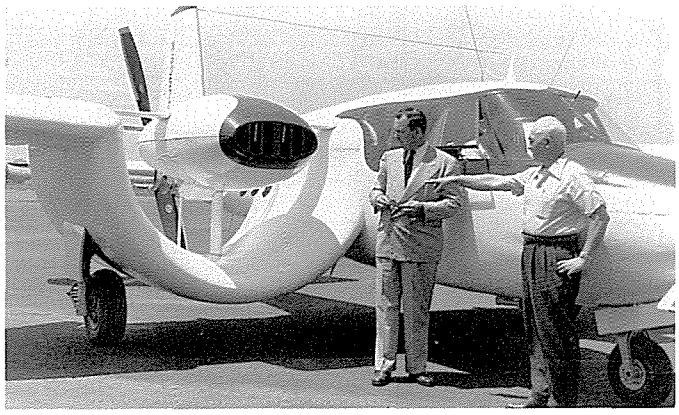
MR. CUSTER AND HIS CHANNEL WING AIRPLANES

by Kent A. Mitchell

Willard Ray Custer was born at the turn of the century in Warfordsburg, Pennsylvania to Clemm T. and Florence M. Byrd Custer. As a youth, Custer learned to work with his hands helping his blacksmith father in the family business. At the age of 13 he had to leave school to work full time. That was the end of his formal education. It was about this time that gasoline engine-powered vehicles replaced the horse on the farm and for travel—and so Willard gave up being a blacksmith and became a self-employed "pretty darn good mechanic" (in his words). Of the times, he was quoted as saying: "We built everything we needed, and I got a practical education instead of schooling. I built things from the practical requirement to makes things work." Naturally, as one interested in things mechanical, he was a keen observer of the goings-on with the fledgling airplane. Soon, the two came together.

The year was 1918, Willard was working on a farm tractor in the middle of a field when a violent storm approached. He ran into a nearby barn for shelter. No sooner than he had settled-in for the duration—the roof departed the barn. After his heart stopped pounding, Custer began to think. Why do we run an airplane down a field to fly when the barn wasn't going anywhere? Yet the roof "flew." He reasoned that if the air could be pulled over a wing instead of running the wing through the air — an airplane would fly without using a lot of unnecessary runway. In other words, he was thinking about creating static lift. Custer spent the next several years in his spare time building airplane models of his design to test his theory.His first successful model was a twin-engine design with conventional wings well forward, with a vertical fin and rudder at each wing tip. The two model-airplane engines and propellers were mounted at the trailing edge of each wing and drew the air across the airfoils, thus producing static lift. With Custer placing the vertical fins in the wing tip locations, he inadvertently created "end- plates" which improved wing efficiency (which is done today with swept-up "winglets"), but which also eventually gave him the idea to curve the airfoils up to form a U-shaped channel around the propeller to produce static lift. Custer would demonstrate that model on a table in his home with its tail tied fast to a wall. When the engines were revved up, the model would lift off above the table.



Coincidently, famed Australian pilot Captain Charles Kingsford- Smith claimed to have made an actual similar take-off from a small forest clearing after a forced landing in a tri-motor airplane. An Associated Press dispatch stated that the aviator tied the tail of the plane to a tree with a piece of rope and was enabled to rise in the following manner: After the pilot

Above: *The unpainted CCW-5 sits on the ramp at the Hagerstown, Maryland airport. Evident are the semi-transparent fiberglass inner channel skins. (Raup Photographic Studios, Author's Collection)* ***Left:*** *The second CCW-5 at Oxnard, CA 19 June 1953. Mr. Custer at right. (Photo by Harry Gann)*

warmed up the engines and opened the throttles wide, and when the plane lifted from the ground, a farmer cut the rope and the plane flew away. While the possibility that this actually occurred as described is very unlikely, famous magazine publisher Hugo Gernsback wrote letters to several aviation experts of the time asking them their opinions on the matter of producing static lift. Their replies, which appeared in the July-August 1930 issue of *Aviation Mechanics* magazine, are in themselves interesting to read, as in the following excerpts: C.S. "Casey" Jones, President, Curtiss-Wright Flying Service: "Flying is dependent upon forward speed, so that as the machine moves through the air, because of the nature of the surface of the wings certain effects on the air currents are formed causing the plane to rise, but in this case without forward speed I do not believe that the plane would lift."

Karl Arnstein, Goodyear—Zeppelin expert: "Of course, the only way an airplane obtains lift is through the motion of air over its wings. In a case such as the one described, the only appreciable lift would be caused by the propeller slip-stream. It is very certain that there is no plane built today which can lift itself in this manner."

Captain E.V. "Eddie" Rickenbacker, Vice-President, Director of Sales, Fokker Aircraft Corporation: "It is not possible for an airplane to rise from the ground until its wings move forward through the air."

Alexander Klemin, Professor, New York University: "A conventional airplane cannot possibly rise without a preliminary run, even if engines are powerful."

F. Edsted, ex-R.A.F. officer and war [WWI] flier: "You ask

Left top: *In 1961, Willard Custer donated his CCW-1 aircraft to the Smithsonian Institution. The fuselage is seen here being carried from his back yard shop to the Institute's truck. Mr. Custer is in the center facing the camera. The light weight of the CCW-1 fuselage is evident as it is carried by only a few men through Custer's back yard. (Raup Photographic Studios, Author's Collection)* ***Left center:*** *One stub wing and the main landing gear of the CCW-1, with CAA registration NX 300, are seen prior to loading on the Smithsonian truck. (Raup Photographic Studios, Author's Collection)* ***Left bottom:*** *Workers lift one of the CCW-1's channels overhead, showing its light weight. (Raup Photographic Studios, Author's Collection)* ***Opposite:*** *Rear view of the CCW-2 clearly shows the proximity of the propellers to the rear edge of the channels. (Photo by Lyle S. Mitchell*

whether a feat of this kind is possible. The answer is no. In the first place a plane gets its lift from the currents of air passing over the top of the wings and causing a suction."

Lt Ralph S. Barnaby, U.S. Navy, Bureau of Aeronautics: "The answer to your letter is NO! An airplane will not leave the ground until it attains flying speed." And further, "If the slipstream could lift the plane off it would be entirely out of control as the ailerons are beyond the slipstream."

