A. M. O. Smith

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1911–1997

Elected in 1989

"For practical contributions to aerodynamics and rocketry and especially for many pioneering advances in computational aerodynamics."

BY ROBERT LIEBECK

APOLLO MILTON OLIN SMITH, chief aerodynamics engineer–research at the Douglas Aircraft Company and creator of the fundamental techniques for the calculation of aerodynamic flows, died on May 1, 1997, at the age of 85. "AMO," as he was known, passed away in his home in San Marino, California, where he lived for 54 years.

AMO was born in Columbia, Missouri, on July 2, 1911, and his early years were spent in Missouri, Oklahoma, Kansas, and Indiana. His father was a chemist, working primarily for oil companies. While living in Oklahoma and in the fifth grade, AMO came down with phlebitis and typhoid fever. To quote AMO, "This is certainly the sickest I have ever been. I seemed to be unconscious, and my mother called our doctor and said 'you better come over right away; he's dying.' I was not really unconscious and said 'huh?' This shook her up a bit."

In 1925 AMO's father became chief engineer at Skelly Oil Company, a consequence of the cracking stills he helped develop. This led to a move to Long Beach, California, in 1927, where AMO entered Woodrow Wilson High School. He joined the orchestra, played 2nd clarinet, and considered becoming a professional musician. By the time he became a senior his focus turned to mathematics and engineering with a goal of entering Caltech. A classmate was John Pierce (winner of the National

Medal of Science and member of the NAE), and AMO, John, and two others set about building a glider. The glider can now be regarded as a cornerstone for AMO's career in aeronautics.

Following a steep learning curve, including stalls and crashes, AMO and John Pierce both entered a contest at Pacific Beach near San Diego. AMO won three cups—distance, endurance, and altitude. To quote AMO: "My altitude launch was peculiar. Launchings were with a shock cord pulled by about 20 Navy seamen. The glider was anchored to a truck and released by a trigger. The acceleration was 4Gs so that the glider was flying in about four feet. Our control stick had a bicycle grip for a handle. In my winning flight, the acceleration was so great that the grip came off the stick. There I was climbing steeply with a free control stick. By the time I had recovered and gained control, I had won the altitude contest. The temporary lack of control is probably why I won the contest. People on the ground said I uttered a startled 'gosh.'" AMO summarized his Woodrow Wilson High School career by stating, "In my senior year I made all As without ever taking a book home."

AMO was accepted at and entered Caltech in the fall of 1929, planning to become a chemist like his father. His first year did not go well and his grades were mostly Cs. He left Caltech and went to work at Western Oil & Refining, where his father was superintendent. At the same time he went to Compton Junior College where he focused on improving his math and did very well. When he reapplied to Caltech in the fall of 1931, he was welcomed back. On his return he decided to major in mechanical engineering, hoping to eventually major in aeronautical engineering—but there were no aeronautics classes for undergraduates. On completing his junior year, he again left Caltech to work and earn the money to continue. He returned to complete his BS in mechanical engineering in 1936.

AMO then entered graduate school and obtained a job helping Frank Malina prepare illustrations for a book being written by Theodore von Kármán and Maurice Biot. Because many of the figures were graphs of mathematical functions, AMO had to learn and understand the functions themselves.

In the end, AMO made the majority of the illustrations and it was a valuable experience. At the same time, Malina was also working on rockets, and AMO became interested and joined in.

A rocket motor was built in the fall of 1936 by Malina, John Parsons, and Edward Forman, and AMO went along for the first test in an isolated area above Devil's Gate Dam. There is a historic picture of the group with AMO wearing peculiar headgear. In fact it was an explorer's helmet that AMO had modified to improve ventilation. Said improvement was made from his mother's pepper box using tin snips and a soldering iron. This initial firing of a rocket motor in the Arroyo Seco resulted in the Jet Propulsion Laboratory (JPL) being built there. And there is a bronze plaque referencing the Malina group and a replica of the now famous photo.

Smith graduated from Caltech in 1938 with master's degrees in both mechanical and aeronautical engineering. He went to work for the Douglas Aircraft Company, El Segundo Division, as assistant chief aerodynamicist, a position he held until 1942. His early work included wind tunnel testing of the A-20 light bomber, performance analysis of the DC-5 transport, and aerodynamic design (particularly of the wing) of the A-20 (later called the B-26). He was largely involved with the aerodynamic design of the D-558 Phase 1 airplane, a world speed record holder. This was a jet-powered research airplane that pioneered the investigation of the transonic flight regime.

One of AMO's early challenges was to resolve a performance issue with the Douglas SBD *Dauntless* Navy dive bomber. The first prototype had flown very well, and the second prototype came off the line with a striking Navy paint job (dark blue fuselage and bright yellow on the upper surface of the wing, with the entire lower surface of the airplane Navy grey). The first airplane was plane aluminum as it was intended solely for flight test. The second prototype did not fly well—its stall speed was higher and the airplane was difficult to fly at low speed, dropping one wing or the other. The Navy was scheduled to take delivery of the second airplane to begin its own flight testing in a few days. A careful check of the airplane's geometry and rigging showed no defects. AMO was called in to fly in the back seat of the SBD and observe the problem firsthand. As he walked up to the airplane he noticed a masking tape line on the wing's leading edge that separated the yellow on the top from the grey on the bottom. AMO took out his pocket knife (a device he felt all engineers should carry) and began to remove the ridge left by the tape. A Douglas marketing man became concerned and asked AMO to stop because he was tarnishing the striking paint job. AMO prevailed and then asked the test pilot to try the now-tarnished SBD. After a short flight, the test pilot returned all smiles. The tarnished airplane flew just like the first prototype—very well! AMO explained that the tiny tape ridge was in effect a stall strip that disturbed the thin boundary layer just aft of the leading-edge stagnation point. Later, he expressed disappointment that his ingenuity precluded an opportunity to fly in the SBD.

