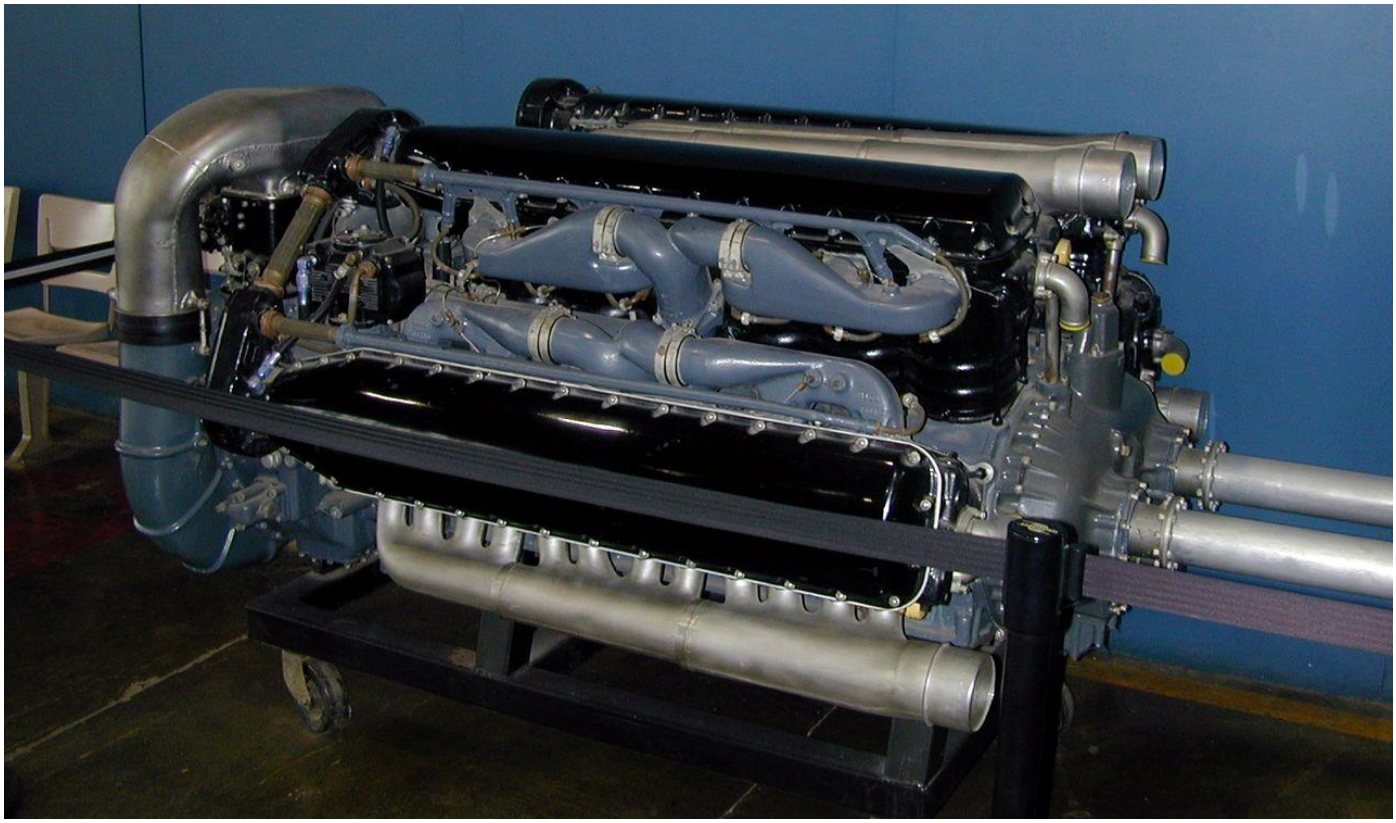
Allison V-3420



L'Allison V-3420 est un moteur d'avion à pistons américain expérimental avec une configuration en W.

