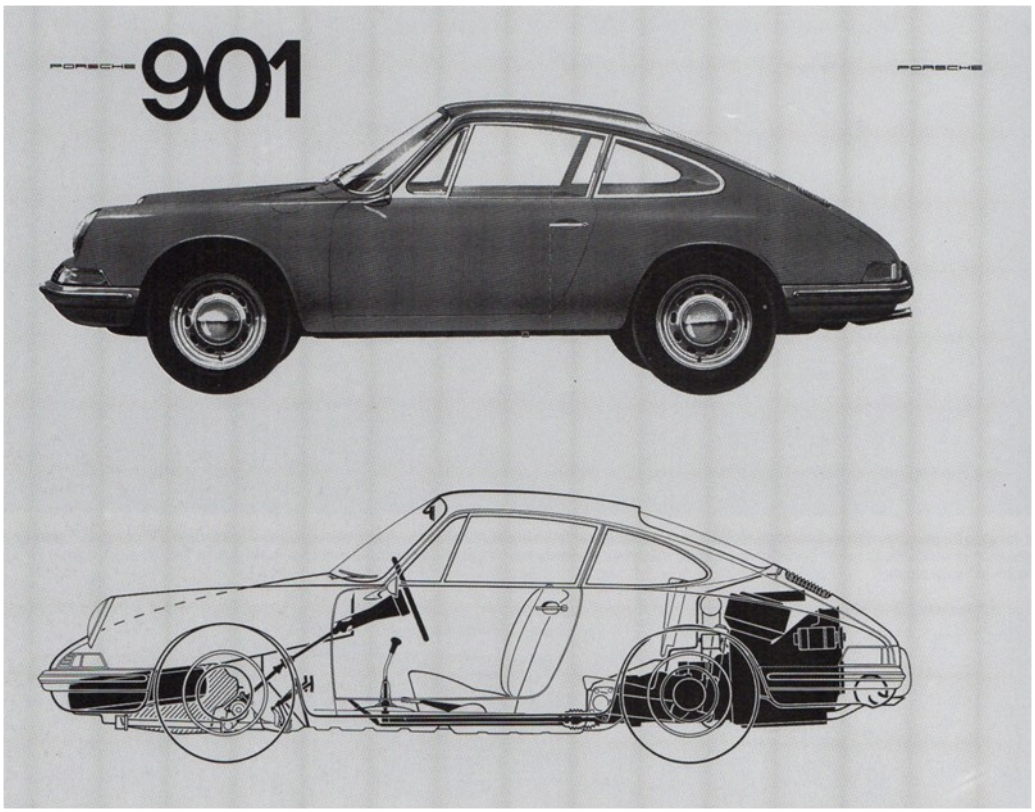
Porsche Club Tasmania

THE DESIGN AND ORIGINS OF THE PORSCHE 911

By Andrew Forbes

First published in the July and October 2018 issues of *Flat Chat* the quarterly newsletter of the Porsche Club of Tasmania.



DESIGN ORIGINS OF THE PORSCHE 911

By Andrew Forbes

CHAPTER I

I suspect that like me, you have more Porsche books than Porsches.

While my youthful dreams of a 930 Turbo were free, the real thing was wholly out of reach, so for many years, books had to suffice. Consequently, my home library contains eleven Porsche books. Luckily, over time I have reduced the books to cars ratio from 11:0 to 3.7:1!

In researching the topic of the development of the design of the 911, I dived into this little treasure trove of text and illustrations, trying to find the essence of how and why the 911 shape, sound, presence and performance has achieved legendary, some say iconic status. I believe that essence is… *evolution*.

In classic Darwinian evolution, adaptation favours survival of the fittest. In Porsche's case, engineering and design evolution (with a healthy dose of experimentation) has been used to improve the basic concept, model by model, year by year, and by doing that, they have outlasted, out-witted and out-performed most their competitors for 70 years. That's what I call evolutionary survival of the fittest!

Tracing the evolution of the 911 cannot be done without first considering the 356. The 356 started as a handful (only 51) of hand-built aluminium-bodied, essentially VW-engined cars, built in Gmund from 1948 through 1951.

The concept of a rear engined 356 was carried over from the VW as it provided more room for passengers than the mid-engine chassis prototype (designated 356/1) and the lightweight aluminium body increased the power to weight ratio, extracting surprisingly lively performance from the 40 bhp on tap. The 356 was improved incrementally through the "A", "B" and "C" series, reaching its peak of development in 1965.

For fifteen years, the Porsche 356 showed the world what small, light, relatively low powered sports cars could do until, in the early sixties, Mercedes and Jaguar started to overtake the little Porsches (literally) on the autobahns of their home country, Germany. At 160 kph, the highly developed pushrod 356C would start to overheat if top speed were maintained for too long. A maximum of 130 hp was all that Porsche could wring out of their air-cooled little wonder, but it just didn't have the legs to stay with the big, lazy, water cooled engines of the competition, designed for sustained high speed running.

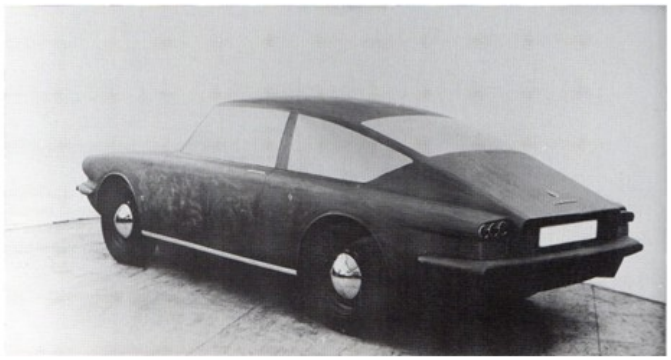
Consumers were also demanding more luxury, more space and more carrying capacity (golf clubs *plus* luggage!) than the 356 with its cramped front boot and small rear jump-seats. It was time for a change if Porsche were to keep its market share, and thankfully, Porsche was not completely caught napping.

