

Kawasaki Ki-64 'Rob'

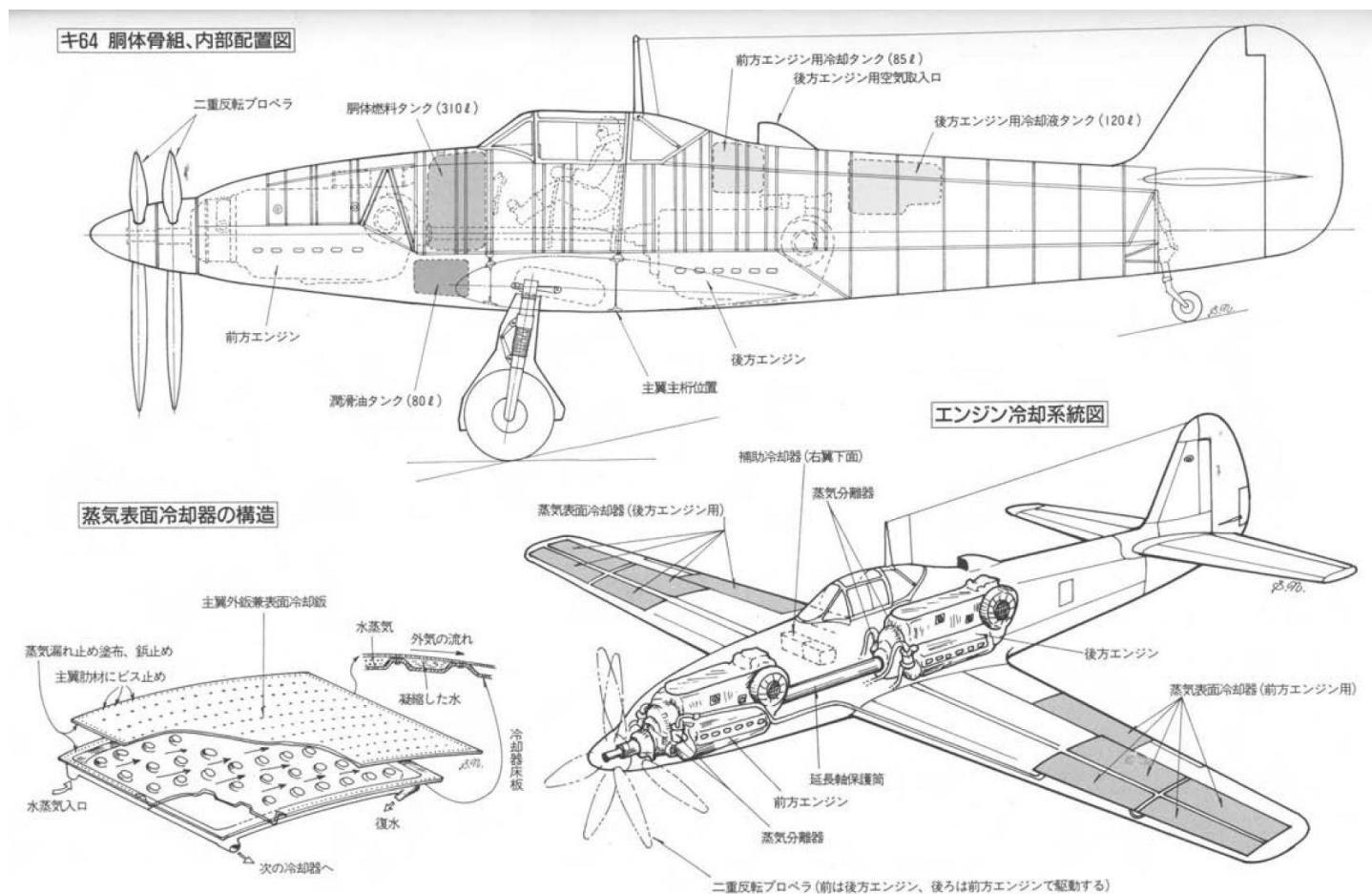
Durant la Seconde Guerre Mondiale, l'industrie aéronautique japonaise fut en mesure de produire des dizaines de milliers d'avions de combat pour soutenir l'effort de guerre du pays dans le Pacifique. Bien que ne disposant pas de ressources équivalentes à celles des forces alliées, les militaires japonais purent trouver les moyens de combattre pendant près de quatre années, tout en continuant de développer de nouveaux armements et matériels innovants. Cependant, ce manque de ressources et la pression croissante des puissances alliées empêchèrent souvent le Japon de tirer profit de ces nouveautés.



