Geschichtskreis Motorenfabrik Oberursel e. V.

Helmut Hujer

The Oberursel Rotary Engine - 100 Years of Fighter Aircraft

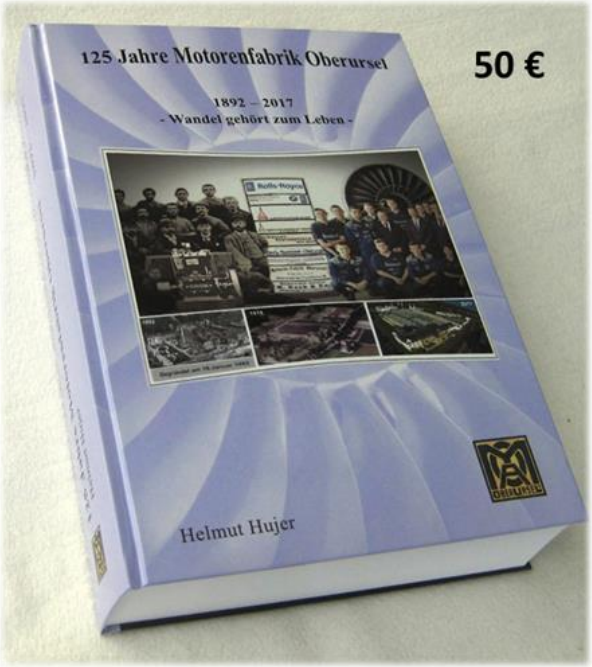
The very first German Fighter-aircraft, a Fokker E I, powered by a80 HP Oberursel rotary engine U 0

Special print of an article contributed by Helmut Hujer to the JOURNAL of
The Rolls-Royce Heritage Trust, Issue 3 and 4 in 2015

The author of this article has published in 2017 a comprehensive book about the 125 years of history of the Motorenfabrik Oberursel in German language. Some more information about this book is given on the following page.

Zum Autor und dessen Buch „125 Jahre Motorenfabrik Oberursel“

Der Autor des Aufsatzes hat, beginnend mit einer Werkzeugmacher-Lehre 1961 und nach dem anschließenden Maschinenbau-Studium, sein gesamtes Berufsleben in der „Motorenfabrik Oberursel“ gearbeitet. Anschließend hat er wesentlich mitgewirkt an der Gründung des „Geschichtskreis Motorenfabrik Oberursel“ im Jahr 2010, und zugleich hat er sich an die Erforschung der Werksgeschichte gemacht. Das Ergebnis ist sein im Jahr 2017 herausgegebenes Buch „125 Jahre Motorenfabrik Oberursel - 1892 bis 2017“.



Dieses Buch, mit 896 reich bebilderten Seiten im Format A4, kann im Vortaunusmuseum in Oberursel eingesehen und erworben werden (50 €), im Werksmuseum bei Rolls-Royce Deutschland oder direkt beim Autor, Kontakt: hujer.helmut@t-online.de, Tel. 06081/3611 und 0170 4375 178.

Das Inhaltsverzeichnis sowie das Repertorium, mit Personen-Register und chronologischen Produkte-Wegweiser, können auf den Webseiten www.gkmo.net und www.ursella.info als digitale und per Schlagwort durchsuchbare Dokumente eingesehen und kostenlos ausgedruckt werden.

Die Motorenfabrik Oberursel, im Jahr 1892 gegründet und seit dem Jahr 2000 ein Standort der Firma Rolls-Royce Deutschland, gilt als die älteste noch in Betrieb befindliche Flugmotorenfabrik der Welt. Sie geht zurück auf eine sogar noch zehn Jahre früher gegründete Fabrik für Müllereimaschinen, die seinerzeit erste Maschinenbaufabrik in Oberursel. Groß geworden mit den Stationärmotoren „Gnom“, entwickelte sie sich Anfang des 20ten Jahrhunderts zum zweitgrößten Hersteller für Motorlokomotiven in Deutschland. Mit den während des Ersten Weltkriegs gebauten Oberurseler Umlaufmotoren wurden die ersten deutschen Jagdflugzeuge ausgerüstet, die mit dem Fokker-Dreidecker des Manfred Freiherr von Richthofen in Erinnerung geblieben sind. Zwischen den Weltkriegen wurden dann in Oberursel auch jene Deutzer Motoren in großen Stückzahlen gebaut, die im „Bauernschlepper“ und im „11er Deutz“ die Mechanisierung in der deutschen Landwirtschaft voranbrachten. Daneben arbeitete man ab 1941 an der Entwicklung von Groß-Flugmotoren. Nach dem Zweiten Weltkrieg wurde die Fabrik ein Opfer der Reparationsdemontage und die US-Army nutzte sie elf Jahre lang als Instandsetzungsbetrieb und Kaserne. Anfang der 1960er Jahre zog wieder der Flugmotorenbau mit verschiedenen Lizenzfertigungen und Eigenentwicklungen in der Fabrik ein. Ein kleines Drohnentriebwerk wurde zum ersten nach 1945 in Deutschland entwickelten und in Serie gebauten Strahltriebwerk. Im Jahr 1990 begann mit der Firma BMW Rolls-Royce AeroEngines eine neue Ära. Hier in Oberursel nahm die Entwicklung der BR700 Schubtriebwerke für Regional- und Geschäftsreiseflugzeuge ihren Anfang, für die auch die wesentlichen Bauteile in Oberursel gefertigt wurden. Nach dem Übergang in die Firma Rolls-Royce Deutschland entwickelte sich das Werk zum Kompetenzzentrum für rotierende Triebwerkbauteile, insbesondere für Verdichtertrommeln, für Verdichterräder in BLISK-Bauweise und für Turbinenscheiben.

In der Stadt Oberursel gehört die Motorenfabrik schon von ihrer Gründung an zu den größten Industriebetrieben und Arbeitgebern, und sie war seitdem und ist auch nach dem Strukturwandel in der zweiten Hälfte des 20ten Jahrhunderts von großer Bedeutung für den Wirtschaftsstandort und für die Menschen in Oberursel.

The Oberursel Rotary Engine – 100 years of fighter aircraft

by Helmut Hujer

Above: the Oberursel works today

This year Rolls-Royce celebrates 25 years in Germany. In 1990 the BMW AG, which came into existence in 1916 as an aero-engine manufacturer, bought the Oberursel Motorenfabrik from Kloeckner-Humboldt-Deutz, and, together with Rolls-Royce, set up a new firm BMW Rolls-Royce. Here in Oberursel development of the core of the new generation turbo-fan-engines BR 700 started. After the establishment of the new headquarters in Dahlewitz, close to Berlin, Oberursel was transformed into a modern centre of excellence for the manufacture of rotating engine components. In 2000 Rolls-Royce took over full ownership and formed Rolls-Royce Ltd & Co KG.

