Flying High

An engineering lineage

Courtesy of BMW

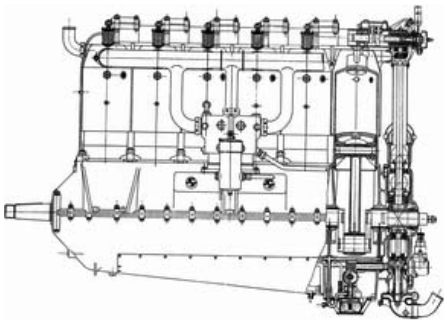
It's no exaggeration that BMW has always been known for the excellence of its engines. And one reason for that is the company's lineage: it started as a manufacturer of aircraft engines. Supercharging, turbocharging, smart engine management and variable cam timing – welcome to the world of pre-WWII BMW aircraft engines!

It was in February 1917 that a new Chief Engineer joined Rapp-Motorenwerke: Max Friz came to Munich from Daimler Motoren-Gesellschaft, bringing with him the idea for an aircraft engine he had not been able to turn into reality in his former job. His concept was to build an extra-large, extra-high-compression power unit enabling an aircraft to reach higher altitudes than ever before.

This was the greatest demand made by the military of engine manufacturers during World War I, since the ability to reach a higher altitude gave pilots a significant strategic benefit.

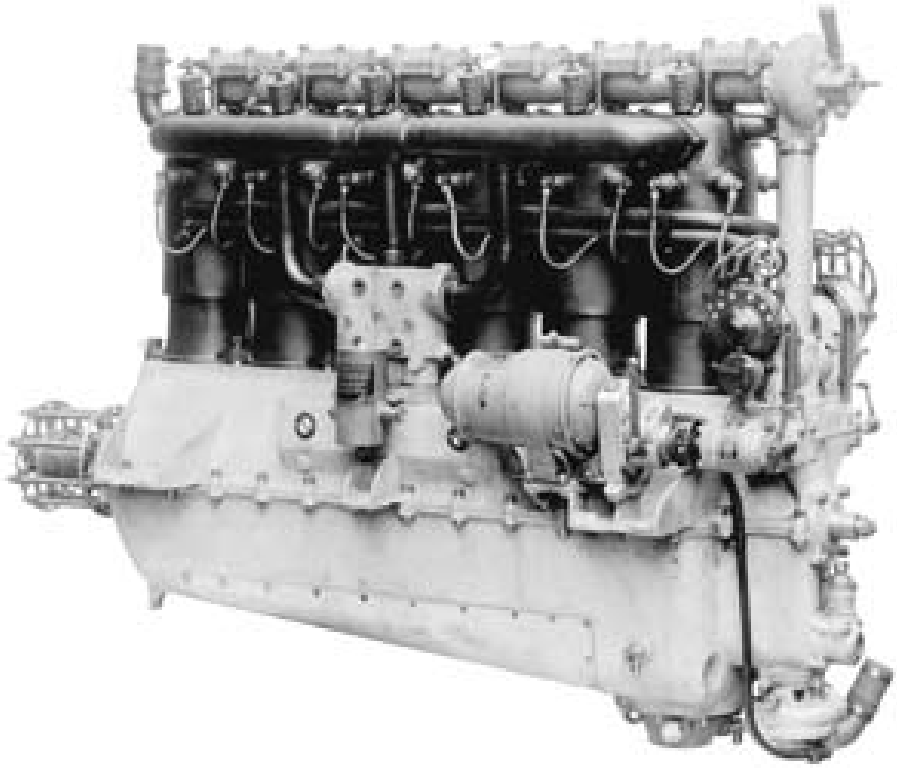
With air density decreasing as a function of height, conventional engines quite literally ran out of air at altitudes above 3,000 metres or about 10,000 feet. An engine with extra-large capacity and a higher compression ratio, on the other hand, operates in thin air like a normal engine on the ground. But on the other hand such an engine must be throttled back in its performance when close to the ground in order to avoid any overload on the components.