As early as 1956, designs of a four-seater Porsche were already being considered, not as a replacement for the 356, but as an additional model.

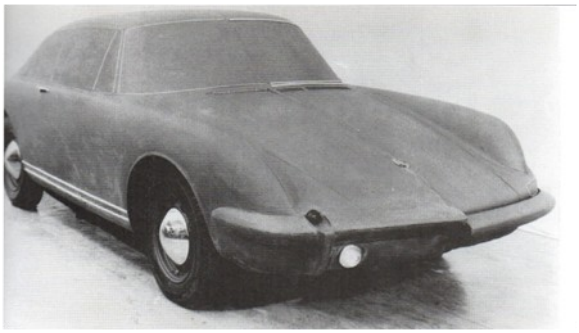
Erwin Komenda, who had been responsible for sheet-metal technology and body design at Porsche since 1931, submitted his ideas for a new model, but in 1957 Ferry Porsche decided that Komenda's concepts were outdated and insufficiently differentiated from the 356.

So, in the spirit of experimentation, Ferry Porsche engaged an American designer, Albrecht Goetz, who was responsible for the elegant BMW 507 of 1955, to design a fast-back with increased interior space. The first iteration was, not surprisingly, too "American", a step too far from the successful silhouette of the 356.

3Ferry didn't give up entirely on Goetz though. He simply widened the field of designers both in-house and externally.



In-house, his son "Butzi", recently graduated from Ulm College of Design, joined Komenda in the Porsche design department and they both worked on Project 695 with Heinrich Klie, who headed the clay modelling shop.

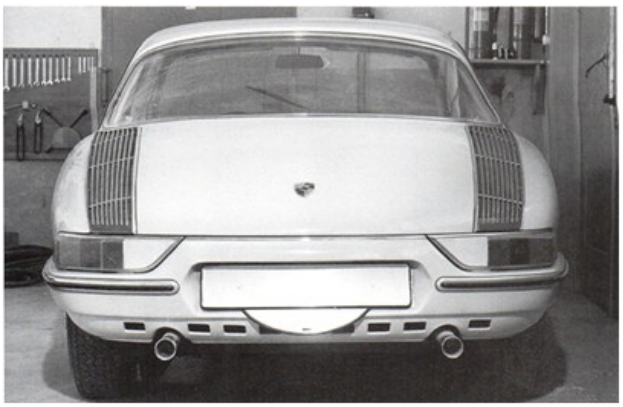


Externally, Goetz continued to work on a second design, and Reutter Body Works contributed further ideas.

Butzi Porsche favoured a new material, plasticine rather than clay, and many 1/10th and 1/5th models were laboriously constructed (plasticine had to be heated to hand-blistering temperature to become pliable enough to mould) to better visualise the designers' sketches and drawings.

There was no shortage of ideas; Fritz Plaschka, and Konrad Bamberg joined the design team, and modellers Ernst Bolt, Hans Springman and Heinz Unger all had an influence on prospective designs. Slowly, through the Type 530 and the Type 754 T7, details were refined until a driveable prototype of the Type 754 was made at the Reutter Bodyworks in 1960. Its underfloor engine was unacceptably noisy, but the shape was moving in the right direction.

However, Ferry Porsche declared that it was too bulky and he set a wheelbase limit of 2.2 metres with a fastback rear, not notched as required to seat four adults comfortably. Two design factions emerged, one led by Butzi Porsche, with his 644 T8 and the other led by Erwin Komenda, with his 754 T9. Komenda's versions T9/1, T9/2 and T9/3 were all modelled full size in wood and metal, each growing bigger and heavier in appearance.



Ferry then took his son's 644 T8 model to Reutter's and had detailed drawings made, from which a full size model could be created.

By 1961 it was clear that Butzi's design was the winner,. A 2+2 fastback on a 2100 mm wheelbase, although still only modelled at 1/7.5th . A full size metal and wood display model of the T8 with a longer wheelbase of 2200 mm was built in 1962, newly designated Type 901.

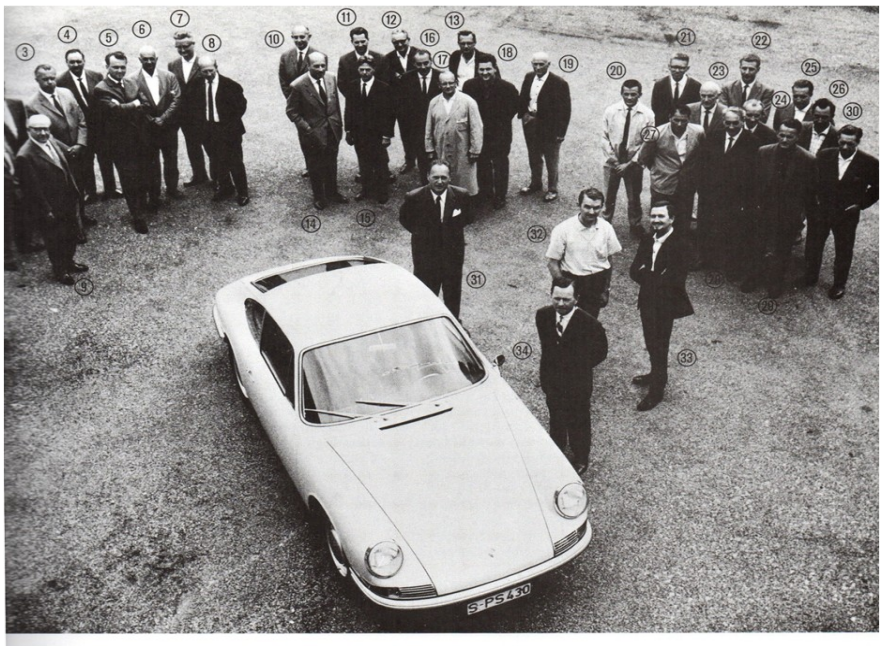
With the body shape and design details virtually finalised in 1963, the considerable engineering resources of Porsche were applied to specifying and integrating major components; engine, transmission, suspension, fuel tank, steering, cooling.