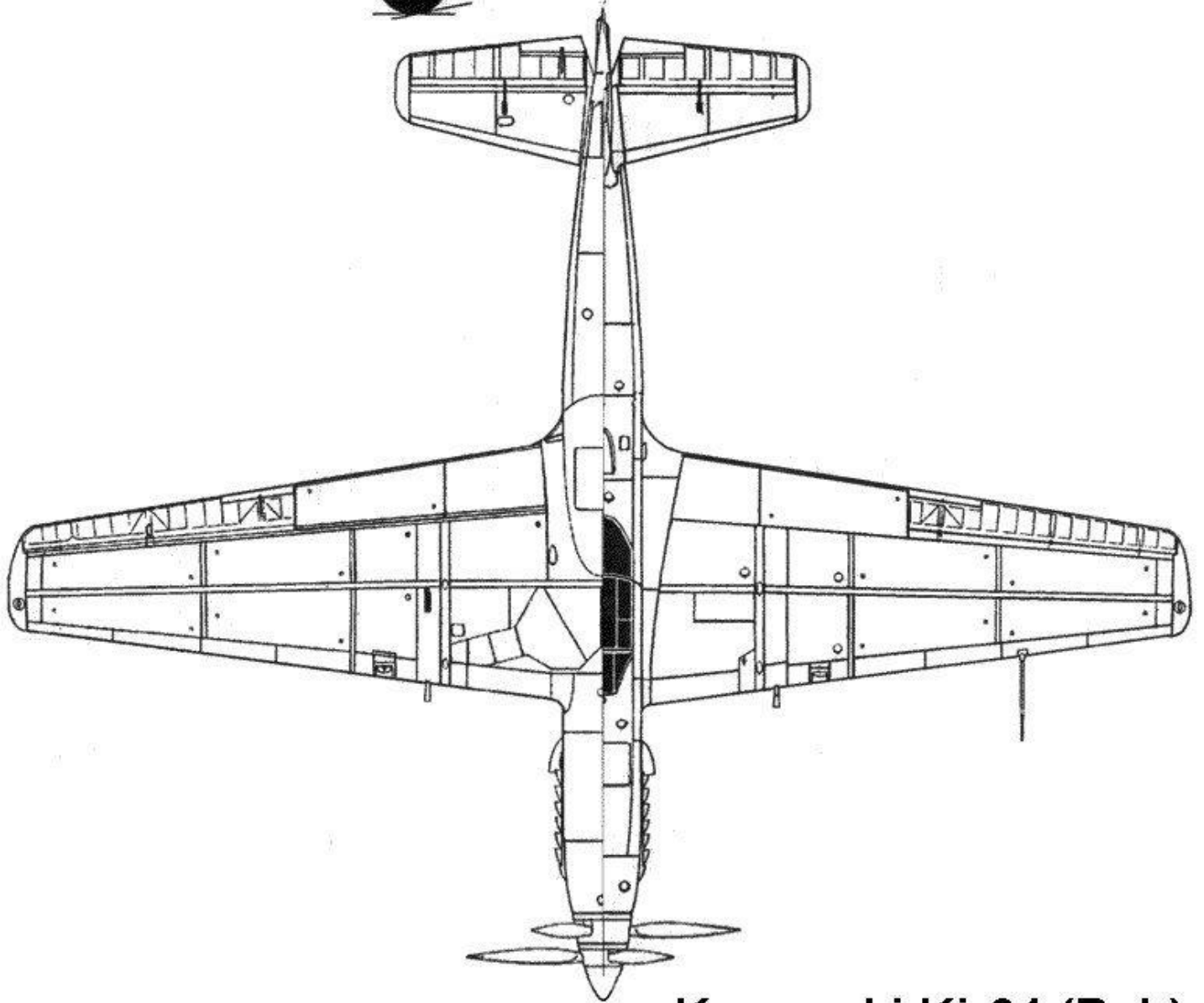
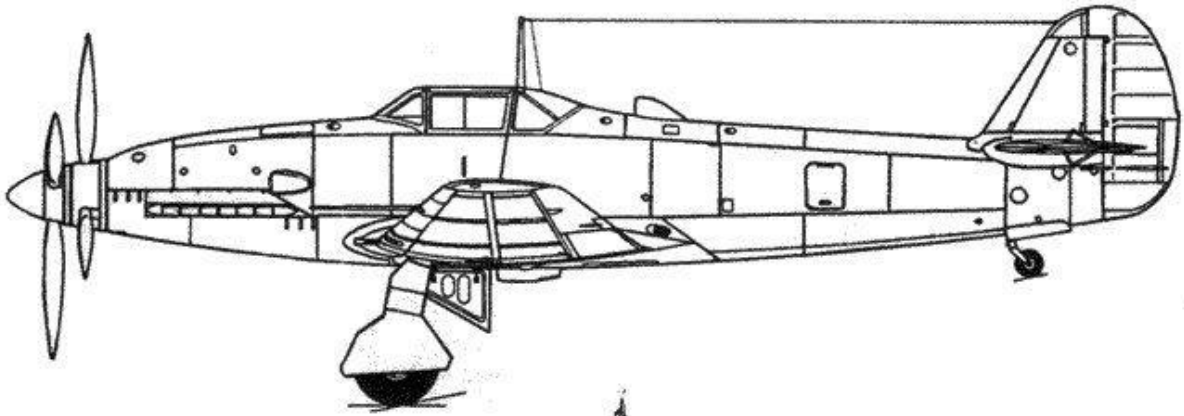
Dans le secteur de l'aéronautique, l'avionneur Kawasaki s'était lancée en avril 1940 dans la conception de deux nouveaux chasseurs motorisés par le Daimler-Benz DB-601A, moteur dont la licence de fabrication venait d'être acquise par le Japon. Rebaptisé Kawasaki Ha-40, ce nouveau moteur devait équiper le futur chasseur de l'armée impériale (le Kawasaki Ki-61 fut choisi en janvier 1943) mais aussi susciter des développements inattendus. Les ingénieurs de Kawasaki se mirent en effet en tête de concevoir un nouveau chasseur lourd équipé d'une motorisation inédite rassemblant deux Ha-40 en tandem. La conséquence fut l'apparition du Ki-64.



