

Identification of Allison V-3420-A8R As Manufacturer's Number 173

Background: Allison built the XV-3420-1(A1R) in 1938 for the U.S. Army Air Corps. At the time there was no application for the engine, which had been originally intended for the Very Long Range Bomber program (XB-19) as the X-3420, but that project was delayed pending Type Testing of the V-1710. The availability of the V-3420 was of interest to the U.S. Navy who were building the first of their fast patrol torpedo boats and sought a lightweight aviation engine for use in their forthcoming aluminum hulled PT-8 boat. For this they selected right and left-handed running Allison V-3420s, buying a pair for the project. Allison identified these engines as their V-3420-A8R/L models and assigned them manufacturer's numbers 173 and 174 respectively; they were the second and third V-3420s to be built.

The engines were delivered to the Navy in late 1941 but were only in the PT-8 for about a year as the boat was to require considerable development and furthermore, aluminum had been designated a strategic material for aircraft, and was therefore not available for boats. The engines were removed from PT-8 and returned to Allison where they were 'modernized' and adapted for use by Gar Wood in his ORCA experimental boat, to be powered by the now designated V-3420-A8RW/A8LW, the engines on loan from the Navy.

This program lasted about a year and again the engines were returned to Allison, where they were returned to the original V-3420-A8R/L configuration. While no documentation proves this point, both of the engines are known to exist and by observation, they are so configured at this time.

After modernization, V-3420-A8R #173 performed the Model Test in the spring of 1942. This engine is now in the hands of Gary Larkins, however its data plate is devoid of all of the usual stampings and identifications typically seen. Serial Number 174 is in the collection of Kermit Weeks in Florida and is clearly identified as the V-3420-A8L on its data plate. The purpose of this paper is to establish a basis for designating Gary Larkins engine as V-3420-A8R #173.

The following pages compile the inspection and observational findings that are related to establishing the identity of the engine as #173.

Dan Whitney, author of *Vees for Victory, the Story of the Allison V-1710*, and a long time collector, historian and observer of Allison engines has personally inspected Gary's engine and reviewed his observations and findings. These are recapped on the following pages.

As a result of the accumulated information, I have no difficulty in stating that the engine in question is the original V-3420-A8R, Allison serial number 173.

Daniel D. Whitney, PE

November 13, 2019, Orangevale, CA

ALLISON ENGINE COMPANY

Development Timeline for the V-3420-A8R and V-3420-A8L Marine Engines

The V-3420 was formally begun in November 1936, with construction of the XV-3420-1(A1R) under U.S. Air Corps experimental contract W535-ac-09678, issued in March 1937. The engine was running in April 1938, but due to a somewhat short sighted development policy, a number of minor items were used to delay acceptance by the Air Corps until December 30, 1938. The only substantive issue during the initial testing was that the center crankcase section had developed a crack. It was a couple of years later before the Air Corps had cause to order another V-3420, having previously not had a requirement for an engine of its capability.

1939 – The U.S. Navy purchased the second and third V-3420s built and together with the Allison Engine Company and Cleveland Diesel proceed to "marinize" them, creating the 2,000 bhp, at 2600 rpm, V-3420-A8R and the V-3420-A8L for use in the Navy's experimental PT-8, a fast motor torpedo boat. This 75 foot boat was of all aluminum construction having been designed and built by the U.S. Navy in its Philadelphia Ship Yard. Following more than a year of planning and negotiations, one engine of each rotation, right and left, were procured from the Allison Engine Company under Navy Contract 68427 in December 1939. These engines incorporate a unique "flexible coupling" from the reduction gear to a short drive shaft that connected through another "flexible coupling" to a transmission built by the Allen Gear Company. Other "marine" adaptations included a machined spacer plate, approximately one inch thick fitted between the cylinder head exhaust ports and the exhaust gas cooler. It thermally isolated the cylinder heads from the cold cooler while providing enough room for the spark plugs to be removed and replaced, along with a special governor and variable spark timing.¹

1940 – Engine V-3420-A8R (Allison S/N 173) was completed and shipped to the U.S. Navy in June, while the second engine, V-3420-A8L (Allison S/N 174) was completed and shipped that September. Both engines were installed in the PT-8, "Fast Patrol Boat."² Boat trials started in November 1940.³

1941-42 – Extensive 'sea trials' are conducted with PT-8, showing that the boat was too heavy and had a number of design issues, such as the variable pitch propeller which folded up on first use, to be resolved. Note: This is the first actual use of a V-3420 engine of any type.⁴ In July 1941 the engines were returned to Allison for overhaul, having acquired about 75 hours of service. Other than one damaged cylinder, the result of mistreatment, they were in fair condition and following overhaul are reinstalled in PT-8 and testing continued. After only a year of experimentation the project was abandoned.⁵ At this time

¹ Allison Engine Company records, via Dan Whitney's "Vee's for Victory". Page 308.

² Allison Engine Company records, via Dan Whitney's "Vee's for Victory". Page's 401, 402, 427 and 442.

³ Status of V-3420 Marine Project, J.L. Goldthwaite, October 23, 1942.

