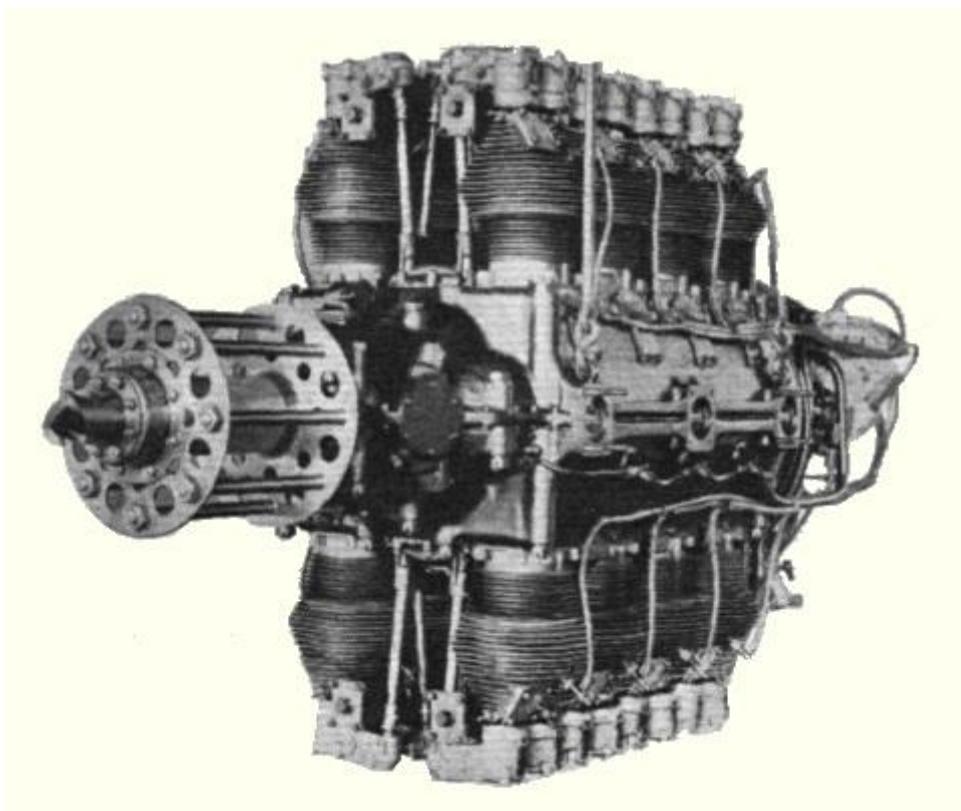


Napier Rapier



Le Napier Rapier était un moteur à refroidissement par air, seize cylindres en H (deux huit cylindres à plat superposés), construit avant la Deuxième Guerre mondiale. Ce moteur compact et d'une surface frontale réduite, était d'une cylindrée de 8,83 litres (alésage de 89,0 mm, pour une course de 89,0 mm), il était globalement formé de deux huit cylindres à plat superposés, placés verticalement, et entraînant deux vilebrequins parallèles. Le principe de moteur à plat, avec les cylindres opposés, assurait un bon équilibrage, puisque les centres de gravité des éléments mobiles étaient symétriques par rapport à l'axe du vilebrequin, et procurait un fonctionnement régulier.

La puissance maximale de ce propulseur, pour un Rapier VI, était de 400 ch à 4.000 tr/min, à 1.830 m. La puissance au décollage était de 370 ch à 3.500 tr/min. La vitesse de rotation maximale était élevée pour l'époque, puisqu'elle atteignait 4.000 tr/min. Le taux de compression était de 7,1:1. Le poids à sec était d'environ 325 kg, et les dimensions étaient, longueur de 1,457 m, largeur de 59,4 cm, hauteur de 91,4 m. La distribution était classique, avec soupapes (une d'admission, une d'échappement par cylindre), tiges et culbuteurs. Le carburateur était un Napier-Claudell-Hobson. Ce moteur était doté d'un réducteur d'hélice (rapport de réduction 2,5625:1).

Le carter, en alliage de magnésium, était assemblé dans le plan des deux vilebrequins parallèles. Ces derniers, sans contrepoids, étaient montés sur bronze au plomb, et entraînaient un pignon commun solidaire de l'arbre d'hélice. Les culasses en alliage léger, étaient vissées à chaud sur les fûts fixés au carter par des goujons. Les soupapes en tête étaient disposées dans la même plan, elles étaient actionnées par des culbuteurs et des tiges, dont les conduits étaient placés, à l'intérieur du H, de manière oblique, à la façon des moteurs en étoile. Le graissage était fait sous pression via des conduits pris dans la masse, menant aux différents points (axes de pistons, manetons du vilebrequin). Le compresseur, placé en arrière, alimentait les groupes de cylindres, via quatre sorties radiales, l'admission et l'échappement se faisant sur l'extérieur du H. L'allumage comprenait deux magnétos dont l'avance était couplée à la commande de gaz, et deux bougies placées latéralement, une de chaque côté des cylindres. Tous les accessoires étaient placés latéralement, à l'arrière du bloc moteur.

