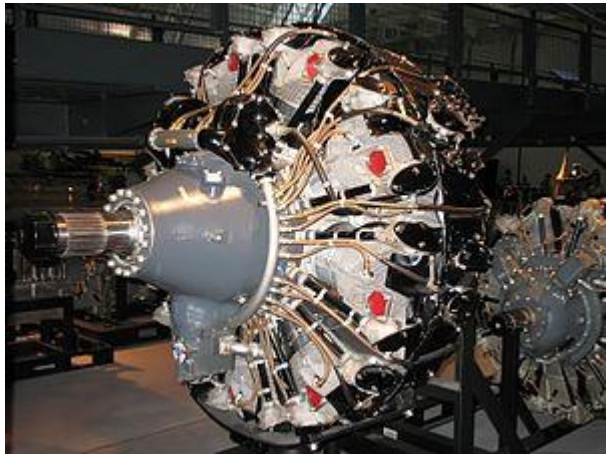
Wright R-3350 Duplex-Cyclone



Wright R-3350

Type	Radial engine
National origin	United States
Manufacturer	Wright Aeronautical
First run	May 1937
Major applications	Boeing B-29 Superfortress Douglas A-1 Skyraider Lockheed Constellation Douglas DC-7 Lockheed P-2 Neptune
Developed from	Wright R-1820

The **Wright R-3350 Duplex-Cyclone** was one of the most powerful radial aircraft engines produced in the United States. It was a twin-row, supercharged, air-cooled, radial engine with 18 cylinders. Power ranged from 2,200 to over 3,700 hp (1,640 to 2,760 kW), depending on the model. Developed before World

War II, the R-3350's design required a long time to mature before finally being used to power the Boeing B-29 Superfortress. After the war, the engine had matured sufficiently to become a major civilian airliner design, notably in its Turbo-Compound forms. The engine is now commonly used on Hawker Sea Fury and Grumman F8F Bearcat Unlimited Class Racers at the Reno Air Races.

Design and development

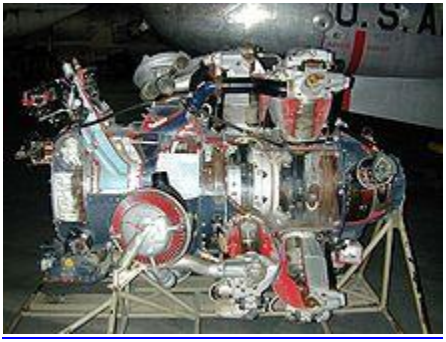
In 1927, Wright Aeronautical introduced its famous "Cyclone" engine, which powered a number of designs in the 1930s. After merging with Curtiss to become Curtiss-Wright in 1929, an effort was started to redesign the engine to the 1,000 hp (750 kW) class. The new Wright R-1820 *Cyclone 9* first ran successfully in 1935, and would become one of the most used aircraft engines in the 1930s and World War II, powering all frontline examples (the -C through -G models) of the B-17 Flying Fortress Allied heavy bomber aircraft to serve in the war, each power plant assisted by a General Electric-designed turbocharger for maximum power output at high altitudes.

At about the same time Pratt & Whitney had started a development of their equally famous Wasp design into a larger and much more powerful twin-row design that would easily compete with this larger Cyclone. In 1935 Wright decided to follow P&W's lead, and started to develop much larger engines based on the mechanics of the Cyclone. The result were two designs with a somewhat shorter stroke, a 14-cylinder design that would evolve into the Wright R-2600, and a much larger 18-cylinder design that became the R-3350. An even larger twin-row 22-cylinder version, the R-4090, was experimented with as a competitor to the P&W R-4360 but was not produced.

The first R-3350 was run in May 1937. Continued development was slow, both due to the complex nature of the engine, as well

as the R-2600 receiving considerably more attention. The R-3350 did not fly until 1941, after the prototype Douglas XB-19 had been redesigned from the Allison V-3420 to the R-3350.

Things changed dramatically in 1940 with the introduction of a new contract by the USAAC to develop a long-range bomber capable of flying from the US to Germany with a 20,000 lb. (9000 kg) bomb load. Although smaller than the Bomber D designs that led to the B-19, the new designs required roughly the same amount of power. When preliminary designs were returned in the summer of 1940, three of the four designs were based on the R-3350. Suddenly the engine was seen as the future of army aviation, and serious efforts to get the design into production started.



Wright R-3350 Turbo-Compound radial engine. Two exhaust recovery turbines shown outside impellor casing area (top (silver) and lower (red blading)) that are geared to the crankshaft.

By 1943 the ultimate development of the new bomber program, the Boeing B-29 Superfortress, was flying. The engines remained temperamental, and showed an alarming tendency for the rear cylinders to overheat, partially due to minimal clearance between the cylinder baffles and the cowl. A number of changes were introduced into the Superfortress' production line in order to provide more cooling at low speeds, with the aircraft rushed into operational use in the Pacific in 1944. This proved unwise, as the early B-29 tactics of maximum weights, when

combined with the high temperatures of the tropical airfields where B-29s were based, produced overheating problems that were not completely solved, and the engines having an additional tendency to swallow their own valves. Because of a high magnesium content in the potentially combustible crankcase alloy, the resulting engine fires — sometimes burning with as high a core temperature approaching 5,600ºF (3,100ºC) from the Duplex Cyclone's magnesium engine crankcase alloys — were often so intense the main spar could burn through in seconds, resulting in catastrophic wing failure.