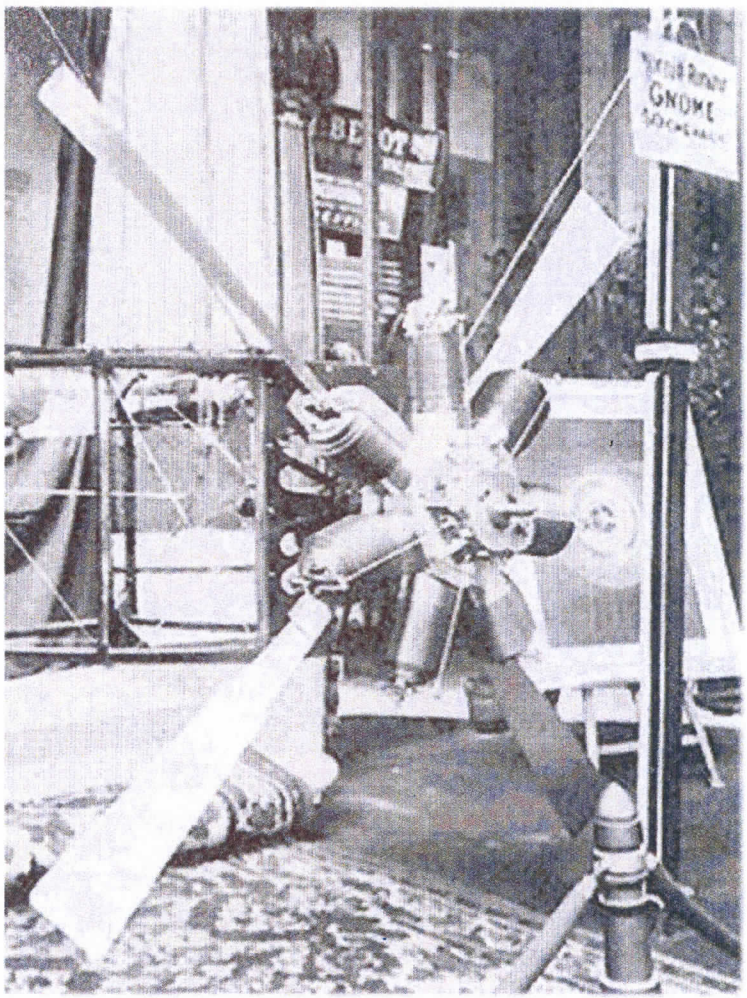
A striking feature of the Oberursel works is the almost century old main office building of the former Motorenfabrik Oberursel AG. This office building, as well as the industrial building behind it, came into being during the First World War to produce rotary aero-engines for the new generation of fighter aircraft.

The basic catastrophe of the 20th Century

The terrible war of 1914 –1918 was the first war in history in which the front line soldiers were exposed, more or less continuously, to the impact of enemy fire for days, weeks and even months. The then new weapons were cannons firing on them from 10, 20 kilometres or more, new and deadly machine guns, awesome tanks, even terrible poison gas, and not least – military aircraft. At the beginning of the war these tiny aircraft were used primarily for reconnaissance and for artillery guidance. But very soon they had adopted additional roles which became the recognisable roles of today, as bombers, fighters (initially named fighting scouts) and ground support aircraft.

1915 - The Advent of Fighter Aircraft

To prevent enemy reconnaissance, the pilots soon began shooting at each other with guns and rifles, even throwing hand grenades. Then, Roland Garros, a well-



Right:
The Gnome Omega, on display in the Salon de l'aeronautique at the Paris Motor Show in 1908

known French flying pioneer, started to experiment with machine guns fixed to his Morane-Saulnier aeroplanes and fired through the propeller. This worked well and made the German pilots more or less defenceless. Thus the Germans were without air reconnaissance during the battle over the Champagne region in spring 1915, which was a big disadvantage for them. To avoid damage the French had protected their propellers with steel deflecting plates. However, on April 18, 1915 Roland Garros was shot down behind enemy lines with such a plane, which was captured largely intact. The Germans tried to imitate the arrangement, but their hard-shell bullets went through the deflector plates and damaged the propeller. This inspired Anthony Fokker to develop a functional interrupter gear, synchronising the gun to the engine-revolutions. This principle had been patented already some time before the war, but had since then not been made fit for practical use. Fokker managed to accomplish this within a few days, but it took some time to produce enough of the light-weight air-cooled machine guns, as well as the rotary engines required for the new fighter aircraft.

Finally, in early autumn 1915, enough Fokker monoplanes had been produced to break the allied air superiority and soon the allied pilots spoke of the 'Fokker scourge'. This marked the advent of fighter planes in the German forces, and all these first generation Fokker fighter planes were powered by rotary engines produced in the Motorenfabrik Oberursel. In 1914 the Motorenfabrik Oberursel was one of only five aero-engine manufacturers for the German military, alongside Daimler in Untertuerkheim near Stuttgart, Benz in Mannheim, Argus in Reinickendorf near Berlin, and Motorenbau Friedrichshafen on the shores of Lake Constance.

The Motorenfabrik Oberursel

The rise and fall of the Motorenfabrik AG is strongly linked to the course of the Great War. The Motorenfabrik Oberursel was originally founded in 1892 by Wilhelm Seck. Being a millwright he had built up the factory ten years previously to produce roller-mills for grinding corn. It was Seck's son Willy, who invented a stationary piston engine named GNOM, which led to the establishment of the firm. This sturdy and reliable engine became quite successful, and it attracted Louis Seguin, a French engineer. In 1895 he had set up his first workshop in Gennevilliers near Paris to produce and maintain piston engines. Already in the same year he had taken a licence from Willy Seck to manufacture and sell this engine in France. He named it GNOME, adopting the French spelling. In June 1905, Louis Seguin founded the new 'Société des Moteurs Gnome', in Gennevilliers. He employed his younger brother Laurent, an engineer, who apparently took up the rotary principle and started design of such engines. This was in 1907, when all France had become euphoric about flying machines.

The soaring Société des Moteurs Gnome, which had grown out of the 1895 workshop and the licensed fabrication of the Oberursel GNOM, became the precursor to the Snecma aero-engine-company formed in 1945. So some roots of Snecma reach back to the Motorenfabrik Oberursel.

The Fascination of Flying

The success of Seguin's engines was based upon the impressive power to weight ratio inherent to the rotary engine principle. With a cylinder 'star' rotating around a fixed crankshaft there was neither a need for a heavy

water-cooling system nor for a flywheel. They managed to present their first seven-cylinder rotary engine, which they called 'Gnome', in the aviation section of the Paris Motor Show on December 24, 1908. The engine attracted great interest and saw its breakthrough at the Grande Semaine d'Aviation de la Champagne held near Reims in France during August 1909. It was the first international public flying event and has to be seen as marking the coming of age of heavier-than-air aviation. Almost all of the prominent aviators of the time took part, and the 500,000 visitors included Armand Fallières, the President of the French Republic and the British Chancellor of the Exchequer, David Lloyd George.

The most attractive part of this prestigious competition was the distance flying, offering six prizes of an incredible 50,000, 25,000, 10,000, 5,000, 5,000, and 5,000 Francs. The world record was broken three times in three days, and eventually Henri Farman succeeded with a flight of 180 Kilometres in his Farman III biplane (which was powered by a 50 HP Gnome Omega rotary engine). This was the public debut and the breakthrough of the Gnome engine, which both light in weight and relatively reliable, was a major advance in aviation technology.

