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CLARK BLANCHARD MILLIKAN

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A Biographical Memoir by

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CLARK BLANCHARD MILLIKAN was born in Chicago on August 23, 1903, almost simultaneously with the decision of the Wright Brothers that their airplane was ready to fly under its own power. The brothers shipped their frail craft from Dayton to Kitty Hawk in September of that year. Whether or not this coincidence was important can never be known, but it is a fact that, in his early impressionable years, Clark was surrounded by the publicity attendant on the rapid development of this new means of transportation.

Being the son of Robert Andrews Millikan, at that time Professor of Physics at the University of Chicago, Clark was sure to develop any latent interest in the new advances in science and technology. According to his own memory, Clark was only eight or nine years old when he first decided to make his life's career in some area associated with aeronautics. During this eight- or nine-year period many firsts in aviation were accomplished. After the first Wright Brothers' flight in December 1903, news announcements of startling events, both in the United States and abroad, were a regular occurrence. The first Aero Exhibition in America was held in New York in 1906 and the first airplane was ordered from the Wright Brothers by the Army Signal Corps in 1908 for a price of $25,000.

The first transcontinental flight was made in 1911, and in 1912 Congress appropriated $125,000 for Army aeronautics. All of these events would surely have been discussed at the home of a university professor, and it is little wonder that one of his sons saw glamorous possibilities in aeronautics as a future career.

Clark attended the University of Chicago Elementary and High Schools, and during this time he continued his interest in aeronautics by building model airplanes. It is unfortunate that none of these exist today for it would be fascinating to compare them with the complex machines that he was concerned with during the last years of his life. While in elementary and high school Clark found an outlet for his intense physical energy in athletics.

After spending a year divided between the University of California (Berkeley) and Throop Institute of Technology (now the California Institute of Technology), he entered Yale as a freshman in the fall of 1920. The decade between 1910 and 1920 really saw aviation technology and the science of aeronautics become accepted. The altitude record had risen from 9,700 feet to over 38,000 feet and Congressional appropriations for aeronautics reached nearly $18 million in 1916, the year before World War I. Although Clark specialized in physics and mathematics at Yale, it is obvious that the impact of the airplane on the world conflict between 1917 and 1919 must have left a strong impression on his mind. At that time very few schools had courses in aeronautics, although Jerome Hunsaker was detailed (from the Navy) to Massachusetts Institute of Technology in 1913 to develop courses in aerodynamics.

While at Yale, Clark continued his interest in athletics, specializing in running the hurdles for the track team. In addition, he found a new avocation in music and sang in the Yale Glee Club. By the end of his undergraduate years he had

firmly established the pattern of his future life. Its major facets consisted of solid strength in the fundamentals of mathematics and physics, an intense interest in all phases of aeronautics, a love of music both as a participant and as a listener, and a physical energy that he enjoyed expending out of doors in some form of athletic activity. Binding all this together was an outgoing personality which made him many friends from all walks of life. Alive, vibrant, dynamic, and friendly were the adjectives which described Clark Millikan to those who knew him best.

He entered the Graduate School at Caltech in the fall of 1924 and continued to specialize in mathematics and physics. Although there were no formal courses in aeronautics at that time, Professor Harry Bateman, the distinguished mathematician and physicist, had a strong interest in theoretical aerodynamics. It was under Professor Bateman that Clark did his doctoral dissertation on "The Steady Motion of Viscous Incompressible Fluids." He received his Ph.D. in 1928. His interest in all phases of aeronautics remained high, as evidenced by the fact that he and two colleagues, Arthur L. Klein and Albert Merrill, designed, built, and flew a revolutionary new type of biplane in which control was established by moving the complete biplane wing assembly. The placement of the two wings was such as to develop a built-in stability, and this airplane, fondly named the "Dill Pickle," could be flown "hands off," an unusually daring feat in those days.

