Focke Wulf 190 24" and 59" Wing Span (1m and 1.5m) plan.

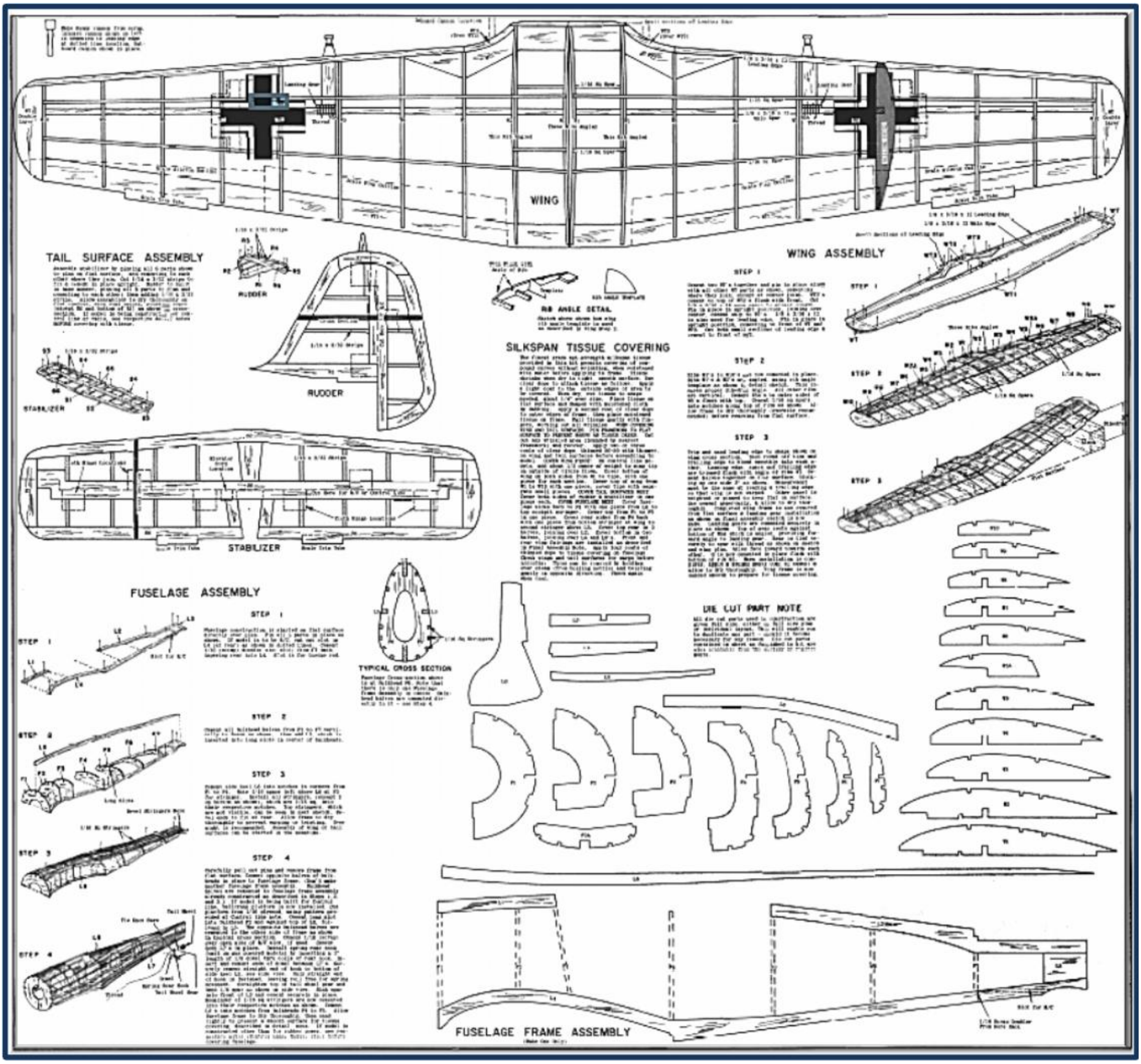
(Other minor plans included)

The **Focke-Wulf Fw 190 *Würger*** (Shrike) was a German Second World War single-seat, single-engine fighter aircraft designed by Kurt Tank in the late 1930s. Powered by a radial engine, the 190 had ample power and was able to lift larger loads than its well-known counterpart, the Messerschmitt Bf 109. The 190 was used by the *Luftwaffe* in a wide variety of roles, including day fighter, fighter-bomber, ground-attack aircraft and, to a lesser degree, night fighter.