Up to the outbreak of the First World War the Seguins produced nearly 4000 Gnome rotaries, three in 1908, 35 in 1909, rising to 400 in 1910, to 800 in 1911, to 1000 in 1912, and finally to 1400 in 1913.

In Germany, where the big airships of Graf Zeppelin received much more attention than in other countries, heavier-than-air aviation was years behind the developments in France. In order to start pilot training in July 1909, the German military had to acquire French aircraft; Farman biplanes with Gnome engines. In 1911 just three German manufacturers could provide aero-engines, namely Daimler, Argus and NAG; all water-cooled and heavy weight stationary engines producing about 100 HP. However, ten of the 22 aircraft procured by the military in 1911 were equipped with the miraculous French Gnome engine. So in 1912, in order to promote development of aero-engines, Emperor Wilhelm II finally set up a competition with alluring prizes. However, a condition was, that the engines had to be produced in factories in Germany without use of parts made abroad. This ruled out the French Gnomes, and three types of German-made rotaries failed in the competition. Whilst this restriction to German-made engines was no problem for heavier aircraft, powering the light reconnaissance aircraft became a challenge.

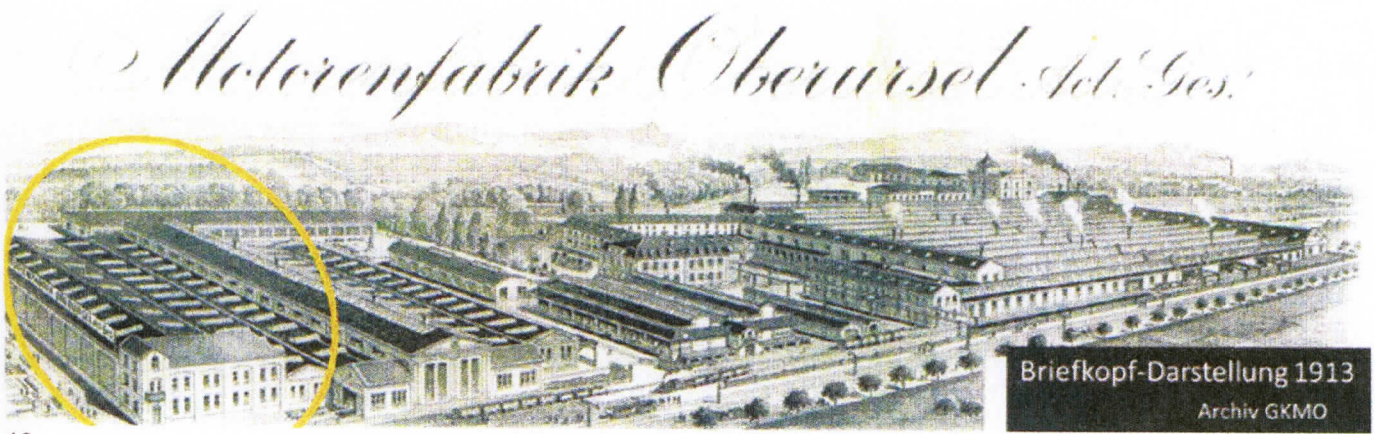
Rotaries from Oberursel

Already in 1911 the German aviation pioneer August Euler, realizing the unique features and potential of the light-weight rotaries, had attempted to get a licence from Seguin. Based on verbal agreements he had already launched the manufacture of ten of the 80 HP Gnome-Lambda at the Frankfurt Adlerwerke. But Euler failed to get a written agreement, even though he sued Seguin for that. Instead, the Oberursel Motorenfabrik, Seguin's licensor of 1895 and propellant for his early business, was more successful. Negotiations in the spring of 1913 soon resulted in a licence agreement with the Société des Moteurs Gnome, which was signed in April 1913 in Paris. This licence covered the manufacture and sale of the Gnome engines exclusively in Germany and its colonies, and the sale of them non-exclusively in Austria, Hungary, Holland, Denmark, Sweden and Norway. The licence was to apply as long as the patents were valid in Germany, with a licence fee of 22% of the sales value.

The following engine types were included

- 7-cylinder 50 HP-Motor Omega,
- 7-cylinder 70 HP-Motor Gamma,
- **7-cylinder 80 HP-Motor Lambda,**
- **9-cylinder 100 HP-Motor Delta,**
- 14-cylinder 100 HP-Motor Omega-Omega

The Motorenfabrik Oberursel, shown on a 1913 letterhead – circled is the 1913 factory extension for aero-engines



Briefkopf-Darstellung 1913
Archiv GKMO

Motorenfabrik Oberursel – engine acceptance testing

- **14-cylinder 160 HP-Motor Lambda-Lambda,**

and

- 18-cylinder 200 HP-Motor Delta-Delta.

Apart from a single development unit of the 18-cylinder engine, which saw flight testing in an Euler aircraft, only the engine types marked in bold were put into production in Oberursel.

Apart from Germany, Gnome or Le Rhone engines were also licence-manufactured in Great Britain, Sweden, Russia, the United States and Japan. Great Britain will be covered later, and in Sweden the Thulinverken company acquired a licence for the 9-cylinder and the 11-cylinder Le Rhone engines in 1915. For the other countries no evidence has been found.

In anticipation of this aero-engine business, the Motorenfabrik had already started to build a new workshop for the Gnome, with its special parts and materials. Conversion of the French drawings, procurement of raw materials and manufacture of parts was begun immediately. As early as November 1913, the first seven-cylinder 80 HP engine, S/N 101, was presented to the military, successfully running on the factory's testbed. In January and February 1914 this engine, after 80 hours of bench testing in Oberursel, plus engine S/N 102, had been successfully tested by the German Military Testing Establishment in Adlershof near Berlin. Engine 102 was then given to aircraft manufacturer LVG for installation and testing in a monoplane aircraft, which also proceeded very successfully. Reliability, performance and fuel consumption of the Oberursel rotaries were rated as very similar to the original Gnome, and interchangeability of parts and maintainability were superior to the French original. The Oberursel engineers had established appropriate manufacturing tolerances for all parts and dimensions. These results led to approval of the Motorenfabrik Oberursel as an engine manufacturer and the Oberursel rotaries were assigned military designations. Since 'O' had already been given to Opel, Oberursel was given 'U' as manufacturer code. In 1916, with the introduction of engine types of the le Rhone type, those Oberursel engines got the manufacturer code 'UR'. The engine designation was completed with a Roman figure for its performance class, which meant:

0 up to 80 HP,
I 80 to 100 HP,
II 100 to 150 HP,
III 150 to 200 HP,
and later in time,
IV 200 to 300 HP,
V 300 to 400 HP,
VI 400 to 500 HP,
and
VII beyond 500 HP nominal performance.

The following engine models were produced in Oberursel in series production:

•	U 0	7-cylinder	80 HP-Motor
•	U I	9-cylinder	100 HP-Motor
•	U III	14-cylinder	160 HP-Motor
•	UR II	9-cylinder	110 HP-Motor
•	UR III	11-cylinder	160 HP-Motor

The German military recorded a total number of 2932 engines received from the Motorenfabrik Oberursel up to the end of 1918.