Conception et développement
En 1937, à la demande de l'United States Army Air Corps, la Société Allison Engine Company fut mandatée pour concevoir et construire un moteur d'avion de grande puissance avec une grosse cylindrée. Le résultat fut le V-3420 qui était en fait le couplage d'une paire de moteurs Allison V-1710. Les deux moteurs V12 étaient reliés selon un angle de 30° entre les bancs des cylindres intérieurs et partageaient un carter commun. Les vilebrequins des deux moteurs étaient reliés par un boitier pour ne donner qu'un seul arbre porte-hélice. La plupart des pièces du V-3420 étaient interchangeables avec celles des moteurs V-1710-E et V-1710-F.
Le V-3420 avait un rapport poids-puissance de 1,6 kW/kg, ce qui était excellent pour l'époque. Moteur puissant et compact son utilisation fut envisagée pour plusieurs projets avancés de l'US Air Force, comme le Douglas XB-19, le Boeing XB-39 Superfortress, le Lockheed XP-58 Chain Lightning et le Fisher P-75 Eagle. Ces modèles ayant été produit de façon très limitée, ce ne sont environ que 150 exemplaires du V-3420 qui furent construits.

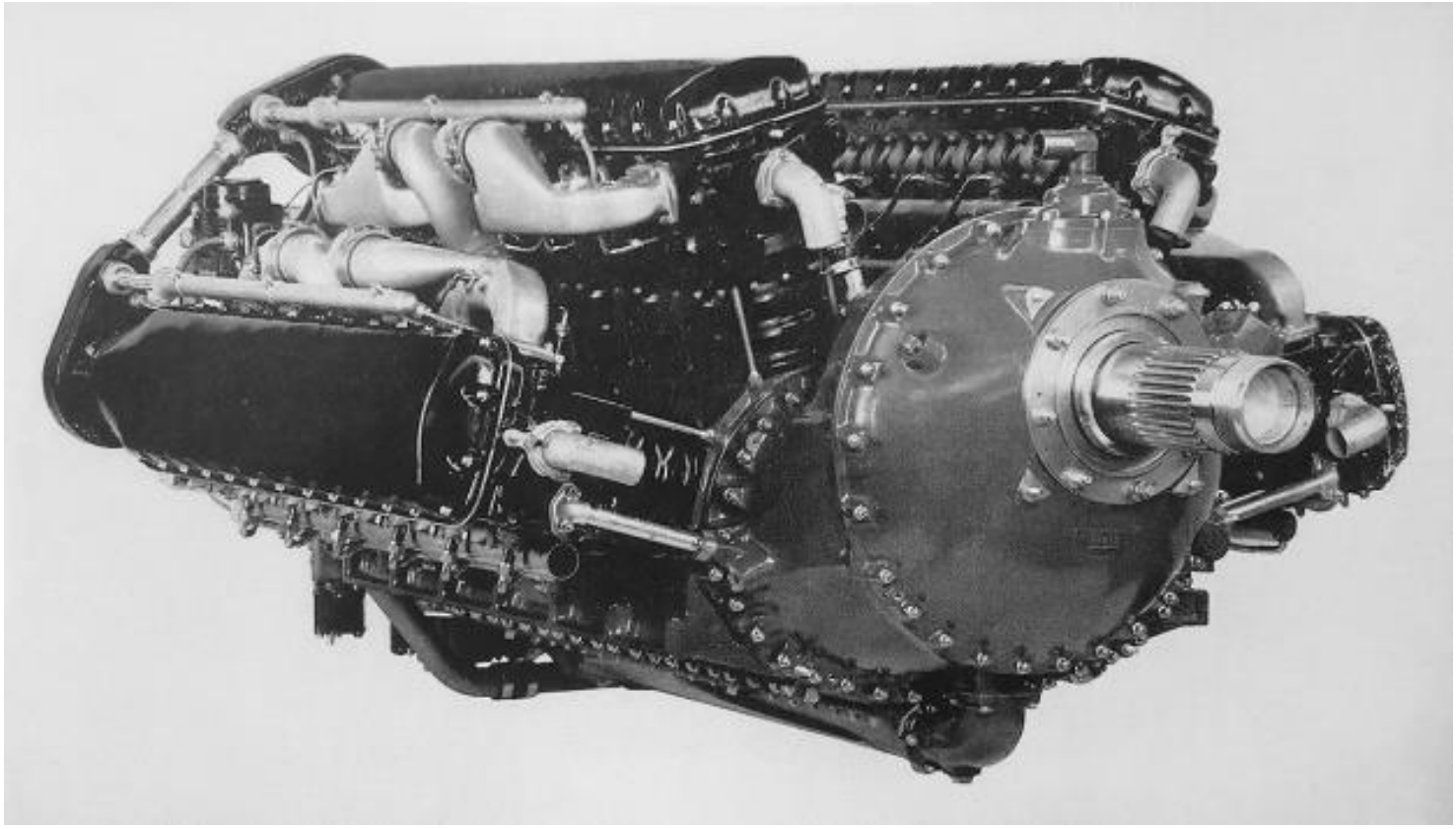
Variantes
Sauf précision contraire, cette section de l'article a pour source : (en) Paul H. Wilkinson, Aircraft Engines of the World, Londres, Wilkienson, 1970 (1re éd. 1944) (OCLC 841159367).
V-3420-A16R (-11)
V-3420-A16L (-13) Rotation de l'hélice à gauche, compresseur et turbocompresseur à un seul étage et intercooler
V-3420-A18R (-17)
V-3420-A124 Compresseur avec ratio 7.2:1
V-3420-B (-23) Semblable aux séries A, mais avec compresseur mécanique à deux vitesses variables