⁴ Allison Engine Company records, "Inter Office Memo, June 10, 1941, To: R. M. Hazen, Subject: V-3420 Engines For Navy" by J. L. Goldthwaite. Also via Dan Whitney's "Vee's for Victory". Page's 292, 293, 294, 297, 306 and 399.

⁵ Status of V-3420 Marine Project, J.L. Goldthwaite, October 23, 1942.

the engines had acquired approximately 200 hours, mostly at or near full power; and they were again overhauled and made ready for loan to Gar Wood. During overhaul it was found that both center crankcases were cracked and new crankcases, bearings, crankshafts, and connecting rods, all of the latest design, were installed.⁶

PT-8 Summary – The overweight PT-8 had performed well and proved to be a faster "Patrol Boat" than was then available; the Navy however is unable to proceed with its development due to the outbreak of World War II and aluminum being designated a critical strategic material for use only in aircraft. Furthermore, there were numerous issues with the installation of the engines in the PT-8. The fuel supply piping restricted fuel flow to the point of causing chronic engine overheating and backfiring.⁷ Contributing to the backfiring was the initially specified intake valve clearance of 0.010 inch. During 1941 Allison was besieged with backfires causing fires in the V-1710, these were caused by poor fuel distribution and the tight intake valve clearance. Allison changed the intake valve clearance to 0.015 inch which resolved the backfire issue in April 1941. The intake system fires were resolved by changing to aluminum intakes having the improved 'streamlined' internal passages in July 1942.⁸

1942 – Both V-3420-A8 engines are loaned by the U.S. Navy to boat builder and race car/boat driver Gar Wood, who had the Allison Engine Company design and build a new nose case for each engine incorporating two extension shafts, each connected directly to a crankshaft and extending to a remote 1:1 gearbox with a single output shaft upon which is installed a "variable Pitch" propeller, controlled by a solid rod extending through the center of the hollow prop shaft. The "variable pitch" propeller is of General Motors design and construction.⁹

Allison redesignated these engines as their Models V-3420-A8RW and V-3420-A8LW respectively. The "W" representing the Gar Wood revisions. In addition, the "Military Model Number" is changed to V-3420COMM for "Commercial." These two engines becoming the first and only "Commercial" V-3420 engines built.¹⁰

To ease manufacture of the new configuration Allison retained the integral reduction gears in the nose of the engine, now serving as timing gears, and only a simple cover casting and a few small parts were necessary for the conversion of the basic engine. The extension shafts and their couplings were standard V-1710-E engine parts, while the new reduction gear castings were designed for green sand with as few cores as possible, and with relatively heavy walls to permit liberal foundry tolerances. Gear loadings were conservative, utilizing helical gears, which were advisable because of the rather high pitch line speeds in the 1:1 gear box.¹¹

First drawings for these engines were released in January 1942, with Gar Woods ORCA

⁶ Status of V-3420 Marine Project, J. L. Goldthwaite, October 23, 1942.

⁷ Allison Engine Company records, "Inter Office Memo, June 10, 1941 by J. L. Goldthwaite.

⁸ Allison Engine Company records, via Dan Whitney's "Vee's for Victory". Page 114.

⁹ Status of V-3420 Marine Project, J. L. Goldthwaite, October 23, 1942.

¹⁰ Allison Engine Company records, via Dan Whitney's "Vee's for Victory". Pages 442 and 443. And correspondence of Tuesday, January 8, 2019 from Dan Whitney regarding a response from RRHT/Allison, Mr. John Leonard, Archivist.

¹¹ Status of V-3420 Marine Project, J. L. Goldthwaite, October 23, 1942.

being launched July 4, 1942, and trial runs beginning the next day.¹² The boat was laid up for the winter in November 1942 and John Goldthwaite recommended that the new Venturi manifolds should be installed before operation during the next season due to the poor fuel distribution typical of the old style manifolds previously used.¹³ It is likely that the Gar Wood engines always had the “streamlined” manifolds at the cylinder banks, though prior to the third overhaul they were likely made of magnesium, and seen in the Allison photos, but here he is talking about the “Madam Queen” venturi inserted in the gas pipe between the supercharger and manifolds, which is the unit installed in #173 today. This venturi picks up any liquid fuel and reatomizes it providing a uniform mixture to the cylinders.

1943 – “Mr. Wood is working on a new Torpedo Boat design of some 100 – 110 foot length that somewhat resembles his present boat (ORCA?) but with different lines under water and with much less space for engines. He suggested the use of four V-1710 engines; two coupled to each propeller shaft through suitable gearing as the V-3420 engines were too wide for proper installation in the narrow space available. I suggested that the Navy might be able to obtain the engines for him; Allison themselves could not divert engines from the Army airplane program. By widening the hull above water it might be possible to install the present V-3420 engines.”¹⁴

Documentation regarding the subsequent history of these two very unique engines has not been found, however we do know that they both still exist, itself quite a feat!

Also, both engines were returned to their original V-3420-A8 configuration, rather than the Gar Wood revision. It is not apparent that they were otherwise updated or improved.

Revision of Gary Larkins write-up
Dan Whitney, November 6, 2019

¹² Status of V-3420 Marine Project, J. L. Goldthwaite, October 23, 1942.

¹³ Allison Engine Company records, "V-3420 MARINE PROJECT: May26, 1943; Report of Conference with Gar Wood, May 5,1943,Chief Engineer, Mr. R. M. Hazen".