The Austro-Hungarian troops had in service a total of 96 Fokker-aircraft powered by Oberursel rotaries, 64 with the U 0, 24 with the U I, and 8 with the U III. Some of those aircraft came from German military surplus, but some new production aircraft might have come directly from Fokker with engines additional to the total number given for Germany.

Detailed delivery schedules are not recorded, but the following approximate delivery numbers are given in secondary literature:

1913-1915	383 U 0	7-cylinder 80 HP
1915-1918	1009 U I	9-cylinder 100 HP
1914-1916	595 U III	14-cylinder 160 HP
1917-1918	575 UR II	9-cylinder 110 HP
Year 1918	211 UR III	11-cylinder 160 HP
Total	2773 all types	

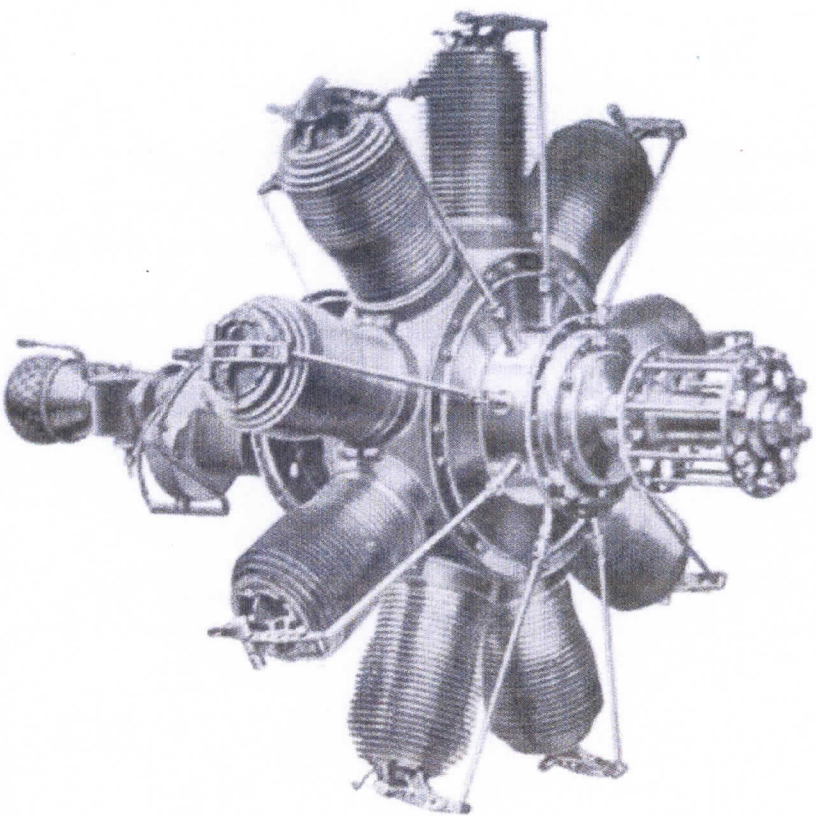
This total is 159 engines short of the German military's count, which cannot be explained. Except for the UR II engine the delivery figures more or less match with the number of aircraft equipped with Oberursel engines. For the UR II the above count shows 575 engines, whilst the number of respective aircraft is given with 655. This difference can be explained by engines produced in 1918 under Oberursel licence by the Rhenania-Motoren-Fabrik AG in Mannheim (Rhemag). Quite likely the number of such engines, designated as UR II Rh, remained below 80. Furthermore, a few engines might have found their way from Sweden to Germany. The Thulinverken company had acquired a licence in 1915 from Gnome and Le Rhone, but even by 1918 production was limited. Another potential source of engines for Fokker's 1917 Dr I triplanes and the 1918 D VIII monoplanes were captured French Le Rhone or Clerget engines, of which the German military had stocked several hundred in their depots.

1915 – The Time of the Monoplanes

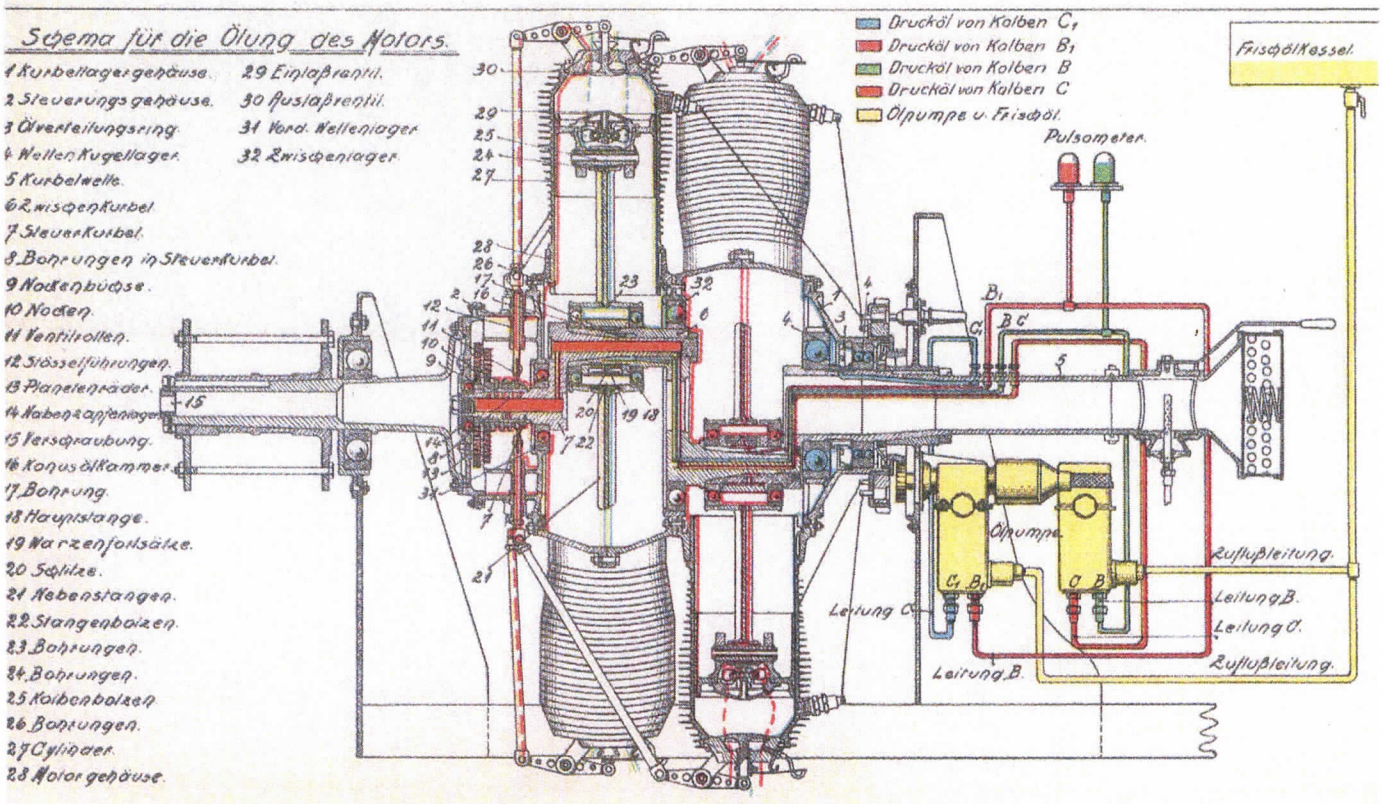
As mentioned already, the Oberursel rotaries were perfect as a power source for the light reconnaissance and artillery spotter aircraft in 1914, and from 1915 onwards for the new fighter aircraft. Most of the Oberursel engines went into Fokker aircraft, followed by Pfalz and Euler aircraft.