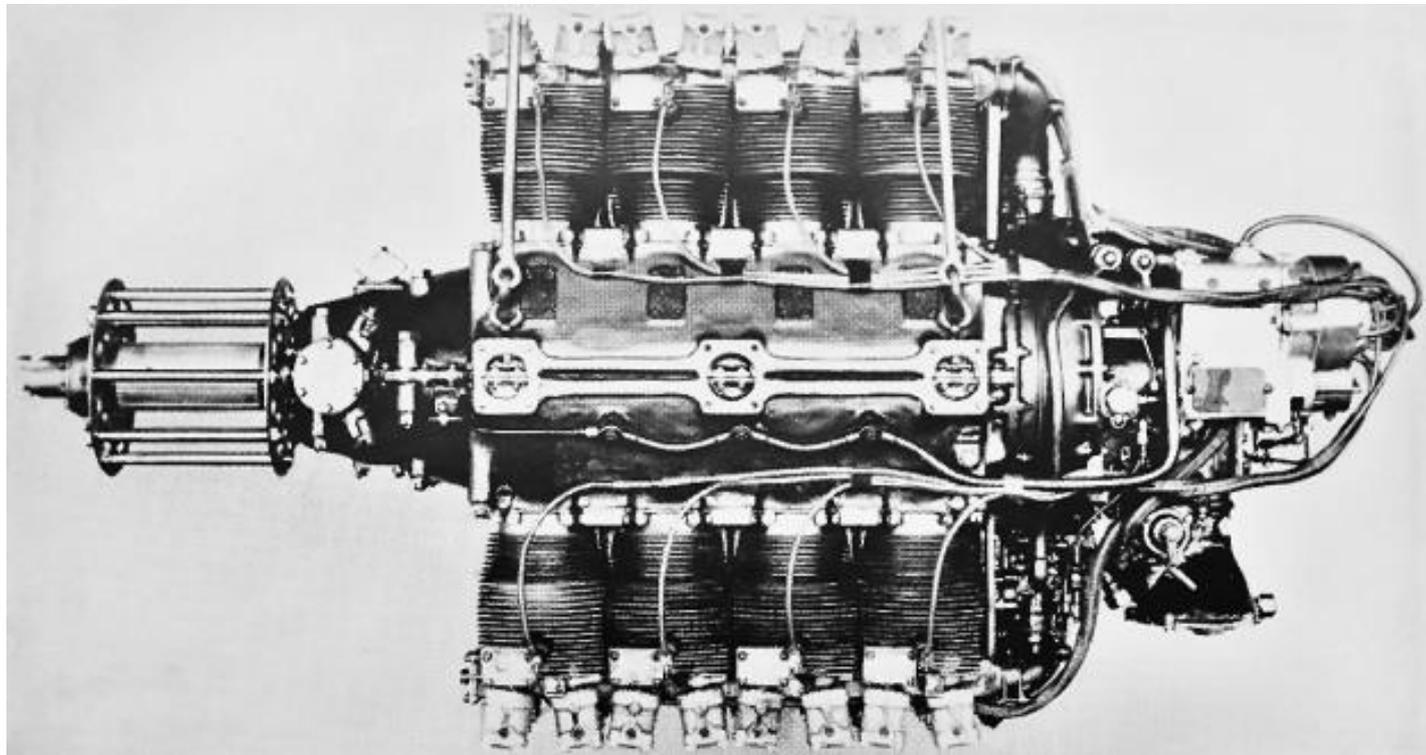
Le Napier Rapier fut monté sur l'hydravion embarqué Fairey [Seafox](#), et l'hydravion civil Short [S.20](#) faisant partie du Mayo S.20/S.21 Composite. Il fut aussi employé, mais de manière marginale, ou pour des essais, sur le Airspeed [A.S.5](#) Courier, le Blackburn H.S.T.10, le Bristol [Bulldog](#), le chasseur expérimental de Havilland [D.H.77](#), et le Saro Cloud A.19/1. Cependant, bien qu'étant reconnu comme un bel ensemble mécanique, ce moteur fut victime des mêmes problèmes que le propulseur dérivé, le Napier [Dagger](#), et ne fut finalement pas un succès.

Source partielle : Gallica, Les Ailes, décembre 1938.

Source : http://jnpassieux.fr/www/html/Napier_Rapier.php

Version anglaise

Frank Bernard Halford had been an aircraft engine designer since World War I. In 1923, he established himself as a for-hire consultant to design aircraft engines for established manufacturers. By 1927, Halford had designed a new high-revving aircraft engine with numerous small cylinders and minimal frontal area. Halford's belief was that a smaller engine running at a faster speed would produce the same power as a larger engine running at a slower speed. The new engine design was a vertical H with four cylinder banks, each with four individual cylinders.

