Aviation's Unsung Hero – Glenn Hammond Curtiss

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I read with interest the article by George Fox Lang in the August 2012 issue of *Sound & Vibration* about Igor Sikorsky and his early involvement with the flying boat. In the 1920s and '30s, flying boats opened up the airways for transoceanic transportation. The article sparked my interest, since I was involved as a volunteer at the Glenn Curtiss Museum with the construction, testing and documentation of a reproduction of the world's first multi-engine flying boat, the 1914 Curtiss *America*.

In the early days of aviation, what materials were used for airframes and engines? What are their important characteristics? How can 100-year-old engines survive and fly again? What are shock and vibration concerns? What are some technological advancements that led to the development of aviation, the navy PBY, aircraft carriers and transatlantic flight? Is today's four-valve-per-cylinder engine technology really new?

When talking with visitors at the museum and engineers at tradeshows, I was surprised to learn how little was known about Glenn Curtiss, his engines and airplanes. I learned of the conflicts between the Wrights and Curtiss over issues involved with controlled flight.

History has shown that advancement in virtually any area of technology usually results from building on the successes of others. Did not the dream of flight start with observations of birds in flight, then experimentation by many in development of kites, gliders, aircraft, jets, rockets and eventually trips to the moon and now Mars?

A few years ago, while vacationing in the Finger Lakes region of central New York, I chanced upon the Glenn Curtiss Museum located in the quaint little town of Hammondsport, where, more than a 100 years ago the U.S. Navy took delivery of its first aircraft, the Curtiss A-1 Triad amphibian.

As I wandered through the museum into the restoration shop, I noticed volunteers working on what appeared to be the keel of boat. When asked what they were building, they replied, "*A multi-engine transatlantic flying boat!*" Furthermore, they indicated it was planned to fly over Keuka Lake and that it would be *"powered by two original Curtiss V-8 engines that were almost 100 years old."*

As I stood there in amazement, I wondered what the MTBF (mean time between failures) might be on aeroplane engines that old. As I would learn later, after a series of actual flight tests using these engines – they proved to be quite reliable. I had never seen a 100-year-old airplane engine, let alone one in flight condition.

At the time of my visit to the museum, I had recently "semi-retired" from PCB Piezotronics, so getting involved in aeroplane restoration activity at the museum restoration shop sparked my interest. I can recall as a kid back in the 1930s, just seeing an aeroplane fly over was not common. At the sound of an airplane, all eyes turned to the sky.

As I got involved, I learned the volunteer team consisted of a wealth of individual talents including aeronautical engineering, wood and metal working, engine, and welding. Others had flight experience in private, commercial, and military PBY seaplanes. I found my niche helping to document with pictures and video construction details, testing and flight of these historic aeroplanes.

Like much of the public, I realized that I knew very little about Glenn Curtiss. As time passed, I was surprised to learn of his many accomplishments in the development and advancement of the practical aspects of aviation. Author Seth Schulman, in his book *Unlocking the Sky*, comments "despite the lack of schooling, historians credit Curtiss with a central role in no fewer then 500 innovations . . . many still in use in today's airplanes." These include everything from ailerons, retractable landing gear to the enclosed cockpit and the design of hulls and pontoons used on seaplanes. It was Alexander Graham Bell and his Aerial Experiment Association that got Curtiss involved in aviation because of his knowledge of engines.

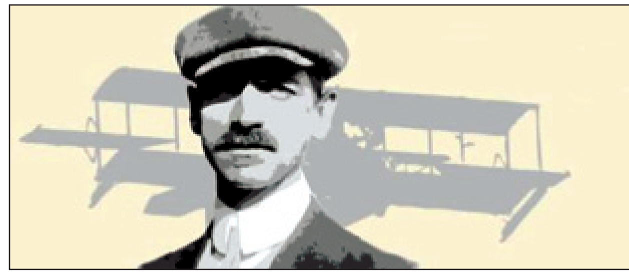

Figure 1. Glenn Hammond Curtiss, 1878-1930.

At the time of my involvement as a volunteer, the Curtiss restoration shop was in the process of building a flying reproduction of the world's first multi-engine flying boat, the *America*. Curtiss built the original *America* in response to an offer of a $50,000 prize by the London Daily Mail for the first transatlantic flight by a heavier-than-air flying machine. Rodman Wannamaker, of Philadelphia department store fame, put up $25,000 to construct a flying boat capable of flying across the Atlantic. It was to be named *America* in recognition of 100 years of peace with England after the War of 1812. The *America* was to be flown by an ex-British naval officer, Lt. John Cyril Porte and a Curtiss co-pilot and mechanic, George Hallett, who would service the engines, even in flight. Engine service required adding engine oil, manual lubrication of the overhead valves and in the event of an ignition failure, spark plug replacement – all done while the engine was running. Electric start capability had not yet been invented.

