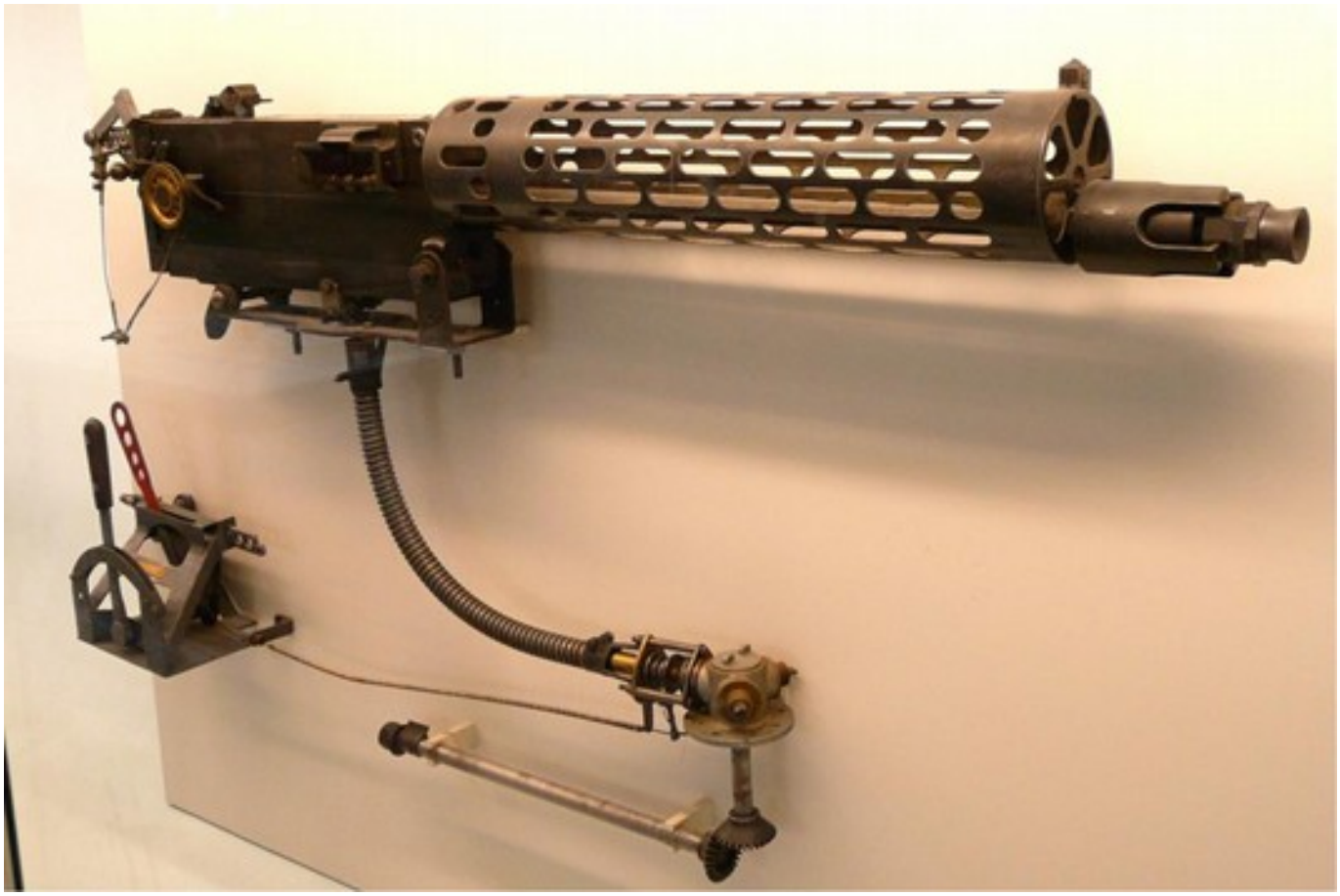
Development of
Fokker and others
Synchronization Systems
By
Hans Appel



Preface

There are those anecdotes in which people assume that they are correct. After all, you have never heard anything else and at first the story does not seem illogical.

The Fokker synchronization mechanism in the First World War that would have been devised and constructed in a few weeks is such a story for me.
It concerned disputes about patents, technically incorrect assumptions, whether or not Fokker designed the solution, taking down Roland Garros, etc., etc.

With this article I have tried to deepen and unravel the issue.

August Euler

Long before the First World War, there were already some people involved in aviation who saw the new phenomenon, the aircraft in 3D space, as a potentially interesting development for military deployment.
August Euler was one of them.