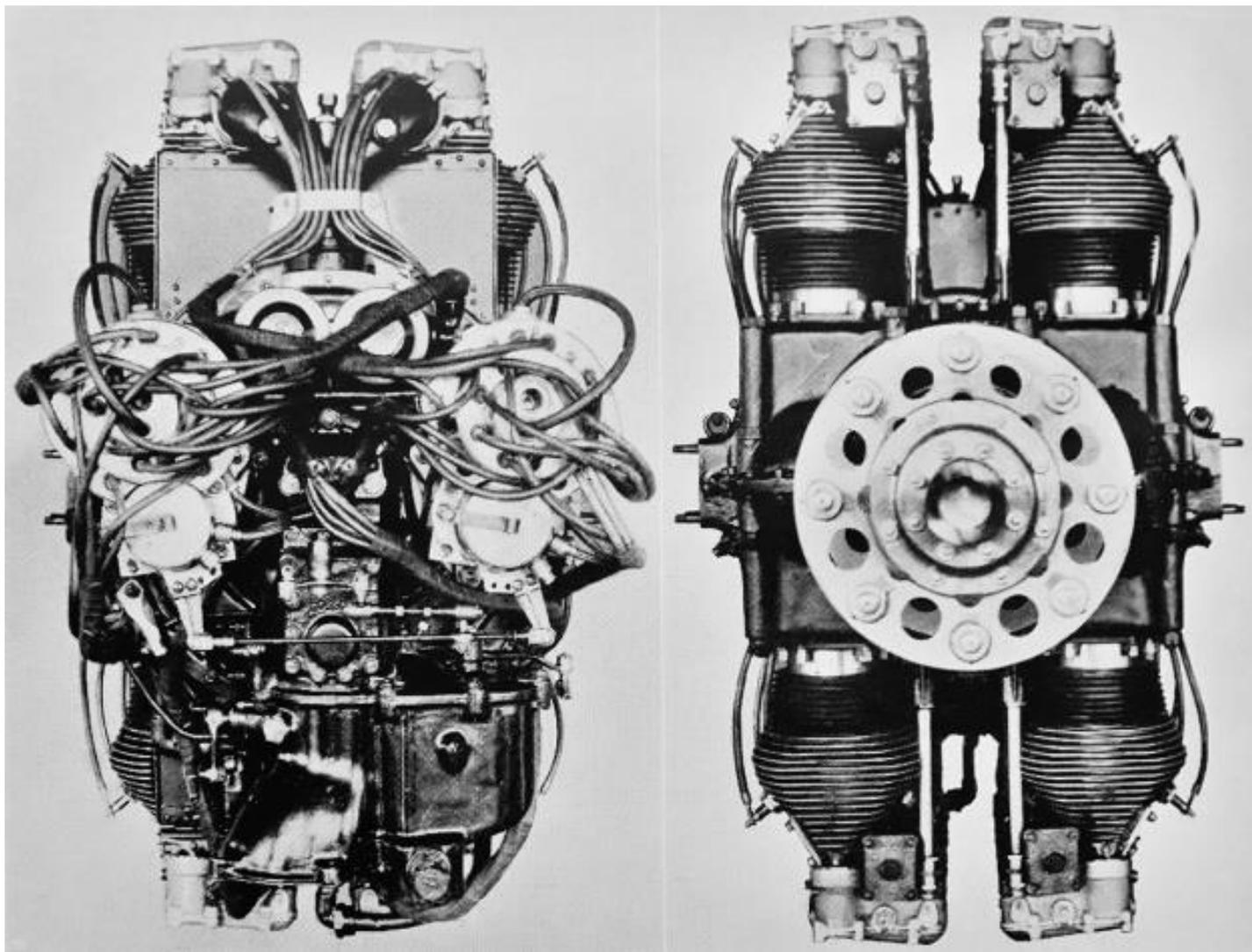


The Napier Rapier I with its intake and exhaust ports mounted on opposite sides of the cylinder, Note the magnetos mounted to the rear of the engine and the external oil line on the crankcase.

Halford showed the design to George Purvis Bulman, the Chief Inspector (of engines) for the British Ministry of Munitions. Bulman was impressed with the design and knew that the British engineering firm D. Napier & Son (Napier) was in search of a new product. Napier's Lion W-12 aircraft engine was designed 10 years previous, and the company had stopped producing automobiles in 1924. Napier wanted to pursue the development of new aircraft engines but felt that its current in-house design department did not have the needed experience.

Bulman introduced Halford to George Pate, Napier's Production Chief Engineer. With the blessing of Napier's board of directors and its chairman, Montague Stanley Napier, Halford was contracted in 1928 to design aircraft engines for Napier.

One stipulation was that the engines must fall between a displacement of 404.09 and 718.37 cu in (6.62 and 11.77 L) to not conflict with any of Halford's projects with other companies. Halford immediately began detailed design work on the H-16 engine, which would eventually be known as the Rapier. The engine is often referred to as the Napier-Halford Rapier.



Rear and front views of the Rapier I. On the left, the upper "Y" intake pipe can be seen behind the spark plug wires. On the right, the intake manifolds can be seen atop the inner side of the cylinder banks, just under the valve rocker housings.