¹⁴ Allison Engine Company records, "V-3420 MARINE PROJECT: May26, 1943; Report of Conference with Gar Wood, May 5,1943,Chief Engineer, Mr. R. M. Hazen".

Identifying Allison V-3420-A8R, AEC Serial Number 173

Methodology to identify this engine: The engine in question has a blank data plate, that is, none of the values specific to the engine were stamped into it, nor has the engine serial number been found stamped into the crankcase. The Navy V-3420-A8 engines were identified by their Allison Serial Numbers as #173 and #174. Data plate #174 is mounted on the V-3420-A8L engine in Kermit Weeks collection at the Fantasy of Flight Museum in Florida. By first showing that the Gary Larkins engine is a V-3420-A8, of which only two were built, by deduction we will know that it is the V-3420-A8R #173. Other supporting information found on or within the engine will validate the conclusion that this engine was one of the two installed in the Navy PT-8 in 1940.



Figure 1 The Navy's Allison V-3420-A8 powered PT-8 underway during testing.

Factual Information:

(1) Located on each crankshaft of this engine, at the front of the engine, is written the following letter/number sequence. "T.O. 8 #173".



Figure 2 T.O. 8 #173 written on Crankshaft output flange.

Allison Engine Company records indicate that the V-3420-A8R engine they contracted to build under Navy Contract 68427 in 1938 and delivered to the U.S. Navy in 1940 having right hand prop rotation and left hand crank rotation was "serial number 173". Also delivered with engine #173 was V-3420-A8L with left hand prop rotation and right hand crank rotation and was "serial number 174". The V-3420-A8L is located at the Fantasy of Flight Museum and photos provided by Dan Whitney of the Data Plate clearly show the model and serial number 174.



Figure 3 Data Plate on Kermit Weeks V-3420-A8L #174. Note, the Intake Valve clearance of 0.010” was changed on all Air Corps V-1710s to 0.015” in May 1941 to eliminate backfiring. It is curious that the change was not stamped on #174’s data plate when the engine went through overhaul for Gar Wood in Spring 1942.

(2) The location of the Engine Data Plate is on the right side at the center of Larkins engine. Externally, the two engines are identical, except the Kermit Weeks engine is "serial number 174", further suggesting that the Larkins engine is serial number 173. As such, this is one of the two V-3420-A8 engines contracted for by the Navy, subsequently returned to Allison for overhaul and then transferred to Race Boat builder and driver Gar Wood, at which time the engines’ designation was changed to "V-3420-A8RW", the "W" standing for Wood, concurrently they became the first and only "Commercial" Allison V-3420 engines. Information from Dan Whitney upon his inspection of this engine and his book on Allison engines "Vee's For Victory".

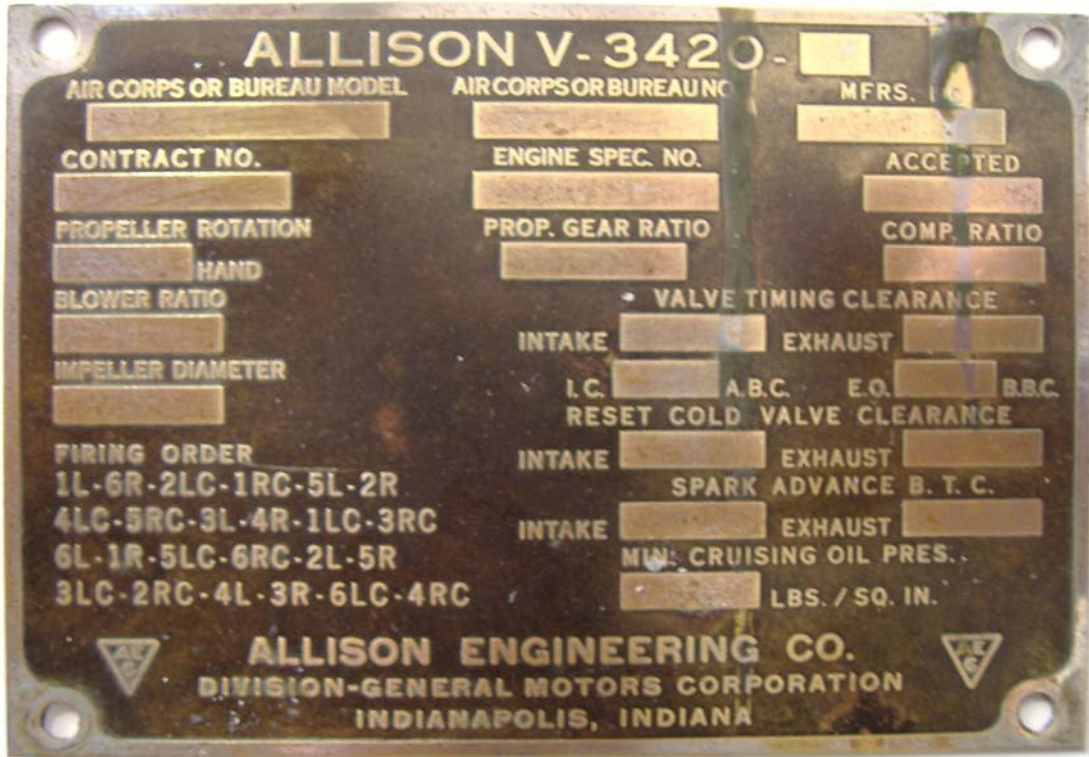


Figure 4 Blank Data Plate mounted on the Gary Larkins V-3420-A8R.