Curtiss built the original *America* flying boat shown in Figure 2 in about four months. It was painted bright red so it could be easily seen even in the event of an unplanned water landing. It was powered by two Curtiss OXX-6, 100-HP, water-cooled, overhead-valve, dual-ignition, V-8 "hemi" engines. The cylinder block, pan and pistons were of cast aluminum, while the cylinders were cast iron. The overall weight of the 9.3L engine was around 400 pounds. In pre-flight durability testing, the 100-horsepower engines proved themselves in the factory by running flawlessly non-stop for 100 hours. When news of the test became public, the betting odds posted by Lloyds of London for "project failure" dropped from 47 to 1 down to 6 to 1; disappointing for a group of Curtiss workers who had wagered $2000 on the *America's* success.

The flight plan called for fueling stops at St. John's Newfoundland, 1200 miles on to the Azores and the final 500-mile leg to England. Preliminary load calculations for the trans-oceanic flight, including fuel, indicated the America would have to lift 5000 pounds. When tests indicated they could get only get a little over 4600 pounds aloft, Curtiss decided to add a third engine. Before further tests could be completed, WWI broke out and transatlantic flight plans were cancelled.

The original *America* and its back-up were sold to England. The America's key role was to serve as a model for "*. . . development of more reliable, seaworthy and combat-ready flying boats for submarine patrol duty.*" Successors to the *America* were sold to England and other countries, and it was the only aeroplane of American origin to see combat duty in WWI.

Curtiss' dream of transatlantic flight was delayed until the end of WWI. In 1919, he collaborated with the U.S. Navy in building

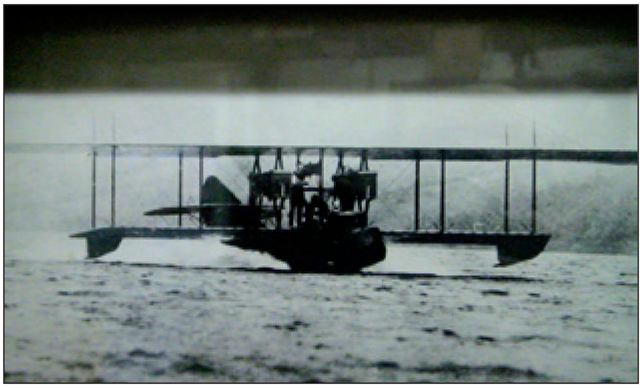

Figure 2. Curtiss flying boat America on Lake Keuka – 1914 (photo courtesy Curtiss Museum).

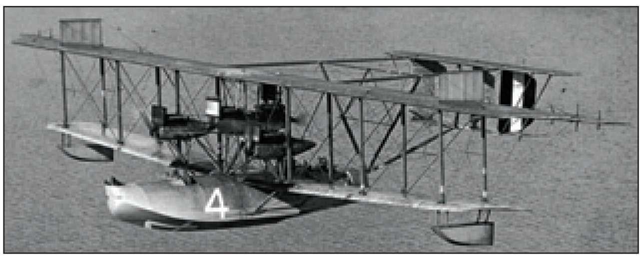

Figure 3. U.S. Navy Curtiss NC-4 flying boat; first transatlantic flight – 1919 (photo courtesy Curtiss Museum).

a larger, more powerful flying boat. The Curtiss NC-4 shown in Figure 3 made the first ever airborne transatlantic crossing on May 27, 1919.* Curtiss considered it "his most important contribution to aviation." The original NC-4 Flying Boat is on display at the Navy National Air Museum in Pensacola, Florida.

Building a Flying Reproduction of the *America*

In 2003, under the direction of Art Wilder, the Curtiss Museum restoration shop took on a project of huge magnitude: building a *flying* reproduction of the 1914 multi-engine flying boat *America*. Some plans, patent drawings and many photos existed. Original materials and fasteners were used whenever possible. Sitka spruce, a strong, light, tight-grained, virtually knot-free wood and ash and pine make up the most used materials. Each piece was individually cut in the museum shop. Laminated ash was steamed and formed for use as the circular hull framing. The *America* would be powered by two original Curtiss OXX-6, 100-HP, water-cooled, V-8 engines (see Figures 4 and 6).