He was granted a patent on 24 July 1910: Patentschrift Nr. 248601 (see appendix). This patent reflects the idea of placing a fixed machine gun in the flight direction, in front of the pilot. So that the controls can be used to accurately aim at the enemy.

There is a drawing on the Patentschrift that shows the construction of this in a home-built French-designed aircraft with a push propeller.
On January 1, 1914, a report from the German General Staff appeared, stating that the idea of a forward-firing machine gun was feasible and interesting when an air-cooled, light machine gun was used.

But because airplanes at the start of the First World War were used for reconnaissance and observation, it seemed to be useless to arm such an aircraft. So, the first reconnaissance planes were not armed at all.

Daimler Motors

The development of aircraft with a pull propeller (propeller before the pilot) was in full swing just before the First World War. Moreover, more and more attention was paid to the military deployment of this new weapon. Armament was crucial for defense and attack, but if they wanted to use a machine gun located in front of the pilot, their own tug propeller would be shot to pieces.
A solution was devised for that.

On January 11, 1913, Daimler Motoren Gesellschaft was granted Patentschrift No. 290120 (see appendix). This describes the construction of a propeller that is not directly coupled to the crankshaft, but is driven by a gear transmission so that the center of the propeller is directly in front of the pilot.

Now a machine gun can be constructed that can fire through the hole in the center of the propeller. This solution was called the "Cannon Engine".

At that moment in time there were still many problems with this solution and it took until the Second World War that a broad use of this technique was made.

Franz Schneider

The "synchronization" mechanism that was eventually applied frequently in the First World War is described in a patent publication no. 276396 (see appendix) by Franz Schneider.
This discloses a synchronization mechanism which, by means of a camshaft coupled to the engine, aligns the propeller and the machine gun.
The Patentschrift explains in broad lines how things should work.
But the implementation is much more complicated in detail than described.
Schneider even applied for a British patent (No. 16,726) on July 21, 1913.

This patent did encourage companies such as "Fokker Aviatik GmbH" in Schwerin to elaborate this idea, an "interruption mechanism".
In the course of 1914 the Fokker engineers seriously started working on this development.

The French propeller armor mechanism

On April 18, 1915, the Morane-Saulnier aircraft, in which the French ace Roland Garros flies, was hit by a grenade and forced to land on the German side of the front.
Roland Garros shot three German planes out of the sky in the weeks before this incident with a remarkable weapon: a machine gun that can shoot through the propeller circle of his plane.
This is remarkable because the use of a machine gun in this way had not been used in practice before. Until now there were only ideas for equipping aircraft with a machine gun that works this way.

The German “Fliegertruppe” immediately investigates and they soon discover the secret behind the used machine gun.
It is actually very simple. On the propeller, at the mouth of the machine gun, armor steel deflector plates are mounted, so that every 3rd or 4th shot fired by the machine gun will bounce off the deflector plate.

This is not a real solution for shooting through the propeller circle, since a defleced bullet or grenade will follow an unpredictable trajectory and can also end up in the cockpit and hit the pilot. In addition, the Germans used ammunition other than the French.
The German machine gun uses hardened steel armored ammunition and it shot right through the deflector plates, so also through the propeller.
Moreover, there was also an irregular bending of the propeller shaft when the shells hit the deflection plates.
And grenades were wasted, which was disadvantageous, because only a limited amount of ammunition could be taken aboard.

But the success of the French aviator Roland Garros convinced the German army leadership that the professional armament of a military deployed aircraft was desperately needed.

That is why the German Inspection der Fliegertruppe (Idflieg) asked a number of manufacturers to come with a working mechanism to equip their aircraft with a forward firing machine gun.
The German General von Falkenhayn, who had a great admiration for Fokker's flying abilities, insisted that Fokker Aviatik GmbH in Schwerin be invited to study the problem.

The Fokker synchronization mechanism

Two Fokker engineers (Heinrich Lübbe and Kurt Herber) had already been working on the idea for a year, as described by Franz Schneider in general in Patentschrift Nr. 276396 (see appendix). Synchronization via a cam disk.

First version and prototype

In the first implementation of the synchronization devised by Fokker, a cam disk was coupled to the oil pump of a rotary engine.
The machine gun was in turn controlled via a rod mechanism. All this was done on two M.5K monoplane from Fokker.
Anthony Fokker himself flew these planes during a demonstration in front of the German General Staff and showed that the machine gun could shoot trough the propeller circle without any problem.

They were impressed and asked to leave both aircraft so that the German military pilots could carry out tests themselves.

Second version

The first version turned out not to be a real success because the oil pump had to cope with the mechanical control of the machine gun. The oil pump was not designed for that.