As it is highly unusual to find a blank Data Plate on an engine, it can be speculated that when the engine was reconfigured as the -A8RW a "W" had been stamped on the original plate, but when it reverted to -A8R configuration a new plate was installed and its stamping awaited the final determination for the configuration to be used in the third boat project. It is recommended that for the rebuilding of #173 a new data plate is obtained, saving this one, and the grease penciled PN 35317 on its back, as historic documents.

(3) This engine still has the original "Flexible Coupling" as used in the PT-8 mounted on the prop shaft. Only the two V-3420-A8 Allison engines contracted for by the U.S. Navy under contract number 68427 were known to have used this type of "Flexible Coupling". The devise is shown in the "Instruction Book, Allison Engines, Model V-3420-A8, Marine Installation PT-8".



Figure 5 V-3420-A8R with Flexible Coupling

(4) This engine has, located at the rear of the engine accessory section, on the vacuum pump mounting pad, a long aluminum casting which extends to a point adjacent to the carburetor throttle linkage. At which position a "Throttle Governor" was located in order to prevent over revving the engine when propeller is out of the water or in the case of a gearbox or propeller failure.

Only the two V-3420-A8 engines provided by Allison to the Navy are known to have incorporated a "Throttle Governor."



Figure 6 The Throttle Governor support also provides a pad for a Vacuum Pump

(5) This engine, as per Dan Whitney's inspection, does not have the many of the contemporary V-3420-A model equipment/parts. Rather, it has been updated with later model Allison engine components, such as intake manifolds, gas pipe and magnetos available at the 1942 time period. These upgrades were known to have been done to both V-3420-A8 engines when they were returned to the Allison Engine Company by the U.S. Navy for complete overhaul and upgrade in early 1942, as stated in the documents we have received from Allison Engine Company Archives.

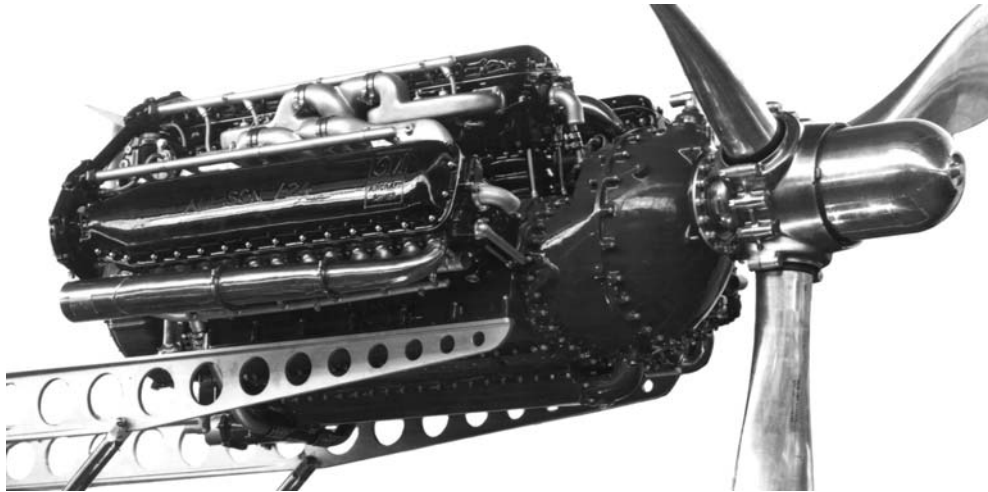


Figure 7 The XV-3420-A1, the first V-3420, was prepped for and shown at the 1939 New York World's Fair. Note use of non-streamlined intake manifolds. Originally the V-3420-A8 engines would have been similarly fitted. Also, there are no mounting pads on the bottom of the crankcase.

(6) This engine has spacers, approximately one inch thick, with Allison part numbers, 35511, located on the exhaust ports of each of the four banks of cylinders. These spacers were unique to the two V-3420-A8 engines in that they gave additional support to the large heavy water filled "Marine Exhaust System," which was provided for the U.S. Navy's secret project PT-8 by the Cleveland Diesel Engine Company. They also served to isolate the thermal interface between the coolers from the expansion of the hot cylinder heads. In addition, the spacers allowed for the removal and replacement of spark plugs without having to remove the large water manifolds, as stated in the "Instruction Book, Allison Engines, Model V-3420-A8, Marine Installation PT-8".

(7) The Data Plate, with PN 35317 is written in grease pencil on its back, which was on the engine and without stamping when we acquired it, is of the correct vintage and firing order as those on Data Plates for contemporary Right Hand Prop rotation V-3420s, Left Hand crank rotation, which is correct for this engine. The firing order on the Data Plate is the same as that given in the "Instruction Book, Allison Engines, Model V-3420-A8, Marine Installation PT-8" for the V-3420-A8R. See Figure 4 above.