Applications
- Boeing XB-39 Superfortress
- Douglas XB-19
- Fisher P-75 Eagle
- Lockheed XP-58 Chain Lightning

Source : https://fr.wikipedia.org/wiki/Allison_V-3420

Version anglaise

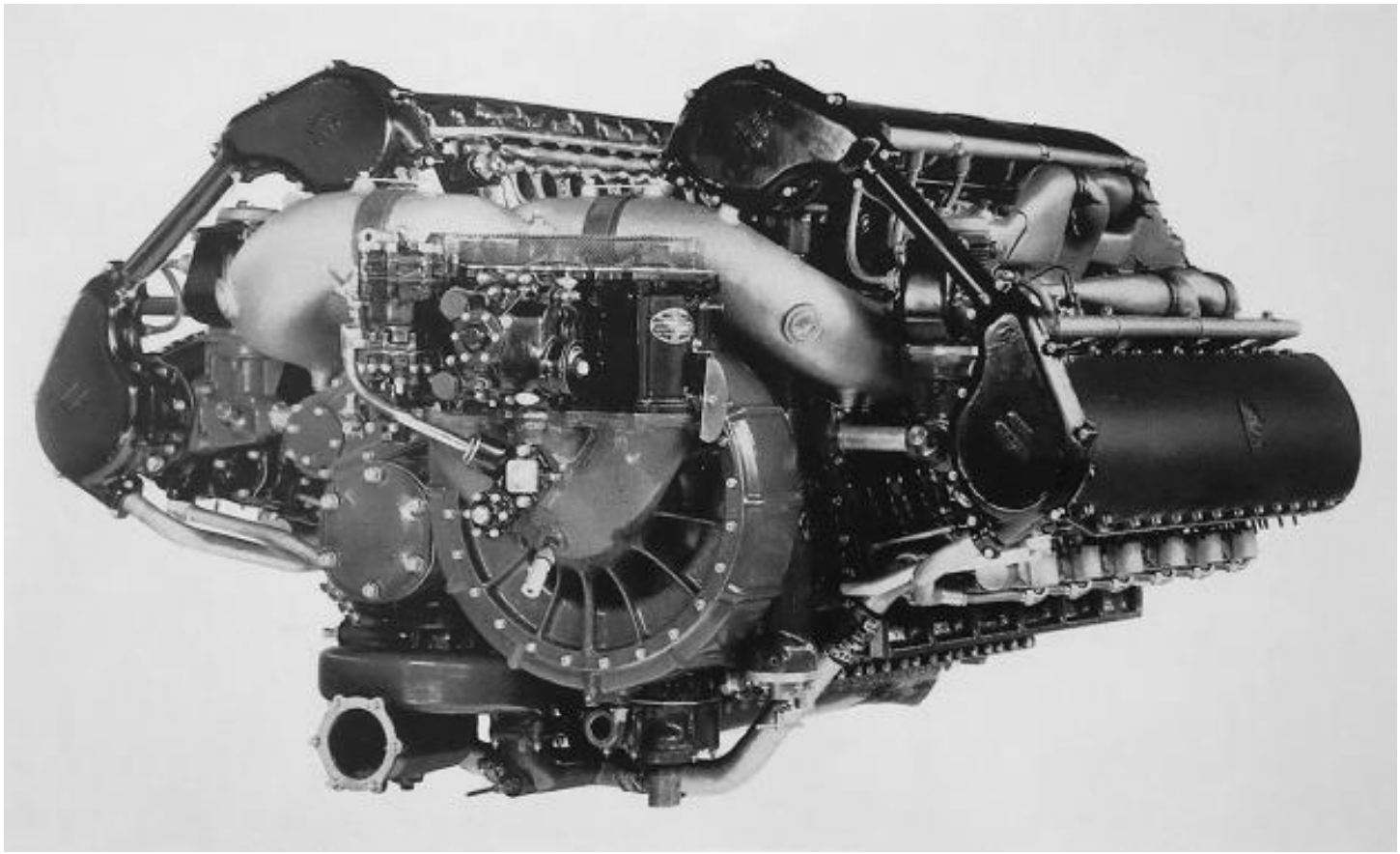
In the mid-1930s, the United States Army Air Corps (AAC) was interested in a long-range bomber. Boeing won a contract to build the aircraft, which was originally designated XBLR-1 (eXperimental Bomber Long Range-1), but ultimately became the XB-15. By 1935, the AAC realized that current engines, and those under development, lacked the power needed for such a large aircraft. At the time, the AAC was pursuing its next experimental long-range bomber, the Douglas XBLR-2. The AAC requested the Allison Engineering Company build a 1,600 hp (1,193 kW) engine for the XBLR-2, which later became the XB-19.



The Allison V-3420 was much more than two V-1710 engines coupled together. However, as many V-1710 components were used as possible, resulting in only 340 new parts. This is a V-3420-A engine with an attached single-rotation gear reduction.

In 1935, Allison was in the middle of developing its 1,000 hp (746 kW) V-1710 engine. The AAC requested that the new 1,600 hp (1,193 kW) engine have a single crankshaft and use as many V-1710 components as possible to keep development time to a minimum. After evaluating a few different configurations, Allison decided to double the V-1710 to create a 24-cylinder engine in an X configuration. This engine became the X-3420. The X-3420 would have an entirely new crankcase, crankshaft, gear reduction, supercharger, and accessory section, but it would keep the basic V-1710 cylinder and head. The X-3420 had a flattened X arrangement with a left and right cylinder bank angle of 60 degrees, an upper cylinder bank angle of 90 degrees, and a lower cylinder bank angle of 150 degrees. The fuel-injected engine would produce 1,600 hp (1,193 kW) at 2,400 rpm for takeoff and 1,000 hp (746 kW) at 1,800 rpm for economical cruise. The engine would have an 8.5 to 1 compression ratio and weigh 2,160 lb (980 kg).