An early 901 prototype was road-tested, suitably disguised (as Porsche still does today), nicknamed Die Fledermaus (The Bat), painted German army olive drab.

(Photo right).

Although a fully engineered prototype could not be produced in time for the 1963 Frankfurt Automobile Show, a near-final design 901 could be publically displayed. As we know, Peugeot claimed that they had exclusive rights to 900 series names with a central zero, so the 901 Porsche became the 911 just in time for the Frankfurt Show. Ironically, in 1964 Porsche used the 904 designation for its superb sports racing car!

To give you an idea of the scale of the 901 project, here's a photo taken in 1963 of the complete team at Porsche.



Engine design:
1. Ruoff, Karl (chief of production engine design) 2. Hetmann, Richard (chief of transmission design) 3. Jäntschke, Leopold (engine designer) 4. Stotz, Erich (rear suspension designer) 5. Binder, Robert (production engine designer under Jäntschke) 6. Hofmann, Rudolf (front suspension designer) 7. Herzog, Hans (logistics, parts lists) 8. Hönick, Hans (Formula 1 engine designer) 9. Reimspiess, Franz Xaver (chief designer)

Body:
10. Kühn, Alfred (logistics within design department) 11. Bauer, Theo (body design within Reutter) 12. Klie, Heinrich (designer, model department) 13. Tengler, Edgar (parts procurement) 14. Beierbach, Walter (works manager at Reutter) 15. Komenda, Erwin (chief of body development) 16. Albrecht, Wilhelm (chief of purchasing) 17. Sturm, Gottlob (chief panelbeater) 18. Schröder, Gerhard (designer) 19. Mozelt, Karl (designer)

Experimental department:
20. Mezger, Hans ('experimental,' racing engine design) 21. Weyersberg, Ernst (planning) 22. Knoerzer, Kurt (road test department) 23. Metzger "senior", Karl (work planning, calculation in Werk II) 24. Martens, Hans (planning) 25. Bott, Helmuth (road test department) 26. Schneider, Adolf (leader of experimental shop) 27. Linge, Herbert (road test department and racing driver) 28. Schilling, Karl (leader of experimental purchasing department) 29. Storz, Eberhard (leader of all engine experimental work, production as well as racing engines) 30. Rombold, Helmut (leader of road test department) 31. Tomala, Hans (overall technical direction) 32. Piech, Ferdinand (engine testing department) 33. Porsche, F.A. (chief of model department) 34. Porsche, Dr. Ferry (chief).

Probably the most important engineering feature of the new car was Ferry Porsche's decision to move away from the 356's four cylinder pushrod engine and design a completely new 2-litre six cylinder engine with an overhead camshaft for each bank of three cylinders.

For quietness and reliability, Reynolds chains (the world's best at the time) were adopted to drive the camshafts. An axial flow fan was designed to replace the radial flow fan of the 356, with the alternator mounted co-axially in the same housing.

The cast aluminium crankcase was split vertically along the crankshaft axis, supporting seven main bearing shells, the whole held together with through bolts. Steel rods connected the crankshaft big ends to cast aluminium pistons. Three Solex single choke overflow carburettors were mounted on a common base plate for each bank of cylinders. The first version of the engine, Type 901/01, developed 130 hp at 6100 rpm on a 9:1 compression ratio. A Fichtel & Sachs clutch connected the engine to a five-speed transaxle also housing the differential.

By using a MacPherson-type front suspension and longitudinal torsion bars, the widest possible luggage space was created. Semi-trailing link geometry was used for the rear suspension, with transverse torsion bars, again creating more room for the largest possible rear "jump" seats.

In final form the re-named 901 became the 911 we know and love.

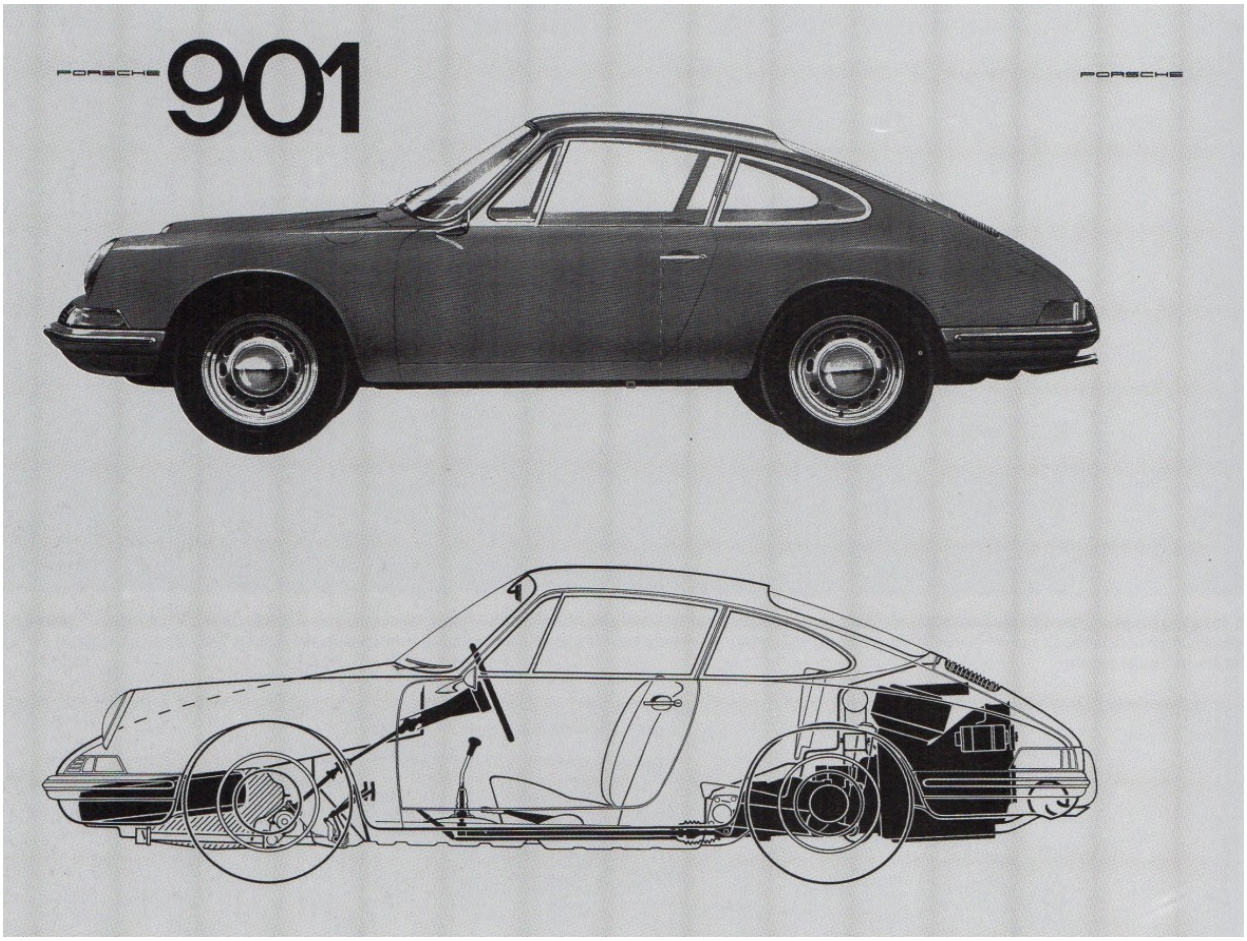
So how did this elegant design, now so highly prized (and priced) by collectors, evolve into the muscular "Poster-boy" 911, the 930 Turbo of 1975?