Since the reproduction was being built to fly, there were some departures from original construction. A modern poly-fiber fabric covering was used instead of silk and modern epoxy adhesives replaced animal glues. Trim tabs, not invented yet, were added to the rear vertical and horizontal stabilizers to ease the load on the flight controls.

As construction of the airframe progressed, two original Curtiss OXX-6 V-8 engines were selected and reworked. One required a new cam to provide for counter-prop rotation. Counter-prop rotation directed the air flow directly across the rear horizontal stabilizer that had been inverted to provide lift. When the engines did not get completed in time for the planned seaplane homecoming, two OX-5 (90 hp) V-8 engines were installed. Unfortunately, these engines did not have enough power to get the tail up and provide lift-off.

The museum had three wooden propellers of unknown thrust capability. To test the propellers, PCB Piezotronics provided a Model 1403-03A, a 1000-lb strain gage load cell, along with a Model 8195 digital readout meter. The load cell was installed between

Figure 4. The original hull of the America (top) and the reproduction hull and wing under construction (photos courtesy Curtiss Museum).

the engine test stand and secured to a heavy fork lift. Comparative thrust measurements on the three props indicated as much as 200 pounds difference. This information helped select propellers that ultimately performed very well (see Figures 5 and 6).

At the Seaplane Homecoming the following year, the reconditioned OXX-6 engines were installed. The *America* was again ready for flight, just as Curtiss designed it – with counter-rotating props and the rear horizontal stabilizer inverted to provide lift. Before flight tests, the engines were run on the test stand for several hours and they performed beautifully. The *America* was then launched in slightly choppy waters into a mild head wind. At this time, pilot Jim Poel only wanted to see if he could get the tail up out of the water – he applied power, the tail went up and the America lifted off in only 11 seconds – quicker than any modern seaplane.

Seven pilots have since experienced the thrill of flying the *America*, which now has more than 4 hours of flight time over Keuka Lake, where Curtiss flew 100 years ago (see Figure 7).

Shock, Vibration and Acoustic Concerns. Shock, vibration and acoustic issues were important in the construction, test and flight of *America*. Noise resonated throughout the cabin from the big, open-exhaust, V-8 engines. A PCB, Larson Davis Model 831A sound level meter served to measure engine cabin noise and suggested the use of ear protection. The engines, directly mounted to wooden

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****Editor's note***: *The accomplishment of the naval aviators of the NC-4 was somewhat eclipsed in the minds of the public by the first* ***nonstop*** *transatlantic flight, which took 15 hours, 57 minutes, and was made by Royal Air Force pilots John Alcock and Arthur Whitten Brown, two weeks later. Twenty-five-year-old U.S. air mail pilot Charles Lindbergh didn't reach world fame until May 20-21, 1927, when he made the first* ***solo, nonstop*** *transatlantic flight.*

Figure 5. Brian Grigsby takes thrust measurements using a PCB load cell and digital readout meter.

Figure 6. Trafford Doherty, executive director of the Curtiss Museum, props the big 9.3L V-8 engine (everyone gets involved).

beams without any form of isolation, sent vibration throughout the airframe. All nut/bolt joints were secured with wire locks. Although modern epoxies were used, each joint was secured by a gusset that was both epoxied and tacked in place with small brass brads. Metal-to-wood joints were secured with thin copper sheet metal wrapped around the metal structure and then tacked to the wood. Gas tanks were much more than hollow containers. They contain baffles to restrict fuel from rapidly shifting which would affect balance and control.

Bamboo was a common hard wood material used for body framing in early single-engine biplanes. It is a hollow, strong, lightweight hardwood. The hollow areas between nodes are banded, since dry bamboo has a tendency to splinter when stressed. The ends were plugged with dowels and metal banded to secure terminations. Particular attention was given to securing and damping of the control and support cables from both mechanical and wind-induced resonance. Early airplanes were literally held together by their support cables that carried the load during take-off, flight and landing. A tension meter was used to measure and adjust the cables for the proper loading in each situation. As a safety consideration, dual support cables were used after a single cable failed a load test. Particular attention was paid to the control cables to assure they were secured and moved freely.

Where does a museum get 100-year-old engines that are suitable for flight? Often, they have been stored and eventually donated. Curtiss built over 12,000 aeroplanes during WWI – as many as 100 in a single week. They were the first mass-produced planes and engines, and many have survived the test of time.