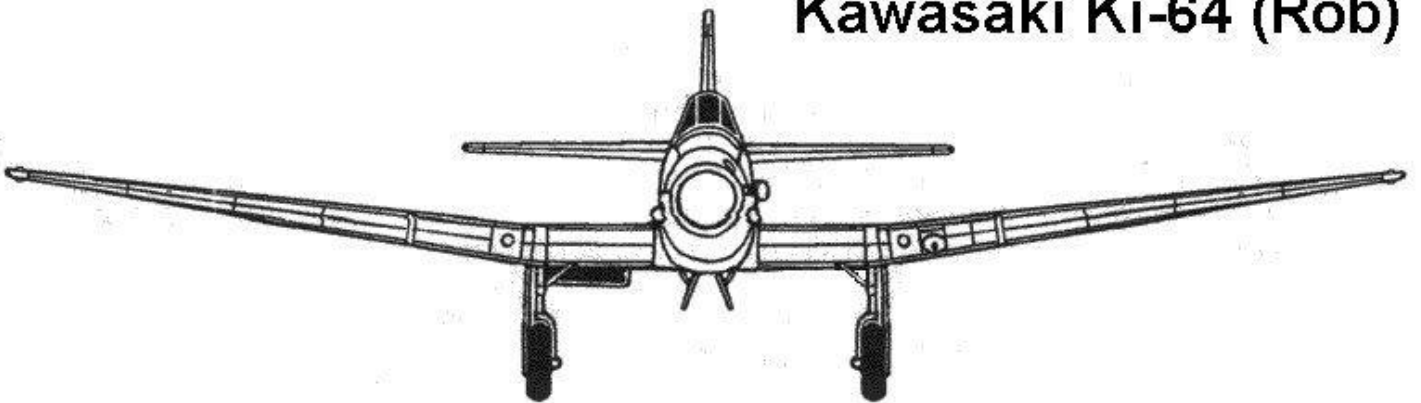
La date à laquelle le programme Ki-64 fut lancé varie selon les sources. L'éventail des dates varie de 1939 à 1943 selon les auteurs ! Toutefois, il est peu probable que Kawasaki ait commencé à travailler sérieusement sur le Ki-64 avant l'été 1940. Edwin M. Dyer évoque le mois d'octobre 1940, date à laquelle les autorités militaires auraient donné leur accord à l'ingénieur Takeô Doi pour étudier un chasseur capable d'atteindre les 700 km/h à 5 000 mètres d'altitude, avec une vitesse ascensionnelle lui permettant d'atteindre cette altitude en cinq minutes. Il est en revanche acquis que le programme fut très lent en raison de sa complexité, des impératifs de la production (Kawasaki étant alors engagée dans la fabrication des bombardiers Ki-49 et dans celle du chasseur lourd Ki-45, ce dernier suscitant autant d'espoirs que de déboires). L'unique prototype du Ki-64 (*Shisaku Kôsoku Sentô-ki* - Chasseur à grande vitesse expérimental) ne sortit de l'usine de Gifu qu'en décembre 1943. Son programme d'essais en vol débuta immédiatement.