When the Fw 190 started flying operationally over France in August 1941, it quickly proved itself to be superior in all but turn radius to the Royal Air Force's main front-line fighter, the Spitfire Mk. V.[1] The 190 wrested air superiority away from the RAF until the introduction of the vastly improved Spitfire Mk. IX in July 1942 restored qualitative parity.[2] The Fw 190 made its air combat debut on the Eastern Front in November/December 1942; though Soviet pilots considered the Bf 109 the greater threat, the Fw 190 made a significant impact. The fighter and its pilots proved just as capable as the Bf 109 in aerial combat, and in the opinion of German pilots who flew both, provided increased firepower and manoeuvrability at low to medium altitude.

The Fw 190 became the backbone of the *Jagdwaffe* (Fighter Force), along with the Bf 109. On the Eastern Front, the Fw 190 was versatile enough to use in *Schlachtgeschwader* (Battle Wings or Strike Wings), specialised ground attack units which achieved much success against Soviet ground forces. As an interceptor, the Fw 190 underwent improvements to make it effective at high altitude, enabling it to maintain relative parity with its Allied opponents. The Fw 190A series' performance decreased at high altitudes (usually 6,000 m (20,000 ft) and above), which reduced its effectiveness as a high-altitude interceptor, but this problem was mostly rectified in later models, particularly in the Junkers Jumo 213 inline-engine Focke-Wulf Fw 190D series, which was introduced in September 1944. In spite of its successes, it never entirely replaced the Bf 109.

The Fw 190 was well liked by its pilots. Some of the *Luftwaffe*'s most successful fighter aces claimed a great many of their kills while flying it, including Otto Kittel, Walter Nowotny and Erich Rudorffer.