You'll have to wait! That's the subject of Chapter II of this fascinating story.

DESIGN AND ORIGINS OF THE 911

CHAPTER II

In the last issue of Flat Chat we looked at the origins of the 911 from the 356 prototypes to the 901 that was quickly renamed the 911.



The article finished with… “So how did this elegant design, now so highly prized (and priced) by collectors, evolve into the muscular “Poster-boy” 911, the 930 Turbo of 1975?”

Here’s how…

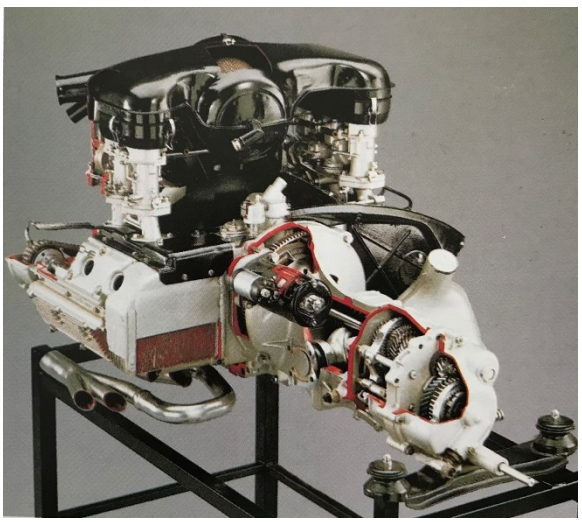
Each of the major components of the 911, engine, transmission, suspension and body all underwent significant change over the first decade of its life, but not simultaneously. Changes were made to one component and if successful were adopted, which would then demand a change in another. We will start with the engine.

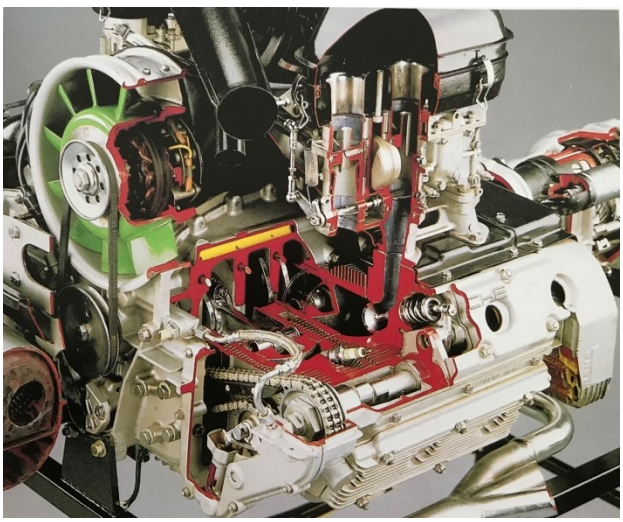
The target output was 130 hp, and this could be achieved more economically with a six cylinder, twin cam, two litre pushrod engine, the Type 745. The other requirement, low noise was, however, not met, and the 745 quickly became nicknamed “the threshing machine”.

Pushrods were therefore abandoned and Hans Metzger was borrowed from the racing engine department and assigned to the development of a DOHC engine whose camshafts were chain-driven (rubber timing belts were not considered reliable enough at this early stage of their development). This, the Type 821, also had main bearings on each side of each connecting rod, greatly reducing distortion and vibration of the crankshaft.

The next major advance was to incorporate, at Ferry Porsche’s insistence, dry sump lubrication to obviate the need for a deep sump originally used to reduce oil starvation induced by hard cornering. At this stage, the engine was designated Type 901. It used individual cylinders and cylinder heads, with pistons made by Mahle, a supplier used by Porsche for many years from 1963 onwards.

Cast iron cylinder liners were used initially, to be replaced in the 1970s by aluminium cylinders containing 17% silicon, etched to expose the silicon. Nikasil cylinders have been used in production Porsches from 1973 to the present day.