Le Ki-64 se présentait comme un chasseur monoplane tout à fait classique, avec une voilure à profil laminaire implantée en position basse au milieu du fuselage et une dérive standard. Sa structure était métallique et son train d'atterrissage (deux jambes de train avant avec roues carénées, une roulette de queue arrière) entièrement escamotable. La verrière du cockpit qui semble-il, était pressurisé, offrait une excellente visibilité facilitant le travail du pilote. Mais la vraie différence se situait au niveau des moteurs. A la différence de la plupart des chasseurs de l'époque, ils se situaient en avant mais aussi en arrière du cockpit.



Kawasaki Ki-64 (Rob)



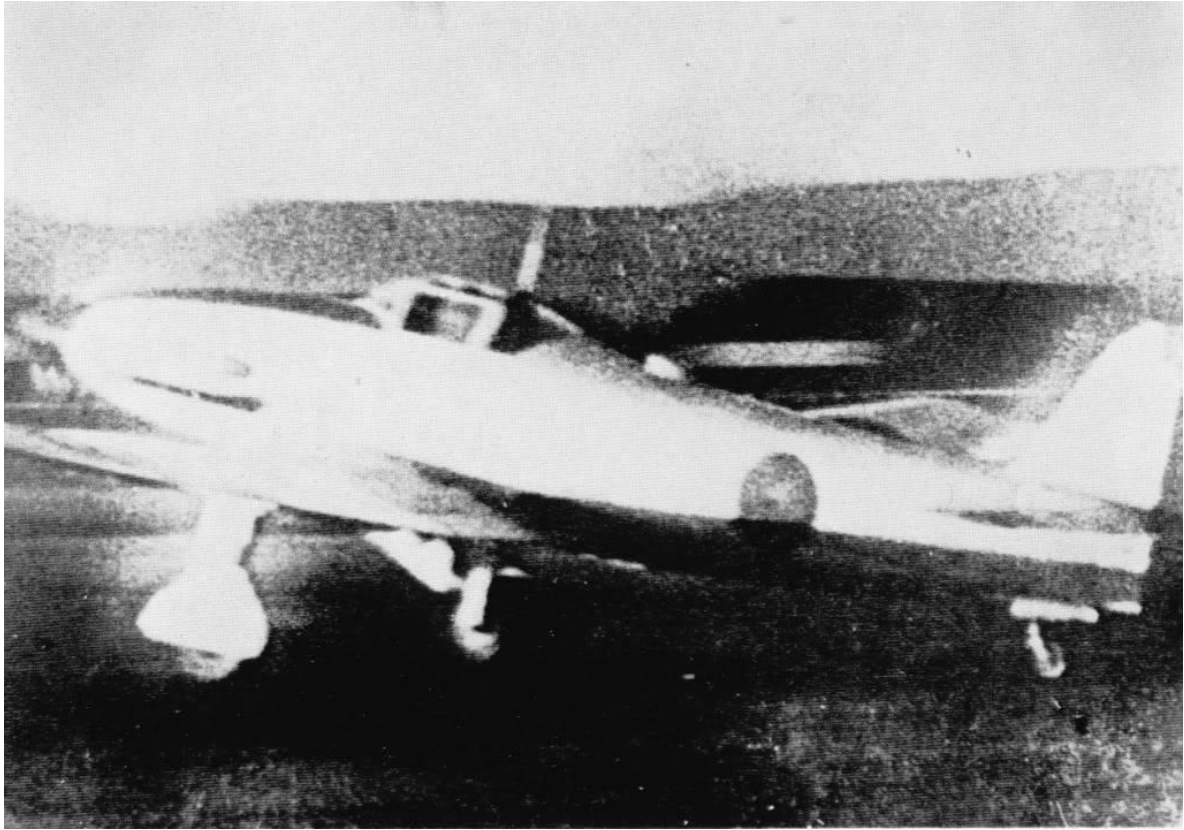
Le Ha-201 était une combinaison de deux moteurs Ha-40 montés en tandem et reliés par un arbre de transmissions passant sous le cockpit (similaire à celui du Bell P-39 *Airacobra*). Ils entraînaient deux hélices tripales métalliques contrarotatives. L'hélice avant (entraînée par le moteur le plus à l'arrière) était à pas variable, l'hélice arrière (entraînée par le moteur situé devant le cockpit) à pas fixe, ce qui rendait les réglages délicats et pouvait poser des problèmes de fiabilité même si l'avion pouvait voler avec un seul de ses deux moteurs. Ainsi équipé, le Ki-64 pouvait frôler les 700 km/h en vitesse de pointe, soit près de 100 km/h de plus que le Ki-61 et presque 150 km/h de plus que le Nakajima Ki-43-III. Pour empêcher la surchauffe des moteurs à refroidissement liquide et pour réduire la traînée en vol, les radiateurs furent intégrés à la voilure : l'air chaud était refroidi par l'eau contenue dans deux réservoirs montés dans les ailes (cinquante-huit litres chacun), les volets ainsi que la partie extérieure des ailes assurant son passage dans les moteurs.