Throughout the 1920s there was an ever-growing activity in aviation in Southern California. By 1926, when the Loughead Brothers started what was to become the Lockheed Aircraft Company in nearby Burbank, Douglas was already a thriving company in Santa Monica and the whole Los Angeles area was becoming aviation-minded. Small firms were springing up from Burbank to San Diego and, since Caltech was one

of the leading engineering schools in Southern California, it was natural that there should be an early and continuous contact between this new and exciting industry and the staff and students of Caltech. Donald Douglas, Sr., and his chief engineer, Arthur Raymond; "Dutch" Kindleberger, who went from Douglas to North American; "Kelly" Johnson, from Lockheed; and Jack Northrop were all friends of Caltech and soon became close personal friends of Clark Millikan. Through them he saw how aircraft were built and flown, thus rounding out his theoretical knowledge of the subject.

Another movement of importance was taking place during this period which had its influence in his life. In 1925 Daniel Guggenheim donated $500,000 toward the development of a School of Aeronautics at New York University. At about the same time the Daniel Guggenheim Foundation for the Promotion of Aeronautics was established. From this Foundation Caltech was granted funds in 1928 to establish the Daniel Guggenheim Graduate School of Aeronautics and to build the Guggenheim Aeronautical Laboratory. The Fund also arranged for a visit of Dr. Theodore von Kármán to the United States from Aachen so that he could participate in the plans for the laboratory. Although the contribution of von Kármán was great, it was actually Clark Millikan and Arthur Klein who did the detail design work on the laboratory and its major piece of research equipment, a Gottingen-type, closed-return wind tunnel with a working section ten feet in diameter.

This wind tunnel, which had for that time the very high velocity of 200 m. p. h., was operated, calibrated, and turned into a highly efficient research tool largely through the efforts of Clark Millikan, "Maj." Klein, and a handful of graduate students in this embryo Aeronautics Department at Caltech. It was during this period that the acronym GALCIT (standing for the Guggenheim Aeronautical Laboratory of the Cali-

fornia Institute of Technology) was coined, and ever since the words GALCIT and Clark Millikan have been synonymous.

GALCIT was under the directorship of von Kármán from 1930 until 1949. During that time Clark was in charge of the Applied Aerodynamics phases of the laboratory's activities and supervised all of the testing and research carried out in the wind tunnel. Since this was the only available large wind tunnel in Southern California, the local, and sometimes some distant, aircraft companies found it an ideal piece of test equipment for developing new aircraft designs. The entire DC-series of Douglas airplanes and many of the early Boeing airplanes, as well as those of North American Aviation, Northrop, Lockheed, and Consolidated, were put through their aerodynamic paces in the GALCIT wind tunnel. This was always done under the watchful, critical, and analytical eyes of Clark Millikan. In fact, in the early days he could often be found performing manual labor as part of the test-operating crew just because he liked to be doing something useful.

Through these contacts he had a very significant influence on the early development of many of the important airplanes of the 1930s and 1940s. Concurrently with this activity, he was also an excellent teacher, and he rose from Assistant Professor in 1928 to Associate Professor in 1934 and to full Professor in 1940. He always prepared his lectures meticulously and, because his classes knew he performed many experiments in aerodynamics himself and was thoroughly acquainted with all the new developments in the field, they knew they were getting the latest and the best information.

In addition to his more than full academic life he also took a leading role in the activities of the Institute of Aeronautical Sciences (later the American Institute for Aeronautics and Astronautics) and was its president in 1937. He was made an Honorary Fellow of that society and was also a Fellow of the

Royal Aeronautical Society of Great Britian, the American Academy of Arts and Sciences, and the American Physical Society, as well as a member of the American Association for the Advancement of Science and the honorary societies of Phi Beta Kappa, Sigma Xi, and Tau Beta Pi. Unlike many people in the engineering and scientific world who join societies but take no part in them, Clark Millikan was not only a member of the above organizations but was usually an "'active" member in the truest sense of the word. He served as an officer on executive councils and advisory boards, and his advice and participation were not only solicited but were given generously. In this manner, his influence extended far beyond the confines of his already broad academic activity at Caltech.