(8) This engine has large brass fittings attached to the engine driven oil pump. They are of "Marine" type NOT aircraft type as would normally be attached to an Allison engine. These "brass fittings" are referred to in the "Instruction Book, Allison Engines, Model V-3420-A8, Marine Installation PT-8" and are visible in photo's located in this Instruction Book. No other V-3420 engines were known to use this type of oil line fitting.



Figure 8 Oil Pump, with Marine Type Brass Fittings as used on V-3420-A8 engines.

(9) The valve covers on this engine are of a very rare and early type with the Allison Engine Company "A.E.C." emblem presented in a raised casting. These valve covers can be clearly seen in photos of not only the U.S. Navy PT-8 project but also in photos of Gar Wood's Top Secret "ORCA" project.

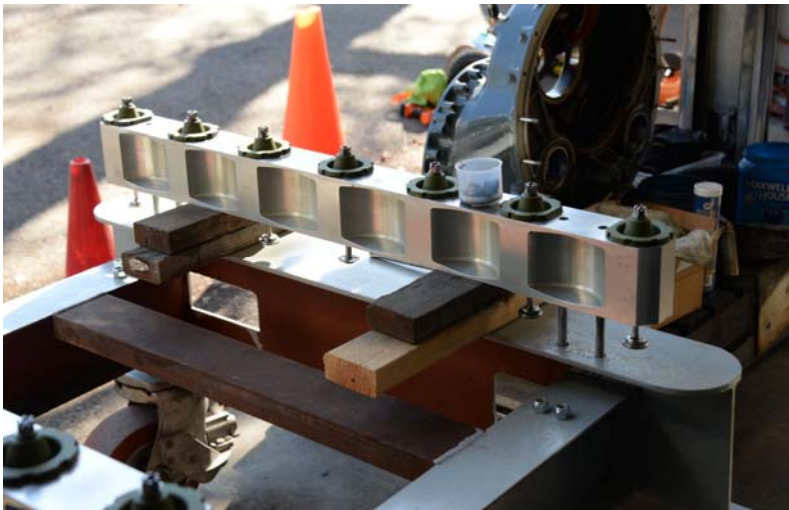


Figure 9 Aluminum mounting rail for the Larkin engine, with vibration damping mounting studs as on V-3420-A8L #174.

(10) The engine mounts are quite unique, being aluminum billets milled to accommodate clamping devices to connect the rails to the boats structure and each having seven rubber mounted studs that bolt to the seven support lugs on each side of the engine crankcase. The crankcase does not have the four mounting plates on its bottom that are found in subsequent

V-3420 engines. Interestingly, each of the rails is stamped “Forward” and “Aft”, and on the aft end both are stamped “Port Aft.” As the V-3420-A8R was installed on the “Port” side of PT-8, this becomes another confirmation that the engine is a –A8. Kermit Weeks #174 has the same mounting rails.



Figure 10 Port side engine in PT-8 mounting rail, Aft end as found on V-3420-A8R #173.

Interestingly, Gary Larkins noted that the “Port” stampings on the rails are at an angle, which when he measured it is 12 degrees. Exactly the same as the inclined angle of the engine when installed in PT-8, suggesting that the stampings were done with the engine installed in the boat!

(11) On disassembly of the nose case the oiling nozzle for the Propeller Shaft/Bull gear was missing. This is likely to have occurred during the reconfiguration for Gar Wood as the V-3420-A8RW, which substituted a new remote 1:1 reduction gear nose case driven by engine speed extension shafts. The original Bull gear was retained as an idler gear, locking the two shafts together as a way to maintain the proper phasing between the crankshafts. The consequently lightly loaded gear may not have required lubrication, and furthermore the new front cover may have interfered with the oil pump. According to contemporary Allison documentation, following the use by Gar Wood the engines were rebuilt for use in a third boat project, a remotely controlled target ship in Florida, and were returned to their original V-3420-A8R/L configuration.

