Curtiss OX-5

By Kimble D. McCutcheon

The Curtiss OX-5 has the distinction of being the first mass-produced aircraft engine in the United States. First available in 1915, it served in trainers through World War I, continued to be produced by Curtiss as well as other licensees until 1918 or 1919, and then powered a veritable explosion in general aviation after the end of the war and for a decade to follow. In 1929, 2,510 of 6,631 licensed airplanes (38%) were powered by OX-5s. In the eleven months ending March 1, 1930, 4,574 planes were licensed. Of these, 1,359 were powered by war-surplus OX-5s and only 1,016 by brand-new state-of-the-art Wright Whirlwinds. Though in 1930 almost all aircraft engines were better, few could compete with the cost of war-surplus engines (some sold new in the crate for a mere $20.00). The story of the OX-5 is one of long evolution, and in many ways, the story of Glenn Curtiss, one of the truly great pioneers of aviation in America.

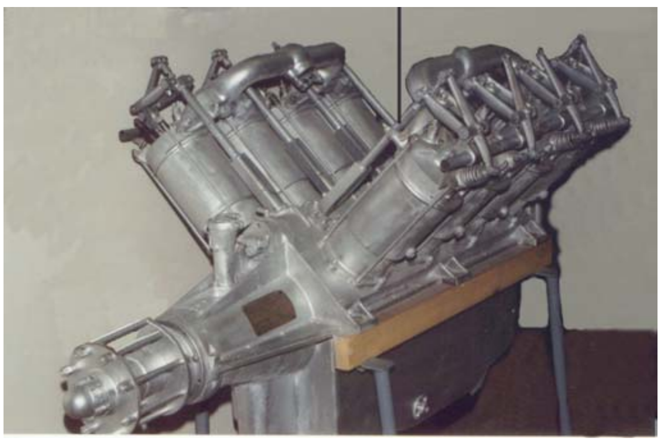

Figure 1. Curtiss OX-5

History

Glenn Hammond Curtis was born May 21, 1878 in Hammondsport, New York, the son of a harness maker. Though Curtiss showed an early aptitude for mechanical things, he disliked formal schooling and dropped out of high school at the age of fourteen. While working as a camera assembler at Eastman Kodak, Curtiss became interested in racing bicycles, eventually opening several bicycle shops. In 1901, after seeing a “Thomas Auto-Bi” motorcycle at the Pan-American exposition in Buffalo, New York, he got the idea of attaching an engine to his bicycle. He built his first engine from “Auto-Bi” rough castings purchased through *Scientific American*. His first carburetor was a tomato can stuffed with steel wool. Unsatisfied with the performance of engines designed by others, he was soon producing motorcycles with engines of his own design, and started the Curtiss Company in 1902. Development of motorcycles led to his January 1907 World Record of 136.36 mph in Ormond Beach, Florida, making him the fastest man on earth for the next seven years.

The first Curtiss aviation engine was a modified 5-hp motorcycle engine sold in 1904 to Captain Thomas Baldwin to power the first successful U.S. dirigible, the *California Arrow.* Curtiss discovered he could sell aircraft engines for the same price as complete motorcycle, though he continued to produce motorcycles and motorcycle engines until 1917. By 1906, Curtiss had developed V-8 air-cooled engines used to power aircraft of the Aerial Experiment Association, led by Dr. Alexander Graham Bell.

Curtiss made his first flight on his 30th birthday--May 21, 1908--in *White Wing*, a design of the Aerial Experiment Association. White Wing was the first plane in America to be controlled by ailerons instead of the wing warping used by the Wrights. It was also the first plane on wheels this side of the Atlantic.

Curtiss had big years from 1908 through 1910. He won the *Scientific American* magazine trophy, the Gordon Bennett Trophy plus a $5,000 prize at the first international air meet at Rheims, France, and the $10,000 New York Times prize for the first flight between Albany and New York City. These accomplishments were primarily due to Curtiss always having the engine edge in his aircraft.

Curtiss deserves credit for pioneering the design of the floatplane, the amphibian, and the flying boat. It was a Curtiss plane flown by Eugene Ely, a company exhibition pilot that made the first successful takeoff from a Navy ship in 1910. Another Curtiss plane, the NC-4, made the first crossing of the Atlantic in 1919. Curtiss built the first U.S. Navy aircraft, called the Triad, and trained the first two naval pilots. He received the Collier Trophy and the Aero Club Gold Medal for the greatest accomplishment in aviation during 1911.