Figure 7. Flying reproduction of 1914 flying boat America – 2008.

According to Norm Brush, restoration shop engine specialist, "the block, pan and pistons are of cast aluminum. The cast iron cylinders are covered by nickel/copper alloy water jackets with excellent resistance to marine corrosion. Engines received are completely taken apart, closely checked, cleaned and lubricated. Most often they require new magnetos, bearings and valve grinding. Once refurbished, they usually start, run a bit rough, and after valve adjustments they run well."

Corrosion and Leakage. Since "wooden boats most always leak," all wooden surfaces, inside and out, including the hull, wings and tail sections were coated with a marine varnish. Over the varnish went a primer coat, an ultra-violet protective paint, then two finish coats of red, aircraft quality paint.

During flight tests, two shock and vibration-related events occurred. In one case, the wooden propeller/hub interface overheated. Although the prop was initially torqued and the nuts and bolts were wire locked, shock induced from cylinder combustion gradually caused the wooden propeller to loosen and overheat – charring the prop/hub interface surfaces. The Curtiss OX-5 manual cautions of this possibility, noting that propellers should be machined to tightly fit specific hubs. It further suggests to physically feel the hub after each flight to check for overheating and re-torque the mounting bolts as required. This process was followed and no further problems were encountered with prop/hub overheating. A vibration-related problem occurred during landing when a tachometer came loose and caused minor damage to the leading edge of a wing surface.

Curtiss A-1 Triad

The past few years, the museum has held a seaplane homecoming in September that features flight of a Curtiss reproduction shown in Figure 8. In 2006, I happened to attend and record video before I became a volunteer. The event was of historical significance – a re-creation of the flight of the first U.S. Navy aeroplane, the Curtiss 1911 A-1 Triad (land-sea-air). With assistance from my daughter-in-law, I eventually learned DVD movie production.

The Navy spec for the A-1 was brief, "Two men aloft on a full tank for two hours." The A-1 was a biplane amphibian with retractable

Figure 8. Reproduction Curtiss A-1 Triad, first U.S. Navy aeroplane on a test run (photo courtesy Curtiss Museum).

Figure 9. An original OX-5, 90 HP, water-cooled V-8 engine used to power a reproduction of the A-1 Triad (land-sea-air) flying boat.

Figure 10. AEA/Curtiss June Bug flight, July 4, 1908 (photo courtesy Curtiss Museum).

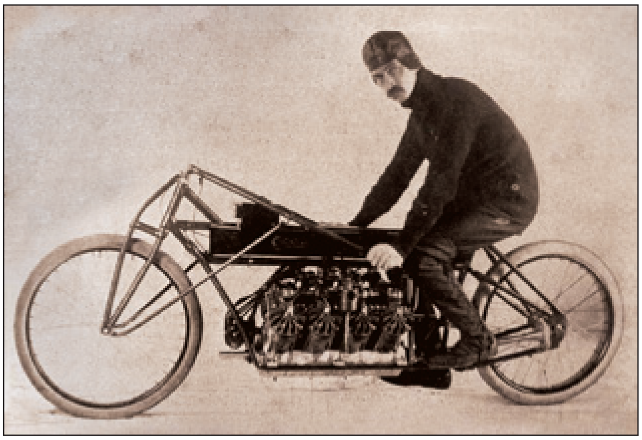

Figure 11. Glenn Curtiss on his air-cooled V-8 motorcycle with direct drive – 1907.

landing gear. It was powered by a Curtiss OX-5 water-cooled, overhead valve, cast-aluminum, 90-hp, V-8 engine. Jim Poel, a retired American Airlines pilot flew many of the Curtiss reproductions. The A-1, at 1500 pounds, was relatively heavy for an early aircraft. It had a unique method of lateral control by means of a "shoulder yoke," leaning to the left or right, moved the ailerons. According to Poel, the A-1 was a very stable plane; he could take his hands off the controls and it would fly by itself. One time I mentioned to him, after observing a sea gull fly by, that he needed to look out for the birds. "No." he replied, "They need to look out for me . . . they fly faster than I do!"

Curtiss Trophies and Awards

So who was Glenn Hammond Curtiss and what were some of his major accomplishments?