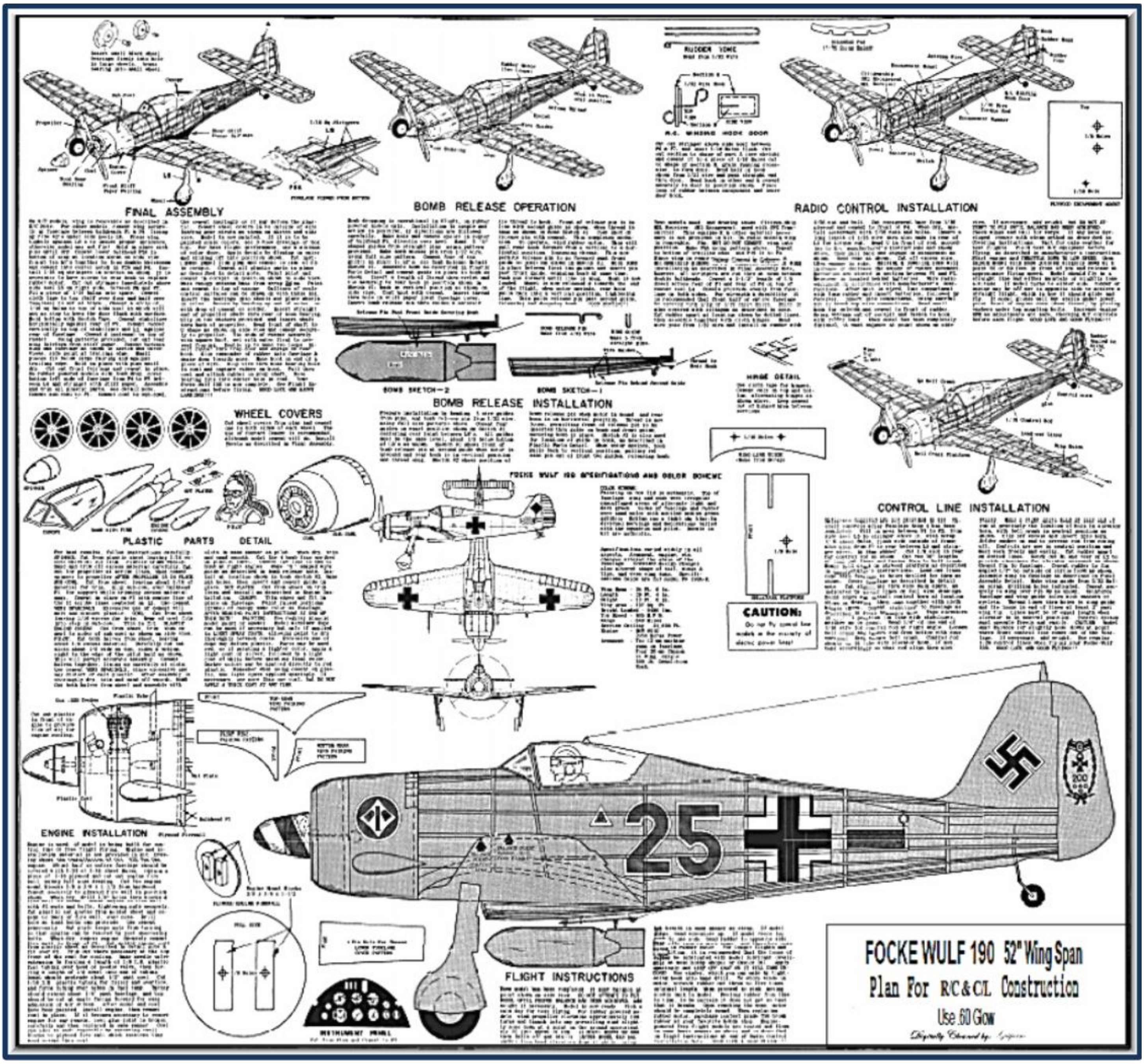
Genesis

In autumn 1937, the German Ministry of Aviation asked various designers for a new fighter to fight alongside the Messerschmitt Bf 109, Germany's front line fighter. Although the Bf 109 was an extremely competitive fighter, the Ministry of Aviation was worried that future foreign designs might outclass it, and wanted to have new aircraft under development to meet these possible challenges.[3]

Focke Wulf 190 24" and 59" Wing Span (1m and 1.5m) plan.

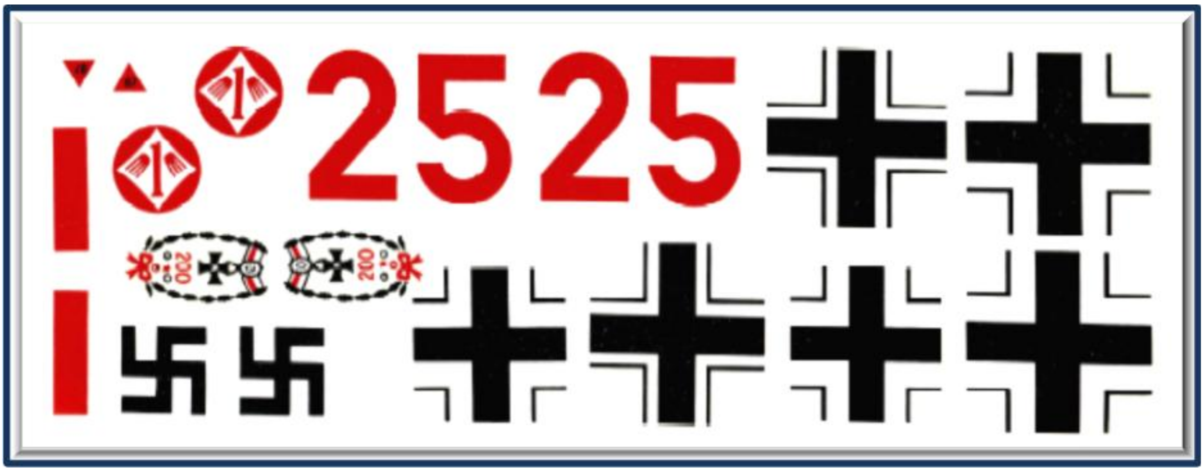
(Other minor plans included)