Over and above all of this he had time to be a person. He loved, enjoyed, and appreciated his family. He made friends easily and had many of them all over the world. All forms of outdoor activity appealed to him, and one of his favorite pastimes consisted of taking trips to the out-of-the-way back country in Southern California along with friends who were *simpatico* with rough modes of travel. Borrego Springs and Painted Canyon, near where his ashes have been scattered, were spots he knew long before they became popular to the general public. In fact, when he used to go into some of the desert areas, he was forced to take along strips of canvas which he would use as a makeshift roadway over some of the more difficult sandy spots. The Navaho country was also one of his favorite vacation areas and the more isolated the region was, the better he loved it. In later years he enjoyed the redwoods of the Bohemian Grove along the Russian River in California and he always returned from a short stay in this spot with renewed physical and mental energy.

Another indication of his affection for people could be found in his club memberships. He belonged to and took an

active part in the activities of the California, Bohemian, Sunset, and Twilight clubs as well as the Yale Club in New York. In all of these he was not just a name on a membership list but was on a first-name basis with nearly all of the people belonging to these organizations.

With all of Clark's outside activities his colleagues were constantly amazed at the impact that he could continue to have on Caltech and the Jet Propulsion Laboratory. He authored approximately forty technical papers as well as the first volume of the GALCIT Aeronautical Series of Textbooks. This book was entitled *Aerodynamics of the Airplane* and was an outgrowth of a course he taught to his graduate students.

During its fifteen-year existence (1945-1960) he was Director of the Southern California Cooperative Wind Tunnel and contributed greatly to its success. This was a joint venture financed by five Southern California aircraft companies and managed and operated by Caltech. It was one of the first large supersonic wind tunnels and was known throughout the world for its efficiency, flexibility, and accuracy. It contributed greatly to the development of postwar commercial and military aircraft, and a large part of this contribution came about because of the intense interest of its Director in every phase of the operation and in the aerodynamic phenomena being studied. One incident, which was typical, shows that Clark Millikan was a real participant in the activities of the wind Tunnel. During the calibration stages he insisted on personally checking the flow patterns while the tunnel was operating. One day, while working in the region just ahead of the working section, he got too close to the contraction section where the velocity started to increase and he was suddenly blown into, through, and then out of the high-speed working section of the tunnel. His deep personal interest in the mechanical and technical, as well as the administrative, aspects of the project was one of

the reasons why personnel morale was exceptionally high in this organization.

His contributions to the military strength of the United States were great. With his wide knowledge of the entire aeronautics field and his personal friendship with so many of its leaders, his services and advice were constantly being sought by—and, what is more, were generously given to—the Armed Services. Although his later activity in the field of missiles and spacecraft was largely connected with the Air Force through his membership on its Scientific Advisory Board (from 1952 until his death), he also had contact with other services. He was a Lieutenant Commander (USNR) from 1942 to 1946; served on the Naval Research Advisory Committee from 1947 to 1950; was a member of the Defense Science Board of the DOD (1957 to 1962); and was chairman of the Guided Missile Committee of the Research and Development Board of the Pentagon. He was influential in Army circles through his membership on the Army Ballistic Research Laboratory's Scientific Advisory Committee.

Both the National Advisory Committee for Aeronautics and its successor the National Aeronautics and Space Administration made use of his knowledge by appointing him to advisory committees and councils. As a result of his activities in both civilian and military aeronautics he was awarded the United States Medal for Merit, the United States Air Force Exceptional Service Award, and the King's Medal for Service in the Cause of Freedom of Great Britian. His eminence in his field was also recognized by membership in the National Academy of Sciences (1964) and the recently formed National Academy of Engineering (founding member, 1964).

The area around Pasadena also felt his influence. He, along with von Kármán and colleagues, started the Jet Propulsion Laboratory, which at one time was a small research group supported by the U.S. Army and connected directly to GALCIT.

Its growth is well known both before and after it became a part of NASA. Clark served on its advisory board from the beginning and was always trying to develop a closer liaison between the activities of JPL and those of Caltech. He was instrumental in the formation of the Aerojet-General Corporation and served on its Board of Directors as well as on its Technical Advisory Board. He was a member of the Board of Directors of the National Engineering Science Company in Pasadena.