While using as many V-1710 components as possible made Allison’s job easier, the X-3420’s single crankshaft and its master and articulating rods required much design work, as did its fuel-injection system. Very quickly, Allison realized it did not have the resources to develop the X-3420 and needed to focus on the V-1710, which was encountering technical issues. Development of the X-3420 was effectively abandoned in 1936. As an alternative, Ron Hazen, Allison’s Chief Engineer, proposed a new 2,000 hp (1,491 kW) engine that had two crankshafts and was more closely based on the V-1710. The engine would produce more power than the X-3420 and be developed in less time. The AAC approved of Hazen’s proposed engine, which became the V-3420. The engine was often referred to as a W-24 or double Vee (DV) and was occasionally called the DV-3420.



Rear view of the V-3420-A shows the supercharger mounted behind the right engine section and various accessories mounted behind the left engine section. The V-3420's design enabled the engine to produce more power than its X-3420 progenitor.

The Allison V-3420 design was more complex than just coupling two V-1710 engines together. As with the proposed X-3420, a new crankcase, gear reduction, supercharger, and accessory section were at the center of the engine, but the V-3420 would utilize many V-1710 components. The use of two V-1710 crankshafts along with their connecting rods made the V-3420's design and development much more manageable for Allison. The engine consisted of two 60 degree V-12 engine sections mounted on a common crankcase and separated by 90 degrees, which gave the inner cylinder banks 30 degrees of separation. As V-1710 development progressed, Allison was able to offer the V-3420 with 2,300 hp (1,715 kW) for takeoff. At 2,300 lb (1,043 kg), the engine would only weigh 140 lb (64 kg) more than the single crankshaft X-3420, but it would produce an additional 700 hp (522 kW). In May 1937, the AAC contracted Allison to build the V-3420 engine prototype. A large aluminum crankcase sat at the center of the 24-cylinder V-3420 engine.

Attached to the crankcase were four cylinder banks. Each cylinder bank consisted of six steel cylinder barrels shrink fitted to a one-piece aluminum cylinder head. Each cylinder barrel was surrounded by an aluminum water jacket. A single overhead camshaft actuated two intake and two exhaust valves for each cylinder. Each cylinder had a 5.5 in (140 mm) bore and a 6.0 in (152 mm) stroke. The engine displaced 3,421 cu in (56.1 L) and had a compression ratio of 6.65 to 1. At the rear of the engine was a supercharger driven by the right crankshaft, and all accessories were driven by the left crankshaft. The engine was also intended to be used with a General Electric turbosupercharger.

This V-3420-B was the type installed in the Fisher XP-75. About 15 ft (4.6 m) of shafting separated the engine from the gear reduction. Note the large first stage of the V-3420-B's two-stage supercharger and compare it to the image of the V-3420-A engine. Unlike the -A, the -B did not use a turbosupercharger.

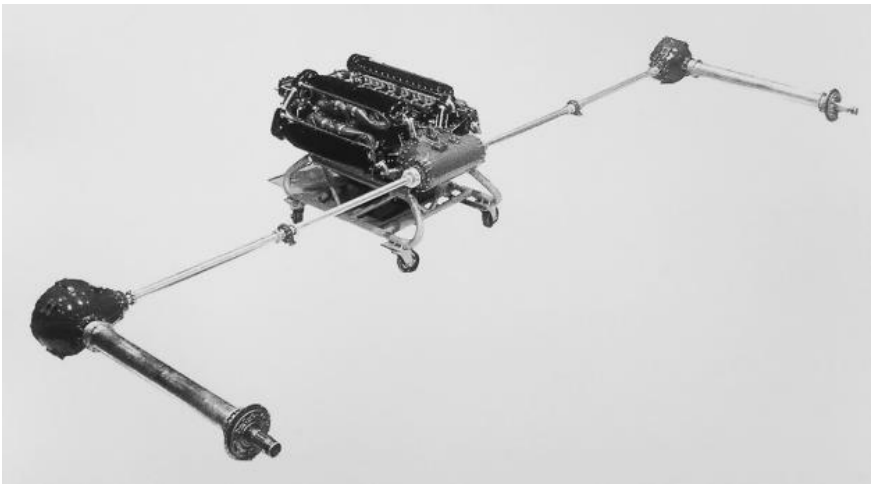
There were only 340 parts unique to the V-3420 engine, and those accounted for 930 pieces of the 11,630 that made up the engine. Initially, the V-3420 had a takeoff rating of 2,300 hp (1,715 kW) at 3,000 rpm, a maximum rating of 2,000 hp (1,491 kW) at 2,600 rpm, and a cruise rating of 1,500 hp (1,119 kW) at 2,280 rpm. The basic 24-cylinder engine was 97.7 in (2.48 m) long, 60.0 in (1.52 m) wide, and 38.7 in (.98 m) tall. The engine weighed 2,665 lb (1,209 kg)—365 lb (166 kg) more than the original estimate. In January 1938, Allison was authorized to release V-3420 engine specifications to aircraft manufacturers and airlines. This resulted in a number of aircraft designs incorporating the engine; however, only four V-3420-powered aircraft types were actually flown.