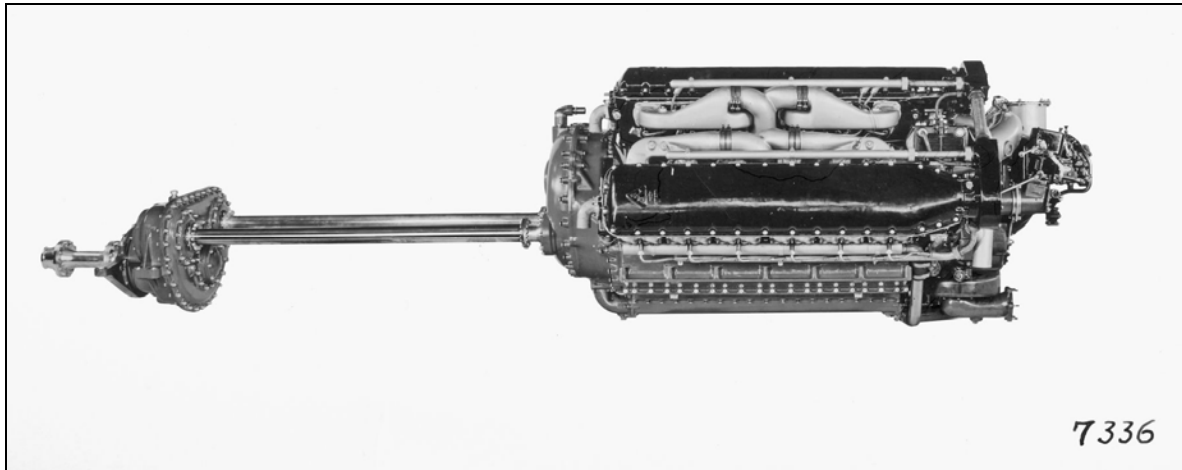


Figure 11 V-3420-A8RW for Gar Wood, June 1942 after modernization. Note use of streamlined intake manifolds, forward discharge coolant outlets and extension shafts to 1:1 reduction gear, as well as “AEC” Logo on cylinder bank valve covers. Note that the engine data plate is not visible on the lower left side of the crankcase, which is consistent with the V-3420-A8R #173 having it on the right side. Photo #7336, was made 6/1/1942, as a ‘copy’ of the original image. Date of original image not known, but was likely in the Spring of 1942.

(12) For the V-3420-A8 installation in PT-8 the cylinder head coolant outlet ports on the front of the cylinder banks are blanked off with aluminum caps, gaskets and retained by nuts and locked using “Pal” nuts, i.e. a permanent installation, one not required to be opened during engine installation. Other V-3420s have a right angle coolant fitting at this location as the coolant is pumped from the aft end of the engine through the cylinder jacket coolant manifold and into the head, exiting from the front as shown in Figure 11 of the V-3420-A8RW above.

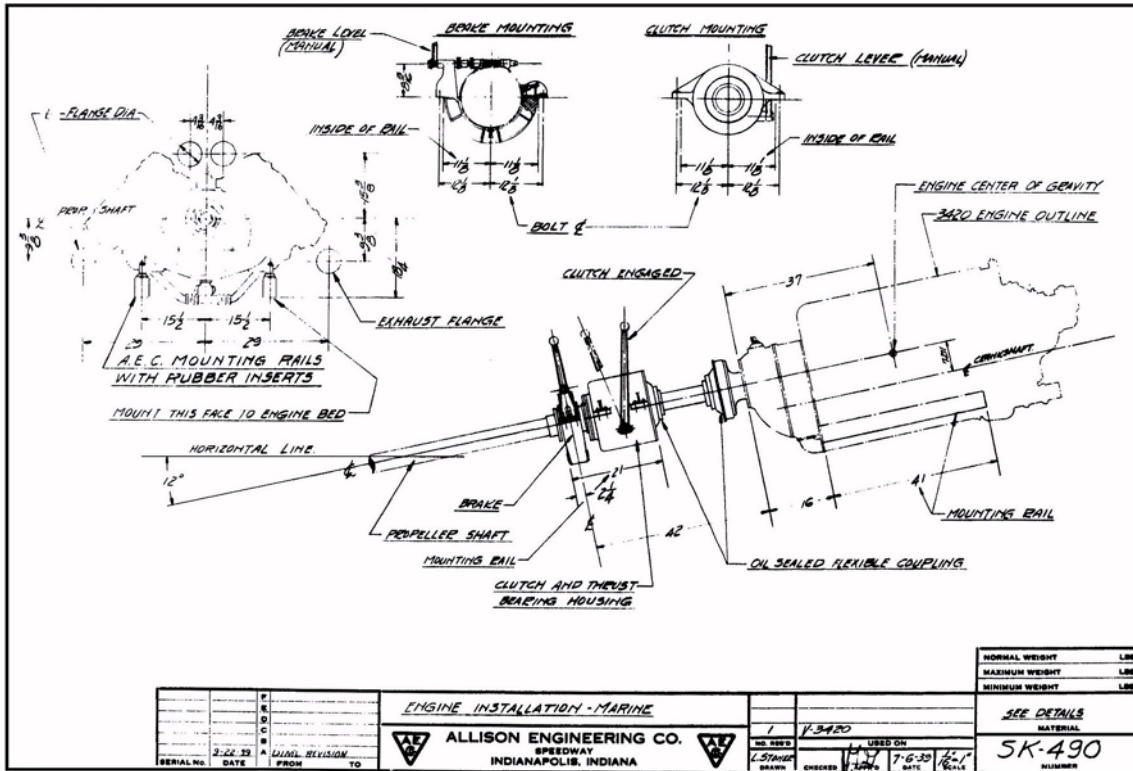


Figure 12 Allison Sketch of V-3420-A8 installation as in PT-8. Note the 12 degree inclination angle.

The V-1710 cylinder bank was designed for installation in either “tail dragger” or “pusher” type aircraft, and as such whichever was the “high” end of the bank was the coolant outlet. When the banks were later installed on higher rated engines Allison utilized both the jacket manifold and aft head coolant ports to supply a greater amount of coolant, with the outlet then being in the front. This V-3420-A8R engine has its coolant outlets at the aft end of the cylinder banks, confirming that it is a very early engine. The engine was installed in the PT-8 at an inclined angle of 12 degrees, aft end high, which is similar to the “tail dragger” configuration and elicits blanking off the coolant outlet ports at the front of the cylinder banks. The cylinder bank forward coolant outlets on V-3420-A8L AEC #174 are similarly blanked off.