In the early 1900s *Scientific American* magazine, a weekly periodical, heard that the Wright brothers flight at Kitty Hawk had been done in seclusion. The magazine sought to bring aviation out into the public view by creating a contest with a silver trophy as a prize. The contest was to include three competitive flight events, each of increased difficulty and required aircraft to take off under their own power. To gain permanent possession of the trophy, an individual must win one of each event in three separate years.

On July 4, 1908, editors of the *Scientific American* and members of the Aero Club of America traveled to the tiny Hamlet of Hammondsport, New York, to witness the first officially recognized, pre-announced, publically observed flight of the heavier-than-air flying machine in America. The *June Bug* shown in Figure 10 had a successful flight of 5090 ft, 1810 ft farther than required, won Curtiss the first leg of the trophy contest. A year later, in 1909, Curtiss flew his *Golden Flyer* and set a new world distance record of 24.7 miles to win the second leg of the competition.

He won permanent possession of the *Scientific American* trophy and a $10,000 prize offered by the *NY World* newspaper in his *Hudson Flyer* after completing the first successful flight between Albany and New York City down the Hudson River. The 150-mile flight gained national recognition and helped establish " . . . the aeroplane as having some practical value. It was even suggested that it might have a wartime use." (See Figure 12.)

Curtiss entered the first International Air Race in Rheims France in 1909, competing against Europe's top aviators. Although the Wrights did not compete, five planes of their designs were entered. Curtiss held off until the final days of the competition and won the Gordon-Bennet Cup speed race averaging 46 mph.

Fastest Man In The World

In 1902, Curtiss and three employees, built and sold motorcycles under the trade name Hercules. In 1907, he built an air-cooled, V-8 powered motorcycle with direct shaft drive, no belts or chains. He also invented the motorcycle handle bar throttle control.

January 23, 1907, in a measured-mile run at Ormond Beach Florida, Curtiss was officially clocked at 136.6 mph on his V-8-powered motorcycle. On that day, and for year's afterward, Glenn Curtiss carried the title "Fastest Man on Earth." Ironically, at that time, airplanes flew only 30 to 40 mph (see Figure 11).

By 1907, Curtiss was making considerable progress in engine development. In a letter to the Wrights, he offered one of his engines free of charge, he noted " . . . we are now turning out, in addition to the 15-, 20-, 30- and 40-HP air-cooled engines, a 4-cylinder vertical 5×5 and V-8, water-cooled engines rated at 50 and 100 HP, respectively."

By 1919, the Curtiss Oriole, with electric start, was powered by a 24 valve, 165-HP in-line six-cylinder engine – engine technology not discovered by the automobile industry until decades later.

Father of Naval Aviation

To history buffs, Glenn Curtiss is known as the "Father of Naval Aviation." He built the first U.S. Navy airplane, trained the first navy pilots and built the NC-4 Flying Boat, the first to cross the Atlantic. Curtiss "pushers" (propeller facing to the rear) airplanes were first to make shipboard take-offs and landings from special platforms constructed on navy ships. Other developments included steerable tricycle landing gear, pontoons and retractable landing gear.

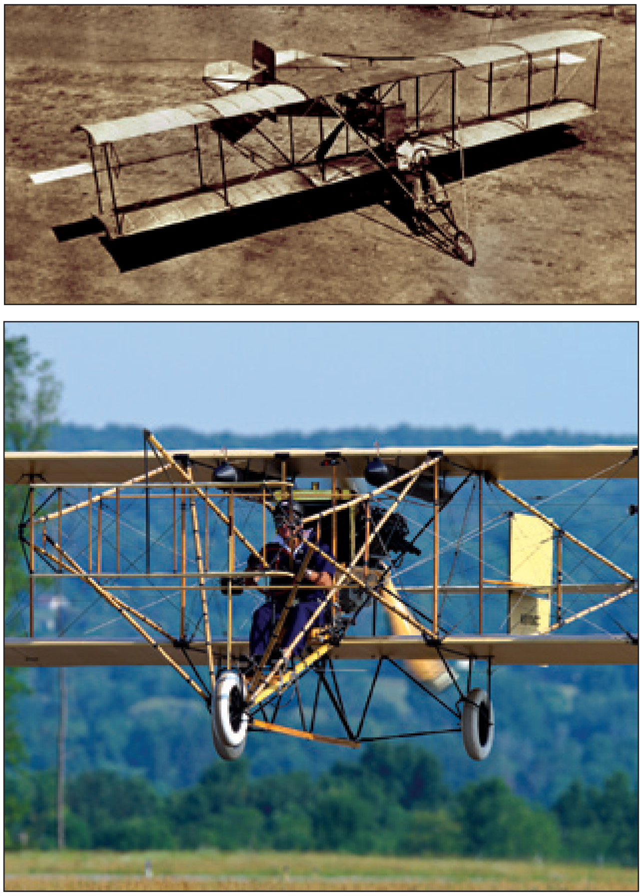

Figure 12. The original Model D "headless" pusher aeroplane (top) and the Hudson Flyer reproduction in flight (bottom).