Ironically, the military's planning had not included production of such rotaries beyond the spring of 1915. They thought their requirements for light reconnaissance aircraft would have been satisfied for good by then. But the advent of the fighter-type aircraft with fixed machine guns had changed all that. Anthony Fokker, both an inspired pilot and salesman, had equipped one of his monoplanes with such a machine gun firing through the propeller, and went on a road show in June 1915. He successfully displayed his plane to the German Army headquarters in France. The flying aces Max Immelmann and Oswald Boelcke got the plane for testing – and they became enthusiastic. Now they were in a position to keep an enemy plane in sight and chase it, and to aim with the complete aircraft at the target and shoot with all power in the right moment. This was the birth of unique fighter planes and would revolutionise the design of fighter aircraft.

1915 became the year of such monoplanes, on the German side most of them powered by the 100 HP nine-cylinder U I engines. Such monoplanes from Fokker and Pfalz began to rule the air, and the time of the so-called 'Fokker scourge' began. In 1915 and 1916 Fokker produced 377 single seat monoplane fighter aircraft powered by Oberursel rotaries, and the Bavarian Pfalz-Flugzeugwerke an additional 198, some already powered by the powerful 14-cylinder twin rotary 160 HP U III engines.



Left:
Oberurseler 100PS
Umlaufmotor U I



Oberurseler 160PS Umlaufmotor U III – lubrication scheme with inlet valve arrangement

1916 - New Biplanes End the Fokker Scourge

Then, in March 1916, the new French Nieuport 17 reached the front line, soon followed by similar types of biplanes. With its 110 HP nine-cylinder Le Rhone rotary engine the Nieuport showed outstanding manoeuvrability capabilities and an excellent rate of climb. This heralded the end of the reign of the Fokker monoplanes. During the battle at the river Somme from July through to November 1916, one of the bloodiest battles in history, German fighters were at a disadvantage against their allied opponents. This was not only because of the numerical superiority of the allies, but also because of the technical superiority of their new airplanes. Controlled inlet valves had resulted in a noticeable power increase, which caused the German military to specifically recommend reproduction of the nine cylinder Le Rhone engine. But that would take time.

At first the German aircraft manufacturers imitated the allied biplanes, with the Albatros D III becoming the most successful model. Arriving in January 1917, the newer twin-gun Albatros with its stationary six-cylinder Benz engine, outclassed the Nieuport 17. In parallel to the Albatros D III and some other planes powered by stationary engines, Fokker pioneered new planes powered by rotary engines. During 1916 and 1917 Fokker produced a total of 646 single seat biplane fighters, which were still powered by Oberursel Gnome-type rotaries, 470 with 100 HP nine cylinder U I engines, and 176 with the 150 HP 14 cylinder double-row U III engines. From the end of 1916 onwards the Euler-Flugzeugwerke AG in Frankfurt came in and provided another 131 such biplanes, a few powered by the 80 HP seven cylinder U 0 engines, the majority by the nine cylinder U I. These Eulers were used primarily for pilot training.

To be continued.

About the Author:

Helmut Hujer, born 1945, grew up in sight of the impressive old buildings of the Motorenfabrik Oberursel, where he started his professional career as an apprentice toolmaker. Following military service, he trained as a mechanical engineer and continued at the Motorenfabrik, working in the KHD-group in manufacturing and industrial engineering, as a shop floor manager, in Program Management, Customer Support and Sales and Contracts for the Military Business. After his retirement in 2008 he continued as a consultant, which resulted in 50 years' company service. In 2010 he established the Historical Society Motorenfabrik Oberursel (www.gkmo.net), which has assumed responsibility for the factory museum. Helmut is now researching the history of the Motorenfabrik with the aim of publishing a book in 2017, when the Motorenfabrik celebrates its 125 year birthday.

The Oberursel Rotary Engine – 100 Years of Fighter Aircraft, part two

by Helmut Hujer

Rolls-Royce Germany - Oberursel

In Issue 3 of the *Journal* Helmut Hujer described the origins of Oberursel Motorenfabrik and the development of its rotary engines during the early years of the First World War – here he takes up the story in 1917

Above: The Fokker Dr I triplane
Photo courtesy of SDTB (Stiftung Deutsches Technikmuseum Berlin)

1917 - The Triplanes Arrive

In January 1917 a new design aircraft appeared on the scene, the British Sopwith triplane. Fitted with a nine-cylinder 130hp Clerget 9B rotary, this fighter was immediately successful. Until the superior single-seat Sopwith Camel biplane arrived in the latter half of 1917, just about 150 such triplanes had been built. This Sopwith Camel, powered by more modern rotaries like the 110hp Clerget 9B, the 110hp Le Rhône 9J or the 150hp Bentley BR1 engines, was more than equal to the Albatros D III. But already the earlier Sopwith triplane had given the Albatros a hard time. Anthony Fokker observed that at first hand during a frontline visit in April 1917. Impressed with what he saw, he started immediately to develop a counterpart which became the Fokker Dr I (pronounced 'der' like in under). This triplane, powered by the long-awaited Oberursel UR II engine, would become the most famous Fokker and German aircraft of the First World War.

Just in time – the Oberursel UR II Engine

But first we must look at what had gone on in Oberursel. Due to the fact that the German military had declared rotary engines almost dead in early 1915, the building of the Motorenfabrik Oberursel had been put on hold until spring 1915 when the success of the Fokker fighter planes began to reverse this attitude. But expanding a factory and increasing the output needed some time. Well into 1916 Oberursel still could not meet the demands of the Military, which grew even greater when the allies started their offensive at the Somme in July 1916. The superiority of allied aircraft in this battle resulted in an order to the Motorenfabrik to develop a rotary engine with controlled inlet valves, like the Le Rhône engine.

The new nine-cylinder Oberursel engine with 110hp nominal power got the designation UR II. The R refers to the Le Rhône principle of controlled inlet valves. Design work and fabrication started in December, and by February 1917 certification testing had begun. The tests went very well when using castor oil for lubrication, but problems arose when using substitute lubrication oils. Castor oil had become scarce in Germany, like other materials such as tin for bearings and nickel for crankshafts and other highly loaded components. The allied naval blockade was taking effect, and such shortages also forced redesign of the conventional U I and U III engines in order to utilise substitute materials.

At about the same time Oberursel engineers started the development of a high-powered 11-cylinder rotary, the UR III with 160hp nominal power. This was a unique German development, the French only getting started one year later with an equivalent 11-cylinder.