Another factor showing the upgrade level of the engine are the cylinder banks, as defined by part number. Installed as the left and right banks positions are PNs 42021 and 42020 respectively. These banks were in production in 1942 and were built with bronze intake valve seats and hollow stem intake valves, subsequently superseded by PNs 42900, 42901, 42902, 42903 which had steel intake valve seats and sodium cooled valves. These cylinder banks would not have been on the engine when installed in PT-8, but probably were used on Gar Woods ORCA.

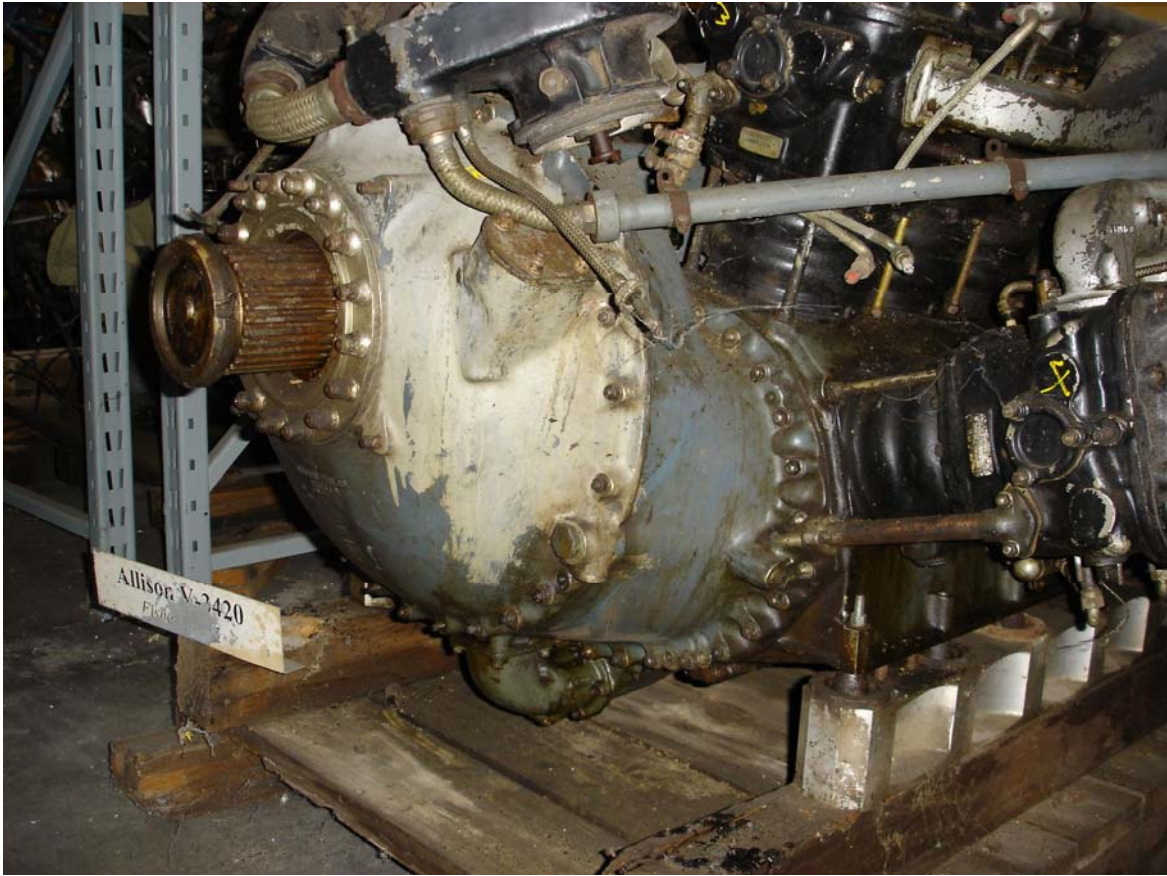


Figure 13 Kermit Weeks V-3420-A8L #174, clearly shows blanked coolant outlets, aluminum mounting rails and the special propeller shaft.



Figure 14 Aft end of V-3420-A8R #173 showing the coolant return pipes (curved-vertical) exiting from the aft end of each cylinder bank. Note also the Throttle Governor pedestal and Vacuum Pump mount as well as the brass pipe fittings on the oil pump.