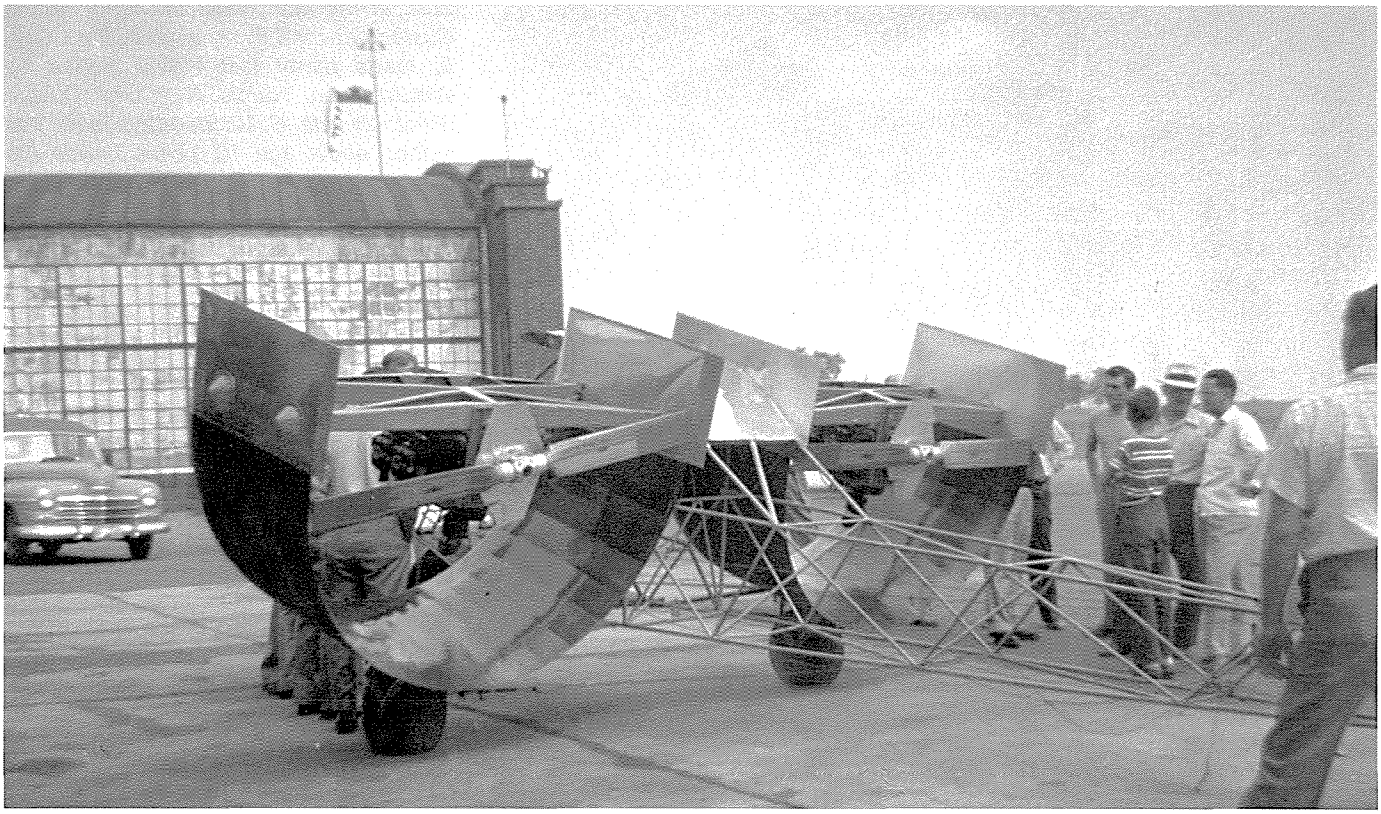
Walter Hinton, U.S. Navy trans-Atlantic flier: "In reference to your letter in regard to the statement made by a certain news item that a plane could rise from the ground by means of securing the tail to a tree, is beyond the wildest stretch of my imagination; because lift is dependent upon the speed of the plane through the air. The average speed a plane must attain before it can rise from the ground ranges between approximately 35 to 50 miles per hour."

Morton Schwam, designer, Engineering Dept. U.S. Naval Aircraft Factory, Philadelphia, Pennsylvania: ". . . we can only count on that portion of the wing within the slipstream to produce lift. Therefore if the design of the plane was such that the entire wing span was within the slipstream . . . the plane would rise off the ground Even with such a design, I doubt if the plane would stay up in a flying position off the ground because of the turbulence of air over the wings caused by the slipstream which produces eddy currents and does not produce an even flow of air over the wings as if the plane were moving in a forward direction through the air to give the best lifting effect of the wing section."

F.E. Loudy, aeronautical engineer: "It would be impossible for an airplane to lift itself from the ground in the manner prescribed." Further, "If the airplane could rise in the manner stated the pilot would have no aileron control as these organs would be outside the slipstream."

C.F. Taylor, Acting Head, Course in Aeronautical Engineering, Massachusetts Institute of Technology: ''The average airplane needs a uniform speed of air past the entire wing surface of around 50 miles an hour in order to take off. Obviously' even if the propeller could supply a blast of this speed . . . it would only apply to a very small portion of the wing surface . . ." Continuing, "The only way I know of to supply the necessary air speed past the entire wing surface is for the airplane to attain a relative speed through the air equal to its takeoff speed."

Earl D. Hay, Professor, Head, Department of Mechanical



Engineering, University of Kansas: "If it were possible the navy has been doing a lot of useless work in perfecting very expensive and elaborate catapulting apparatus for launching their planes from the decks of battleships."

Ceorge J. Higgins, Professor, University of Detroit: "The slipstream of the propeller passing over part of the wing might cause a small lifting force proportional to the area of the wing in the slipstream and to the square of the velocity of the slipstream; this would be a very small force . . ."

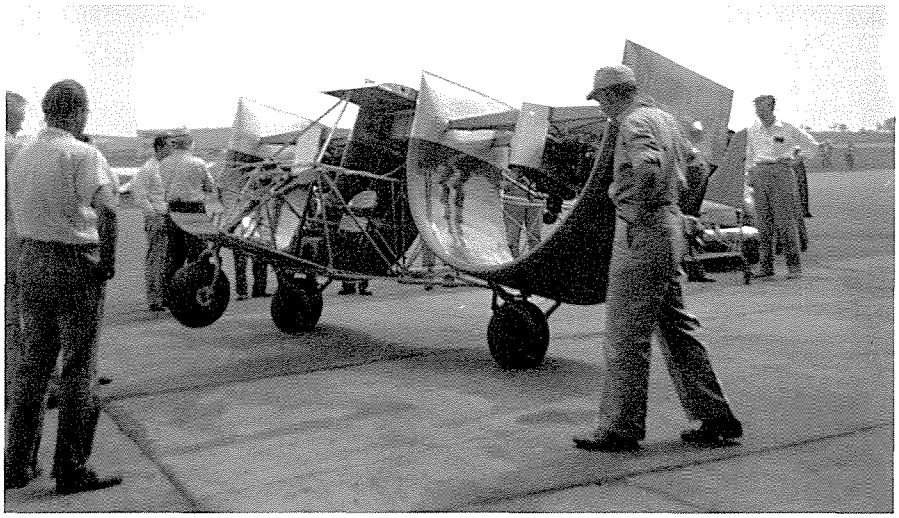
William A. Bevan, Major Air-Reserve, Professor of Aeronautical Engineering, Iowa State College: "A very powerful and light engine installed in a very light airplane might accomplish this." Also, "There is no airplane built today that can accomplish such a feat."

Apparently Custer did not read the opinions of the experts about creating static lift—or if he did, chose to ignore them—and continued to experiment with his designs. He built both single- and twin-engine airplane models and test flew them up until 1940, Then, having selected what he considered his best twin-engine design, Custer started construction of a full-size airplane in a shed behind, his home at Hagerstown Maryland.