Much of Halford's previous aircraft engine experience was with air-cooled cylinders, and the 16-cylinder Rapier was no different. An Air-cooled engine was lighter and less complex than a liquid-cooled engine. The Rapier had a two-piece aluminum crankcase that was split horizontally at its center. The left and right crankshafts were supported between the two crankcase halves via five main bearings each. Each one-piece, four-throw crankshaft served one vertical and one inverted bank of cylinders. The crankshafts were phased at 180 degrees (some sources say 90 degrees, and it may be that the Rapier I was so phased and that later engines were at 180 degrees). Power strokes occurred simultaneously for both crankshafts. The connecting rod attached to each crankpin was a master rod with an articulating rod mounted to its end cap. When viewed from the rear, master rods served the upper left and lower right cylinder banks. Spur gears at the front of each crankshaft meshed with a larger gear that was mounted to the propeller shaft, which turned at .390 crankshaft speed. When viewed from the rear, both crankshafts rotated clockwise, and the propeller shaft rotated counterclockwise.

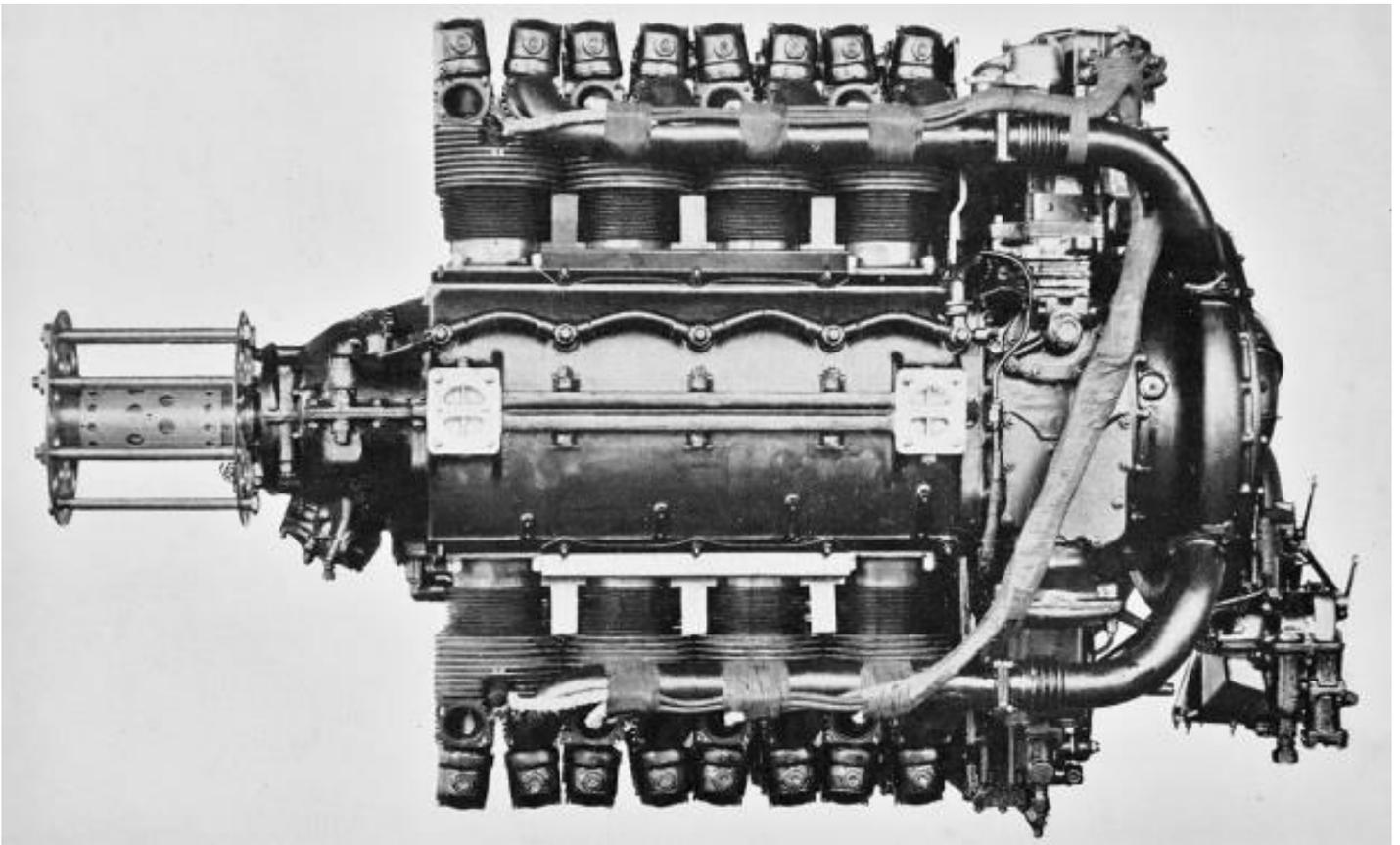
The air-cooled cylinders were made of aluminum heads that were screwed and shrunk onto forged steel barrels. Each cylinder was mounted to the crankcase via four studs. The cylinders had a 6.0 to 1 compression ratio, and each cylinder had a single intake and a single exhaust valve. The intake port was on the inner side of the cylinder, and the exhaust port was on the outer side. The valves for each set of eight upper and lower cylinders were actuated by a single camshaft via pushrods and rockers. Each camshaft was located between its respective set of cylinders (upper and lower). Each cylinder had one spark plug mounted on its outer side and another mounted on its inner side.