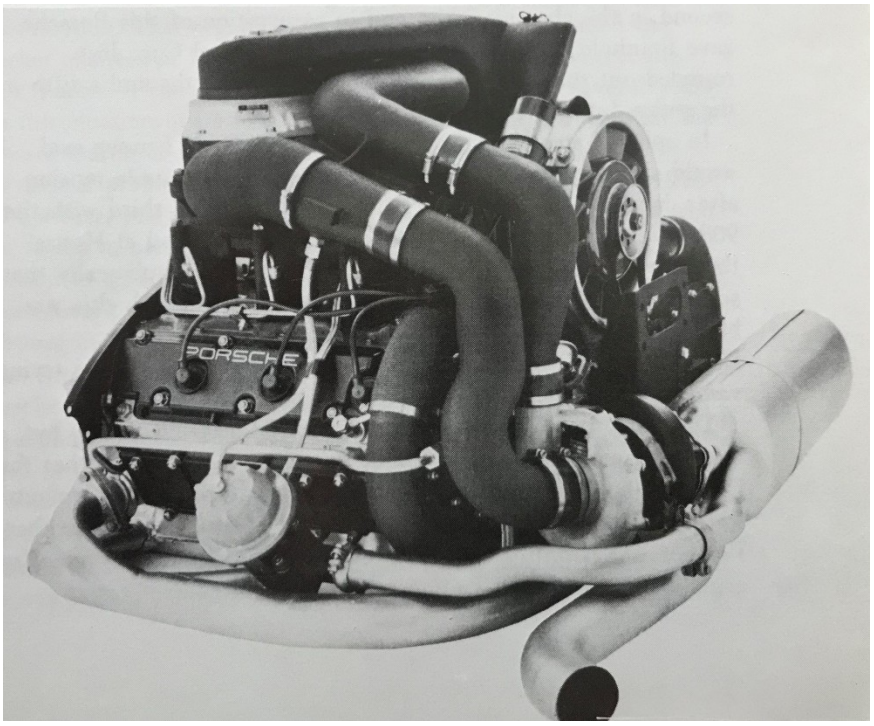




Cylinder heads were pressure cast from exceptionally high-grade AlCuNiMg alloy until the turbo was introduced, necessitating a change to AlCuNiCoSbZr alloy to cope with higher thermal loads.

The first ten years (1964-1973) of engine development saw significant increases in power and torque, despite having to meet California emission standards, through the introduction of mechanical fuel injection and thermal reactors (“afterburners”). The second decade (1974-1984) brought with it Bosch’s K-Jetronic electronic fuel injection. Lower specific output resulted from even higher emission standards compounded by demand for more fuel efficient engines (remember the 70’s oil crisis?), so Porsche compensated by increasing displacement to 3 litres and adding catalytic converters.

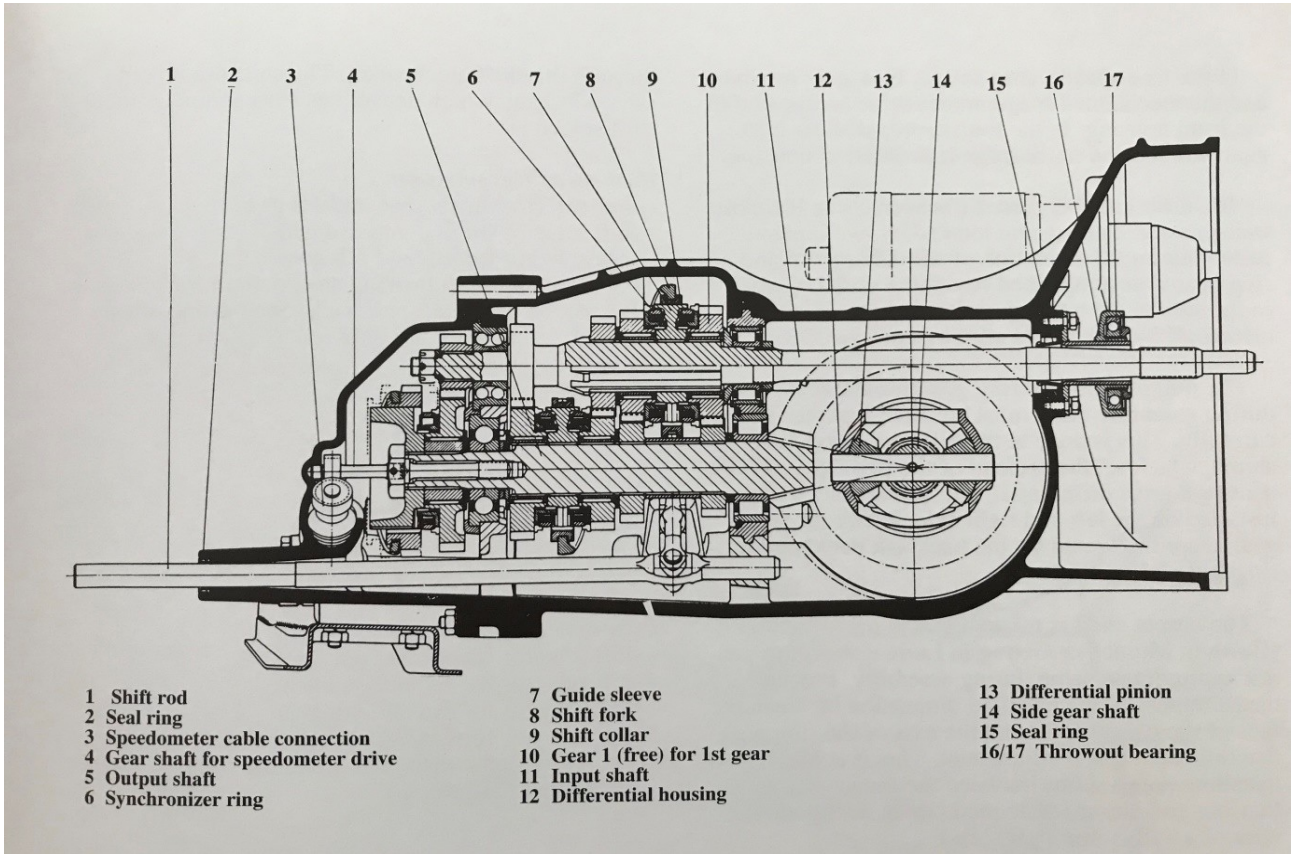
In 1972, despite market uncertainty, Porsche took the bold step in applying its extensive knowledge of turbo charging racing engines to the development of a road-going turbo model, the 930 Turbo. As Porsche’s flagship model, launched in 1974, it was a runaway success, demand quickly exceeding supply of the originally planned production run of 400 cars.