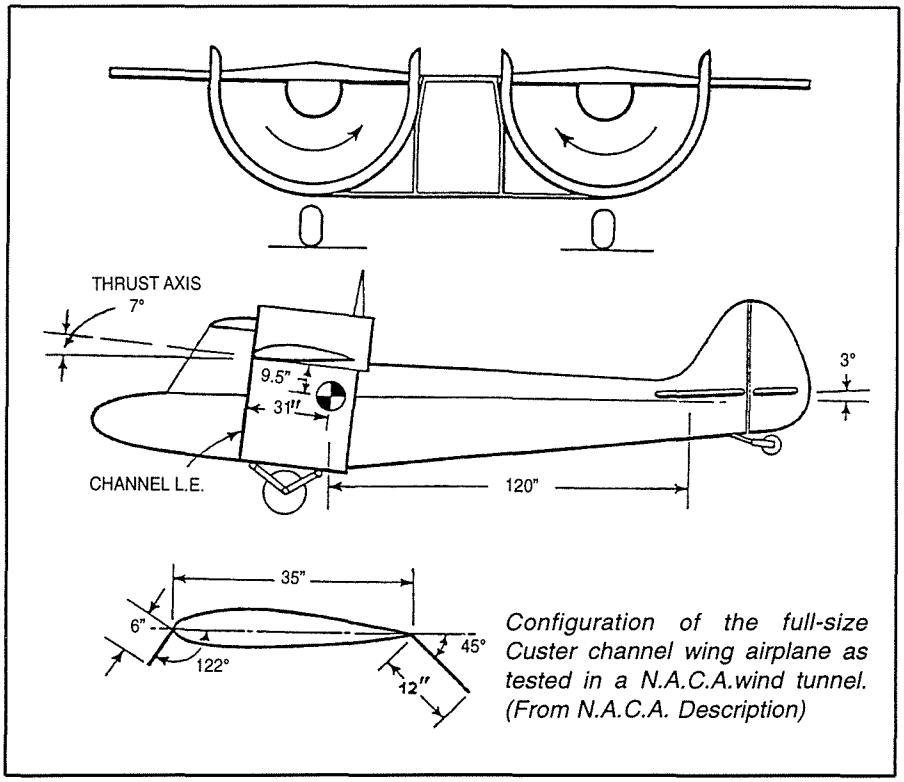
Completed in 1943, the prototype channel wing plane was of all wood construction and, even discounting the large U-shaped channels under each wing, was unusual in appearance in that the fuselage was oval shaped in cross-section and was teardrop-shaped from nose to tail. Another unusual aspect of the plane was that the entire plane was covered with a thin wood veneer (such as were the wings on the PT-19s that Fairchild Aircraft was building on the other side of town). Called the CCW-1 (for Custer Channel Wing Number 1), the plane was powered by two 75-horsepower Lycoming engines and was probably very underpowered, although it made many flights.

Examination of a photograph of the prototype shows that the engines were mounted between the front and rear wing spars which placed the propellers at the mid-point of the channels, which were half the diameter of the propellers, i.e., creating a half venturi. Also seen is a considerable gap between the propeller tips and the channel's surface. Later refinements of the channel wing concept placed the propellers at the extreme aft end of the channels and with practically no tip clearance to provide maximum propeller efficiency. When looking at the later models of Custer's airplanes without the engines running, there does appear to be a gap but, in fact, when the propellers were producing thrust they flexed forward and closed the gap. (That's how accident investigators can look at a metal prop and determine if an engine was providing power at time of ground contact — the tips are bent forward, contrary to what one would think, rather than bent to the rear, as with a retarded throttle or a failed engine.)

Although Mr. Custer maintained that his aircraft would fly with only the channels providing lift, the prototype also had short conventional wings — because that was the only way he could entice any pilots to make test flights. (Custer was not a pilot himself.) As the pilot's confidence gradually increased, the idea was to was to gradually decrease the length of the conventional wings until they were removed entirely. The author can attest to Custer's later machines flying without conventional wings, having witnessed numerous test hops as the "boy on a bicycle" at the Hagerstown airport. In addition, the author also has video tape copies of rare 16mm motion picture films owned by the Custer family that show some remarkable take-offs. The films also show a tethered channel wing airplane sus-



***Left:** In the late 1940s and early 1950s Custer's second flying aircraft, the CCW-2, made many test flights piloted by Willard's son, Harold R. "Curly" Custer. (Photo by Lyle -S. Mitchel)* ***Opposite:** The author, about age 10, poses beside the Custer CCW-2 channel wing. Under power, the propellers flexed forward to close the gap between their tips and the channels. (Photo by Lyle S. Mitchell)*



Configuration of the full-size Custer channel wing airplane as tested in a N.A.C.A.wind tunnel. (From N.A.C.A. Description)

pended from a pole in Custer's back yard while performing hovering flight.

The first pilot to fly the CCW-1 was Frank D. Kelley, a local Hagerstown businessmen , who, among other things, operated a photographic business as Kelley's Studio and specialized in aerial photos. Interested in aviation beginning in the early 1920s, Kelley was a longtime pilot and had been an instructor in the Civilian Pilot Training Program (CPTP) in the early 1940s. Kelley, and a group of other businessmen, joined with Custer to form the National Aircraft Corporation to promote the channel wing concept and intended to license its principal to aircraft manufacturers for production.

The initial test results had been so promising that Custer tried to interest the largest potential customer of the time (wartime) in his designs — the Army Air Forces. Indeed, the Army did agree to conduct wind tunnel tests of a 1/3-scale model of Custer's prototype channel wing to determine the increase in lift due to operation of the propeller, mounted at the aft end of the channel. These tests were conducted in the 5-Foot Wind Tunnel at Wright Field, Dayton, Ohio, from June 6 to July 3, 1944.

In the Conclusions section of the Technical Report resulting from the wind-tunnel tests, it was stated that ". . . the increment of lift due to propeller operation on the device under test is caused by the slipstream velocity . . ." And, "The magnitudes of the lift increments obtained show that the present device . . is superior to conventional wing-propeller arrangements in producing both static lift and lift when forward velocity exists." But, the report also said, "The present device does not show sufficient promise of military value to justify further development by the Army Air Forces." It was recommended that no further consideration of the present device be given ". . until improvements, expected by the inventor, have been verified."

Encouraged by the positive results of the Army wind-tunnel tests, proving that the channel-wing did produce static lift, Custer continued to have further tests conducted by L.H. Crook, of Catholic University, Washington, D.C., in his Aerodynamic Laboratory. Those tests resulted in refinements of the channel wing, such as a reduction of its chord that improved its performance (by increasing its aspect-ratio) and fine-tuning of the gap between the propeller tips and the channel trailing edge.

Custer informed the Army that improvements had been made and he demonstrated them with a model on May 29, 1945 in his shop at Hagerstown, Witnessing the demonstration was D.W. Young of the Engineering Division of the Air Technical Service Command, who had conducted the original tests at Wright Field in 1944. He concluded that "The arrangement indicates sufficient merit to warrant further investigation" and recommended that "The facilities and services of the inventor be utilized as much as is feasible."

However, because more accurate power input and thrust data was desired, a third series of tests were conducted at

Wright Field from February 6 to May 22, 1946 — again in the 5-Foot Wind Tunnel. These tests, which included 53 different model configurations, were made on two different length channels, with two and three blade propellers of various planforms and blade angles. The test results were presented in numerous tables and graphs, due to the large number of model configurations, and provided much useful data.

With this data in hand Custer, who had been busy building many single- and twin-engine configuration models, began construction of another full-size flight article. In order to save weight, time, and money—an uncovered Piper Cub light plane structure was utilized as the fuselage along with its vertical and horizontal tail surfaces and tail wheel. The fuselage was hung beneath a very hefty truss center-section as were two Lycoming engines and channel wings. There were no straight, conventional wings. The aircraft also had a nose wheel which, because on the ground it was tail heavy, did not touch the ground unless the pilot was aboard.

An interesting historical footnote: to build the aircraft, having outgrown his back yard shop, Custer rented the hangar at the Hagerstown airport which previously had been owned and used by the Kreider-Reisner Aircraft Company and later by Fairchild Aircraft.