Early versions of the R-3350 had carburetors, though the poorly designed elbow entrance to the supercharger led to serious problems with fuel/air distribution. Near the end of WWII, the system was changed to use direct injection where fuel was injected directly into the combustion chamber. This change improved engine reliability. After the war the engine was redesigned and became a favorite for large aircraft, notably the Lockheed Constellation and Douglas DC-7.

Following the war the Turbo-Compound system was developed to deliver better fuel efficiency. In these versions, three power-recovery turbines (PRT) were inserted into the exhaust piping of each group of six cylinders and geared to the engine crankshaft by fluid couplings to deliver more power. The PRTs recovered about 20 percent of the exhaust energy (around 450 hp) that would have otherwise been wasted, but reduced engine reliability (Mechanics tended to call them Parts Recovery Turbines, since increased exhaust heat meant a return of the old habit of the engine eating exhaust valves). The fuel burn for the PRT-equipped aircraft was nearly the same as the older Pratt and Whitney R-2800, while producing more useful horsepower. Effective 15 October 1957 a DA-3/DA-4 engine cost $88,200.

By this point reliability had improved with the mean time between overhauls at 3,500 hours and specific fuel consumption in the order of 0.4 lb./hp/hour (243 g/kWh, giving it a 34% fuel efficiency). Engines in use now are limited to 52 inches of mercury (1,800 hPa) manifold pressure, being 2,880 hp with 100/130 octane fuel (or 100LL) instead of the 59.5 in Hg (2,010 hPa) and 3,400 HP possible with 115/145, or better, octane fuels, which are no longer available since many formulations are toxic.

Several racers at the Reno Air Races use R-3350s. Modifications on one, Rare Bear, include a nose case designed for a slow-turning prop, taken from a R-3350 used on the Lockheed L-1649 Starliner, mated to the power section (crankcase, crank, pistons, and cylinders) taken from a R-3350 used on the Douglas DC-7. The supercharger is taken from an R-3350 used on the Lockheed EC-121 and the engine is fitted with Nitrous Oxide injection. Normal rated power of a stock R-3350 is 2,800 horsepower at 2,600 rpm and 45 inches of manifold pressure. With these modifications, Rare Bear's engine produces 4,000 horsepower at 3,200 rpm and 80 inches of manifold pressure and 4,500 horsepower with Nitrous Oxide injection.

Variant

Wright R-3350 Turbo-Compound radial engine fitted at the Number Four position on the starboard wing of a Lockheed Super Constellation

- **R-3350-13** : 2,200 shp (1,640 kW)
- **R-3350-23** : 2,200 shp (1,640 kW)
- **R-3350-24W** : 2,500 shp (1,860 kW)
- **R-3350-26W** : 2,800 shp (2,090 kW)
- **R-3350-32W** : 3,700 shp (2,760 kW)
- **R-3350-34** : 3,400 shp (2,540 kW)
- **R-3350-42WA** : 3,800 shp (2,830 kW)
- **R-3350-53** : 2,700 shp (2,010 kW)
- **R-3350-57** : 2,200 shp (1,640 kW)
- **R-3350-85** : 2,500 shp (1,860 kW)
- **R-3350-89A** : 3,500 shp (2,610 kW)
- **R-3350-93W** : 3,500 shp (2,610 kW)

Applications

- Boeing B-29 Superfortress
- Boeing XC-97 Stratofreighter
- Boeing XPBB Sea Ranger
- Canadair CP-107 Argus
- Consolidated B-32 Dominator
- Curtiss XBTC-2
- Curtiss XF14C
- Curtiss XP-62
- Douglas A-1 Skyraider
- Douglas BTD Destroyer
- Douglas DC-7
- Douglas XB-19
- Douglas XB-31
- Fairchild C-119 Flying Boxcar
- Fairchild AC-119
- Lockheed Constellation
- Lockheed L-049 Constellation
- Lockheed C-69 Constellation
- Lockheed L-649 Constellation
- Lockheed L-749 Constellation

- Lockheed L-1049 Super Constellation
- Lockheed C-121 Constellation
- Lockheed R7V-1 Constellation
- Lockheed EC-121 Warning Star
- Lockheed L-1649A Starliner
- Lockheed P-2 Neptune
- Lockheed XB-30
- Martin JRM Mars
- Martin XB-33 Super Marauder
- Martin P5M Marlin
- Stroukoff YC-134

A Wright R-3350 radial engine, showing, R to L, propeller shaft, reduction gear case, magneto (silver) with wiring, two cylinders (rear with connecting rod), impellor casing (and induction pipe outlets) and injection carburetor (black); separate accessory gearbox at extreme left..

Specifications (R-3350-C18-BA)

General characteristics

- **Type:** Twin-row 18-cylinder radial engine
- **Bore:** 6.125 in (155.6 mm)
- **Stroke:** 6.312 in (160.2 mm)
- **Displacement:** 3,347 in^3 (54.86 L)
- **Length:** 76.26 in (1,930 mm)
- **Diameter:** 55.78 in (1,420 mm)
- **Dry weight:** 2,670 lb. (1,212 kg)

Components

- **Valve train:** Pushrod, two valves per cylinder
- **Supercharger:** Two-speed single-stage
- **Fuel system:** Chandler-Evans downdraft carburetor
- **Fuel type:** 100/130
- **Oil system:** Dry sump
- **Cooling system:** Air-cooled

Performance

- **Power output:** 2,200 hp at 2,800 rpm (takeoff power)
- **Specific power:** 0.66 hp/in³
- **Compression ratio:** 6.85:1
- **Power-to-weight ratio:** 0.82 hp/lb.