Lightweight engineering: pistons and crankcase made of aluminium



Introducing this concept, Friz took up a proposal Wilhelm Maybach had made a year before, one which however had not gone into series production. This was that while high performance was important, it was far from everything – at the same time engines had to be as robust, light and aerodynamic as possible. Friz's particularly innovative approach was to combine Maybach's new idea with proven technologies. So on 20 May 1917, the Development Department registered the first construction drawing for a new engine conceived by Friz – a low vibration straight-six.

This concept helped to significantly reduce the structural loads acting on the aircraft, which in those early years was still a relatively fragile construction. The slender frontal area of the engine and the compact arrangement of the ancillaries served to reduce air resistance. However, the substantial engine capacity of 19 litres and the high compression ratio called for relatively large components. So to keep weight within limits, Friz opted for a crankcase and pistons made of aluminium.



In Friz's design the cylinder head and cylinders formed one inseparable unit, with the steel cylinder liners simply being bolted into the cylinder head extending far down into the engine block itself. In this way Friz was able to do without a cylinder head gasket. Dry sump lubrication and dual ignition gave a reliable and consistent supply of oil and kept the engine running reliably at all times.

Just how modern this concept was is shown by the valve control system, with the valves being driven by rocker arms running on an overhead camshaft that was driven not by a chain, but rather by a vertical layshaft.

High-altitude carburettor for enhanced output and fuel economy

One of the most important components of the innovative power unit designed and built by Friz was the special high-altitude carburettor – a system made up of three mixing chambers, three air and fuel supply nozzles in each chamber and five throttle butterflies interacting with one another to efficiently adjust the fuel/air mixture to suit the respective altitude. To make the required adjustments, the pilot had two levers for normal and high-altitude gas; that is a fuel/air mixture control system destined to give the engine an excellent balance of output and fuel economy.

The design and construction drawings had not even been completed when a group of specialists from the German Reichwehr visited Rapp-Motorenwerke in July 1917, seeking to obtain further information on the project. After Friz had presented and explained his construction, the military were so convinced that they ordered 600 engines, requesting delivery at the earliest possible time.

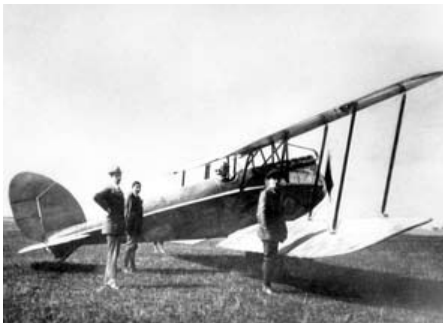
The birthday: 21 July 1917

As a result of this completely surprising success within a company which so far had not exactly enjoyed a great time in the market, Rapp-Motorenwerke soon had to be re-organised: founder Karl Rapp left the company and the Meeting of Partners decided to give the company a new name – Bayerische Motoren Werke. Just one day later, on 21 July 1917, the new name of the company was entered in the trade register, the change then becoming absolutely official another two days later when, on 23 July, the company's top management wrote to the Ministry of War: "We hereby inform you that as of today we have changed the name of our company to Bayerische Motoren Werke."

Even so, the old name and logo – a horse in the silhouette of a black chess figure – still appeared at the time on the company's letterhead as a symbol for the name Rapp. But, reflecting the new name of the company, the symbolic knight soon disappeared and was replaced by the white-and-blue colours of Bavaria. And since the new name was too long, it was cut back to three short letters – BMW. Then, on 5 October, the German Imperial Patent Office registered the new logo as the trademark of the company.

Taking off for the first time on 23 December 1917 in the Rumpler C IV biplane, BMW's first engine bore the model designation 'IIIa'. With its output of 185 horsepower, the engine fulfilled all the expectations of the military users, who promptly placed an order for 2,500 units. And while not all of these engines were completed by the end of the war, the engines used at the time quickly gave the BMW brand its great reputation for reliability, power, and economy.