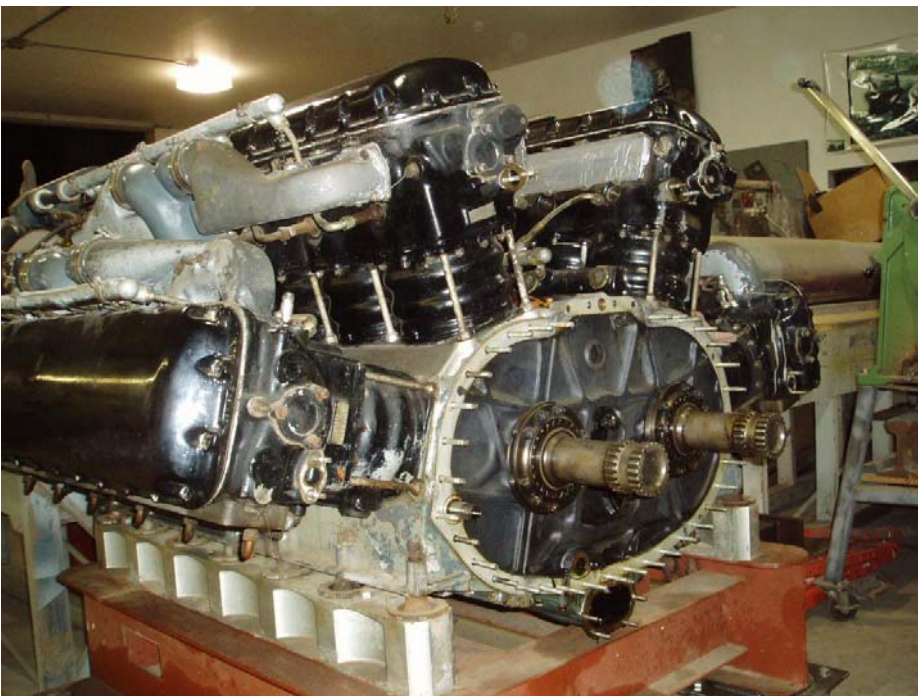


Figure 15 Front end of V-3420-A8R #173 showing the capped off coolant outlet ports. Also prominent are the mounting rails and the exhaust port spacers.

(13) The V-3420-A8 engines were mounted using unique heavy aluminum rails two each attached to the seven mounting lugs on the outside edges of the crankcase. The attachments themselves were via rubber mounted studs fitted within the rails. This arrangement appears to be unique to the -A8 engines as mounted in the PT-8. The following photo shows a bottom view of an aircraft configured V-3420-A18 crankcase and clearly shows the four mounting pads, which are not a part of the XV-3420-A1 or V-3420-A8 engines crankcases.

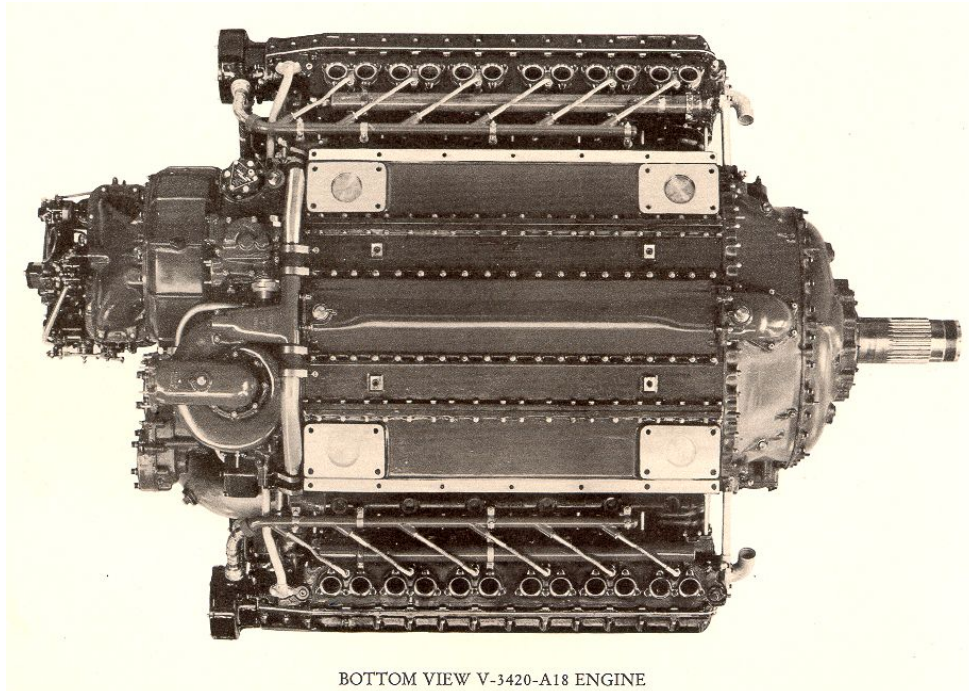


Figure 16 Bottom view of V-3420-A18 showing the four mounting pads used on all V-3420s following the -A8s, as well as the seven mounting holes along each crankcase side rail.

(14) The Allison Photo Log shows that a full series of images was made of the -A8 model test engine, which is identified therein as the “V-3420-A8L, #173.” in May 1942. It was Allison’s practice to take such photos prior to a Model Test. It is likely that it was #173 that was tested as they typically tested “right hand” engines, and that the Photo Log erroneously recorded #173 as the -A8L, when it was actually the -A8R. Interestingly, the test was run after the engine had been installed and operated in PT-8, and after it had been updated to 1942 production standards, i.e., the engine configuration today is not the same as it was when operated in PT-8. We also have photos of the engine in Gar Wood’s configuration, V-3420-A8RW, dated in June 1942. This suggests that conversion to the Gar Wood configuration was done immediately following the Model Test.



Figure 17 Gar Woods ORCA featured a stepped hull that was essentially “split” in half making it into a catamaran. Its development was lengthy, troubled by details regarding hull shaping.



Figure 18 ORCA engine room. Note arrangement of the water cooled exhausts, the short extension shafts, “AEC” logo on the valve covers and the streamlined intake manifolds installed when the engines were modernized.