The first shipboard landing is shown in Figure 13. A hook attached to the landing gear caught a series of ropes that were attached to sand bags stretched across the deck, this brought the aeroplane to a safe stop on the 120-foot-long platform. This series of successful tests led to the development of the aircraft carrier.

How Did Curtiss Get Involved in Aviation?

Glenn Curtiss was born in Hammondsport, NY in 1878. His insatiable curiosity, mechanical ability and ambition soon became evident. By the time he reached his teens, bicycles and speed had become a near obsession. He was a champion bicycle racer for years and quite naturally progressed to designing and building his own machines. As his engine technology became known, famed balloonist Thomas Baldwin ordered a Curtiss twin-V engine to power his lighter-than-air ship, which in 1904, became the first successful dirigible.

Alexander Graham Bell, who had been experimenting with kites and gliders from his Canadian home on Cape Briton, contacted Curtiss about joining his Aerial Experiment Association. The AEA included the famous inventor, Alexander Graham Bell, F. W. Casey Baldwin, J. A. D. McCurdy, and U.S. Army Lt. Thomas Selfridge. The AEA focus was to get a man in the air and Curtiss was needed for his engines.

A series of airplanes were designed and built under the auspices of the AEA. In March 1908, the *AEA Red Wing*, with Baldwin at the controls, made the first public flight in America of a heavier-than-air machine taking off frozen Keuka Lake. It flew 318 feet before crash landing. Two months later, the *White Wing*, with the addition of "horizontal rudders" to the wing tips – a precursor to ailerons, and with Curtiss at the controls, covered a distance of 1017 feet of controlled flight. Using knowledge gained in these two flights, Curtiss built the highly successful *June Bug*, of which thousands were built during WWI.

The Curtiss Legacy

Known as the "Father of Naval Aviation," Curtiss built the first

Figure 13. Note the "Tail Hook" arresting system; a hook attached to the landing gear used to catch a series of ropes attached to sand bags. January 18, 1911; first shipboard landing of a Model D Curtiss flying boat by Eugene Ely on a 120 × 30 ft wooden platform on deck of the USS Pennsylvania (photo courtesy Naval Historical Heritage).

Figure 14. Glenn Curtiss at the controls of a Model D.

Navy aeroplane, trained the first pilots and demonstrated capability to make shipboard take-offs and landings – leading to the development of aircraft carriers. Curtiss factories employed thousands during WWI building flying boats and the famous *Jenny*, earning him recognition as the "Founder of the American Aircraft Industry." For an individual who did not earn a high-school diploma, he had an amazing grasp of aeronautical and internal combustion engine technology for both aircraft and road vehicle applications.

With regard to the conflict between Curtiss and the Wrights, author Seth Schulman, expresses it well in his book, *Unlocking the Sky*: "At the core, the long, bitter fight between Glenn Curtiss and the Wright Brothers pitted the virtues of open, shared access to innovation against the driving economic pressure for monopoly ownership, a debate that resonates through the years. Having accomplished a tremendous breakthrough in aviation, Wilbur and Orville Wright tried to control the development of the airplane in its first decade through patents and by aggressive business tactics. Ultimately, their effort would fail."

"By contrast, Glenn Curtiss permitted anyone to use the principles underlying his inventions – a strategy that enormously benefited the emerging industry. Curtiss believed his inventions and products should succeed or fail in the marketplace on their own merit. This is the way he would have wanted his career to be judged . . . by the lasting, unrivaled success of the aeronautical inventions he created."

Curtiss-Wright Corporation Today

In 1929 Curtiss Aeroplane and Motor Company and Wright Aeronautical merged, and they listed on the NY Stock exchange as Curtiss-Wright Corporation. Today it is a $2 billion company that continues to provide innovative, high performance technologies to the defense, commercial, aerospace and energy markets.

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You can see flight videos of both the *America* and A-1 Triad reproductions at www.youtube.com/user/JFL9180. SV

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