Spot the Turbocharger!

Transmission:

A distinguishing feature of Porsche transmissions from 1952 to 1988 is Porsche’s patented synchromesh system, based on “a slotted synchro ring with spring type action” and “shift collars whose teeth also serve as friction surfaces during the synchronisatio n process”. At the time, this system allowed faster shifts than rival systems, with greater reliability, so with correct clutch operation, it was designed to last the life of the car.



From 1972 to 1986 the 901 was replaced by the Type 915 transmission in response to the increased torque of the 2.4 litre engine. It was reinforced throughout with greatly improved bearings for input and output shafts, and strengthened and improved Porsche synchromesh. New pull-actuated clutch release bearing and provision for a transmission oil pump completed the picture. A changed shift pattern placed 1st and reverse gears diagonally opposite, meaning that "rocking" the car to gain starting traction in slippery conditions was rather awkward.

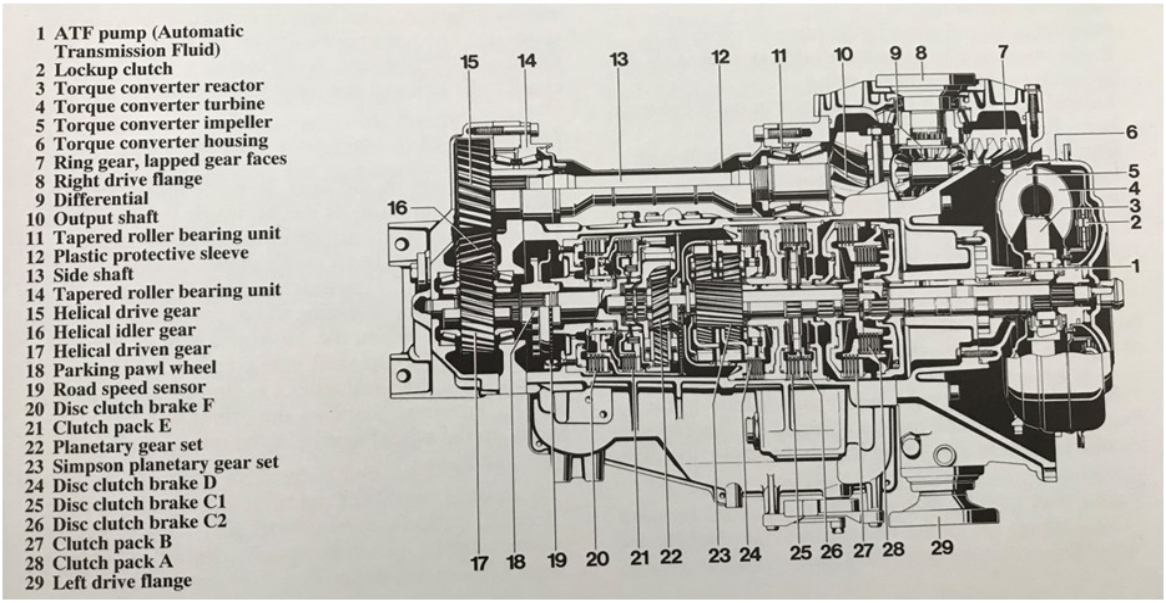
A "helper" spring was introduced in 1977 to reduce cable-actuated clutch pedal effort, until superseded by a hydraulic actuation system. *As an aside, this writer once bought an 80's 911, whose clutch occasionally baulked during the pre-purchase test. The seller revealed that he knew of this, saying "Oh, it might need a new clutch", so discounted the asking price by the cost of having a new clutch installed. The deal was done, and the new owner (yours truly) happily found later that the problem was simply caused by a broken helper spring, a $30 part!*

The increased torque of the 930 Turbo engine required a redesign of the 915 transmission. There was no room for a fifth speed, but the gears for the remaining four speeds were once again reinforced and made easier to change for racing applications.

The Sportomatic transmission deserves mention, if only because it illustrates Porsche's desire to respond to North American market demands.

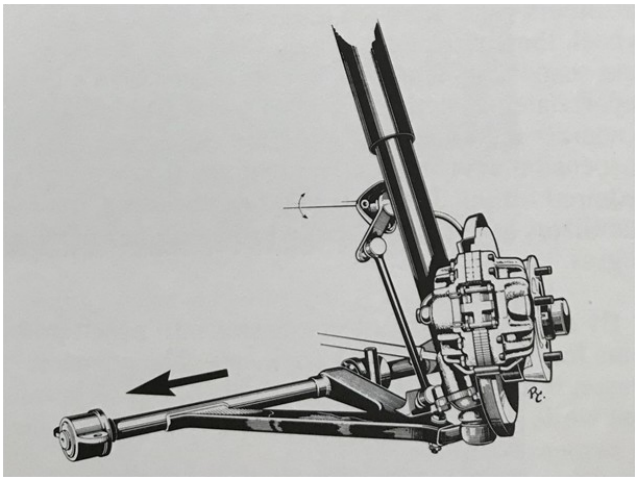
Most American cars were (and still are) delivered with fully automatic transmissions using fluid torque converters, and many younger Americans (potential Porsche buyers) could not operate a manual gearbox. They had learned to drive on cars equipped with automatic transmissions, so there was a market for a sports car (other than a Corvette) with an automatic gearbox.