Kurt Tank responded with a number of designs, most incorporating liquid-cooled inline engines. However, it was not until a design was presented using the air-cooled, 14-cylinder BMW 139 radial engine that the Ministry of Aviation's interest was aroused. As this design used a radial engine, it would not compete with the inline-powered Bf 109 for engines, when there were already too few DB 601's to go around.[4] This was not the case for competing advanced designs like the Heinkel He 100 or Focke-Wulf Fw 187, where production would compete with the 109 or Messerschmitt Bf 110 for engine supplies. After the war, Tank denied a rumour that he had to "fight a battle" with the Ministry to convince them of the radial engine's merits.[5]



Design concepts

At the time, the use of radial engines in land-based fighters was relatively rare in Europe, as it was believed that their large frontal area would cause too much drag on something as small as a fighter. Tank was not convinced of this, having witnessed the successful use of radial engines by the US Navy, and felt a properly streamlined installation would eliminate this problem.[4]

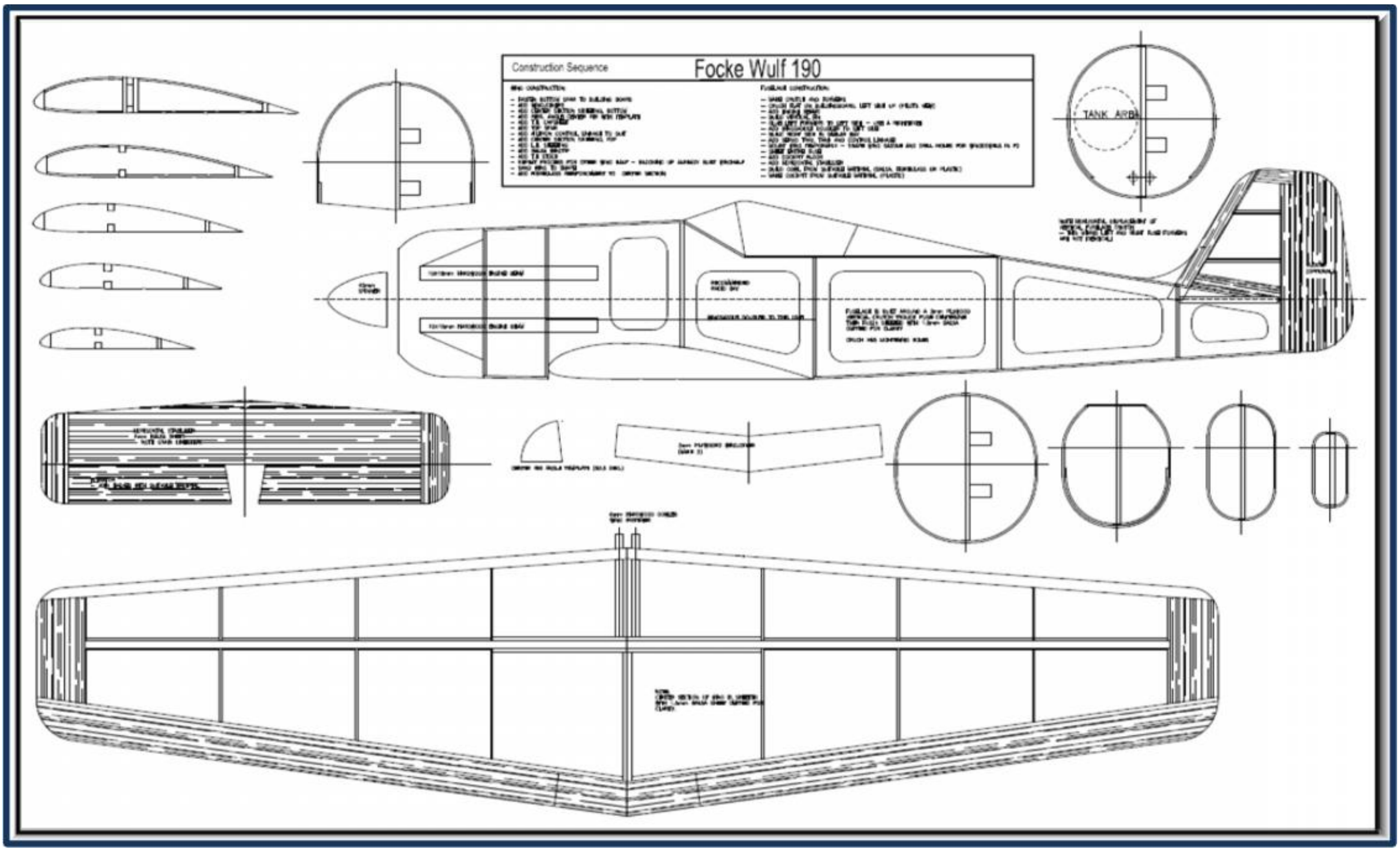


The hottest point on any air-cooled engine are the cylinder heads, located along the outside diameter of a radial engine. In order to provide sufficient air to cool the engine, the cowling needed to allow airflow at this outer edge, which generally resulted in the majority of the front face of the engine being left open to the air. During the late 1920s, NACA led development of a dramatic improvement by placing an airfoil-shaped ring around the outside of the cylinder heads. The shaping accelerated the air as it entered the front of the cowl, increasing the total airflow, and allowing the opening in front of the engine to be made smaller.[6]