This aircraft made many test flights in the late 1940s and early 1950s at the Hagerstown airport with Willard's son, Harold R. "Curly" Custer at the controls.

In 1953, the wingless aircraft was transported by truck to the National Advisory Committee for Aeronautics (N.A.C.A.) for evaluation in a full-scale wind tunnel at Langley Field, Virginia. Once again, under strict conditions, the N.A.C.A. tests demonstrated that the Custer channel wing airplane could lift itself when tethered. (Of course, the static lift created was insufficient for a vertical take-off under load—plus the aircraft had no control provisions for that.)

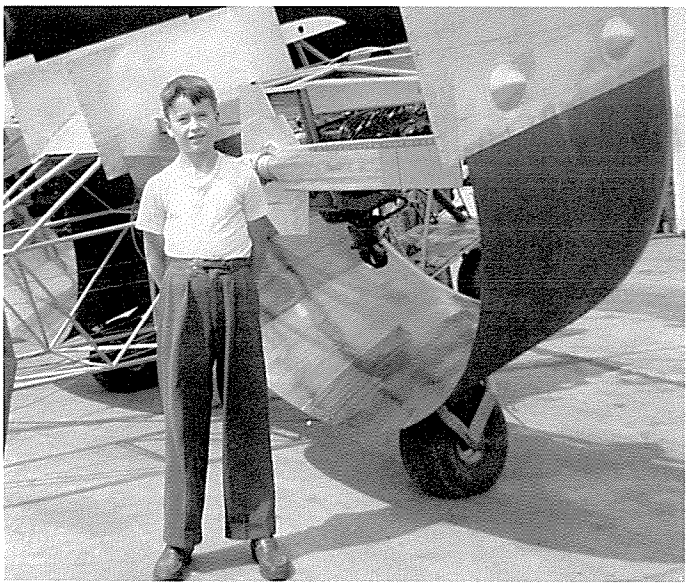
In spite of the Army and N.A.C.A. and his own test results, Custer was unable to interest any aircraft manufacturers in his unconventional wing concept. So, Custer continued to go it alone, financed by "public subscription." The name of the company was changed to the Custer Channel Wing Corporation, with the Hagerstown address of 1905 West Washington Street (his home).

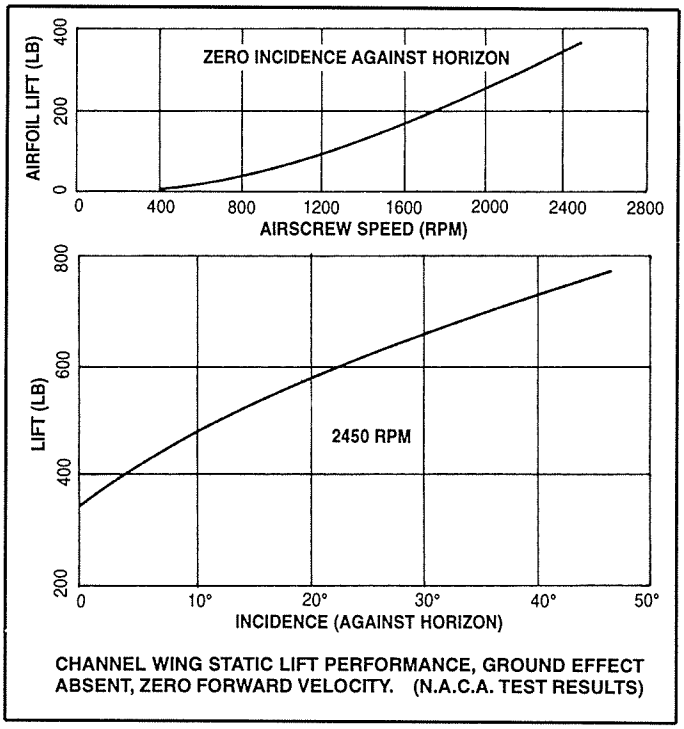
In 1952, California aeronautical engineer Jack Boyer Baumann had built a one-of-a-kind aircraft he called the Baumann *Brigadier* B-290. That five-place, all-metal, twin-engine plane had two 145-hp Continental engines in a pusher propeller configuration. It looked like a perfect candidate for conversion to a channel wing airplane. Therefore, in 1953 Custer gave Baumann a contract to modify the Brigadier to become the Custer CCW-5 channel wing.

During the modification, the powerplants were upgraded to more powerful 220-hp Continental 0-470 engines driving 7 ft. diameter fully feathering Hartzell propellers. The aircraft retained its conventional outboard wings, not only to provide aileron controls, but more so to provide space for fuel tanks.

On its maiden test flight in California, it was reported that the 2-ton CCW-5 aircraft took off after a ground run of only 100 feet. Mr. Custer also reported that his airplane landed from its first test flight with the power off at less than 40 mph.

Returned to Maryland, the CCW-5 continued to be demonstrated for several years before potential customers and/or investors.





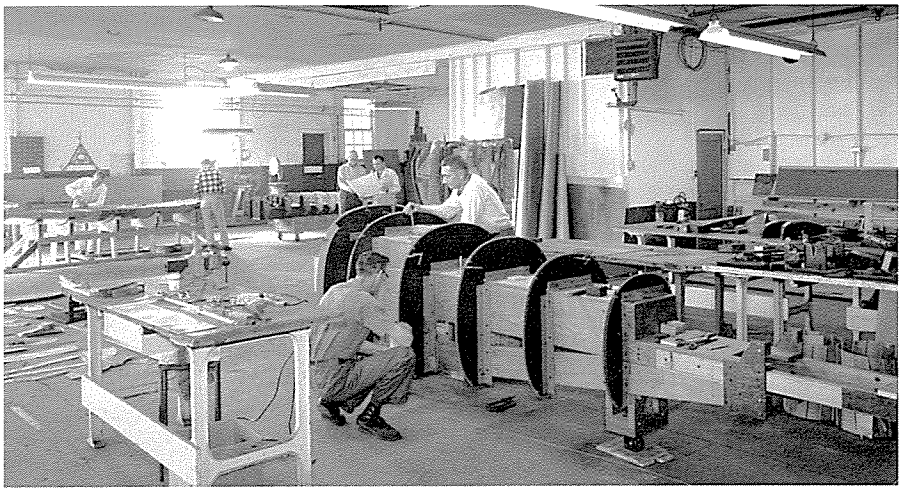
CHANNEL WING STATIC LIFT PERFORMANCE, GROUND EFFECT ABSENT, ZERO FORWARD VELOCITY. (N.A.C.A. TEST RESULTS)