The more advanced UR II engine, after various modifications to accommodate the substitute lower quality materials, finally passed certification in early August 1917. Flight testing with Fokker's new Dr I triplane went very smoothly and resulted in its certification with the Oberursel UR II engine in the middle of August. The first two planes reached the front on August 30th. Lieutenant Werner Voss was the first to fly a pre-series Dr I and shot down an allied aircraft the very same day. He went on to shoot down a further 19 allied aircraft before September 23rd, when he was himself shot down in a dogfight with six British fighters.

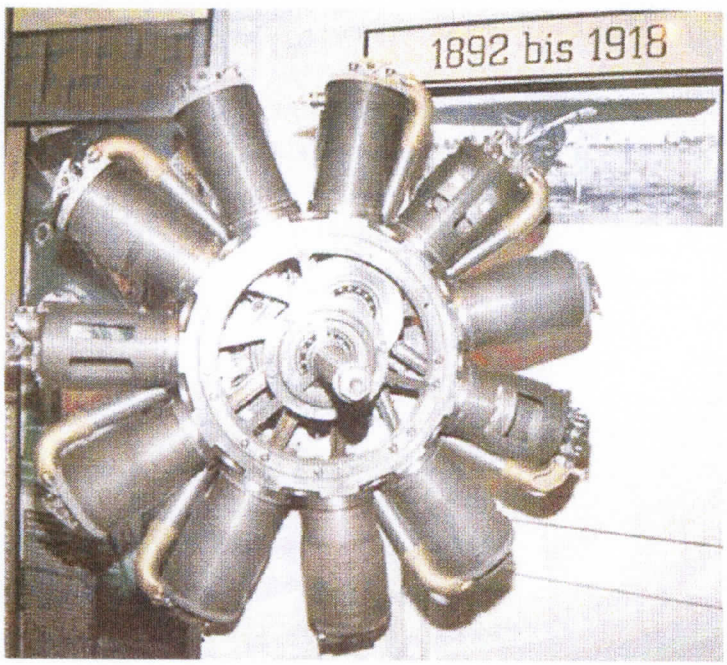
The Red Baron

The second pre-series Dr I was given to Captain Manfred von Richthofen, who claimed his 60th success on September 1st. He added a further 19 victories with Dr I triplanes to his account before he was killed by a bullet from an anti-aircraft gunner on April 21st 1918 just north of the village of Vaux-sur-Somme. His plane was soon cannibalized by souvenir hunters and the Oberursel nine-cylinder UR II rotary was taken to England. The engine is currently on display in the Imperial War Museum in London.

The standard engine of the Dr I was the 110hp nine-cylinder UR II rotary, made in Oberursel. This engine gave the Dr I enormous climbing ability and high manoeuverability making it a lethal opponent in dog fighting, despite its low speed of only about 165kph and its low endurance of just 80 minutes. A total of 322 Dr I engines were produced to re-equip the three German fighter wings. But even during its peak time in May 1918, just 171 Dr I triplanes were based in the fighter wings at the western front. By June 1918 the remaining Dr Is were returned to Germany to defend the country from allied air attacks and were replaced on the front line by the new Fokker D VII.

Above: Baron Manfred von Richthofen (right) beside his Fokker Dr I

Photo courtesy of SDTB (Stiftung Deutsches Technikmuseum Berlin)



The immortal fame of the Dr I triplane is invariably linked to Freiherr (Baron) Manfred von Richthofen, even though many other German aces fought with the Dr I. Richthofen, with 80 victories, was the leading ace in Germany and perhaps the most widely known fighter pilot of all time, famously flying his bright red Dr I. The 'Red Baron' and his squadron, called the 'Flying Circus' because of their colourfully painted triplanes, achieved legendary status both during, and after, the First World War.

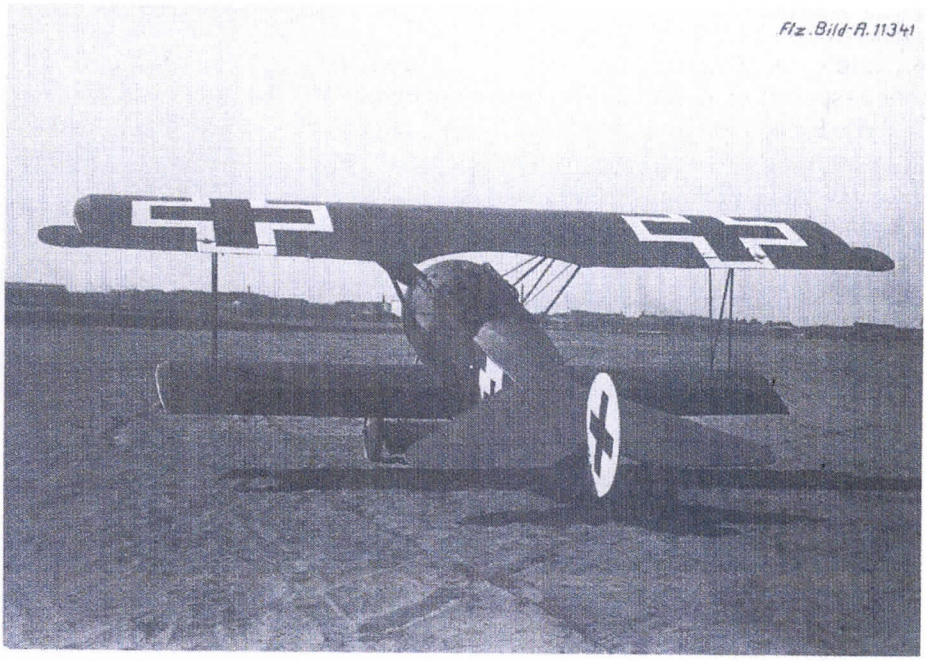
Despite all this, air superiority was permanently conceded to the allies by autumn 1917.

Left: the 11 cylinder 160hp UR III engine on display in the Oberursel museum

Right: the Fokker D VI

Below right: the Fokker D VIII

Photos courtesy of SDTB (Stiftung Deutsches Technikmuseum Berlin)



1918 – Climax and End

Following the famous DR I triplane Oberursel rotaries powered two more fighter aircraft.

The first was the Fokker D VI, which passed type certification in March 1918. Fokker sent two prototypes to the military fighter trials in Adlershof in January 1918, one equipped with the 110hp Oberursel UR II engine, the other with a 160hp Siemens-Halske Sh III. A short time after this trial, Fokker installed and flight tested one of the brand new but not yet fully serviceable, Oberursel 160hp 11-cylinder UR III engines. However, the 59 production aircraft D VII had to use the Oberursel UR II as this was the only engine which was readily available. Thus the aircraft could not develop its full potential.

The last series production aircraft with an Oberursel rotary became the Fokker E V, later re-named D VIII, despite the fact that it was a monoplane. Four hundred D VIII were ordered immediately, with either the Oberursel UR III or the Goebel Goe III rotary engine. Because neither engine was available in any quantity, most production examples used the UR II. Supposedly a total of 289 aircraft were delivered to the military up to the end of the war, and of these 53 were sent without engines. 210 of the aircraft were equipped with the UR II, and only a mere 26 D VIII delivered after October 8th had the160hp 11-cylinder UR III. Only 85 aircraft had reached frontline service before the Armistice.