The Havilland DH.77 prototype fighter monoplane was initially powered by a Rapier I engine, but a Rapier II was later installed. Note the individual exhaust stacks and the machine gun installed on the side of the aircraft.

An accessory drive case was mounted to the back of the engine. A shaft extending back from the propeller shaft powered the accessory drive gears. Driven from the accessory case were the camshafts, magnetos, supercharger, generator, and various accessories. The engine's two magnetos were mounted to the rear of the accessory case, and each magneto fired one of the cylinder's two spark plugs. The single-speed supercharger drew in air through an updraft carburetor and compressed the air and fuel mixture with a centrifugal impeller. The air and fuel mixture exited the top and bottom of the supercharger housing into a Y pipe that distributed the charge to each cylinder via a manifold that ran along the inner side of each cylinder bank. A hand crank or an air starter was used to start the engine.

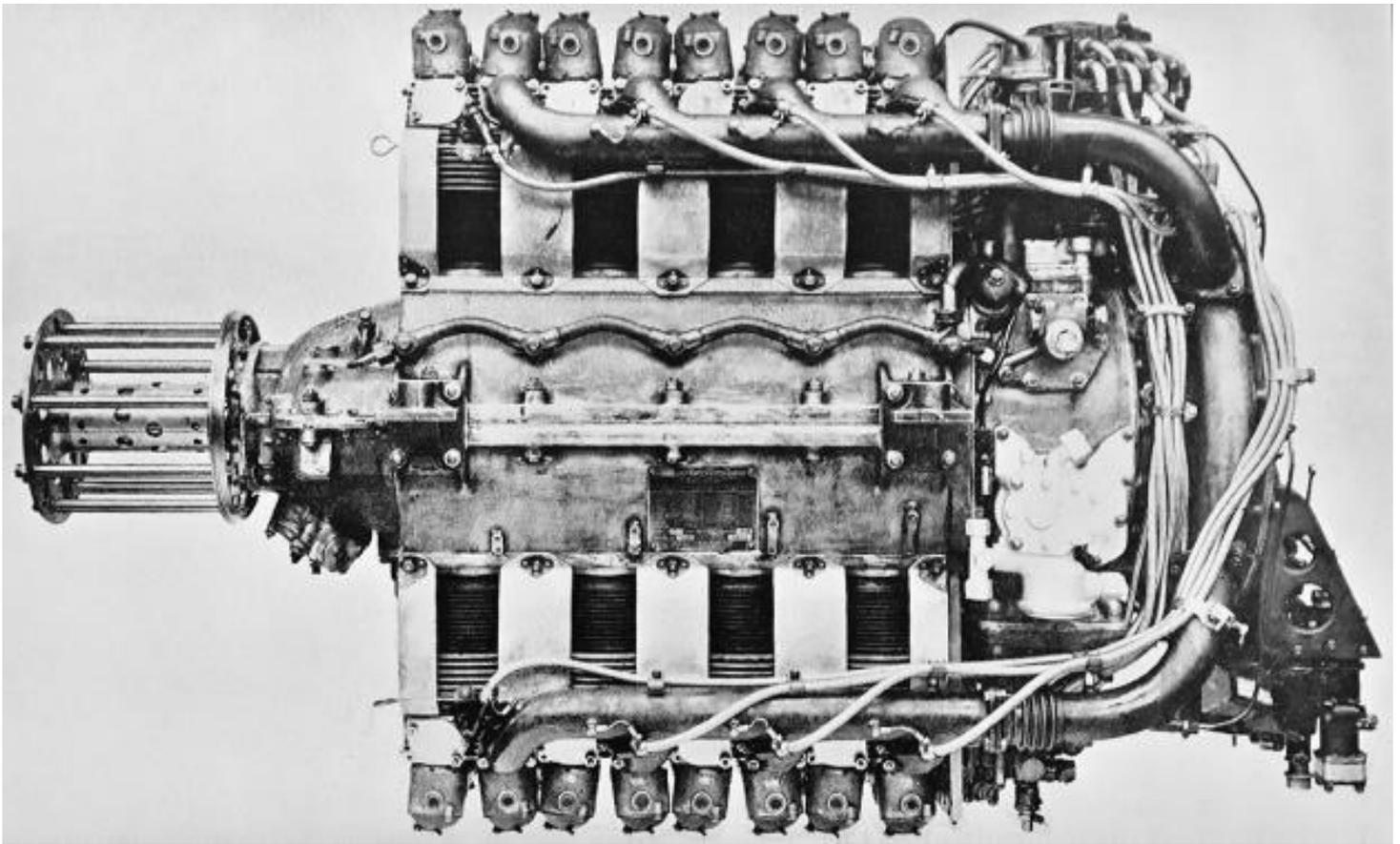
Napier developed a cowling for the Rapier so that the engine could be installed as a complete package. The cowling was narrow in form and had large upper and lower scoops. For engine cooling, air was ducted between the upper and lower cylinders. Baffles directed the air's flow through the cylinders' integral cooling fins and to the outer side of the cylinder banks. The cooling air exited via a cowl flap on each side of the aircraft and behind the engine.