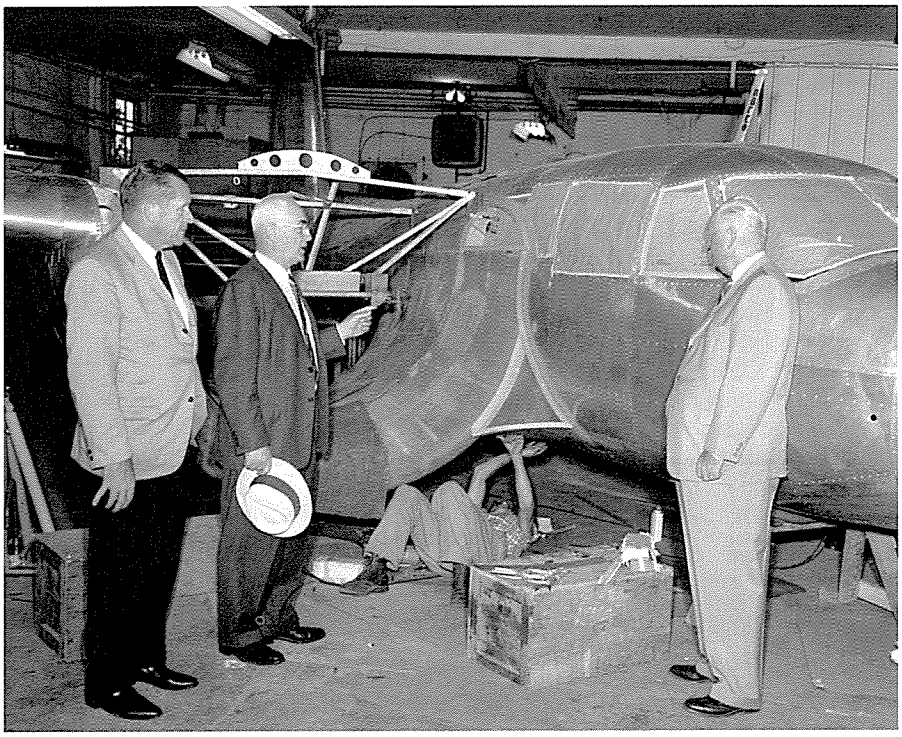
Then an article in the November 24, 1958 issue of *Aviation Week* magazine reported:

"A five-place version of the Custer Channel Wing will go into production in Canada next spring and will be offered in the United States at a price of approximately $55,000, according to J.W. Frazer, a founder and president of former Kaiser Frazer Corp. Frazer and Willard R. Custer, designer of the Custer Channel Wing, have formed the Custer Frazer Corp., New York City.

The Custer CCW-5 will be manufactured in Canada by Noorduyn Norseman, Montreal, under an agreement with Custer Frazer, with final assembly in the United States, Mr. Frazer told *Aviation Week*. Under consideration is a site in Arizona and at Canton-Akron (Ohio) Airport, He noted."

For whatever reasons, those plans did not materialize and





Custer continued to demonstrate the CCW-5 before anyone he could to elicit interest in the aircraft.

The September 28, 1959 issue of *Aviation Week* reported that the then 6-year old aircraft was demonstrated earlier that month to representatives of the three U.S. military services at the Marine Corps base at Quantico, Virginia. The article made some interesting observations about the CCW-5's flight characteristics:

"During the demonstration at Quantico, it showed an ability to climb out of a field at an angle of more than 30 degrees after a ground roll of less than 200 ft. and at about 93% of its 5,000 lb. gross weight. Full stops were accomplished within the same distance on landings.

"The flights were made with a strong wind coming in at 90 degrees to the runway, and it was apparent that considerable pilot skill is required to make maximum performance takeoffs. The nose has to be rotated upward at precisely the right moment or the high velocity air stream passing through the channel will bounce off of the ground and strike the bottom of the tail, forcing it up and the nose back down. If proper rotation is made, the horizontal tail can get under the wash from the channel and will be held down.

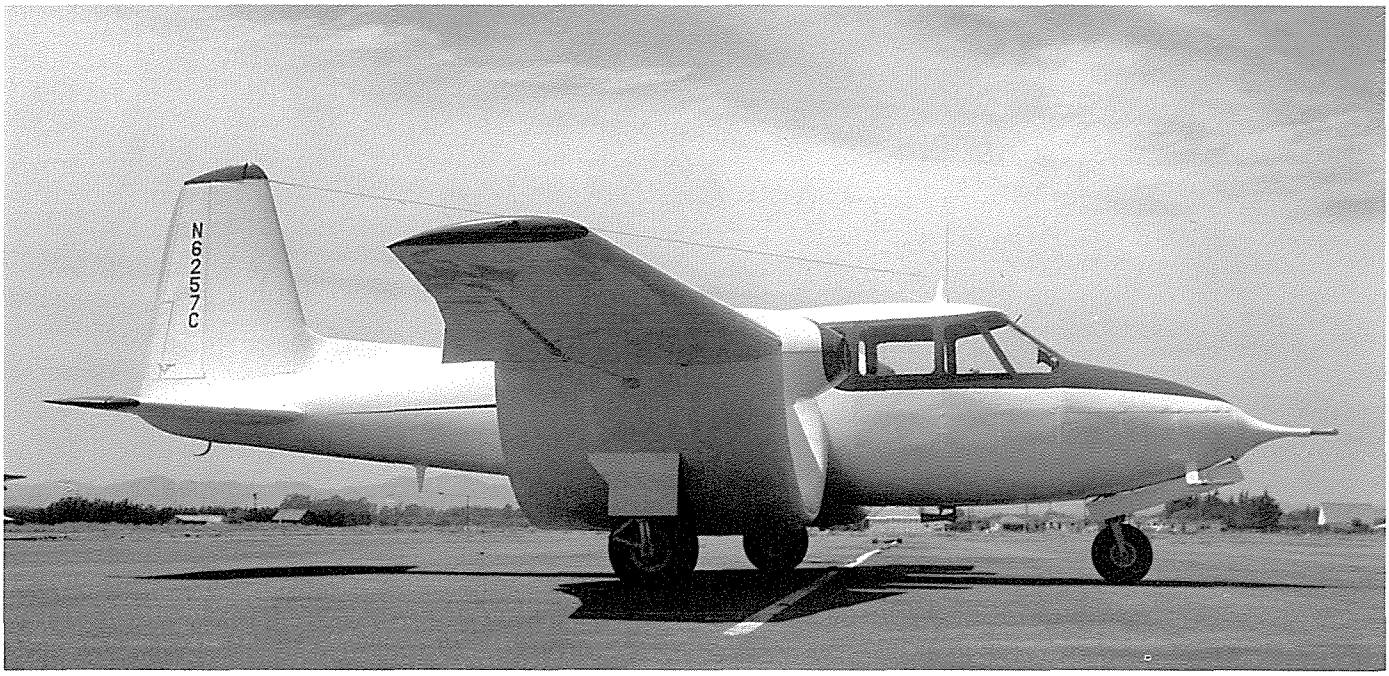
"The company pilot aborted one takeoff during the demonstration, apparently because he had waited too long to make his rotation."

The article also mentioned that the CCW-5 would soon be built in Canada:

"William Spence, president of Custer Channel Wing of Canada, Ltd., said recently that his firm is establishing a production line at Granby, Quebec, near Montreal, and plans to produce 40 of the CCW- 5 channel wing aircraft within the next year. According to Spence, 120 firm orders have been received by his company, with an average deposit of $5,000 for the $55,000 aircraft. Spence said that funds available to the company from a variety of Canadian investors total $5 million."

Those plans, also, did not materialize.