Avec un plafond pratique de 12 000 mètres d'altitude, il pouvait théoriquement intercepter les bombardiers lourds américains avec plus de facilité que les autres chasseurs japonais de l'époque. L'armement demeure théorique, le Ki-64 n'ayant jamais été armé en vol. Le choix des ingénieurs de Kawasaki semble s'être porté sur deux paires de canons Ho-5 calibre 20 mm (deux dans la voilure, deux dans le fuselage), ce qui lui donnait une puissance de feu plus que respectable. Il est aussi parfois évoqué un assortiment de deux canons Ho-5 et de deux mitrailleuses Ho-103 calibre 12,7 mm, et une version encore plus lourde avec deux canons calibre 37 mm. Aucun point d'emport ne semble avoir été prévu. Bien qu'emportant 618 litres de carburant, son rayon d'action était cependant limité.



Malheureusement, le Ki-64 ne put tenir ses promesses. Les essais ne permirent de mener que cinq vols entre la fin de l'année 1943 et le début de l'année 1944. Au décollage du cinquième vol, le moteur arrière prit feu, le pilote parvenant cependant à poser l'avion sur le ventre. Mais cet atterrissage forcé causa de sérieux dommages à la cellule et aux moteurs du prototype. Devant l'étendue des dégâts, impossibles à réparer rapidement, et face à la dégradation de la situation militaire du Japon, il fut décidé par les autorités militaires de suspendre le programme Ki-64 au profit d'autres appareils plus immédiatement disponibles et moins complexes. L'unique prototype jamais produit demeura dans un coin de hangar à Gifu, où il fut trouvé en septembre 1945 par des militaires alliés.