The Rapier II had a revised cylinder with intake and exhaust ports on its outer sides. The supercharger housing was also modified with four outlets serving individual intake manifolds for each cylinder bank. Note the crankcase's horizontal parting line.

The Napier Rapier I was designated by Napier as the E93. The engine had a 3.5 in (88.9 mm) bore and a 3.5 in (88.9 mm) stroke. Each cylinder displaced 33.7 cu in (.55 L), and the Rapier's total displacement was 539 cu in (8.83 L). At sea level, the engine had a maximum output of 350 hp (261 kW) at 3,900 rpm and a normal output of 300 hp (224 kW) at 3,500 rpm. The Rapier I was 54 in (1.37 m) long, 21 in (.53 m) wide, and 35 (.90 m) tall. The engine weighed 620 lb (281 kg).

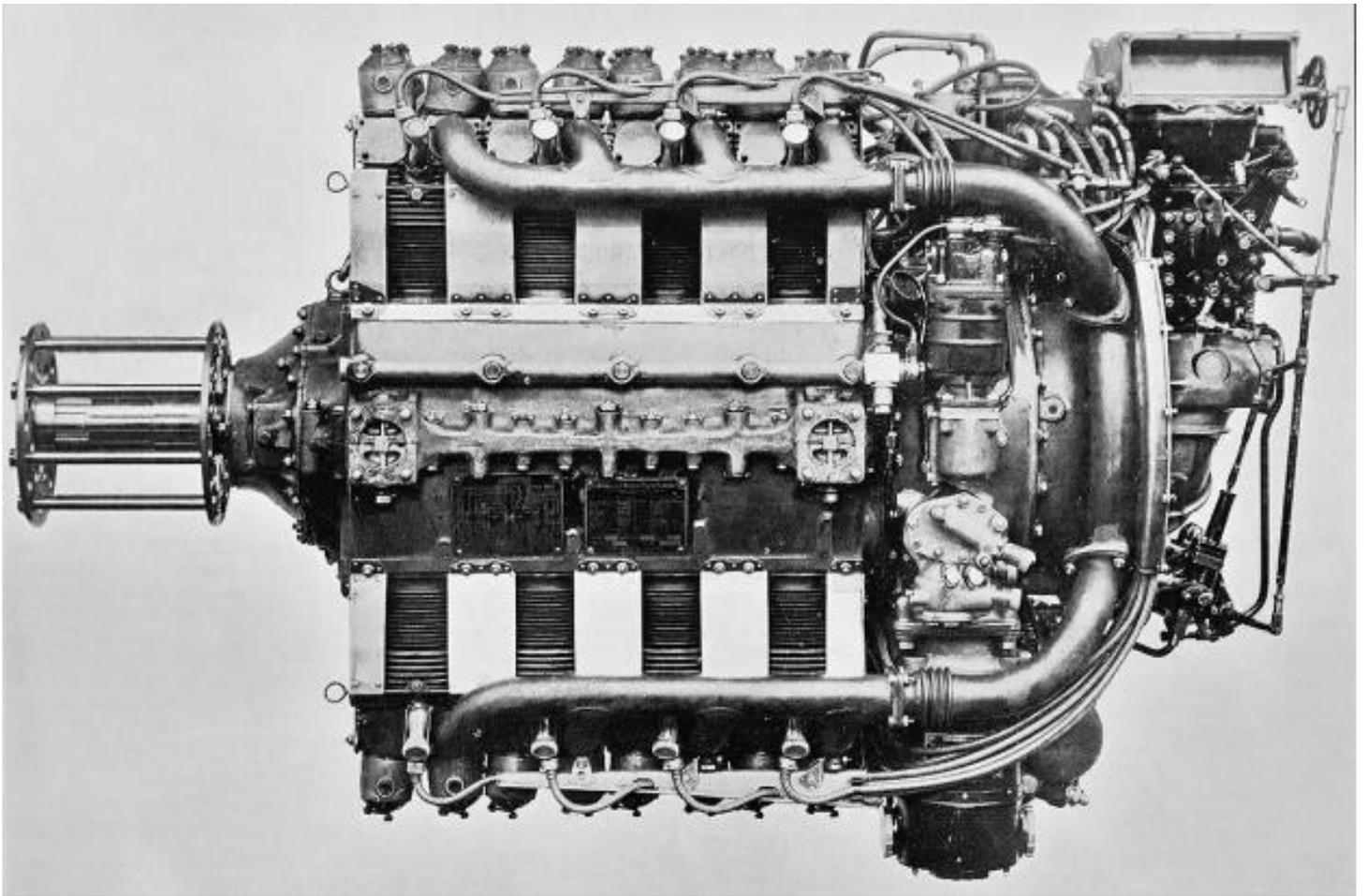
The Rapier I was first run around the start of 1929 and was mainly a developmental engine. The engine was installed in the de Havilland DH.77 (J9771) prototype fighter monoplane, which made its first flight on 11 July 1929. Although the aircraft exhibited good qualities, it was not selected for production. After completing its evaluation, the DH.77 was used to accumulate 100 hours of engine tests until December 1932. A Rapier II engine (see below) was then installed with a modified cowling. Engine development continued until the summer of 1934, when the aircraft was scrapped. The Rapier I was also installed in a Bristol Bulldog TM (K3183) biplane trainer around 1933. The aircraft served as the Rapier I test bed to evaluate the engine and cowling in a wind tunnel and in flight. Bulldog TM (K3183) kept its Rapier powerplant until 1938, when it was used to test another engine.