From 1942 through 1944, AMO had a brief recess from the Douglas Aircraft Company. At the written request of Gen. H.H. Arnold, he was loaned from Douglas to become chief engineer of the Aerojet Engineering Corporation. Under AMO's guidance, the engineering organization at Aerojet was established and grew within 18 months from 6 people to more than 400. He developed and saw into mass production the first JATO-type rocket. This was based on his earlier work on the GALCIT project that led to the founding of JPL. For his work at Aerojet, AMO received the Robert H. Goddard Memorial Award of the American Rocket Society in 1954.

AMO returned to Douglas in 1944 and resumed his work involving aerodynamics and preliminary design. He was responsible for the detailed aerodynamics of the D-558-1 Skystreak research airplane, which for a period held the world speed record. His role in this work is covered in the book *Supersonic Flight—Breaking the Sound Barrier and Beyond*, by R.P. Hallion, published by MacMillan and Co. in association with the Smithsonian Institution. Another of his designs won the competition for a night fighter that became the F3D-1 Skyknight.

At the end of World War II, AMO was a member of the US Naval Technical Mission in Europe. As an indirect consequence of this work, he proposed and began studies of a tailless aircraft. These studies culminated in the F4D-1 Skyray interceptor that for a period held six official FAI World Records, one for absolute speed and the others for climb performance.

In 1948, AMO became supervisor of design research at the Douglas Aircraft Company, a position he held until 1954. During this period he conducted a considerable variety of studies, mostly with an aerodynamic bias. The work receiving the most effort was the field of laminar flow control, but perhaps the most important accomplishment was the development of a very general method of calculating the low-speed flow about bodies of arbitrary geometry. This method is called the Douglas Neumann Program.

In 1954 AMO rejoined the Douglas Aerodynamics Section as supervisor of aerodynamic research, and his work—dealing with aerodynamic problems of a research nature—remained in this area until he retired. The main accomplishments were development of practical methods of analyzing laminar and turbulent boundary layer flow, the hydrogen bubble technique of flow visualization, potential flow analyses, analysis of stability and transition of boundary layers, and introduction of the e^n method of predicting transition. AMO pioneered the application of computers to many of these problems.

From 1969 to his retirement from Douglas in 1975, AMO had the title of chief aerodynamics engineer–research. For his work in the development of potential flow methods, he received the Douglas Engineering Achievement Award in 1958. This may have been his most treasured award—and may yield some insight into the challenge of his early contributions.

AMO was the recipient of numerous honors and awards, including the Wright Brothers Lecture in 1974, an honorary doctor of science from the University of Colorado, honorary fellow of the American Institute of Aeronautics and Astronautics, the Casey Baldwin Award of the Canadian Aeronautics and Space Institute (CASI), and member of the National Academy of Engineering.

Today, AMO's career may appear inverted. He began designing and testing airplanes at the Douglas Aircraft

Company, and experienced the technology needs of the day firsthand. This turned out to be the ideal preface for his next job in 1954 as head of the Aerodynamics Research Group at Douglas. At that time aerodynamic analysis tools were approximate, based primarily on linear methods. AMO initially set about developing a method to analyze a laminar boundary layer, and this was followed by his development of an integral method for solution of the turbulent boundary layer. A very significant contribution to boundary layer theory is AMO's e^n method for predicting transition of a laminar boundary layer to a turbulent one.

What may be one of AMO's most significant contributions is his development of the panel method for the exact calculation of the potential flow about a body of arbitrary geometry. The initial solution, sponsored by the Navy, was an axisymmetric body. Next came two-dimensional flow about an airfoil, and finally three-dimensional flow about a body with wings and lift. AMO named this capability the Douglas Neumann Method after the German mathematician whose boundary value problem it solves. That he did not include his own name in the method says much about AMO's character.

AMO's insight into the physics of fluid flow, coupled with his background and experience in airplane design, enabled him to lead the establishment of the field that is today called computational fluid dynamics (CFD). If CFD is defined as the accurate calculation of the flow about a body of arbitrary geometry, the combination of the Douglas Neumann Method, AMO's laminar and turbulent boundary layer solutions, and the e^n transition prediction can be regarded as the origin of CFD. The aerodynamic design of airplanes entered a new era where the wind tunnel would ultimately become a verification of the CFD calculations.

A thorough documentary of AMO's life and contributions is given in the book *Legacy of a Gentle Genius: The Life of AMO Smith*, by Tuncer Cebeci (Horizons Publishing, Long Beach, California, 1999). Tuncer and the author of this memorial were indeed fortunate to have been members of AMO's Aerodynamics Research Group.

Finally, one of AMO's most special qualities was the scholarly imagination and creativity that he focused on aerodynamics and fluid mechanics. It was typical for him to come up to one of his engineers in the Aero Research Group and say, "Hey, I've been thinking about—." And thus a new aerodynamic concept would be born. An array of these concepts ultimately culminated in his classic 37th Wright Brothers Lecture, "High-Lift Aerodynamics," which has become a required "text" for many aerodynamics courses. It is symbolic of the canonical contributions of Apollo Milton Olin Smith to aerodynamics and the design of airplanes.