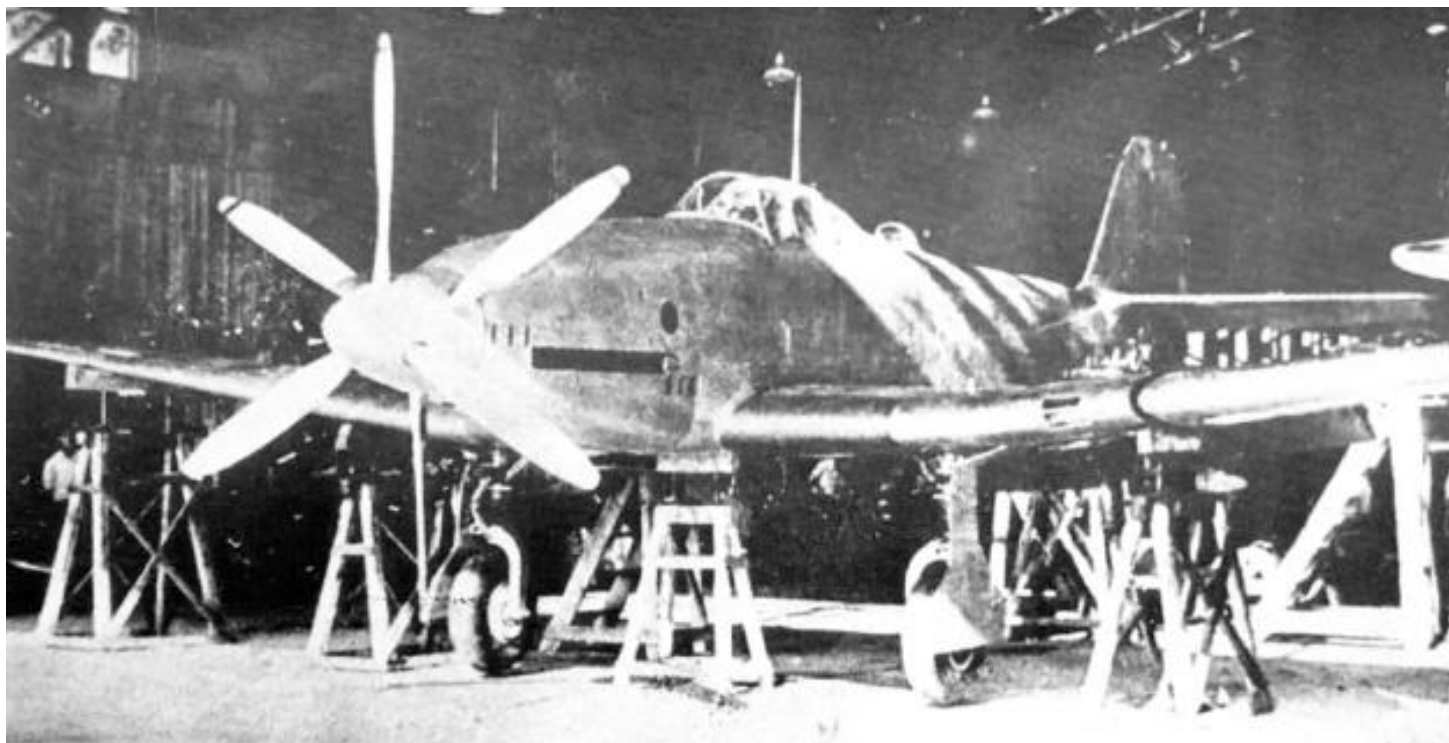


Il semble que certains éléments de l'appareil, notamment son système de refroidissement par les ailes, aient suscité quelque intérêt de la part des ingénieurs américains. Ces éléments auraient été envoyés aux États-Unis, sur la base de Wright-Patterson, pour y être étudiés. Le reste de la cellule disparut après-guerre, sans doute mis au rebut et envoyé à la ferraille. Bien que n'ayant jamais été engagé au combat, le type reçut le nom de code allié *Rob*.



Version anglaise

In the late 1930s, designers at Arsenal de l'Aéronautique in France began working on a new fighter powered by two engines installed in tandem. One engine was positioned in front of the cockpit, and the other engine was behind the cockpit. Each engine drove half of a coaxial contra-rotating propeller. This design was eventually developed into the [Arsenal VB 10](#). Takeo Doi was a Japanese designer at Kawasaki and was aware of Arsenal's tandem-engine design.



The Kawasaki Ki-64 fighter undergoing gear retraction tests in a hangar in Gifu. Note the exhaust stacks for the front engine and the dorsal air intake scoop for the rear engine.

Doi was also aware of the evaporative cooling system used on the German Heinkel He 100. Japan had sent a delegation to Germany in December 1938 that successfully negotiated the purchase of three He 100 and two [He 119](#) aircraft. The He 100s were delivered to Japan in the summer of 1940.

In 1939, Doi began to contemplate a high-speed fighter for the Imperial Japanese Army Air Force that used tandem engines and evaporative cooling. At the time, the Japanese aircraft industry was more focused on conventional aircraft, and Kawasaki and Doi were busy with designing the Ki-60 and Ki-61 *Hien* (Swallow, or Allied code name "Tony") fighters. In October 1940, Kawasaki and Doi received support for the tandem-engine fighter project, which was then designated Ki-64 (Allied code name "Rob"). The aircraft's design was refined, and a single Ki-64 prototype was ordered on 23 January 1941.

The Kawasaki Ki-64 looked very much like a continuation of the Ki-61 design, and while some of its features were inspired by other aircraft, the Ki-64 was an entirely independent design. The single-seat aircraft had a taildragger configuration and was of all-metal construction. Although designed as a fighter, the Ki-64 was primarily a research aircraft intended to test its unusual engine installation and evaporative cooling system. Proposed armament included one 20 mm cannon installed in each wing and two 12.7 mm machine guns or 20 mm cannons installed in the upper fuselage in front of the cockpit. The armament was never fitted to the prototype.