Tank introduced a further refinement to this basic concept. He suggested placing most of the airflow components on the propeller itself, in the form of a oversized propeller spinner whose outside diameter was the same as the engine itself. The cowl around the engine proper was greatly simplified, essentially a basic cylinder. Air entered through a small hole at the center of the propeller, and was directed through ductwork in the spinner so it was blowing rearward along the cylinder heads. To provide enough airflow, a cone was placed in the center of the hole, over the propeller hub, which was intended to compress the airflow and allow a smaller hole to be used. In theory, the tight-fitting cowling also provided some thrust due to the compression and heating of air as it flowed through the cowling.[7]

As to the rest of the design philosophy, Tank wanted something more than an aircraft built only for speed. Tank outlined the reasoning:

The Messerschmitt 109 [sic] and the British Spitfire, the two fastest fighters in world at the time we began work on the Fw 190, could both be summed up as a very large engine on the front of the smallest possible airframe; in each case armament had been added almost as an afterthought. These designs, both of which admittedly proved successful, could be likened to racehorses: given the right amount of pampering and easy course, they could outrun anything. But the moment the going became tough they were liable to falter. During World War I, I served in the cavalry and in the infantry. I had seen the harsh conditions under which military equipment had to work in wartime. I felt sure that a quite different breed of fighter would also have a place in any future conflict: one that could operate from ill-prepared front-line airfields; one that could be flown and maintained by men who had received only short training; and one that could absorb a reasonable amount of battle damage and still get back. This was the background thinking behind the Focke-Wulf 190; it was not to be a racehorse but a *Dienstpferd*, a cavalry horse.[8]