World high-altitude record: 9,760 metres (32,013 feet)



Proceeding from this successful engine, the engineers at BMW built further variants in the last few months of the war, among them the even larger 250hp BMW IV. This was the engine that on 9 June 1919 took test pilot Zeno Diemer to an unprecedented altitude of 9,760 metres or 32,013 feet. Never before had anybody reached an altitude of this kind – meaning that Max Friz had impressively proven the potential of his innovative engine concept.

Twelve-cylinder with magnesium crankcase for the "Rail Zeppelin".

With post-World War I restrictions imposed on German aviation being gradually loosened in the mid '20s, the six-cylinder again provided the starting point for the ongoing development of BMW aircraft engines. What was needed at the time were large engines able to develop a high level of consistent output over a long period. So again, the engineers optimised a proven basic design and added both trendsetting and reliable new concepts.

The engineers at BMW put together two units of the BMW IV six-cylinder in 1924, creating a 12-cylinder V-engine delivering 580hp. And to save weight, they used not only aluminium on the new engine, but in some cases even magnesium on the crankcase. This powerful engine was destined to become famous as the BMW VI quickly became the benchmark of its time, numerous aircraft relying on the BMW V12 on both their maiden and record-breaking flights. And indeed, this unique power unit quickly proved its merits not only in the air, but also in a particularly spectacular manner in the early '30s in the German "Rail Zeppelin", a high-speed train driven by an air propeller at the rear. The BMW power unit accelerated this streamlined railcar to a speed of no less than 230 km/h or 143 mph, again setting a new world record.

The final highlight was that the engine was not only delivered from Munich to customers all over the world, but was also built by licensees in Czechoslovakia, Japan and Russia.

In the late '20s BMW further expanded its leading position as a manufacturer of aircraft engines, focusing on the production of air-cooled radial power units. To gain adequate experience with this new technology, the specialists in Munich started building Pratt & Whitney Hornet engines under a licence agreement, as of 1929. With its maximum output of 450 hp, the Hornet engine was not as powerful as BMW's BMW VI power unit but the radial engine was significantly lighter.

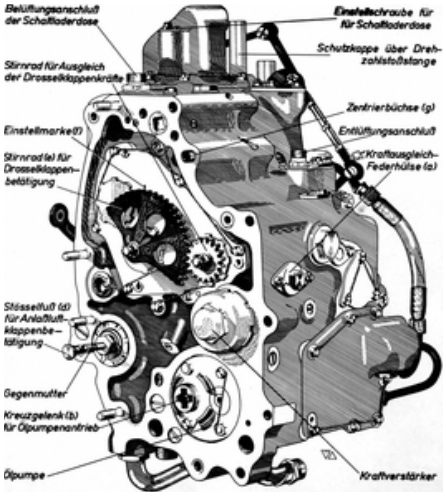
Radial engine with direct gasoline injection

Once again, BMW's development engineers struck out to optimise proven technology, increasing engine output to 690hp while leaving engine capacity unchanged and adding only a little extra weight. To achieve this improvement, both the crankcase and cylinder heads of the new BMW 132 were made of aluminium, with a supercharger to provide extra boost at high altitudes being fitted directly on the rear end of the crankshaft.

Becoming a great success, this superior radial engine gained fame particularly as the power unit featured in the three-engined Junkers Ju 52. Indeed, in its process of ongoing development, the BMW 132 quickly became the spearhead for other, innovative technologies: The BMW 132F, for example, was BMW's first power unit with direct gasoline injection. And in the mid '30s, the development engineers converted the nine-cylinder to diesel combustion, added water cooling on certain components, and gave the new engine the designation BMW 114.

Running on special fuel and with multi-stage supercharging, the radial engine in its last stage of development even broke the 1,000-horsepower barrier, at least for short spells and bursts of power. But soon even this was not enough: in late 1938 the specialists in Munich started developing a double-radial engine with no less than 14 cylinders, that is, two radial units with seven cylinders each behind one another. To ensure an adequate flow of air for the cylinders at the rear, the 'basic' nine cylinder was cut back accordingly and the two radial units were slightly offset from one another. Displacing no less than 42 litres, the BMW 801 aircraft engine weighed approximately one tonne and developed a continuous output of no less than 1,500hp.