During wartime the engine manufacturers had just one customer, the military procurement agency. Procurement and distribution of the engines to the various aircraft manufacturers or to the troops was the sole responsibility of the military. The number of series production aircraft with Oberursel rotaries as the standard power plant amounted to a total of some 2,400 units. In addition a considerable number of engines were used in various other experimental and pre-production aircraft, and an unknown number assigned as spare and replacement engines.

Total Aero-Engine Production Quantities

The statistics of the German military show a total number of 2,932 rotaries of the various types delivered by the Motorenfabrik Oberursel up to the end of 1918. Although far behind Daimler (45.7%) and Benz (26.2%), Oberursel, with 6.7%, ranked as the third biggest aero-engine manufacturer in Germany. The total engine production quantity in Germany at the end of 1918 amounted to 43,500 aero-engines, whilst Germany's ally Austro-Hungary produced about 4,400 engines.

Whilst the two companies of Gnome and Rhône, which had merged in 1915, produced from their combined factories more than 20,000 engines during wartime, a total quantity close to 92,500 aero-engines were produced throughout France. More than 24,000 of these engines found their way to the allies of the French. In contrast to the Germans, who combed the factories

to get every last man into the trenches, the French repeatedly went through the trenches to find skilled men, especially aircraft and aero-engine mechanics.

The British, who did not have a service aircraft flying with a British-built engine in 1914, had produced about 41,000 aero-engines by the end of 1918. In addition they procured close to 17,000 units from abroad for their aircraft, especially from France. Supposedly close to 1,000 Gnome engines were produced under licence in England, most of them at the Daimler Company at Coventry. The majority were seven-cylinder 80hp Gnome Lambda, but 14-cylinder 160hp Lambda-Lambda engines and nine-cylinder 100hp Delta engines were also produced. The story is that Mr Holt Thomas had acquired a manufacturing licence for the Gnome engines, and in August 1914 he invited the Daimler Company at Coventry to manufacture these rotaries under licence. Thomas set up 'The Gnome Engine Company' located at 47 Victoria Street, London, the sole representative of the French Société des Moteurs Gnome for Great Britain. *[The Victoria Street premises were very close to the Victoria Railway Station, only a few streets away from Buckingham Palace, and very close by the current Rolls-Royce HQ at 62 Buckingham Gate - Editor]* Instead of waiting for drawings and specifications from Paris, Thomas provided an engine to Daimler, and within seven days they produced no fewer than 300 drawings from actual measurements. Only eight weeks later the first engine ran on the test bed. By 1917, now extended to the 'Gnome & Le Rhône Engine Company', the company was registered with a works in Walthamstow in the Greater London area, which perhaps was a repair shop.

Italy boasted a production quantity of about 38,000 aero-engines, and the US mass produced some 22,000 units of their standardised Liberty engine from the beginning of 1918.

Some Interesting Associated Topics

To conclude this historical overview given from the perspective of the Oberursel rotary engines, some further subjects need to be mentioned:

Repair and Overhaul of Aero-Engines

Besides a military establishment for aero-engine repair, which had been set up in Adlershof at the end of 1914, the German engine manufacturers were strongly involved from day one in heavy repair of their engine types. Because of increasing total numbers, more repair and overhaul work had to be given to industry from about summer 1916. Whilst the water-cooled stationary engines had a time between overhauls of at least 60 hours, the rotaries were due after as few as 20 hours. In 1917 the repair and overhaul of engines almost reached new production quantities, with about two thirds of these defect engines going to industry. Since no other information is available, this should be assumed for Oberursel too.

The 'Motorenschule' in Oberursel

In late 1914 the military had established aero-engine training centres for mechanics at the various engine manufacturers. In Oberursel such courses started in

Below: Oberursel engine training course, 1915

early 1915 and continued until November 1918. About 100 to 120 servicemen at a time spent four weeks in Oberursel, resulting in a total of about 5,000 by the end of the war. A few came back after the war.

A Giant Among Rotaries

In 1916 Oberursel ventured towards the development of the 18-cylinder 200hp motor Delta-Delta. One development engine was built and put on the test-bench. However, material stresses in this heavy engine would have required quite extensive design efforts, but on the other hand Fokker had rejected the design because of its excessive gyroscopic effects on the aircraft. The abandoned engine was given to the Euler-Flugzeugwerke AG in nearby Frankfurt, where it became installed in their DR 4 experimental aircraft in April 1917. This DR 4 triplane did not gain approval by the German military, so the plane was disassembled again in July 1918.

Rotaries in Austro-Hungary

In June 1916 the 'Oesterreichische Waffenfabriks-gesellschaft' in Steyr got a manufacturing licence from the Motorenfabrik Oberursel for the genuine Oberursel rotaries. There is some information that they started with manufacture of the 14-cylinder 160hp U III and the nine-cylinder 110hp UR II, but none found their way into service. In 1918 series production was taken up for the UR III with 160 HP nominal power, referred to also as the 'St 160' engine. Production capability is thought to have been 15 to 20 engines per month, however, actual output figures were probably lower but remain unknown. There are reports of about 16 aircraft installations for the St 160; nine in biplanes D VI provided by Fokker; four in Austrian Aviatik biplanes; one in a Fokker monoplane D VIII, and one in an Austrian Zaparka experimental biplane. In total the Austro-Hungarian troops had 188 rotary-powered aircraft in service during wartime, and besides the 16 planes powered by the UR III / St 160 there were 75 planes with Gnome or Le Rhône engines, and 97 with various other types of Oberursel-made rotaries.

Oberursel Eight-Cylinder V-engine

Shortly after America entered the war on April 6th 1917, the Germans launched a rearmament programme. It was evident to the air-troops that only superior aircraft could help, because the numerical superiority of the allies could never be broken. This resulted in the Motorenfabrik Oberursel having to switch production from the UR II as soon as possible to a new stationary 220hp eight-cylinder V-engine. This engine, designated as U IV, also referred to as the Becker-engine, was designed by Prof Dr Becker. A production order for 200 such engines was placed in July 1917, even though the engine was just evolving on the drawing board. From the power to weight ratio and the power to displacement ratio, this engine was very much comparable to the Rolls-Royce Eagle engine. However, development was hampered by the shortage of high quality materials, and suffered greatly from lack of qualified personnel and the general exhaustion in German labour. The engine ran for the first time on the test-bench in April 1918, but never came to series production.

Function and Technique of Rotaries

The Gnome was one of several rotary type engines popular on fighter planes during the First World War. The unique feature of this type of engine is that the crankshaft is mounted on the airplane, while the crankcase and cylinders rotate with the propeller. The crankcase and cylinders provided more than adequate momentum to smooth out the power pulses, thus eliminating the need for a heavy flywheel. And since the rotating cylinders were exposed to the cooling airstream, no other cooling devices were required. Despite the resulting windage losses, these factors gave the rotary engines the best power-to-weight ratio of any configuration at the time, making them ideal for use in light fighter planes.