The American entrance into World War I produced huge orders for the Curtiss Company, and made Glenn Curtiss a rich man. The company continued to improve its line of engines through the 1920s but fell on hard times in the late 1920s due to its involvement in the Army Air Corps’ misguided attempts to build high-temperature liquid-cooled engines. The Curtiss Company merged with Wright in 1929 to become Curtiss-Wright. Glenn Curtiss died in July of 1930 from complications of appendicitis

Design and Development

Early Curtiss aircraft engines were variants of his air-cooled V-twin motorcycle engine. The design philosophy espoused minimal weight consistent with acceptable reliability, advanced mechanical features, and careful machining. These early engines showed remarkable insight in their crankshaft design by incorporating roller main and big end rod bearings. Engines were enlarged by bolting the V-twins together until finally a V-8 was appeared in 1906. The cylinders and valve gear were unremarkable F-head suction-intake designs with cast-iron cylinders and pistons that overheated on anything but the shortest flights. By 1908, engines had become large enough so that air-cooling gave way to water cooling in the form of Monel (a nickel-copper alloy) water jackets brazed onto cast-iron cylinders. Later engines used brazed-on steel water jackets. Each cylinder was secured to the aluminum wet-sump crankcase by four nickel-steel studs, contributing to engine lightness. Curtiss spared little expense, using the best materials and considerable machining and assembly labor. By 1909, cross-flow overhead valves with double-acting cam, a pull tube actuating the intake valve and a push rod actuating the exhaust valve were introduced. This was refined into the first OX series of engines, introduced in 1912, the result of a U.S. Navy power requirement for the A-1 amphibian.

Curtiss was able to attract and afford some of the best engineering talent available at the time. This included Henry Kleckler, Charles Kirkham, and Charles Manly. Kleckler had come up through the ranks at Curtiss after beginning as shop foreman in 1906, and handled many of the day-to-day shop issues. Charles Kirkham, chief of engine design, was the son of John Kirkham, whose machine shop had built Curtiss' early engines. Kirkham had manufactured a line of both motorcycle and aircraft engines of his own before coming to Curtiss. Charles Manly was a former SAE president and had built the 1903 Manly-Balzer 5-cylinder radial to power the Langley *Aerodrome.* This team refined the OX-5 pistons, valve gear, intake manifold, magneto drive, and carburetor in 1915, improving the power and reliability of the engine.

A few of the aircraft using OX-5 engines were the Laird Swallow, Travel Air 2000, Waco 9 and 10, the American Eagle, and some models of the ubiquitous Curtiss JN-4 "Jenny". It is interesting that these large, fairly heavy aircraft performed as well as they did with only 90 hp (though the "Jenny's" climb has been described as "imperceptible"). Some authors have attributed this to the engine having great torque, which in their mind made up for horsepower. Horsepower, however, is nothing but torque times RPM. Though the OX-5 developed its maximum torque at a low 1,000 RPM, two factors were responsible for its better-than-expected performance. First, its rating of 90 hp was at 1,400 RPM, though it was capable of running as fast as 1,800 RPM for short periods, and producing nearly 105 hp. This slow engine speed, especially when compared to modern direct-drive aircraft engines, allowed propellers to be much larger and more efficient, producing greater thrust.

Service

When the OX-5 was introduced it was as light, efficient and reliable as any other aircraft engine. By the end of its use nearly 30 years later, it was considered heavy and unreliable. Since it had been used largely in training and barnstorming aircraft, some think it contributed to the death of quite a few students.

A number of design and production problems gave rise to these reliability difficulties. As with all separate cylinder engines, the crankcase had to be extremely heavy in order to be sufficiently rigid to avoid flexing. Though the OX-5 bottom end was reasonably good, typically having a time-between-overhaul (TBO) of a few hundred hours, the valve gear was both fragile and troublesome. It had no provisions for lubrication other than grease and oil applied by hand. Fifty hours was the typical limit of the valve train. The single ignition typically powered by a Dixie or Berling magneto did not stand up well in service. In fairness to the design, Bosche magnetos were originally specified, but were unavailable due to the war. Later Scintilla units fared better. Other problems resulted from vibration-induced cooling leaks. The large volume of oil in conjunction with long intake manifolds made cold weather starting difficult. Pilots would often drain the oil from the engine and keep it warm overnight to aid cold starting. Since the engine had been widely licensed, Curtiss had no control over the quality. Though Curtiss-produced engines were of high quality, many of the licensed units exhibited appalling quality. During the 1920s a thriving after-market of improved top-end overhaul components (roller rockers, lubrication upgrades, dual ignition, etc.) appeared.

Specifics

Configuration:	8-cylinder, water-cooled 90° Vee
Output:	90 hp @ 1,400 RPM
Weight:	390 lb
Displacement:	503 in^3
Bore x Stroke:	4.0” x 5.0”
Compression Ratio:	4.9:1
Mean Effective Pressure:	100 psi
Specific Weight:	4.33 lb/hp
Specific Output:	0.18 hp/in^3
Cruise Fuel Consumption:	8.0 gal/hr @ 75% power
Cruise Specific Fuel Consumption:	0.53 lb/hp/hr @ 75% power
Cruise Oil Consumption:	0.5 gal/hr @ 75% power
Cruise Specific Oil Consumption:	0.042 lb/hp/hr @ 75% power
Six-hour mission specific weight:	1.53 lb/hp/hr (engine + fuel + oil @ 75% power)

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