That is why a construction was conceived whereby the cam disk was directly coupled to the crankshaft of the rotary engine.
The vertical movement of the rod was converted into a horizontal movement via a rod mechanism and the machine gun was thus controlled.
This version, the “stangensteuerung”, was installed in the first production series of mono planes.

Third final implementation

Finally, a definitive solution that was mechanically strong and reliable was built. This is known as "Zentralsteuerung".
This was done trough a flexible shaft, which was coupled to the rotary motor with a gear transmission. With this the machine gun was controlled.

The pilot was able to a lever to turn the transmission "on" or "off".
It was even possible to link two or three machine guns.
The link with three machine guns was not a success (more on that later).

Advantages of the German armament

The machine gun used on German planes in the First World War were generally of the "Spandau" type.
They were fed by pattern belts with 500 shells.

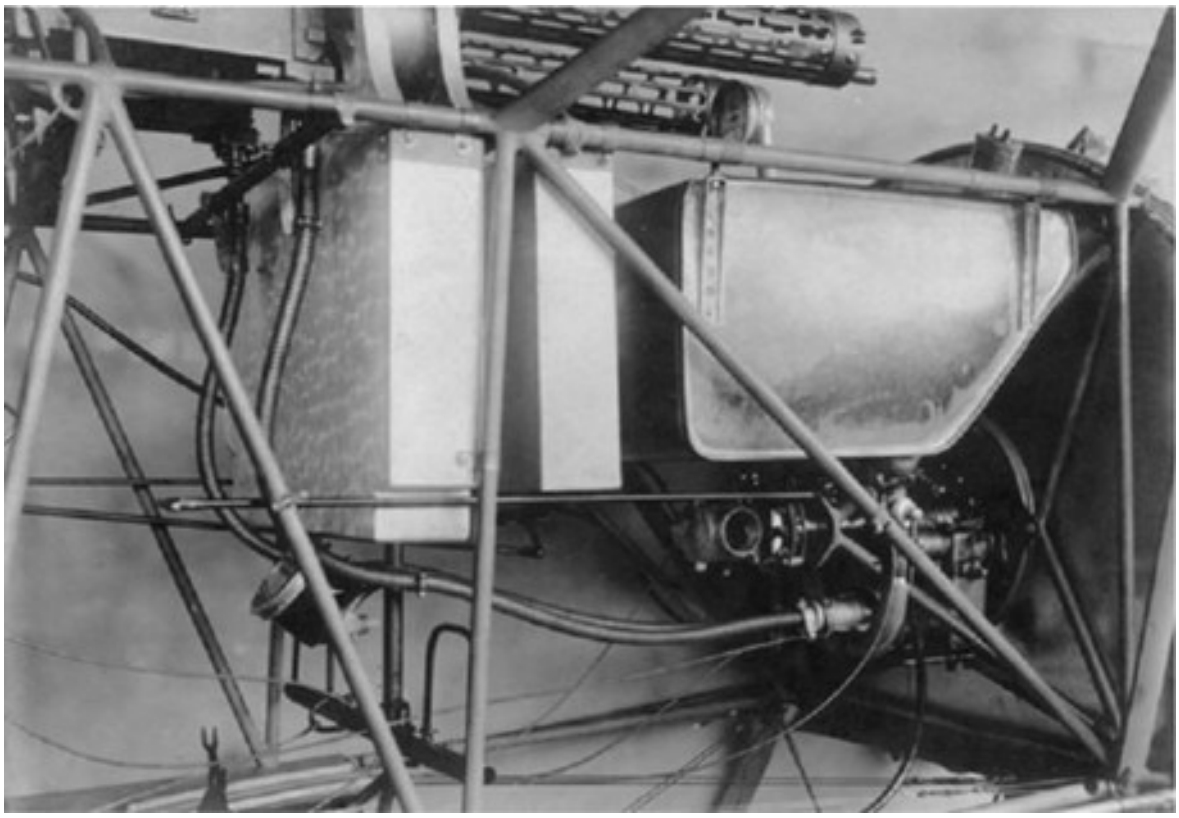
The Spandau machine gun fired at a speed of 800 grenades per minute. While the propeller rotated relatively "slowly" at a speed of 1200 revolutions per minute. This meant that the machine gun was blocked about 6 times per rotation of a propeller blade. That means 12 times for two propeller blades!

In an ideal world: At 800 shots per minute, the machine gun fires a grenade every 75 milliseconds (ms). At 1200 revolutions per minute, the propeller blade passes 50 ms every time. With some calculations it appears that with this data the machine gun is blocked six times per minute.