The Rapier IV was very similar to the Rapier II but with decreased supercharging. The baffles helped direct cooling air through the cylinder's fins. Note the magneto mounted vertically from the accessory case.

The Rapier II was a development of the Rapier I with the supercharger's impeller geared at a higher speed to improve the engine's performance at altitude. New cylinders were used that had the intake and exhaust ports both located on the outer side of the cylinder. The induction system was revised with four outlets from the supercharger that distributed the air and fuel mixture via separate manifolds to each cylinder bank. The accessory case was also updated with the magnetos mounted vertically.

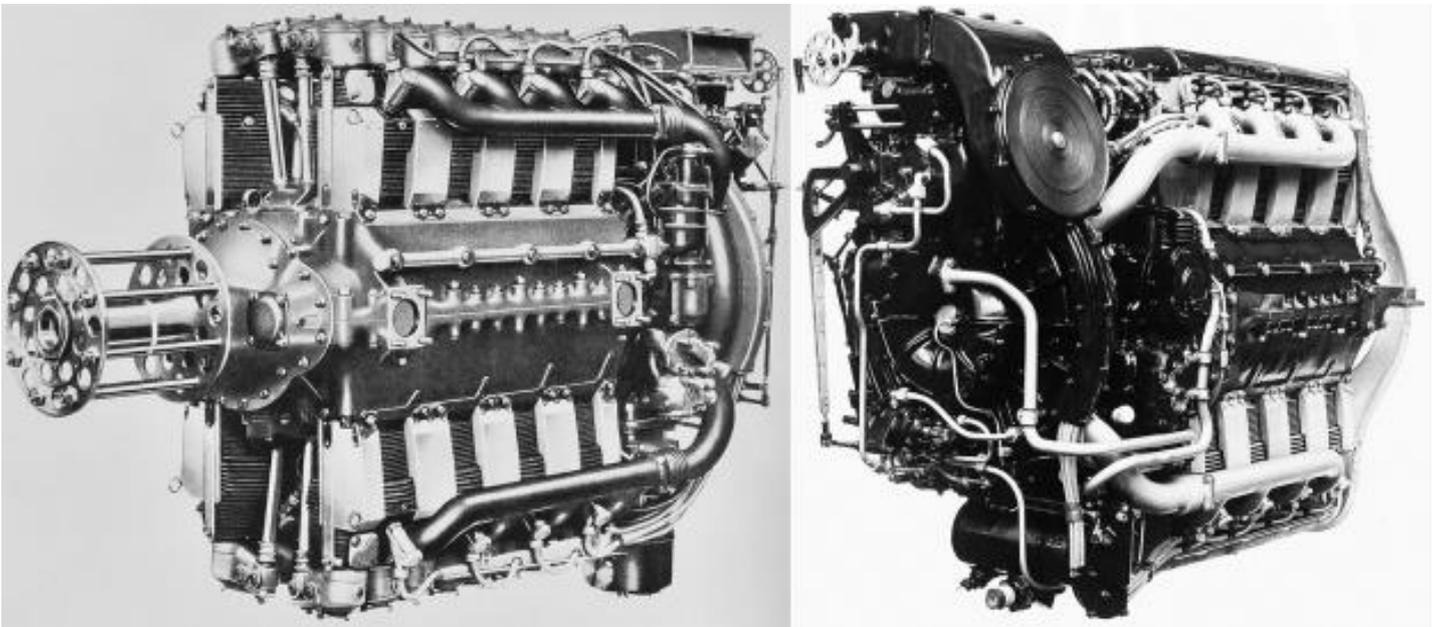
The Rapier II carried the Napier designation E95 and was first run in 1932. At 10,000 ft (3,048 m), the Rapier II had a maximum output of 355 hp (265 kW) at 3,900 rpm and a normal output of 305 hp (227 kW) at 3,500 rpm. The engine was 55.25 in (1.40 m) long, 20.75 in (.53 m) wide, and 35.25 (.90 m) tall. The engine weighed 710 lb (322 kg). As mentioned above, the engine was installed in the DH.77 prototype, which flew in this configuration in early 1933.



The Rapier VI had a revised, magnesium crankcase, a separate gear reduction housing, and used a downdraft carburetor. Otherwise, its structure was similar to that of the Rapier IV.