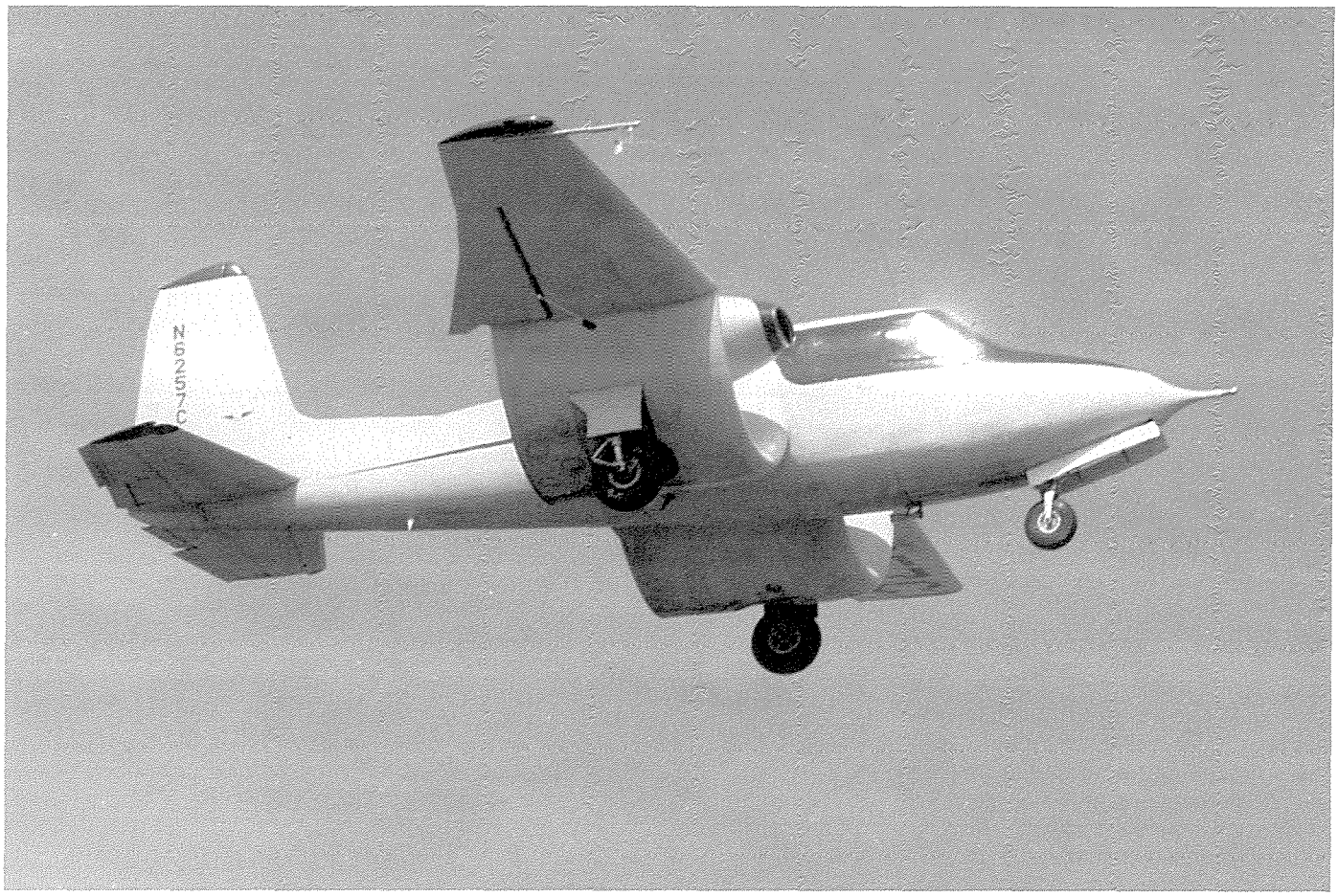
Meanwhile, back in Hagerstown, Custer had obtained the *Brigadier* assembly fixtures from Baumann and was building a second CCW-5 "to production standards." The new CCW-5 had still higher rated power with the installation of 260-hp, fuel-injected, Continental 10-470-P engines. The other differences between the first and second aircraft were



Opposite top: *Custer obtained the* Brigadier *assembly fixtures from Baumann and built a second CCW-5 "to production standards" in his Hagerstown hangar. (Raup Photographic Studios, Author's Collection)* ***Opposite center:*** *Mr. Custer shows the second CCW-5 under construction to a pair of prospective investors. (Raup Photographic Studios, Author's Collection)* ***Opposite bottom:*** *Posing in front of the completed "production" CCW-5 with their ladies are sons Reed and Harold with Willard and Lula Custer. (Raup Photographic Studios, Author's Collection)* ***Right top:*** *Profile view of the second Custer CCW-5 channel wing, N6257C, at Oxnard, CA 19 June, 1953. (Photo by Harry Gann)* ***Right center:*** *Front view of the Custer CCW-5 channel wing at Oxnard, California shows its distinctive channel wing design feature. (Photo by Harry Gann)* ***Right bottom:*** *The one-and-only Baumann* Brigadier B-290 *was modified with the addition of channels to become the Custer CCW-5. (Photo by Lyle S. Mitchell)*

few, mainly the addition of some fairings, minor changes to the wing trailing edge, and the skinning of the channels with fiberglass.

Completed in early 1964, the production prototype was placed in a test program to satisfy Federal Aviation

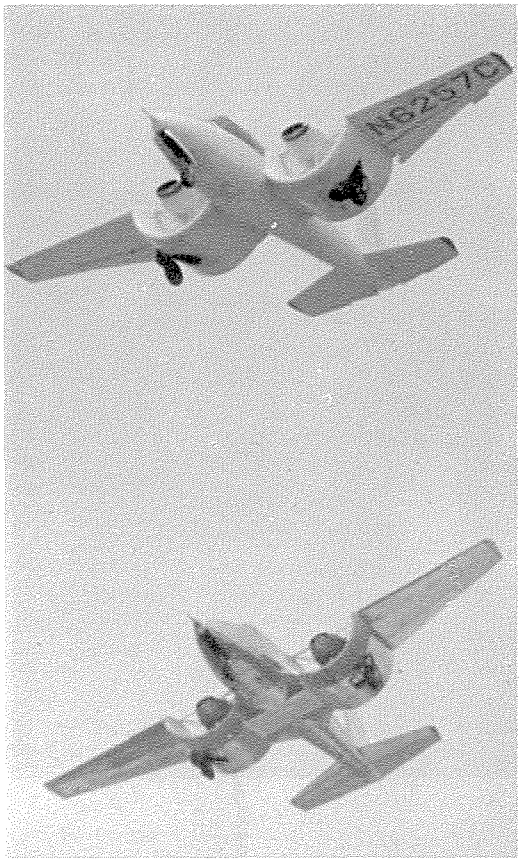


Administration (FAA) standards toward obtaining an Approved Type Certificate (ATC). The company retained the DeVore Engineering Service of Roslyn, New York to assist in the certification work. By July an engineering report on wing air pressure studies had been submitted to the FAA and the company was preparing a basic loads report. The company estimated that a type inspection authorization would be received in about nine months and the aircraft would be certificated in a year. The FAA estimated that about 95% of the certification work remained to be done.