You can fire automatically or semi-automatically when firing a machine gun. With automatic firing it is never possible to predict with certainty when a grenade will be fired. After all, we are dealing with:

- the elasticity of the recoil springs that changes with use,
- the gas that is released with every shot that is almost never the same depending on the grenade filling.
- Then there is the mechanism for ejecting the sleeve and the transport to put a new grenade in the machine gun room ready for firing

In short, there are so many unreliable factors that play a role in automatic firing that can hardly be influenced so, the solution that Fokker engineers finally engineered was based on the semi-automatic firing of the machine gun.



Two Spandau machine guns in the tubular frame of a Fokker

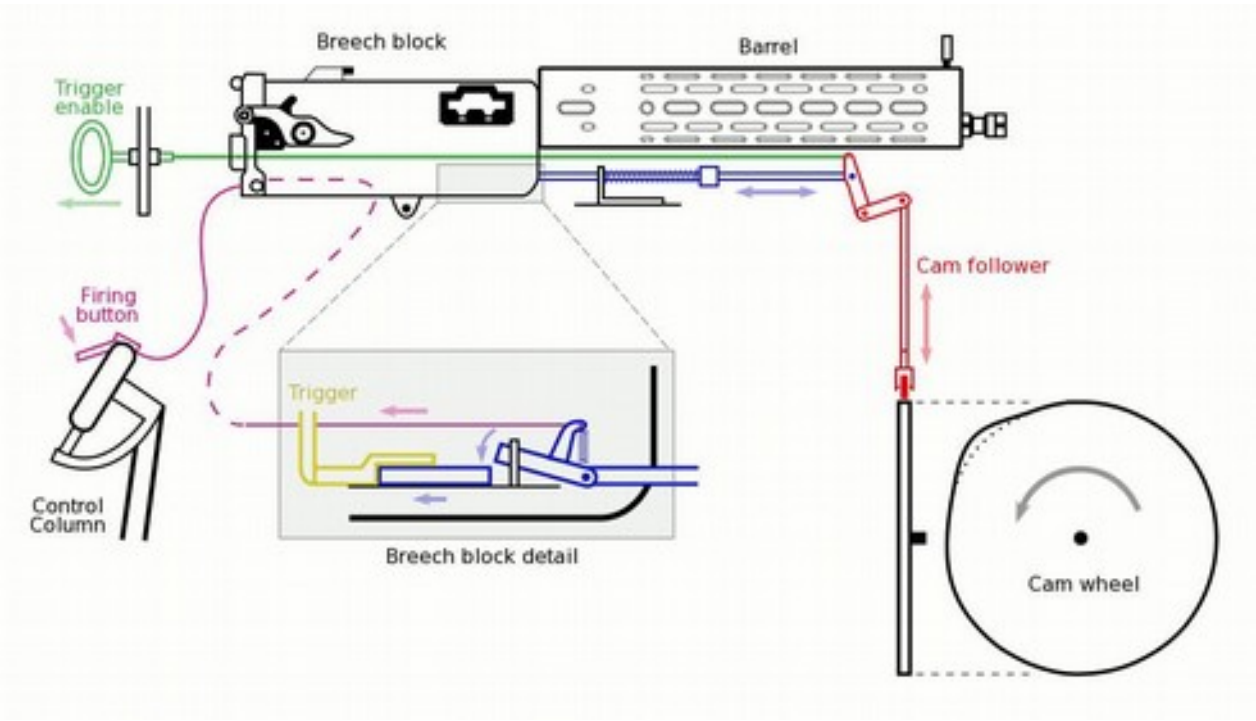
The advantage of the Spandau machine gun was that the transport mechanism had always placed the grenade ready in the room (closed bolt position).
That was a fixed fact that could be assumed.
Now the pilot gave the command: "Firing", then firing was not immediately, but first waited until the propeller blade had passed.
At that time, the "steuerung" coupling passed on the firing signal to the machine gun.
Shooting was therefore semi-automatic. Moreover, that happened only once per propeller revolution.

With the use of two machine guns, the firing was different. This worked satisfactorily.
There has also been a version with three machine guns, but the reliability of this was poor.

The mechanism described above was used in 189 Fokker E aircraft, and gave the German Fliegertruppe a predominance in the air for 9 months, from June 1915 to February 1916.
At that time, the Allies spoke about the "scourge" of Fokker.

To keep aircraft and weapon production separate, Fokker took over a small arms factory (F.H. Zimmermann GmbH) in Reinickendorf near Berlin in 1916 and changed its name to "Fokker Flugzeug Waffen Fabrik".
This also made it easier to concentrate on the further development of weapon systems for aircraft.