Porsche responded by introducing the Type 905 semi-automatic Sportomatic, which responded to a slight touch of the gear lever from Park to Low, Drive or Reverse. It was not met with universal applause, but it did attract new customers to Porsche who would otherwise have not been able to experience a genuine sports car. In 1971, those who elected the Sportomatic option had to pay an extra $315 for the privilege! A second generation strengthened Sportomatic Type 925 was introduced in 1973 to match the higher torque 2.7 litre engines.



Suspension:

It was obvious to the team assigned to develop the suspension for the 911 that McPherson Struts would satisfy the demand for more room in the front boot than the 356 had enjoyed, together with space saving longitudinal torsion bars in place of conventional coil springs.



The addition of a transverse stabiliser bar completed the design.

Early tests proved that the system worked and would be maintenance free with permanently lubricated joints.

The rear suspension was not arrived at as quickly. Various designs were considered, and prototype number 1 ran with 356 B swing axles, torsion bars and camber compensating springs. Another candidate was the complex suspension of the Type 718 Spyder, independent suspension and coil springs. But, Ferry Porsche eventually decided that the new car deserved its own special rear suspension, as he had decreed for the front. By dint of some clever geometry of the trailing A-arms, and robust torsion bars, the target camber of 1 degree did not change appreciably over the range of suspension travel, thus keeping the tyre contact relatively flat even under hard cornering.

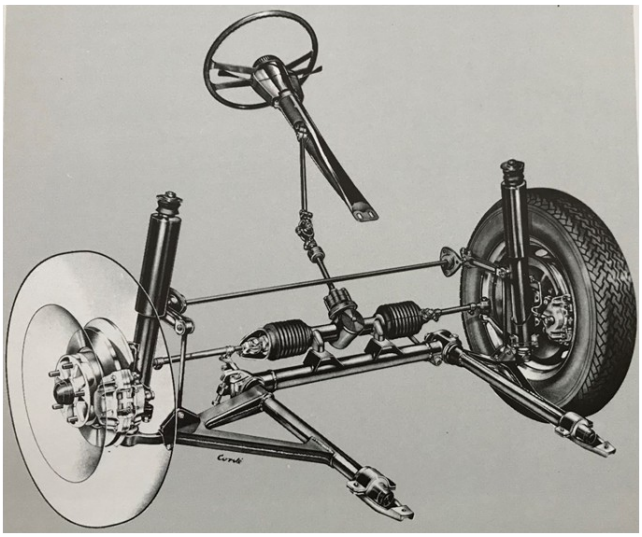
The lack of adjustment of the front suspension did, however, cause some headaches for the design engineers. Production tolerances needed to be extremely tight to achieve the negative 30 minutes camber. The first twelve cars off the production line were carefully checked and found to be highly variable, and considerably out of tolerance. The upper mounting points had to be moved from 35 to 8.3 mm. The caster angles were even worse, requiring mounting point corrections of up to 17.5 mm. Clearly unacceptable, and after Ferry Porsche made his first cross country trip in a pre-production 911, he complained of unsatisfactory straight line stability

Due to their rearward weight distribution, the first 911s had a basic oversteering tendency, poor straight-line stability and high crosswind sensitivity.

Suspension engineer Helmuth Bott immediately installed adjustable suspension pickup points, which after another lengthy test drive, satisfied Ferry Porsche. This became the first modification to the initial front suspension design.

A fundamental handling problem persisted for some time due to the positioning of the engine, like the 356, at the rear. This rear weight bias of course gave great traction under straight line acceleration, but with relatively narrow 4 ½" wheels, sudden oversteer occurred in hard cornering, especially in wet conditions or throttle lift mid-corner. This tendency was reduced in the early years by introducing stabiliser (anti-roll) bars first to the front and then the rear, wider wheels and better tyre compounds. Adjustable suspension, particularly in the front, helped keep the 911 pointed in the right direction under all but extreme steering and throttle input. An almost constant evolution of suspension components for two decades has seen the handling of the 911 improve dramatically. The fundamentals remained the same, but refinements in dimensions, materials (alloy vs steel), and adjustable settings all contributed to greater predictability, stability and tractability.

A unique feature, closely related to the suspension was Porsche's centring of the pinion for the rack and pinion steering with its double universal jointed offset three piece steering column. This meant that if a severe frontal impact unfortunately occurred, the steering column would fold and collapse rather than spear into the driver's chest. Designed-in safety! This also meant that the complete steering rack and column assembly could be used for both left and right hand drive vehicles – a considerable saving in production costs.



Body:

As with engine, transmission and suspension, the body of the 911 has evolved to accommodate changes in one or more of its major components. The reason that the silhouette of the 911 appears timeless is that it hasn't been "messed with". It has grown a little here and there in length and width, and some features like the impact bumpers of the mid-70's and 80's have had to be accommodated to meet regulatory requirements, but if one has to choose a word to describe the consistency of 911 design, it would be "integration".

And, if one has to choose one moment in the evolution of the 911 that epitomises its design, engineering and performance, it would be the Carrera RS 2.7, introduced at the Paris Salon in October 1972. We all know that this is THE classic Porsche to have in one's garage, but why? What's so special?