The command unit: the first mechanical on-board computer

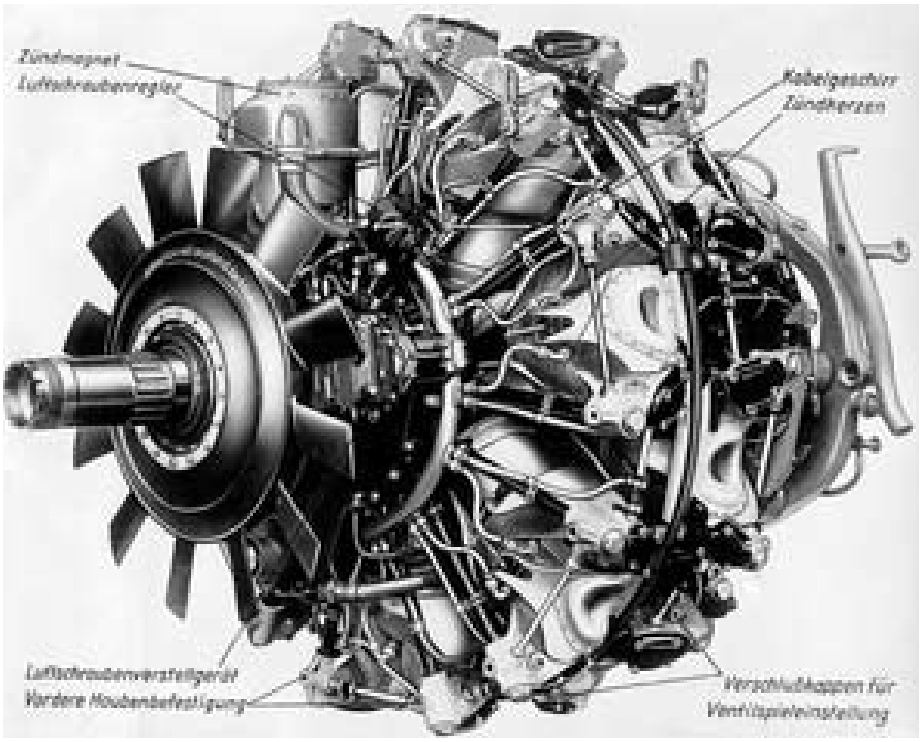


Introducing an innovative engine control concept, BMW's engineers significantly facilitated and streamlined the process of operating the engine. The 'Command Unit' cut back the conventional array of levers for the pilot to one single control unit, thus making the job of controlling the engine and flying the plane much easier and smoother than before. Ensuring supreme reliability, this miracle in sophisticated mechanics automatically controlled the fuel/air mixture and air charge process as a function of load and height, as well as the ignition timing and setting of the propeller. The result was a reduction of fuel consumption and an increase in operating reliability.

In its basic configuration, the BMW 801 came with direct gasoline injection and a mechanical supercharger. But then, in the early '40s, the latter was slowly but surely replaced by a more sophisticated alternative – turbocharging. This created a radial engine with turbocharger technology entering series production as the first aircraft engine of its kind in 1944.

VANOS even back then: an 18-cylinder with variable control timing

To further increase engine output and performance, the engineers at BMW increased the number of cylinders in the BMW 802 aircraft engine to no less than 18. Cooling air plates made sure in this case that despite the small spaces between cylinders, enough cooling air was still able to reach the points subject to high thermal loads and temperatures.



The most particular feature on this 2,500-hp power unit was however the valve timing, with both the intake and outlet valves being masterminded by cam plates able to turn in opposite directions while the engine was running. So it is fair to say that as far back as in 1942, the BMW 802 already came with an early type of VANOS camshaft control now found on modern BMW car engines!