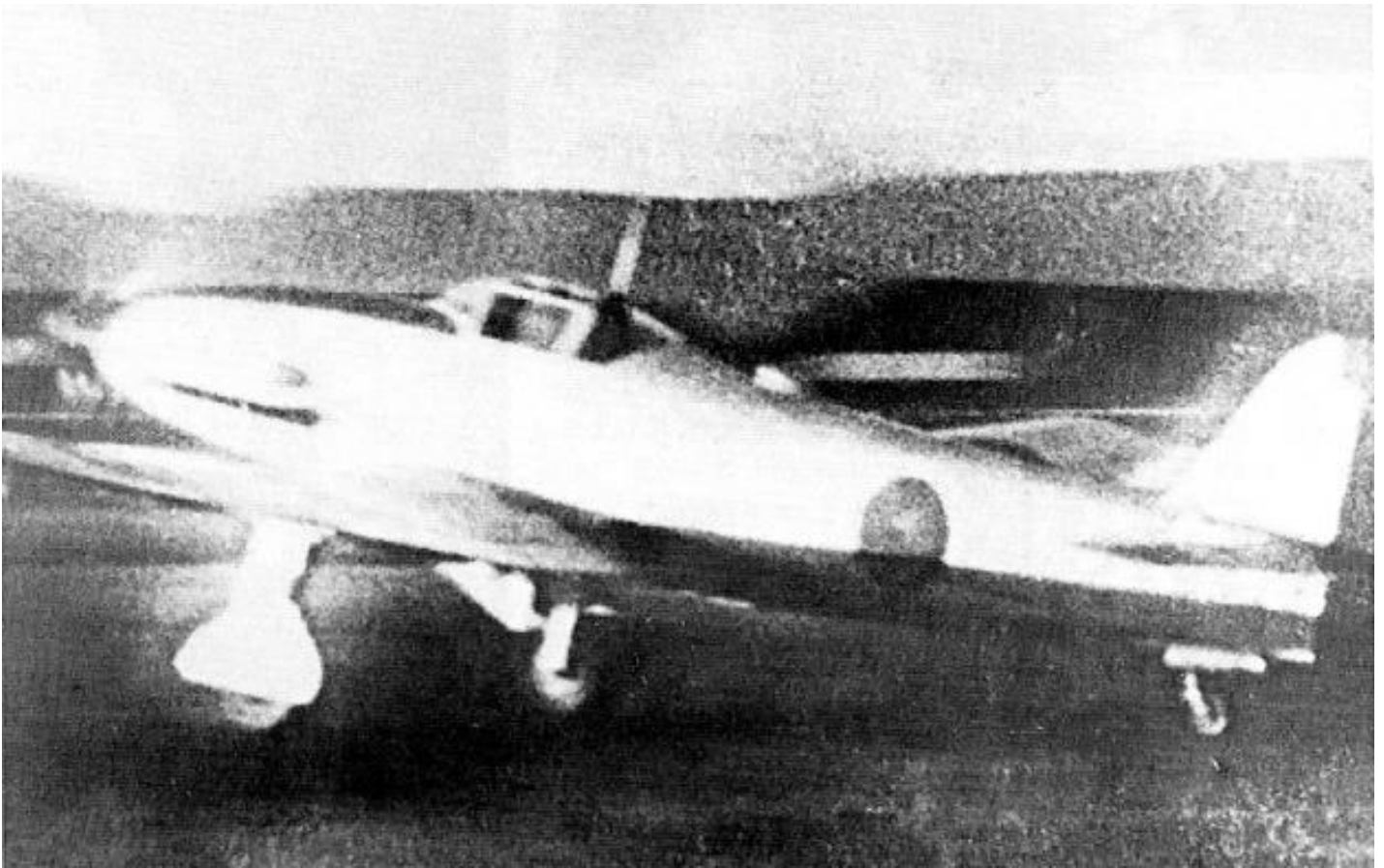


The Ki-64 appears to be preparing for an early test flight. The front engine's intake scoop can be seen just above the exhaust stacks. Note the exhaust stains from the front engine and that the lightning bolt has not yet been painted on the fuselage.

The Ki-64 was powered by a Kawasaki Ha-201 (joint designation [Ha-72]11) engine that was comprised of two Kawasaki Ha-40 inverted V-12 engines coupled to a coaxial contra-rotating propeller. The Ha-40 (joint designation [Ha-60]22) was a licensed-built Daimler-Benz 601A engine and had a 5.91 in (150 mm) bore, a 6.30 in (160 mm) stroke, and a displacement of 2,070 cu in (33.9 L). As installed in the Ki-64, the shaft for the rear engine extended under the pilot's seat and through the Vee of the front engine to the propeller gearbox. The rear engine drove the front adjustable-pitch propeller of the contra-rotating unit. The front engine drove the rear fixed-pitch propeller. Each set of propellers had three blades that were 9 ft 10 in (3.0 m) in diameter. The Ha-201 displaced a total of 4,141 cu in (67.9 L) and produced 2,350 hp (1,752 kW) at 2,500 rpm for takeoff and 2,200 hp (1,641 kW) at 2,400 rpm at 12,795 ft (3,900 m). Each engine section could operate independently of the other.

The engine sections had separate evaporative cooling systems. Heated water from the engine at 45 psia (3.1 bar) was pumped to a steam separator, where the water pressure dropped to 25 psia (1.7 bar), and about 2% of the water flashed to steam. The steam was then ducted at 16 psia (1.1 bar) through panels in the wings, where it was cooled and condensed back into water. The water then flowed back into the engine. The evaporative cooling system eliminated the drag of a radiator, and this enabled the aircraft to achieve higher speeds. It was believed that battle damage would not be much of a problem for the cooling system. The low pressure of the steam combined with steam's low density meant that the amount of coolant lost through a puncture would be minimal, and the separate engines and cooling systems helped minimize the risk of a forced landing if damage did render one system ineffective.