From the time of his graduation with a doctor's degree in 1928 until early 1950 the development of both civilian and military aviation is a matter of history. However, few people who use this mode of transportation for pleasure, business, or warfare ever realize the influence played on their lives by this Professor of Aeronautics. Although he wrote a number of papers, they were generally not deeply scientific in nature. Clark Millikan's influence was through two other major channels. One was his personal contact with nearly everyone who was important in aeronautics. He could exchange ideas with these people and thereby synthesize an over-all picture of the problems and the progress of the engineering and scientific discipline. The other channel was his influence on the students who were trained at and graduated from Caltech.

Following the basic plan established by von Kármán, his policy for GALCIT (Clark became its Director in 1949) was to obtain the best teaching staff in the various aeronautical disciplines, give them the best possible research equipment, pick a small number of carefully selected graduate students, and then turn out a product mix of graduates and research that was second to none in the world. In addition to his interest in the operation of the subsonic wind tunnels in GALCIT, he also had a personal interest in the research in hypersonic flow being carried out in the laboratory. Even with his heavy outside work load he insisted on teaching an advanced course in the theory of real fluids. Just before his death he had com-

pleted a manuscript for a text on this subject which is now being prepared for publication.

His impact on students was both nation- and world-wide. Each year, students from both the Air Force and the Navy were in his classes, as were students from many other nations. He always insisted on knowing these students personally, and the parties he gave in his home in the hills above Pasadena will always be remembered as a welcome relief from the rigors of the Caltech program. Gathered around the piano (he was a good pianist—and his memory of the verses of old drinking songs was fabulous), the students, as well as important guests, would be introduced to the other side of Clark, the side that was warm, home-loving, and that enjoyed good food, good drink, and good friends.

It was in this way that he became acquainted with young men who later became top administrators in aircraft companies or department heads in important educational institutions, and some who became Naval admirals and Air Force generals, along with others who returned to their own countries to take important positions in research, industry, and teaching. His influence on their thinking and their actions is impossible to document, but many of them have said it was great.

In the early 1950s a new facet of aeronautics came into view and Clark received its challenges with his usual enthusiasm. The long-range missile and the concept of satellites and spacecraft became possibilities, but only to men of vision. Of these, one was Clark Millikan. Obviously the Air Force Scientific Advisory Board was in the forefront of the activity and Clark knew many of those in the Ballistic Systems Division who were encouraging much of the new thinking on such subjects. As with everything he had done previously, he became an enthusiastic supporter of these new efforts and was generous of time and talents to those who needed them.

At Caltech, new ideas had to be injected into courses and research programs under his guidance. In order to take care of the new programs the original Guggenheim Laboratory was supplemented by the Firestone Laboratory of Flight Sciences and the Kármán Laboratory of Fluid Mechanics and Jet Propulsion. This new complex retained the GALCIT name but it now referred to the Graduate Aeronautical Laboratories. The programs at JPL had to be rearranged and updated and his activities connected with their programs increased.

Even though he had added these extra burdens, he continued all his other interests in music, club and professional society functions, and civic affairs. He became a member of the Los Angeles Committee on Foreign Relations, an affiliate of the Foreign Affairs Council in New York. In the 1960 presidential election campaign he became active in helping to define the place of the engineer and scientist in national politics.

Clark Millikan never knew how to spare himself and, even when ill, continued a work load that would have been impossible for many men in good health. This refusal to stop may have hastened his passing, but he simply could not live in any other way. If he had a major fault this was it, but it was far overshadowed by his contributions to aeronautics and to society. He worked under a double handicap in that he was the son of the great physicist Robert Millikan and taught in the school his father had made famous. But his achievements and contributions and his place in the annals of aeronautics were his alone and were accomplished by a work-and-play program that set new records for what could be accomplished in a given time. From the first 120-foot flight of the Wright Brothers to men in orbit and interplanetary probes is a distance that few minds can completely grasp. Clark Millikan not only understood this development but contributed to nearly every step along the way.

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KEY TO ABBREVIATIONS

Am. Soc. Mech. Engrs. Advance Pap. = American Society of Mechanical Engineers Advance Paper
J. Aeron. Sci. = Journal of the Aeronautical Sciences
NACA Tech. Rept. = Technical Report of the National Advisory Committee for Aeronautics
Trans. Am. Soc. Mech. Engrs. = Transactions of the American Society of Mechanical Engineers

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