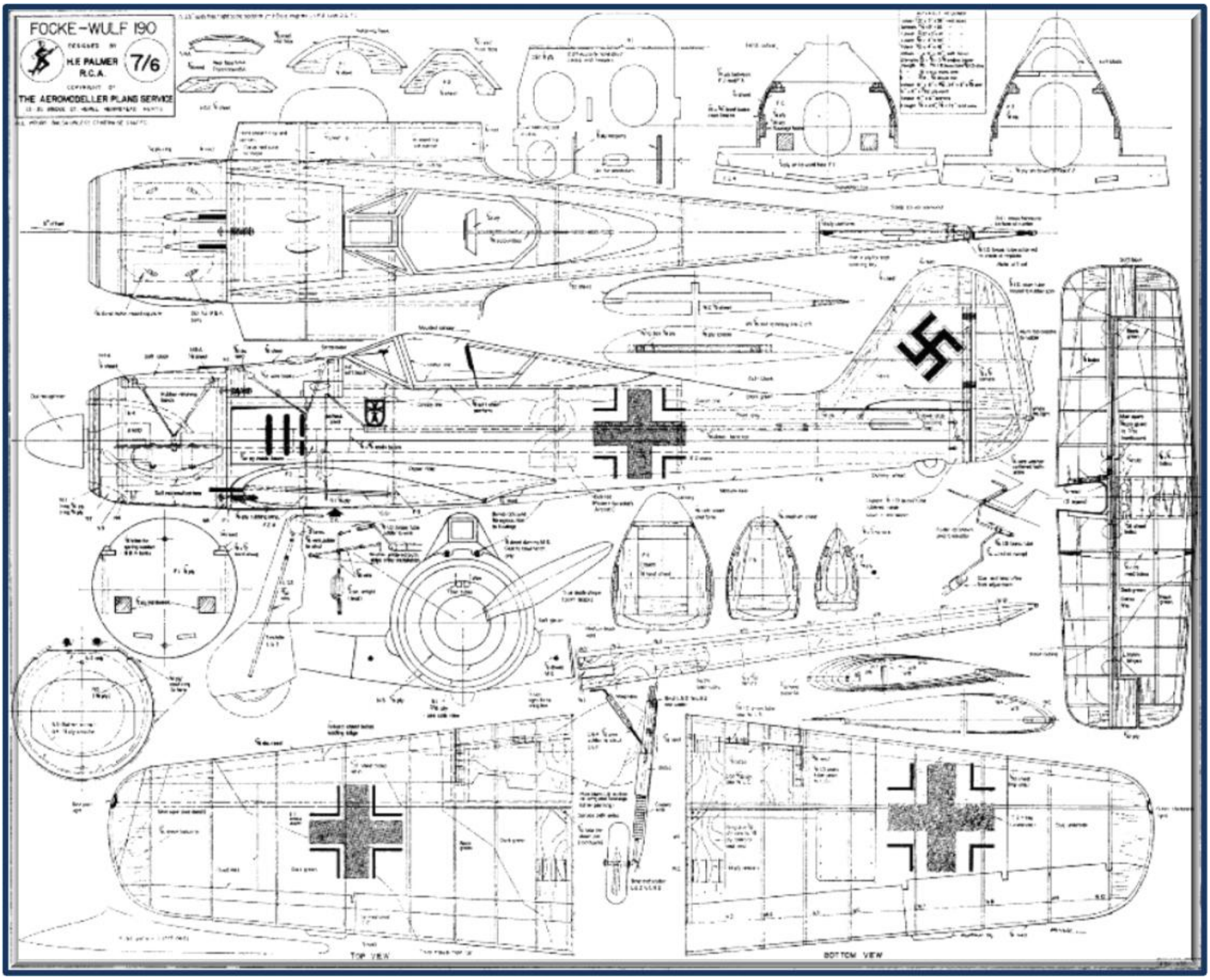
42” Wing Span CAD Plan

A main feature of the Fw 190 was its wide landing gear. Tank appreciated that operating from primitive airfields in wartime would require a stable undercarriage — a lesson learned from witnessing the difficulty of moving machinery in the First World War. The wide-track landing gear spacing gave it better ground handling characteristics, and it suffered fewer ground accidents than the Bf 109 with its narrow-track landing gear. The undercarriage was designed to withstand a sink rate of 15 feet per second (4.5 meters per second, 900 feet per minute), double the strength factor usually required. Hydraulic wheel brakes were used.[9]

Most aircraft of the era used cables and pulleys to operate their controls. The cables tended to stretch, resulting in 'give' and 'play' that made the controls less crisp and responsive, and requiring constant maintenance to correct. For the new design, the team replaced these with rigid pushrods to eliminate this problem. Another innovation was making the controls as light as possible. The maximum resistance of the ailerons was limited to eight pounds, as the average man's wrist could not exert a greater force. The empennage (tail assembly) featured relatively small horizontal and vertical surfaces.[10]