The V-3420 engine was first run in April 1938, followed by an AAC order for six engines in June 1938. An engine was also displayed in the 1939 World's Fair in New York. The US Navy was aware of the V-3420 engine and asked Allison if it could be converted for marine use. Allison responded with the appropriate designs. In December 1939, the Navy ordered two V-3420 marine engines for installation in a new, aluminum-hulled Patrol Torpedo boat designated PT-8. The two V-3420 marine engines were delivered to the Navy, and the PT-8 boat started trials in November 1940. The PT-8 was tested through 1941, but no further boats or V-3420 marine engines were ordered. The sole PT-8 was later re-engined and still exists as of 2017.

On the V-3420-B engine, an idler gear kept the crankshafts in sync. The engine's large crankcase can be seen in this image. The large aluminum casting had front and rear covers and a magnesium oil pan. (Gary Brossett image via the Aircraft Engine Historical Society)

For aircraft use, the V-3420 required further development, which was slow due to Allison's ongoing commitments to the V-1710 engine as well as the AAC's preoccupation with vastly expanding its resources for the coming war. In late 1940, Allison focused on two major models of the V-3420 engine: -A and -B. The V-3420-A had crankshafts that rotated the same direction—either clockwise or counterclockwise, depending on the desired rotation of the propeller. The -A engine used a single-rotation propeller with either an attached or remote gear reduction, but most commonly with an attached gear reduction. The V-3420-B had crankshafts that rotated in opposite directions and was used with contra-rotating propellers.

Different versions of the -B engine could accommodate either an attached or remote gear reduction, which allowed a number of propeller shaft configurations, including right-angle drives. The -B engine almost always had a remote gear reduction. The two crankshafts of the V-3420-B were kept in sync by idler gears at the front of the engine. The idler gears also balanced power loads from the crankshafts to the contra-rotating propeller shafts. In September 1940, Allison's V-1710 commitments became overwhelming, and development of the V-3420 engine was put on hold. As a result, the XB-19 had four 2,000 hp (1,491 kW) Wright R-3350 18-cylinder radial engines installed in place of the V-3420s. However, the R-3350 was encountering its own extensive developmental issues that put its use in the Boeing B-29 Superfortress in question. In February 1941, the AAC requested that Allison restart development of the V-3420-A with an output of 3,000 hp (2,237 kW) as a possible replacement for the Wright R-3350. The B-29 bomber was too important for its fate to be tied to one engine.



One V-3420-B engine was built to be mounted in an aircraft's fuselage with extension shafts leading through the wings to right angle drives that would connect to the propellers. This type of engine configuration would have been used in the McDonnell Model 1. Only one engine was built with this configuration.