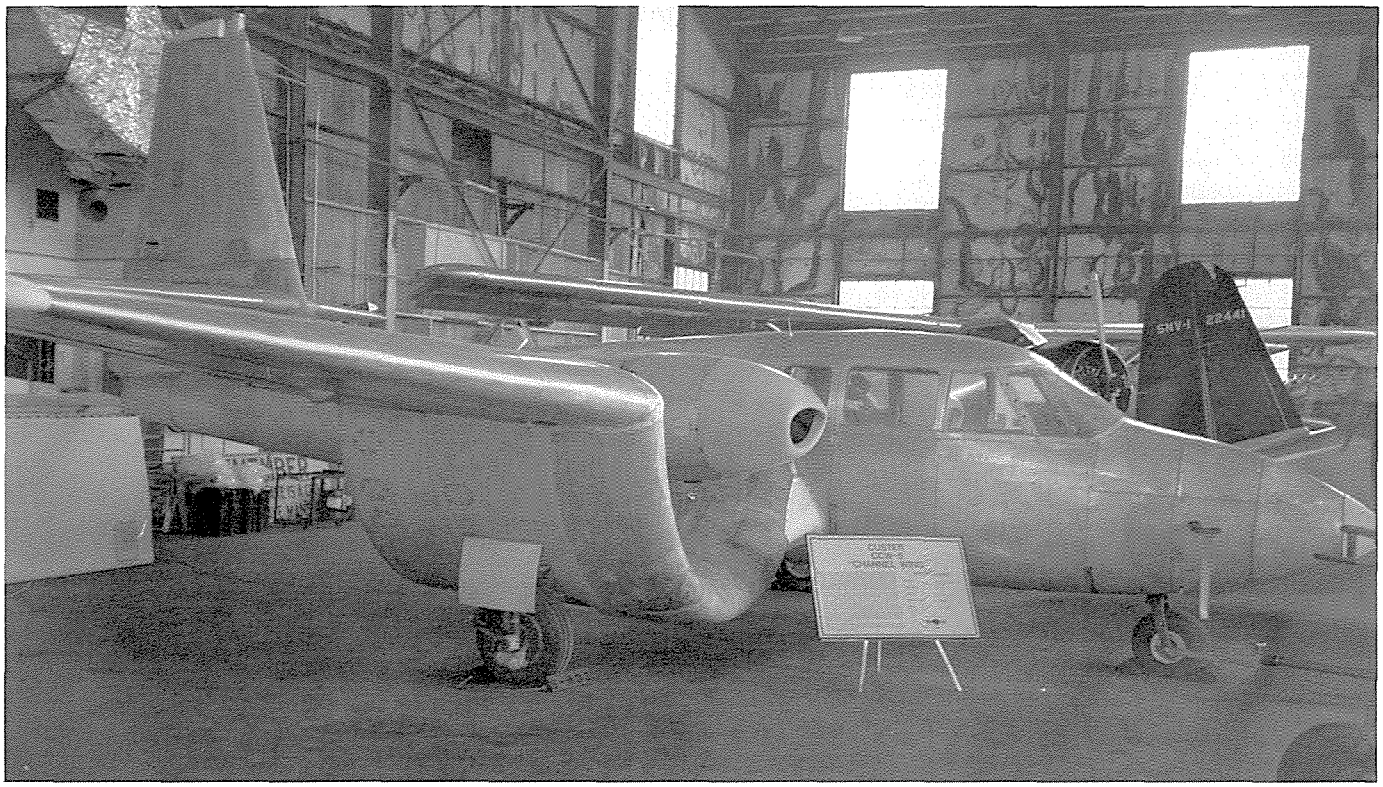
On July 4, 1964 a public "roll-out" was held at the Custer hangar complete with brass band, local dignitaries and politicians with accompanying speeches, a christening of the new airplane by Mrs. Custer breaking a bottle of champagne over its nose, and flight demonstrations.

The gala celebration was short-lived, however. The Custer Channel Wing Corporation was short on funds. It seems that since the late 1950s, Custer had been at odds with the Securities and Exchange Commission (SEC) who had been keeping a keen eye on the company's selling of stock to finance its activities.

The SEC had issued a December 29, 1960 temporary suspension order with respect to a proposed Custer stock offering. The SEC asserted in its suspension order that the company's offering circular was false and misleading regarding certain material facts. While not having access to the legal documentation for the suspension action, one can surmise that it might have been concerned with the claimed many orders on the



Opposite top: *The CCW-5 was the third Custer airplane to fly, thus the 5 did not denote the fifth design but instead that it was a five-place airplane. (Photo by Lyle S. Mitchell)* ***Opposite:*** *The June 1948 cover of Air Trails Pictorial magazine featured a drawing of a single-engine Custer channel wing airplane. (Air Trails Pictorial Drawing)* ***Left:*** *The only two CCW-5 aircraft ever built make a slow-speed pass in formation. (Photo by Lyle S. Mitchell)* ***Below :*** *Many local townspeople turned out to see the two CCW-5 channel wing aircraft on display. (Raup Photographic Studios, Author's collection)* ***Above:*** *On July 4, 1964 a public "roll-out" was held at the Custer hangar complete with brass band, local dignitaries and politicians. U.S. congressman Charles "Mac" Mathias is seen speaking. (Raup Photographic Studios, Author's Collection)*



books for an airplane that had yet to be certified for production. The Custer Channel Wing Corporation filed a request for a hearing to "vacate" the temporary suspension order.

Then in June 1961, the corporation withdrew its request for a hearing before the SEC. That action caused the suspension order to become permanent. However, Custer continued to sell shares in his company.

Consequently, the SEC obtained a 1962 U.S. court order forbidding public sale of stock in the corporation. Custer continued to sell stock.

On November 12, 1965 Willard R. Custer and the Custer Channel Wing Corporation were convicted of contempt of court for violating the 1962 U.S. court order. Sixty-five year old Custer was sentenced to 183 days in jail and the company fined $5,000. Custer later said that the conviction was a "misunderstanding" between lawyers and the SEC.

Well—that slowed Custer down somewhat, but he still remained undaunted. He continued to seek FAA certification of the CCW-5. An article in the August 1970 issue of *Air Progress* magazine reported that more than 50 percent of the tests had been successfully completed by De Vor Aviation Service.

An article about short-take off and landing (STOL) aircraft in the May 1971 issue of *Private Pilot* contained some favorable comments about the Custer channel wing and elicited a letter from Mr. Custer requesting additional copies "... for presentation to certain Government offices." He never ceased promoting his concept.

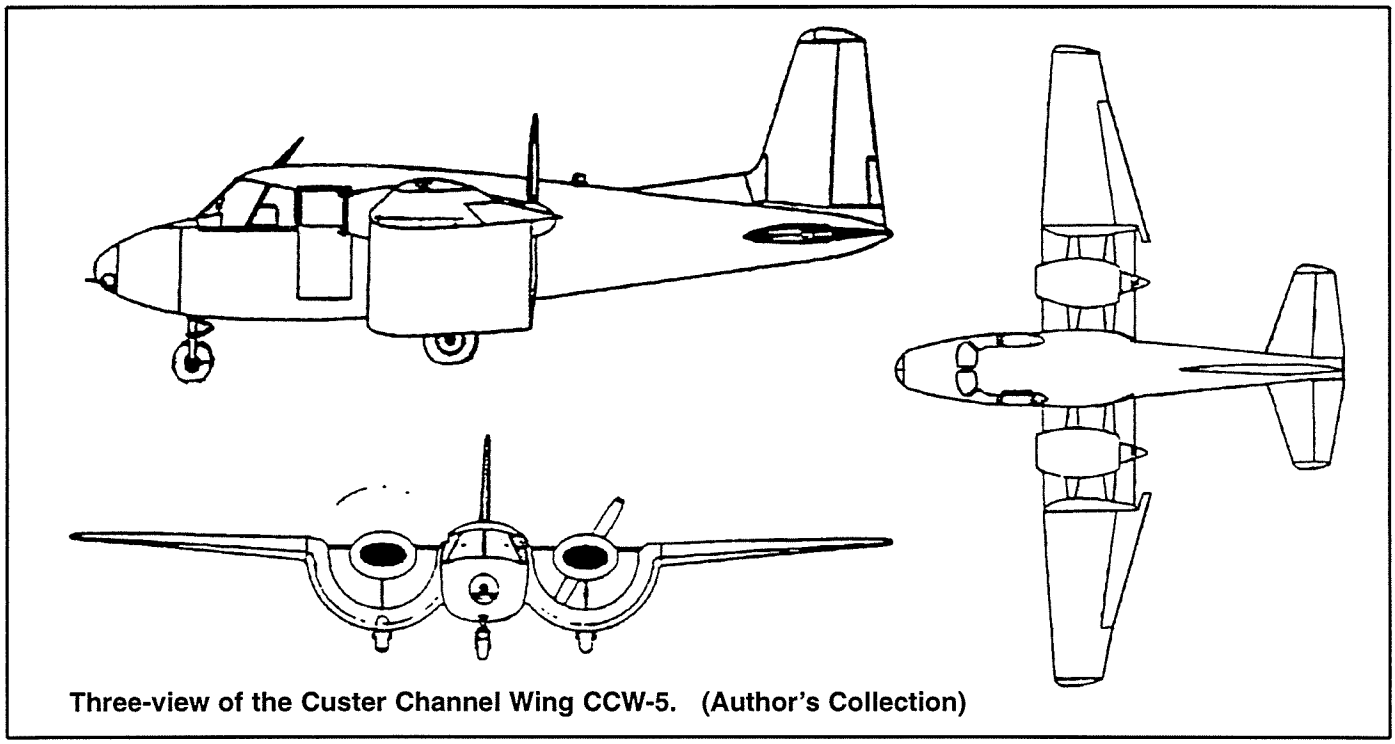
Contacted by an editor of *Air Progress* magazine in 1974, he was found to be a very energetic age 74, presiding over the dormant Custer Channel Wing Corporation —and waiting for a chance to resume work on the CCW-5.