That the mechanism designed by the "Fokker Flugzeug Waffen Fabrik" in Rerineckendorf was a success can be seen from the fact that during the war 42,000 of these machine gun synchronization mechanisms were produced.



The Siegert memo

The further development of weapon systems was now considered important by the management of the Fliegertruppe. Certainly after the successes of late 1915 at the beginning of 1916,
On 16 August 1916, a secret letter from Oberstleutnant Wilhelm Siegert stated that the weapons used so far were not satisfactory. This is because these weapons were developed for use on the ground for infantry, cavalry and artillery.
Siegert was an inspector of the Fliegertruppe at that time and therefore responsible for the equipment of the air weapon

He indicated that weapons for use in aircraft should be very light, have a high rate of fire that only lasted a few seconds.
They also had to be easy to operate at flight speeds of 200 km / h. And also had to function well at high altitudes at temperatures of -40ºC.
He also stated in his memorandum that these types of weapons should be equipped with multiple barrels and that the ammunition transport should be powered by the aircraft engine or electrically.

This memorandum encouraged a large number of weapon manufacturers to launch creative new developments.

The Fokker Flugzeug Waffen Fabrik also devoted itself to the development of new weapons, designed according to the “Siegert standards”. One of them is very remarkable.

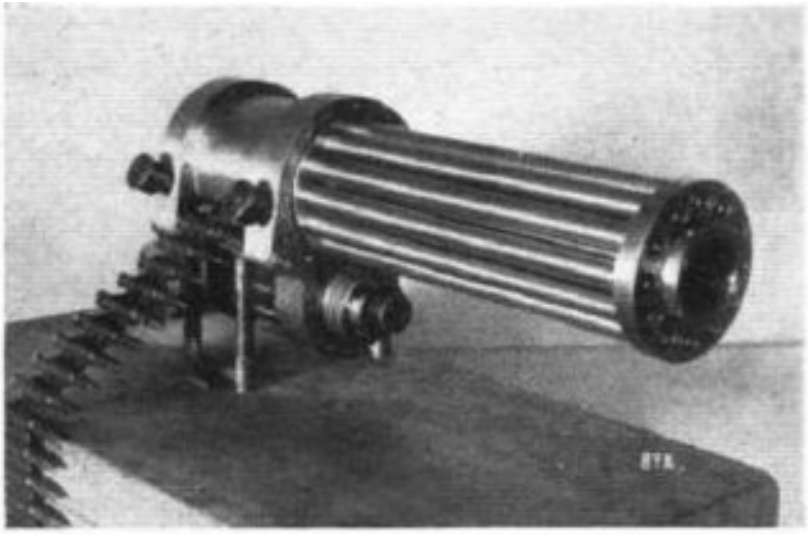
Fokker-Leimberger machine gun

Fokker engineers like Heinrich Lübbe went to work and came up with various designs, of which the Fokker-Leimberger machine gun was the most promising.

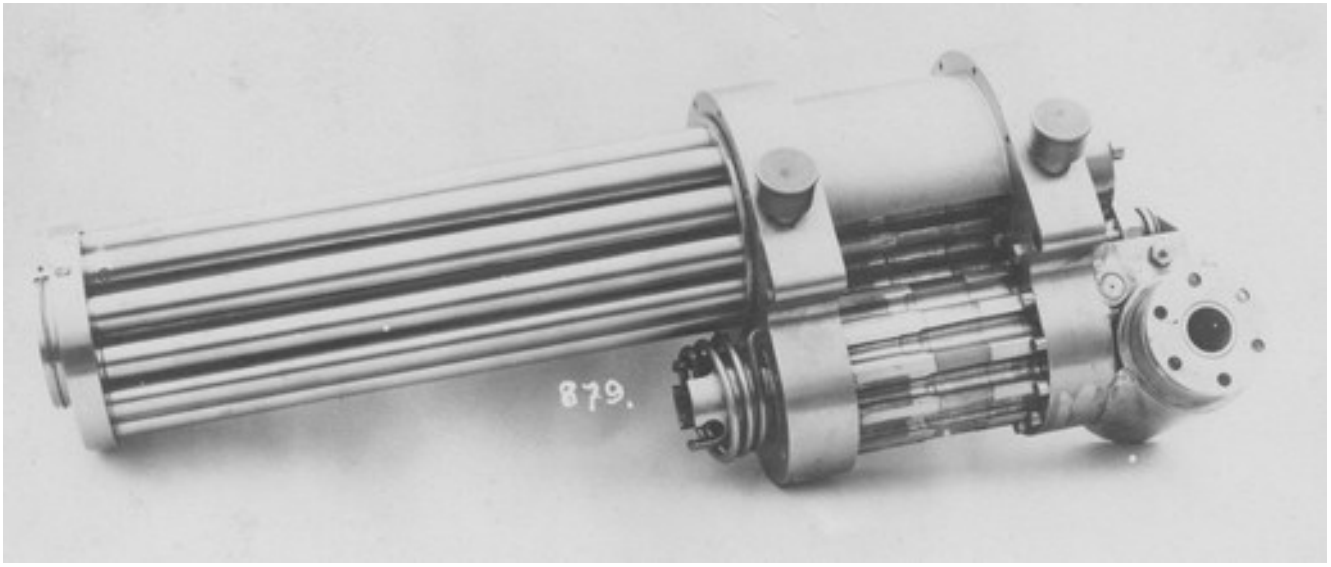
The Fokker-Leimberger machine gun was based on the "Gatling gun" principle. It had 12 barrels mounted on a rotating drum. The grenades were fed with the aid of a cartridge band in which, after firing the grenades, the grenade shells remained. The whole was driven by an electric motor.