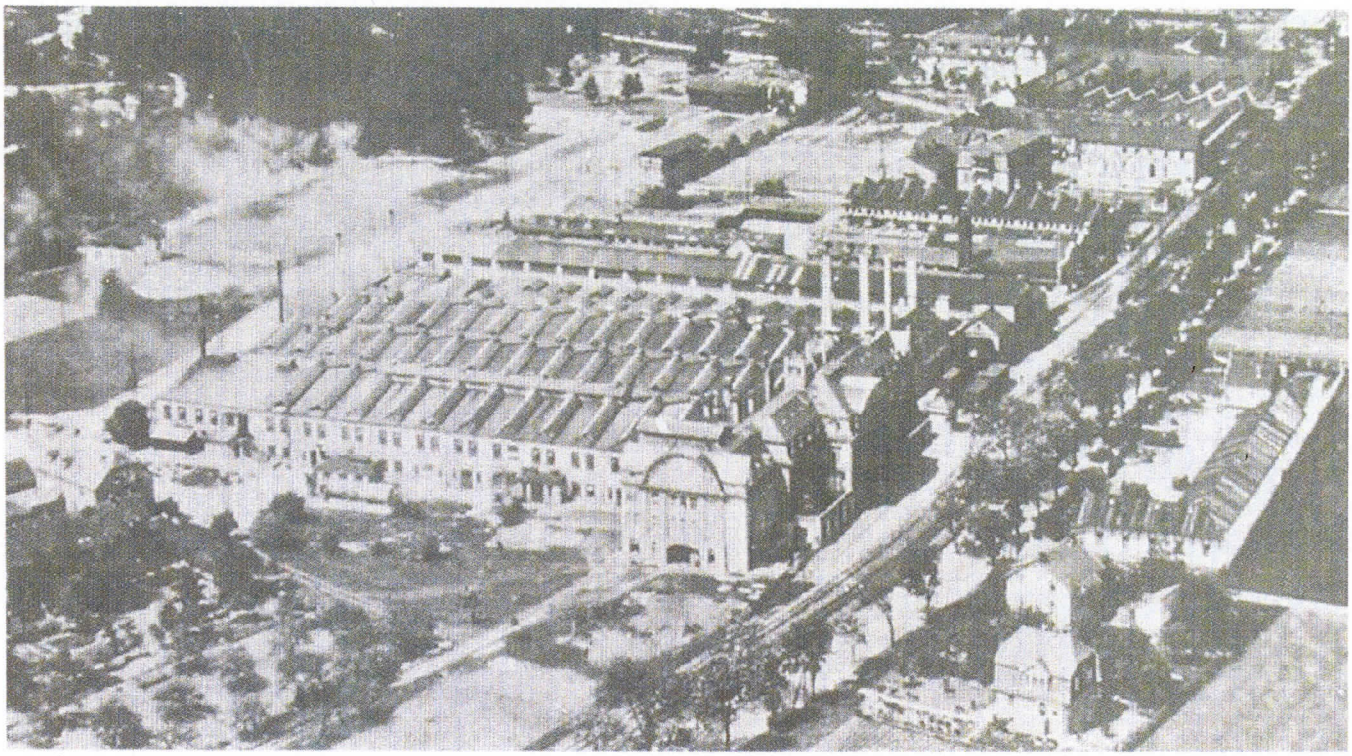
But there were disadvantages as well. Firstly, the gyroscopic effect; this force is created by the spinning mass of the engine acting like a gyroscope and so when changing direction of the airplane, the gyroscopic effect acts in opposition to the direction change. This makes it difficult to manoeuver the aircraft.

Secondly, there is the total loss oil system. Whilst most conventional engines continuously re-circulate a relatively small supply of oil, in rotaries oil is fed to the various lubrication points and finally into the cylinders. Therefore, the aircraft must carry sufficient oil to last the entire flight because it is burnt in the cylinders or lost overboard from the valve-gear when the engine is running.

Thirdly, and especially critical for Germany, was the availability of castor oil. If the Germans had not captured a large amount of castor oil in Antwerp early in the war, their rotaries would hardly have survived beyond 1915. Castor oil with its superb lubrication characteristics is the oil of choice in such rotaries with their rather thin-walled and distortion prone cylinders.

Last but not least, after the stationary engines had achieved an overhaul life beyond 60 hours, the Gnome-type rotaries presented an unattractive alternative with their overhaul life remaining at little more than 20 hours. It was the automatic inlet valves of the early Gnome and the U-type Oberursel engines that were susceptible to wear and required frequent replacement.

The Gnome-type rotaries operated under the familiar Otto four-stroke cycle. During the intake stroke, a vacuum forms in the cylinder, forcing the intake valve open and drawing the fuel-air mixture in from the crankcase. During the compression phase the mixture is compressed and towards the end of the compression stroke, slightly before top dead centre, the spark plug fires. This starts the power stroke, which ends when the exhaust



Above: Motorenfabrik Oberursel showing the old factory (top right) and the aero-engine factory and office buildings (centre) as they were in 1918

valve opens well before the bottom dead centre. During the exhaust stroke the exhaust gas is pushed out of the cylinder through the controlled exhaust valve.

To further demonstrate this principle would be beyond the scope of this article, but there are several animations available on the Internet, just look for something like 'gnome rotary engine animation'.

The Impressive Growth of the Oberursel Factory

The increasing production of aero-engines inevitably resulted in growth of the factory. The early manufacture of parts, along with the assembly and testing of the engines was started in the barely completed factory extension in 1913. In 1915, after Oberursel had been tasked to raise production rates, the workshops in New Plant I were extended in several steps to the final extent, as shown on the photo above. The high point however was the prestigious roadside office-building. Even though the business was obviously quite profitable, it appears rather surprising that such a modern and impressive place could be built during these times of misery and shortage everywhere. This office building was soon called 'the playhouse', and it was established as a national heritage property in 1980. *[Inside the building there is an impressive staircase leading to a large stained glass window – the Oberursel equivalent of the Nightingale Road Marble Hall – Editor]*

Louis Seguin's original 1895 workshop (Seguin was licensee of the Motorenfabrik Oberursel for the GNOM-stationary engine, and his Société des Moteurs Gnome as licensor for the Gnome-rotaries to the Motorenfabrik Oberursel) was taken over by the Snecma company created in 1945. So, whilst Snecma claims to be the oldest aero-engine manufacturer of the world, Rolls-Royce can claim Oberursel as the oldest aero-engine factory in the world, which is still in operation.

1919 - Economic Decline and New Challenges

During the war aero-engine production blossomed in the Motorenfabrik, but its pre-war products were marginalised. By 1919 these engines were technically outdated, and the economic situation in Germany was at rock bottom. Attempts to bring new engine designs on the market, including a tiny auxiliary-engine for bicycles, were of little success. In 1921 the Motorenfabrik Oberursel was thus forced to enter into a joint venture with the older and much larger Deutz engine company. From then on engine models from the Deutz product line were built in Oberursel. During the Second World War aero-engines were again developed in Oberursel, but they did not get beyond bench-testing. In 1945 the Oberursel site was occupied by the US-Army, and the factory was totally dismantled for reparations. In 1959 a new era began with the granting of a licence to manufacture the Bristol-Siddeley Orpheus turbojet or the Luftwaffe's Fiat G-91 fighters and subsequent development of small gas turbines finally led the Motorenfabrik into joining the Rolls-Royce family in 1990. This was 25 years ago. ■