Firstly, perhaps subjectively because it relates to "beauty being in the eye of the beholder", it is visually very attractive. It wears a couple of obvious aerodynamic appendages, a ducktail spoiler (hardly subtle) slightly flared guards and a front air dam. But these are smooth and pleasing to the eye, unlike the ridiculously complex pointy segmented front wingy-thingies that now adorn F1 cars. They offer considerable functional advantages in keeping the car on the road, while remaining simple additions to an already beautifully balanced, clean, pure 911 body design. They subtly remind us that the Carrera RS means business, reflecting Porsche's underlying philosophy of bringing race-like performance to the road in a practical, comfortable, safe yet exhilarating ride. And the sound? Well, it's been said that a 2.7 litre flat six at 7200 rpm is music at its best! It was developed from the 190 hp 2.4 litre engine to yield 210 hp, only 10% increase, but it demonstrates that power alone is not the answer, it's power to weight ratio that decides who has the racing advantage, who gets to the next corner first, goes round it the smoothest and who accelerates away the quickest. I think it was Colin Chapman who said, "to go faster, add lightness". He must have listened closely to Ferry

Customer's orders for the 2.7 RS varied according to their needs and desires. Not every one of the 1 580 examples built went to a racing enthusiast. Not every one was Grand Prix white (with blue green or red trim), 296 were light yellow, some were the Sport version (added "lightness"), 1 308 were the Touring version. But they were all a very desirable special Porsche. This description still holds true today.

This brings us to the final model covered in this chapter, the 930 Turbo.

If you want an iconic Porsche at far less than the eye-watering prices now fetched by 2.7 RS's, consider the 930 Turbo. Of all the early models produced by Porsche, how did the Turbo become legendary?

The answer lies in Porsche's willingness, as a relatively small manufacturer of sports cars, to take risks to satisfy particular segments of the market. Porsche didn't develop the 930 Turbo to convert every existing Porsche owner to a more powerful car. It recognised that there were, in 1974, among the thousands of customers who devotedly followed the factory's racing successes with the Type 917 Can-Am cars, perhaps 500 who might buy a turbocharged road car. But, the 917's were truly exotic, complex, and therefore very costly cars to develop, run, maintain and campaign. 1200 hp was routinely achieved from their twelve cylinder engines, far too much for a road car, and power delivery was very non-linear. To be capable of being driven in city traffic as well as on autobahns, a turbocharged 911 would have to respond progressively to throttle input and revs, not with the all-or-nothing boost of the racing engines.

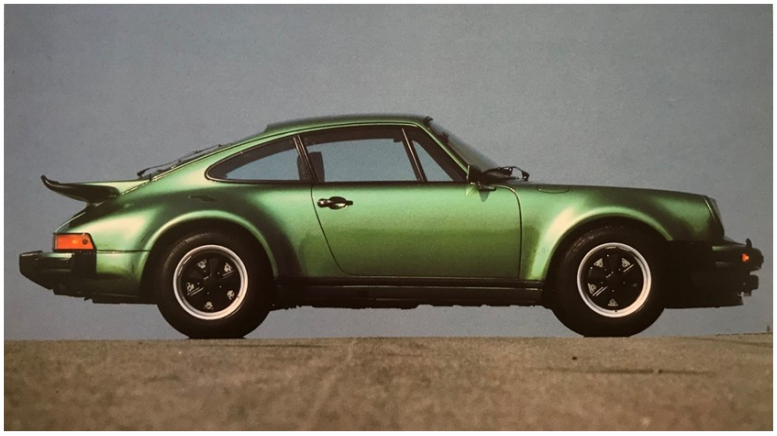
When Ernst Fuhrmann assumed the Porsche reins, the factory racing program was highly specialised and bore little resemblance to its road cars. The massive success of the turbocharged racing cars proved that Porsche designers and engineers were without peer, but at what cost? Porsche could not have mounted such an expensive program without substantial Martini sponsorship. In Fuhrmann's view, the gap between Porsches racing cars and the 911 had grown too far, and what was needed was a racing car that resembled the road car. If customers could afford to buy and campaign a turbocharged racing car, which was also available in a somewhat more comfortable version for road use, then the Porsche brand would benefit at the customer's cost, not the factory's.

Easier said than done, though. From all they had learned about turbocharging racing engines, only the technology to generate compressed air was applicable to a 911 engine. Regulating the amount of power produced was still a problem. Porsche engineers visited Garrett in the US, Bosch in Stuttgart and Eberspacher in Esslingen, seeking a solution. Finally though, they settled on a less well known company, Kuhnle, Kopp & Kausch (KKK) in Frankenthal. To regulate the boost pressure, and have full pressure available as quickly as possible, but not over-pressure at smaller throttle openings, Porsche and KKK jointly developed a special valve on the exhaust gas side of the turbine, called a wastegate. It opened to dump excess exhaust gas pressure when not needed, and closed to deliver full pressure when throttle opening demanded it.

Lubricating the turbine bearings proved a problem early on, as excess oil pooled in the turbocharger because of its position lower than the engine oil reservoir. An additional scavenge pump solved this, but then, the extremely high inlet temperatures (900 C), meant that new materials, seals and bearings had to be developed to withstand this heat, all in the somewhat cramped engine compartment of a 911.

To enter even a single turbocharged 911 in production-based racing, 500 units were required to be built to meet the homologation rules. In 1973, Porsche decided to produce the required number of cars, most of which would ultimately be equipped with normal trim and accessories as road cars, but a smaller number would be stripped out versions for racing. Thus the Type 930 was born. The Weissach facility, well accustomed to building small runs of racing cars was where this first run of specialised intake systems for the 930 Turbo's were built. The broad flared wings were welded on by hand as re-tooling to produce complete pressed panels would have been far too costly for the limited number of the first run of 500. Remarkably, the development of Porsche's most powerful road car to date, was done in very short timeframe, against a background of dire predictions of world petrol shortages and financial pains within the company.

As with the 2.7 RS, the 930 Turbo looked fast, straight off the showroom floor. It came equipped with updated versions of the 2.7's ducktail, now dubbed a "whale tail" and a rubber lip or splitter extending the front air dam even lower. The fender flares, both front and rear, covered wider wheels all round, distinguishing it from its sibling 911's.



At the Paris Salon in 1974, the three litre Turbo was launched and quickly saw orders exceeding the first production run of 500. A second run of 500 cars was also sold as fast as they could be produced. Porsche had taken a risk with the Turbo, but as 1975 ushered in an economic upturn, the company' goose had truly laid a golden egg.

Andrew Forbes

Further Reading:

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