A V-3420 engine was delivered to Wright Field in October 1941, but with the bombing of Pearl Harbor in December, the V-3420 program was again put on hold so that Allison could focus on the V-1710 engine. History repeated itself in mid-1942 when the suitability of the R-3350 engine was again in question. Allison was instructed by the Army Air Force (AAF—the AAC was renamed in June 1941) to prepare the V-3420 for installation in a B-29, which was redesignated XB-39. Nine engines were built and delivered by October 1942. On 1 October 1942, the AAF ordered two Fisher XP-75 Eagle fighter prototypes that were powered by the V-3420-B engine. This was followed by an order placed on 28 October for 500 V-3420-A engines for installation in 100 production B-39 aircraft. As the aircraft projects were underway, continued development of the V-3420 engine increased its output to a takeoff rating of 2,600 hp (1,939 kW) at 3,000 rpm with 8 psi (.55 bar) of boost, a normal rating of 2,100 hp (1,566 kW) at 2,600 rpm at 25,000 ft (7,620 m), and a cruise rating of 1,575 hp (1,175 kW) at 2,300 rpm at 25,000 ft (7,620 m). However, the engine could be overboosted in emergency situations to 3,000 hp (2,237 kW) at 3,000 rpm with 10.2 psi of boost (.70 bar).

The Fisher P-75A was the end of a very tumultuous fighter program. The original design consisted of various parts from other aircraft that, when combined, would somehow make an aircraft superior to all others. The reality was that the combined parts created an aircraft that was downright dangerous and needed to be redesigned. A partial redesign did not completely cure the problems, and problems still existed after a subsequent complete redesigned. Still, 2,500 aircraft were ordered before better judgment prevailed and the program was cancelled. The P-75 was the only aircraft flown with V-3420-B engines.

The first aircraft to fly with the V-3420 was the Fisher XP-75. Developed by the Fisher Body Division of General Motors, the XP-75 was a long-range escort fighter. Through 1943, the AAF felt a desperate need for such an aircraft and ordered six additional XP-75 prototypes, bringing the total to eight. In addition, the AAF expressed its intent to purchase 2,500 P-75s if the prototypes met their performance estimates. The V-3420-B engine for the P-75 had a two-stage, variable speed supercharger (and no turbosupercharger) that was hydraulically coupled to the right crankshaft. The engine alone weighed 2,750 lb (1,247 kg), and its weight increased to 3,275 lb (1,486 kg) with its 3.5 in (89 mm) diameter extension shafts and remote gear reduction.
The XP-75 first flew on 17 November 1943, and the aircraft almost immediately ran into issues. Its V-3420-B engine was not entirely trouble free either; unequal fuel distribution was a continuing problem for the V-3420. The issue was mostly solved by having each alternate engine section fire every 30 degrees of rotation, rather than both engine sections firing every 60 degrees of rotation. The aircraft was redesigned to correct its deficiencies and was given the new designation of P-75A. The AAF ordered 2,500 P-75As on 7 June 1944, and production started immediately. However, the entire P-75 program was cancelled four months later, in October 1944. The P-75A did not live up to expectations, it was outmatched by aircraft already in service, and the end of the war was in sight. Eight XP-75 and six P-75A aircraft were built, but three of the aircraft crashed during testing. One P-75A was preserved and is on display in the National Museum of the US Air Force. The rest of the surviving aircraft were scrapped.

With V-3420-A engines installed, the Douglass XB-19A realized a boost in its performance. While the engines proved reliable, it was very time-consuming for Fisher to design and fabricate the new nacelles to house the V-3420. The same basic nacelle was also used on the XB-39.

Actual work to install V-3420-A engines in the XB-19 started in November 1942 at Fisher. The aircraft was redesignated XB-19A and flew for the first time with its V-3420 engines in January 1944. The V-3420 installation served as a test for the engine's use in the XB-39. With the exception of range, the XB-19A's performance increased across the board: maximum speed increased by 40 mph (64 km/h); cruising speed increased by 50 mph (80 km/h); service ceiling increased by 16,000 ft (4,877 m), but normal range decreased by 1,000 miles (1,609 km). The XB-19A was strictly an experimental aircraft and was never intended to enter production.