The design team also attempted to minimize changes in the aircraft's trim at varying speeds, thus reducing the pilot's workload. They were so successful in this regard that they found in-flight-adjustable aileron and rudder trim tabs were not necessary. Small, fixed tabs were fitted to control surfaces and adjusted for proper balance during initial test flights. Only the elevator trim needed to be adjusted in flight (a feature common to all aircraft). This was accomplished by tilting the entire horizontal tailplane, which could be adjusted by an electric motor from a -3 to a +5 angle of incidence.[11]

Another aspect of the new design was the extensive use of electrically powered equipment instead of the hydraulic systems used by most aircraft manufacturers of the time. On the first two prototypes, the main landing gear was hydraulic. Starting with the third prototype, the undercarriage was operated by push buttons controlling electric motors in the wings, and was kept in position by electric up and down-locks.[12] The armament was also loaded and fired electrically. Tank believed that service use would prove that electrically powered systems were more reliable and more rugged than hydraulics, electric lines being much less prone to damage from enemy fire.[10]



28” Wing Span Plan

As was the case for the 109, the 190 featured a fairly small wing planform with relatively high wing loading. This presents a trade-off in performance; an aircraft with a smaller wing suffers less drag in most flight and therefore flies faster and may have better range. However, it also means the wing cannot generate *extra* lift as easily, which is needed for maneuvering or flight at high altitudes.The wings spanned 9.5 m (31 ft 2 in) and had an area of 15 m² (161 ft²). The wing was designed using the NACA 23015.3 airfoil at the root and the NACA 23009 airfoil at the tip.[13]

First prototypes

The first prototype, the **Fw 190 V1** (civil registration **D-OPZE**), powered by a 1,550 PS (1,529 hp, 1,140 kW) BMW 139 14-cylinder two-row radial engine, first flew on 1 June 1939. It soon showed exceptional qualities for such a comparatively small aircraft, with excellent handling, good visibility and speed (initially around 610 km/h (380 mph)).[14] The roll rate was 162° per second at 410 km/h (255 mph), but the aircraft had a high stall speed of 205 km/h (127 mph).

The cockpit, located directly behind the engine, quickly became uncomfortably hot. During the first flight, the temperature reached 55 °C (131 °F), after which Focke Wulf's chief test pilot, Hans Sander commented, "It was like sitting with both feet in the fireplace."[15] Flight tests soon showed that the expected benefits of Tank's cooling design did not materialize, so after the first few flights, this arrangement was replaced by a smaller, more conventional spinner that covered only the hub of the three-blade VDM propeller.

In an attempt to increase airflow over the tightly cowled engine, a 10-blade fan was fitted at the front opening of the redesigned cowling and was geared to be driven at 3.12 times faster than the propeller shaft's speed. This quickly became standard on the Fw 190 and nearly all other German aircraft powered by the BMW 801.[16] In this form the V1 first flew on 1 December 1939, having been repainted with the *Luftwaffe*'s *Balkenkreuz* and with the *Stammkennzeichen* (factory code).[17] RM+CA.[18]

The Fw 190 V2, designated with the *Stammkennzeichen* alphabetic ID code of *FL+OZ* (later RM+CB) first flew on 31 October 1939 and was equipped from the outset with the new spinner and cooling fan. It was armed with one *Rheinmetall-Borsig* 7.92 mm (.312 in) MG 17 machine gun and one 13 mm (.51 in) synchronized MG 131 machine gun in each wing root.[18]

Later prototypes, BMW 801

Fw 190 V5k. This is the V5 with the original small wing. The 12-blade cooling fan and redesigned undercarriage and canopy fairings are visible.