The firing speed was around 7200 shots per minute (rpm) which amounts to one grenade every 8 ms.
We have previously seen that such fast timing is much easier to synchronize than much slower firing speeds.
Incidentally, the firing speed per run is 7200/12 = 600 rpm. Which in itself is reasonably low, with the advantage of less cooling required.

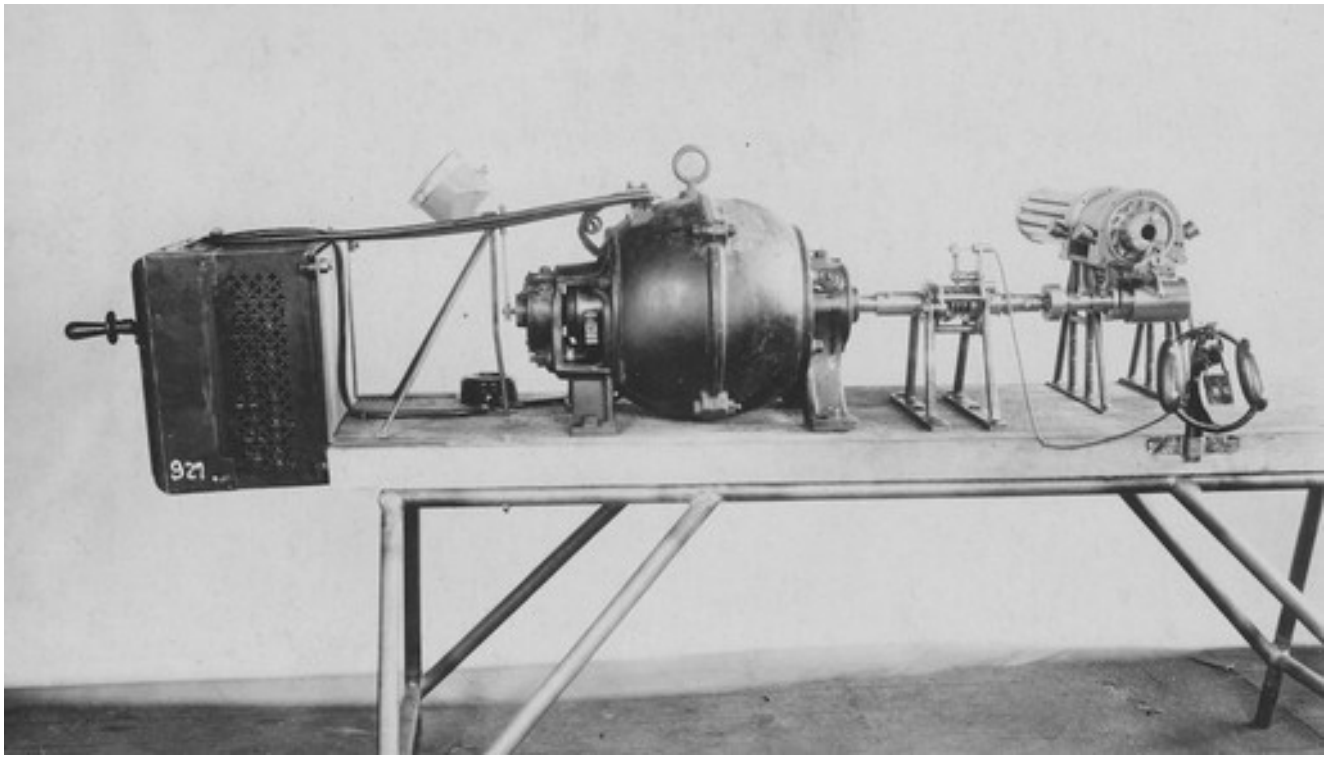
This weapon has never been used operationally and we assume that Anthony Fokker brought the most recent "development version" to the Netherlands in 1919 and later shipped it to the USA in his personal belongings.