As late as 1978, the feisty Mr. Custer was still promoting the channel wing concept when—right in "his own back yard"

in Hagerstown—he observed that the Fairchild Republic Company was building the A-110 *Thunderbolt II* ground support fighter that appeared to utilize his design. Custer filed an $80 million suit in the U.S. Court of Claims charging the federal government (U.S. Air Force) with pirating his channel wing design.

Custer figured that the monetary figure he sought was roughly equivalent to 10 percent of the worth of all the A-10s delivered to the Air Force up until that time. "As the inventor, at least that much is coming to me," he said.

Custer said the A-10A, although not equipped with channel wings as such, did use his patented effect. He argued that Fairchild had mounted the jet engines on the twin-engine *Thunderbolt II* close to the wing trailing edges in such a way that an "induced air flow" was generated. Fairchild engineers maintained that was only coincidental; the main reason for the aircraft's planform was that it was designed to reduce the radar



Three-view of the Custer Channel Wing CCW-5. (Author's Collection)

Opposite lower: *The Custer hangar comes under the wrecking ball. Although Custer had already vacated the premises (Fairchild Aircraft was using it for storage of old parts shelves and racks), its destruction symbolized the end of Custer's decades of promoting the idea of the channel wing concept. (Photo by Lyle S. Mitchell)* ***Opposite upper:*** *The only Custer Channel wing on display is CCW-2 No.2 in the Mid Atlantic Air Museum at the Reading, Pennsylvania airport. (Photo by J. Allen Clopper)*

signature of the two fanjet engines by using the wings to shield the large air intake fans from ground-based surface-to-air missile radar systems. Custer did not get his $80 million.

Willard Custer died December 25, 1985 in his Hagerstown home at age 86 — never seeing his dream of the channel wing idea used on thousands of production aircraft. Thus, Custer joined the ranks of Justus Burnelli and others for whose ideas the time never came.

To see a Custer Channel Wing airplane, one must visit the Mid Atlantic Air Museum at the Reading, Pennsylvania airport. They have the CCW-5 "production prototype" which was donated by the Custer family. The disassembled CCW-1 was donated by Willard to the Smithsonian Institution in 1961 where it is in storage and not accessible for viewing. ❑

REFERENCES

1. Hugo Gernsback (Editor), "Can A Plane Rise When Tied To A Tree?," *Aviation Mechanics* magazine, July-August 1930, Vol.1, No.2, pp.110-112, 184.
2. D.W. Young (Air Technical Service Command Representative), "Test Of 1/3-Scale Powered Model Of Custer Channel Shaped Wing (Five- Foot Wind-Tunnel Test No.487)," Army Air Forces Technical Report No.5142, AAF Air Materiel Command, Dayton, Ohio, September 5, 1944, 34 pages.
3 .D.W. Young, "Custer U-Shaped Channel Wing," Memorandum Report, Engineering Division, TSEAL-2-4586-3-2, Air Technical Service Command, July 28, 1945, 7 pages.
4. D.W. Young, "Test Of Two Custer Channel Wings Having A Diameter Of 37.2 Inches And Lengths Of 43 And 17.5 Inches (Five-Foot Wind Tunnel Test No.545)," Army Air Forces Technical Report No.5568, AAF Air Materiel Command, Dayton, Ohio, April 14, 1947, 69 pages.
5. John Forney Rudy, "Custer Channel Wing," *Air Trails Pictorial* magazine, Vol.XXX, No.3, June 1948, cover, pp.4,22,23,83,84.
6 A.R. Weyl, "High-Lift Generation," *Flight* magazine [United Kingdom] , January 14, 1955, pp,41-43.
7. "Custer Channel Wing Production Planned," *Aviation Week* magazine, November 24,1958.
8. "Custer Channel Wing design to be built in 2 and 5-place models by Texas firm," illustration caption, *Air Progress* 1957/1958 magazine, p.12.
9. "Channel Wing Flown in Demonstration," *Aviation Week* magazine, September 28, 1959, pp.113,114.,
10. "Custer Channel Wing Certification Begins," *Aviation Week* magazine, July 20, 1964, p.21.
11. "Production Custer Channel Wing Makes Its Debut," *The Aeroplane and Commercial Aviation News*, [U.K.] July 30, 1964, p.22.
12. "Custer's Production Model Makes Bow," *Air Progress* magazine, October/November 1964, pp.30,31,90,91,
13. Richard B. Weeghman, "The Queer Birds, Custer Channel Wing," *Flying* magazine, April 1965, pp.42-45.
14. "Willard R. Custer ...," News Digest column, *Aviation Week & Space Technology* magazine, November 22, 1965, p.32.
15. "Custer's Latest Stand," Aeronews column, *Air Progress* magazine, August 1970 970, p.16.
16 Paul Fillingham and Duncan Holmes, "Introduction To STOL," *Private Pilot* magazine, May 1971, pp.23,26.
17, Paul Bertorelli, Custer Will Take On Feds Over His Wing," *The Daily Mail* newspaper, Hagerstown, Maryland, Thursday, May 11, 1978, p.3.
18. Obituary, "Willard Ray Custer," *The Daily Mail* newspaper, Thursday, December 26, 1985, p.D3.

CUSTER CHANNEL WING CCW-5 SPECIFICATIONS

WING SPAN	41 FEET 2 INCHES
LENGTH	28 FEET 8.5 INCHES
HEIGHT (AT RUDDER)	10 FEET 10 INCHES
CABIN INTERIOR (HEIGHT)	4 FEET 5 INCHES
CABIN INTERIOR (WIDTH)	4 FEET 5 INCHES
EMPTY WEIGHT	3,675 POUNDS
GROSS WEIGHT	5,400 POUNDS
TOP SPED	200 MILES PER HOUR
CRUISE SPEED	180 MILES PER HOUR
MINIMUM SUSTAINED LEVEL FLIGHT	35 MILES PER HOUR
TAKEOFF RUN	50 TO 250 FEET
LANDING RUN	300 FEET
CEILING	22,000 FEET