The Rapier IV was similar to the Rapier II, but it generated maximum power at low altitude due to revised supercharger gearing. At sea level, the Rapier IV had a maximum output of 385 hp (287 kW) at 3,900 rpm and a normal output of 340 hp (254 kW) at 3,500 rpm. The Rapier IV was 52.0 in (1.32 m) long, 21 in (.53 m) wide, and 37.7 in (0.96 m) tall. The engine weighed 726 lb (329 kg). The Rapier IV was first run in 1933, and Napier purchased an Airspeed Courier AS.5C (G-ACNZ) touring aircraft to serve as an engine testbed that same year. The AS.5C with its Rapier IV engine was first flown in June 1934. The aircraft was used as a demonstrator for a few years. By 1937, the engine had been replaced, and the aircraft was sold. Prior to AS.5C's delivery, two Rapier IV engines were installed in a Saro A.19/1A Cloud (G-ABCJ) amphibious transport. The A.19/1A was the first testbed for the Rapier IV. The aircraft was loaned to Jersey Airways in August 1935 and withdrawn from service in December 1936.

The Rapier V was a further development of the Rapier line. Changes consisted of a magnesium crankcase, a separate updated gear reduction housing, fork-and-blade connecting rods, and an increased compression ratio of 7.0 to 1. The forked rods were in the rear lower cylinders, second from rear upper cylinders, second from front lower cylinders, and front upper cylinders. The induction system was revised to accommodate a downdraft carburetor. The engine was given the Napier designation E100 and was first run in around 1934. At 10,000 ft (3,048 m), the Rapier V had a maximum output of 380 hp (283 kW) at 4,000 rpm and a normal output of 340 hp (254 kW) at 3,650 rpm. Fuel consumption at cruise power was approximately .429 lb/hp/hr (261 g/kW/h) at 240 hp (179 kW) and 3,300 rpm. The Rapier V was 57.37 in (1.46 m) long, 23.37 in (.59 m) wide, and 36.0 in (.91 m) tall. The engine weighed 720 lb (326 kg). Four of the engines were installed in the Short S.20 Mercury (G-ADHJ) seaplane, which first flew on 5 September 1937. These engines were replaced with Rapier VIs in June 1938.



Front and rear views of the Rapier VI. Internally, the engine used fork-and-blade connecting rods and had a cylinder compression ratio of 7.0 to 1. It was the most powerful of the Rapier engines.

The Rapier VI (possibly E106) was similar to the Rapier V, but with decreased supercharging. The Rapier VI had a maximum rating of 395 hp (295 kW) at 4,000 rpm at 6,000 ft (1,829 m); a normal rating of 370 hp (276 kW) at 3,650 rpm at 4,750 ft (1,448 m); and a takeoff rating of 365 hp (272 kW) at 3,500 rpm at sea level. Fuel consumption at cruise power was approximately .412 lb/hp/hr (251 g/kW/h) at 310 hp (231 kW) and 3,500 rpm. The engine was 56.6 in (1.44 m) long, 22.4 in (.57 m) wide, and 36.0 in (.91 m) tall. The Rapier IV weighed 713 lb (313 kg). The engine was first installed in the Fairey Seafox reconnaissance float plane, which made its first flight on 27 May 1936. Early issues were experienced with engine cooling, but ultimately 66 Seafoxes were built, making it the most successful Rapier application. The Seafox was withdrawn from service in 1943. The Rapier IV was also installed in the Blackburn H.S.T.10 transport, the development of which was halted in 1936, before the aircraft was completed.



The Fairey Seafox reconnaissance float plane was powered by the Rapier VI engine, and 66 examples of the aircraft were built.

As previously mentioned, four Rapier VI engines were installed in the Short S.20 Mercury in June 1938. When the S.20 was mounted atop the Short S.21 Maia, the pair formed the Short-Mayo Composite, which was envisioned to provide long-range transport service. After being hoisted aloft by the Short S.21 Maia on 21 July 1938, the S.20 separated and later completed the first commercial, non-stop East-to-West transatlantic flight by a heavier-than-air machine. The Maia-Mercury composite went on to establish a seaplane distance record, covering 6,045 miles (9,728 km) between 6 and 8 October 1938. The Mercury and Maia made several flights until commercial operations were suspended due to World War II.

Cooling the Rapier engine was particularly difficult while the aircraft was on the ground. The uncuffed propellers did not provide sufficient airflow to effectively cool the engine, especially the rear cylinders. This issue was never fully resolved. In the early 1930s, Napier and Halford were working on the development of other aircraft engines, which would ultimately lead to the air-cooled [Dagger H-24](#) and liquid-cooled [Sabre H-24](#). By mid-1935, resources at Napier were wearing thin, and the decision was made to discontinue Rapier development so that efforts could be concentrated on other projects. Rapier production continued until around 1937. One Rapier VI engine was preserved and is on display at the Shuttleworth Collection in Bedfordshire, England.



The Short S.20 Mercury (top) and Short S.21 Maia (bottom) seaplane composite. Although originally fitted with four Rapier V engines, the Mercury had Rapier VIs installed for its service flights. The Maia was powered by four nine-cylinder Bristol Pegasus radial engines.

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