Even before the first flight of the Fw 190 V1, BMW was bench testing a larger, more powerful 14-cylinder two-row radial engine, the BMW 801. This engine introduced a pioneering example of an engine management system called the *Kommandogerät* (command-device): in effect, an electro-mechanical computer which set mixture, propeller pitch (for the constant speed propeller), boost, and magneto timing. This reduced the pilot's work load to moving the throttle control only, with the rest of the associated inputs handled by the Kommandogerät. The drawback was slight and minor surges that made the Fw 190 harder to fly in close formations.[19] Tank asserted the device did not work well. One of the faults in the system was the violent switching in of the high gear of the supercharger as the aircraft climbed. During a test flight, Tank carried out a loop at medium altitude. Just as he was nearing the top of the loop, at 2,650 m (8,700 ft), the supercharger's

high gear kicked in with a jerk. The Fw 190 was on its back, with little airspeed. The sudden change in torque hurled the aircraft into a spin. Tank's artificial horizon toppled (the cause is not explained). Although Tank did not know whether he was in an upright or inverted spin, he managed to recover after a loss of altitude. The rough transition was smoothed out and the supercharger's gear-change could engage without incident.[20]

The RLM convinced Focke-Wulf and BMW to abandon the 139 engine in favour of the new engine. The BMW 801 engine was similar in diameter to the 139, although it was heavier and longer by a considerable margin. This required Tank to redesign the Fw 190, resulted in the abandonment of the V3 and V4. The V5 became the first prototype with the new engine, being fitted with the 1,560 PS (1,539 hp, 1,147 kW) BMW 801 C-0. Much of the airframe was strengthened and the cockpit was moved back in the fuselage, which reduced the troubles with high temperatures and for the first time provided space for nose armament. It also reduced visibility in nose-high attitudes, notably when taxiing on the ground.

A 12-blade cooling fan replaced the earlier 10-blade unit, and was likewise installed in front of the engine's reduction gear housing, still running with the original 3.12:1 reduction ratio, which was standardised for BMW-powered Fw 190s. The propeller shaft passed through the fan's central plate, which was made of cast magnesium. The fan provided cooling air not only for the engine cylinders' fins, but also for the annular oil cooler, which was located in the forward part of the cowling. The oil cooler was protected by an armoured ring which made up the front face of the cowling.[18] A small hole in the centre of the spinner also directed airflow to ancillary components.[21] Even with the new engine and the cooling fan, the 801 suffered from high rear-row cylinder head temperatures, which in at least one case resulted in the detonation of the fuselage-mounted MG 17 ammunition.

The vertical tail shape was also changed and the rudder tab was replaced by a metal trim strip adjustable only on the ground. New, stiffer undercarriage struts were introduced, along with larger diameter wheels. The retraction mechanism was changed from hydraulic to electrically powered, which became a hallmark of later Focke-Wulf aircraft system designs, and new fairings of a simplified design were fitted to the legs.[18] Another minor change was that the rearmost sections of the sliding canopy were redesigned by replacing the plexiglas glazing with duralumin panels. As this section was behind the pilot's seat, there was little visibility lost.

At first, the V5 used the same wings as the first two prototypes, but to allow for the larger tyres, the wheelwells were enlarged by moving forward part of the leading edge of the wing root; the wing area became 15.0 m² (161 ft²). The V5 first flew in the early spring of 1940. The weight increase with all of the modifications was substantial, about 635 kg (1,400 lb), leading to higher wing loading and a deterioration in handling. Plans were made to create a new wing with more area to address these issues. In its original form, this prototype was called the *V5k* for *kleine Fläche* (small surface).[22]

In August 1940 a collision with a ground vehicle damaged the V5 and it was sent back to the factory for major repairs. This was an opportune time to rebuild it with a new wing which was less tapered in plan than the original design, extending the leading and trailing edges outward to increase the area. The new wing had an area of 18.30 m² (197 ft²), and now spanned 10.506 m (34 ft 5 in). After conversion, the aircraft was called the *V5g* for *große Fläche* (large surface). Although it was 10 km/h (6 mph) slower than when fitted with the small wing, *V5g* was much more manoeuvrable and had a faster climb rate.[22] This new wing platform was to be used for all major production versions of the Fw 190.[18]