The evaporative cooling system for the front engine was housed in the left wing, and the rear engine's system was housed in the right wing. Each system consisted of two steam separators, an 18.5-gallon (70 L) tank in the wing's leading edge near the fuselage, four upper and four lower wing condenser panels, an upper and lower condenser section in the outer flap, and a water tank in the fuselage. Sources disagree regarding the size of each fuselage tank, but combined, the tanks held around 52.8 gallons (200 L). Suspended below the right wing was a scoop that held oil coolers for the engines.



Another image of the Ki-64 doing a ground run. Note the aircraft's resemblance to a Ki-61 Hien. Exhaust for the rear engine was collected in a manifold that exited the fuselage just above where the trailing edge of the wing joined the fuselage. That exhaust exit can just barely be discerned in this image.

The Ki-64 had a 44 ft 3 in (13.50 m) wingspan and was 26 ft 2 in (11.03 m) long. The aircraft had a top speed of 435 mph (700 km/h) at 13,123 ft (4,000 m) and 429 mph (690 km/h) at 16,404 ft (5,000 m). The Ki-64 could climb to 16,404 ft (5,000 m) in 5.5 minutes and had a service ceiling of 39,370 ft (12,000 m). Since the wings housed the cooling system, little room was left for fuel tanks. Each wing had a 22-gallon (85 L) fuel tank, and an 82-gallon (310 L) tank was housed in the fuselage; this gave the Ki-64 a 621 mile (1,000 km) range. The aircraft weighed 8,929 lb (4,050 kg) empty and 11,244 lb (5,100 kg) loaded.

While the Ki-64 was being built, a Ki-61 was modified to test the evaporative cooling system. With its radiator removed and evaporative panels added to its wings, the modified Ki-61 first flew in October 1942. Around 35 flights were made before the end of 1943, and they served to develop and refine the cooling system. The aircraft proved the validity of the evaporative cooling system and achieved a speed 25–30 mph (40–48 km/h) in excess of a standard Ki-61. However, the evaporative cooling system did require much more maintenance than a conventional system.

The Ki-64 was completed at Kawasaki's plant at Gifu Air Field in November 1943. The aircraft underwent ground tests that revealed a number of issues. By December, the issues were resolved enough for flight testing to commence. The aircraft made four successful flights, but the rear engine caught fire on the fifth flight. The pilot was able to make an emergency landing at Kakamigahara, but the rear engine and parts of the rear fuselage and cooling system had been damaged. The Ha-201 engine was sent to Kawasaki's engine plant in Akashi for overhaul, and the Ki-64 airframe was sent back to Gifu for repairs.



A poor image, but perhaps the only one, showing the Ki-64 in flight. The lightning bolt has been painted on the fuselage.

The short flying career of the Ki-64 had shown that its cooling system was insufficient. The system worked well for level flight, but it was inadequate for ground running, takeoff, and climb. When the system was overloaded, steam was not condensed back to water and was subsequently vented overboard via a 16 psi (1.1 bar) relief valve. The cooling system lost about 12 gallons (45 L) of water during a rapid climb from takeoff to 18,000 ft (5,500 m). Water freezing within the system, either while in flight or on the ground during cold temperatures, was another concern. Adding an alcohol mixture to the water coolant was a possible solution, but the Ki-64 never underwent any cold weather testing.

While undergoing repairs, the Ki-64 was to be modified and redesignated Ki-64 Kai. The existing propellers would be replaced with fully adjustable and feathering contra-rotating propellers, which would make it easier for one engine to be shut down in flight. The engines were to be replaced with more powerful Ha-140s (joint designation [Ha-60]41), each of which was capable of 1,500 hp (1,119kW). The coupled engine was designated Ha-321 (joint designation [Ha-72]21) and produced 2,800 hp (2,088 kW). With the changes, it was estimated that the Ki-64 Kai would have a top speed of 497 mph (800 km/h). However, the propeller and engines were delayed by more pressing war-time work, and the Ki-64 program was cancelled in mid-1944.

The Ki-64 airframe remained at Gifu where it was captured by American forces in 1945. Various parts of the cooling system were removed from the aircraft and shipped to Wright Field in Dayton, Ohio for further analysis and testing. The remainder of the Ki-64 was eventually scrapped.



The K-64 as discovered by American forces at the end of World War II. The engines had been removed, and the aircraft was in a rather poor state. Note the canopy frame sitting on the wing.

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