More than 7,000 rounds per minute in 1916—a rare photograph of the Fokker-Leimberger gun described by Mr. A. R. Weyl.



Fokker-Leimberger gun in detail



Fokker-Leimberger gun testbed

Synchronization Systems; Background information

Germany

In Germany, Franz filed a patent application for the use of a machine gun on an aircraft equipped with a traction propeller.
That was granted to him on July 15, 1913 as Patentschrift # 276,396

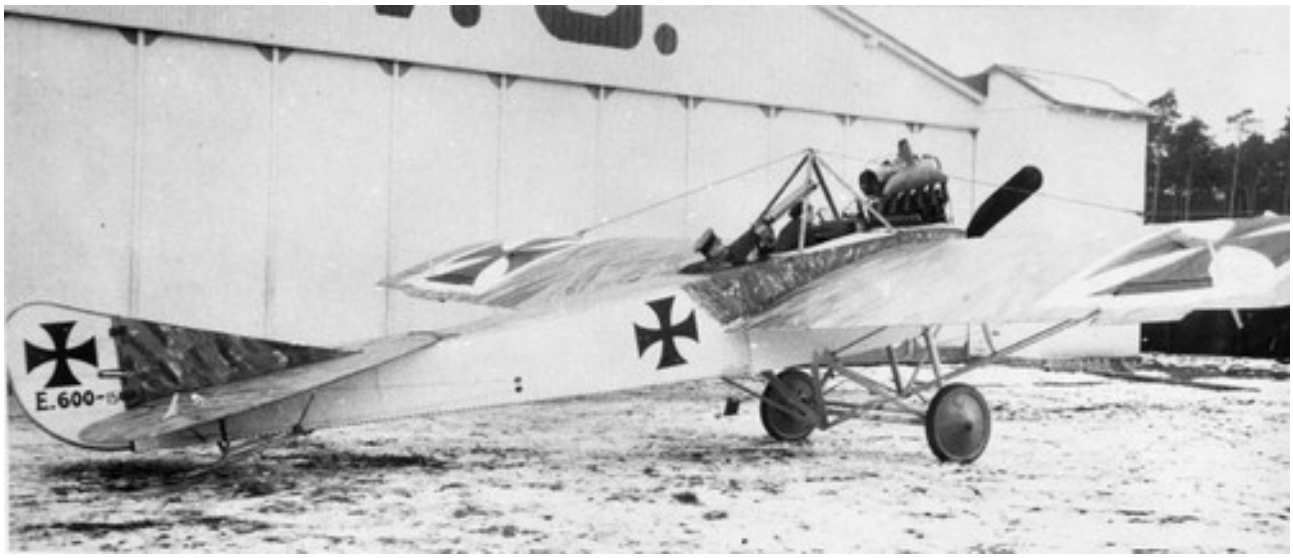
Schneider had successfully conducted a number of tests for the army in 1912, but despite the success of the tests, the army did not comment on the use of this weapon.
They were still under the assumption that an aircraft would never become a fighting machine.

Yet Franz Scheider did not give up his efforts to convince the Fliegertruppe of the usefulness of his invention. At the end of 1914 an L.V.G. E.I built a monoplane two-seater where the rear cockpit was equipped with a mounting ring on which a modified 7.92 mm Parabellum machine gun was mounted.

The front cockpit was fitted with a modified Maxim machine gun that could shoot synchronized by the propeller. Modifications were don by Karl Heinemann (of the D.W.M. weapon factory)

The L.V.G. E.I monoplane was an easy maneuverable plane equipped with ailerons, which was remarkable at the time because most aircraft were equipped with wing-warping (bending the wings in the horizontal plane).

In 1915 the only prototype was destroyed on the way to the front after a number of successful test flights. It is inexplicable why further testing and production were abandoned.



Fokker E-I

Fokker E.I

At Fokker, two engineers (Heinrich Lübbe and Kurt Herber) have been working since 1913 on a synchronization mechanism that was first built into a Fokker M.5K (later called E.I by the military).