In February 1943, V-3420-A engines were selected to power the Lockheed XP-58 Chain Lightning. The V-3420 was not Lockheed's first choice, or second, or third. The XP-58 heavy fighter program was initiated in 1940 but was beset with constant design and role changes, which were made worse by developmental issues of the aircraft's previously selected engines. By the time it was completed, the XP-58 was oversized, overweight, underpowered, and not needed. First flown on 6 June 1944, the aircraft's lackluster performance matched Lockheed and the AAF's enthusiasm for the project. Only one prototype was built, and the XP-58 program was cancelled in May 1945.

The men working on the V-3420 installed in the XB-19A give some perspective as to the engine's size and the size of the aircraft. The V-3420's radiator, oil cooler, turbosupercharger, and intercooler were all mounted in the nacelle, under the engine. This configuration prevented the need for heavily modifying the aircraft.

Even though it helped spur the V-3420 engine program, the V-3420-powered B-29 was the last aircraft to take flight with the engine. A B-29 (actually a YB-29, the first pre-production aircraft) was delivered to Fisher for conversion to an XB-39 with V-3420-A engines. Work on the XB-39 was slow because Fisher's main focus was the XP-75. The XB-39 finally flew on 9 December 1944. Performance of the XB-39 was superior to that of the B-29: its top speed was 50 mph (80 km/h) faster, and it had a 3,000 ft (914 m) higher service ceiling. However, standard B-29s were proving to be more than adequate, and it was not worth the time or trouble to convert any other airframes to V-3420-power.

To meet the power needs for extremely large aircraft designs during World War II, Allison proposed the DV-6840. The DV-6840 consisted of two V-3420s driving a common remote gearbox for contra-rotating propellers. A gearbox for the DV-6840 was completed in 1946, but no information has been found regarding it being tested. Allison had also planned a further development of the V-3420. This fuel-injected V-3420-C engine had a forecasted emergency output of 4,800 hp (3,579 kW) and a takeoff/military rating of 4,000 hp (2,983 kW)—both ratings at 3,200 rpm with water injection. However, the V-3420-C was never built.

The Lockheed XP-58 was another program than inexplicably pressed on despite the many signs that it was heading nowhere. Somewhere between three to seven engines were selected before the V-3420-A was finally chosen to power the aircraft. It was not Lockheed's fault; they had no control over which experimental engines would actually be produced. Lockheed also had no control over the constantly changing roles the AAF asked the XP-58 to fulfill.

The Allison V-3420 was not a trouble-free engine, but it did work well in its few applications once initial issues were resolved. The engine held a lot of potential, but that potential faded as its development languished. At the start of 1944, only 33 V-3420 engines had been delivered, and two of those were marine engines. Had the AAC committed to the engine in 1936 and provided Allison with the resources needed to develop the engine, the V-3420 very well could have powered the B-29 and various post-war aircraft. The four aircraft projects that used the V-3420 did not fail because of the engine. By the time the V-3420 program was in order in 1944, other engines were adequately fulfilling the 3,000 hp (2,237 kW) role.

Allison built a total of 157 V-3420 engines: 37 -A engines (including the two marine engines) and 120 -B engines. A number of V-3420s were sold as surplus after the war. Some eventually made their way into museums, while other engines were used in a hydroplane (Henry J. Kaiser's *Scooter Too* driven by Jack Regas) and a tractor puller (E. J. Potter's *Double Ugly*). However, none of the V-3420 engines took flight again.

The Boeing / Fisher XB-39 program is what put the V-3420 engine back on track to production. It was the most promising aircraft out of the four powered by the V-3420. Delayed by Fisher's work on the XP-75, there was little point to the aircraft when it took to the air in December 1944. The image above shows the V-3420 engines being installed at the Fisher plant in Cleveland, Ohio. Fisher was producing various subassemblies for the B-29, which can be seen in the background. On the right side of the image, just behind the XB-39's wing, is the fuselage of a P-75A. (Mike Veselenak image via Tom Veselenak)

Source : https://oldmachinepress.com/2017/04/20/allison-v-3420-24-cylinder-aircraft-engine/