The advantage of the M.5K was that the frame was entirely made of metal tubes. As a result, adjustments could easily be made by welding.
The adjustments were needed for, among other things, the containers in which the bands with grenades were stored and for the containers for receiving the empty sleeves.

Furthermore, the rebound effect of a machine gun was much heavier if it had initially been assumed. With the fragile wooden planes from that time, that had a catastrophic effect on the construction. It may be clear that the M.5K was not bothered by that.

Incidentally, it should be noted that until long after the First World War a legal battle was waged with regard to patents that would have harmed by Fokker.
See in the annexes from 1924 for the Arrondissements_Rechtbank in Amsterdam (district court of justice).

LMG.08

In the first instance (also during the first demonstrations) a machine gun .14 from D.W.M. (Deutsche Waffen und Munitionsfabriken) was used.
But with the production planes, the much more reliable LMG.08 (Spandau) of the D.W.M. was applied.
Because the factories were in Spandau, people often talk about a Spandau machine gun.

Incidentally, it was the first time that semi-automatic machine guns were to be used in aircraft.
The machine guns had until then been designed for the ground war, but there are different requirements when using weapons in the air. The weapon must be light, so cooling by means of water was not possible, hence the air cooling adjustments.
The feeding belts were made of hemp, which had the advantage that they were light. However, a disadvantage was that hemp attracts water, and that meant that the belts frozen in the winter. After all, above 9000 ft. Is the temperature around 18 ºC colder than at ground level.
The grease to lubricate the mechanics of the machine gun also froze.

The consequences were "jams" that had to be corrected with two hands. For this, the stick had to be held between the knees. Very annoying if you were in an air fight.
Later on the E.II (Fokker M.14) a clamp was applied to the stick so that the elevator could be fixed.

Operational advantage

For 9 months, from June 1915 to February 1916, the Allies had no answer to the Fokker E-I aircraft equipped with a synchronized machine gun. The Allies spoke about the "scourge" of Fokker.
This is remarkable because only 189 aircraft were produced in those months, of which no more than 26 were active on the western front.

Moreover, it was also not the case that the best pilots were selected for flying the E-Is. The pilots that were active with the E-I were selected because they had experience with flying with aircraft equipped with rotary engines.
The effects that the gyroscopic effect of rotary engines had on this type of light aircraft, plus the fact that the engine was only "on" or "off", required adapted use of the flight controls.

Response from the Royal Flying Corps (RFC)

The management of the RFC was nevertheless wary of the effects of the Fokker E aircraft equipped with a synchronized machine gun. So that an order was issued on January 14, 1916 that was rather drastic. It says:

> *Until we have better aircraft that are a match to the Fokkers:*
> *A reconnaissance / observation aircraft must be escorted by at least three (3) fighter aircraft. The aircraft must maintain a closed formation. The reconnaissance / observation must be aborted if one of the aircraft, for whatever reason, becomes separate from the rest.*
> *This applies to both short and long-distance missions.*
> *The same conditions apply to photo scouts who have to perform missions east of the front line.*
> *Experience shows that lately the Germans fly in flights of three (3) or Four (4) in a closed formation.*
> *All our pilots will have to practice intensive flying within a closed formation.*

England

In England, as early as 1911 Major Brooke-Popham (Royal Engineers) placed a rifle on a Blériot monoplane! He was immediately ordered to remove the gun.

In the summer of 1914, a new attempt was made by the Edward Bros to interest the RFC in a synchronized machine gun.
They even filed a patent for that (UK patent 23,790). But they too were told that the RFC did not provide any money for this type of testing.

One of the reasons for this position was that the British used reconnaissance and observation aircraft at the beginning of the First World War that were very stable and very slow. They were two-seater fitted with a push screw.

The observer's cockpit was initially equipped with a Vickers Maxim machine gun (developed in 1888). Later, two modified Lewis machine guns (97 cartridges) were used that were placed in the observer's cockpit.

In 1916 a new British system was introduced which was conceived by George Constantinesco (a Romanian engineer) and Major G.C. Colley (Chief Experimental Officer at the Artillery). They came up with a system that worked on the basis of hydraulics. This system is much more reliable than the systems that used a mechanical transmission.
In addition to reliability, this system was faster and more accurate and without specific adjustments to be used on any combination of aircraft and machine gun.
A Patent Application was filed on July 14, 1916 (# 512).

This so-called C.C. The system was operationalized by the RFC from March 1917. The RNAS (Royal Navy Air Service) also used this system.
Between January and October 1918 alone, more than 20,000 C.C. used. It was used until 1937!

Incidentally, the Dutch Aviation Department was not so pleased with this system.

This appears from a test report of 28 October 1924 (see appendices).

