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A Biographical Memoir by

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DEAN E. WOOLDRIDGE WAS a physicist, industrialist, and writer whose contributions had a profound effect on science and technology. He became one of the country's eminent scientists as well as a leading technological industrialist at a time when the nation was in dire need of such leadership. His broad range of contributions makes him one of the significant figures of 20th-century engineering and science. Throughout his life he set standards for outstanding achievement while always accomplishing his goals with speed, commitment, and concentration.

He was born in Chickasha, Oklahoma, on May 30, 1913. After finishing high school at the age of 14, Wooldridge earned his bachelor's and master's degrees before the age of 20 from the University of Oklahoma. In 1936 he was awarded a doctoral degree in physics from Caltech with the highest possible distinction of summa cum laude. Dean's early educational background was colorful and diverse; a picture of what one might expect from someone who pursued and realized the American dream. In an eighth grade wood shop class he applied a coat of lacquer to some wood without letting the previous coat dry, a little disaster that earned him a B in the class. But for the rest of his academic life he was strictly an A student. He entered the University of

Oklahoma on a scholarship that he won in a typing contest, typing a very impressive 200 words a minute on a standard mechanical typewriter.

For the first three years at the University of Oklahoma he was a prelaw major. But during physics classes, he discovered that he loved the subject and changed his major to physics. He was fortunate to have impressed a physics professor named Dwayne Roller, who became a mentor and lifelong friend of the Wooldridge family. It was Professor Roller who helped Dean get into Caltech with a glowing letter of recommendation. His thesis adviser was William Smythe, who literally wrote the book on electromagnetism, and was also the adviser of Nobel Laureate Charles Townes.

In the same year he received his doctoral degree he married Helene Detweiler and began his career. The authors learned in an interview with Dean's son, Jim Wooldridge, that the marriage was a strong one. Helene hailed from Indiana and was a Methodist minister's daughter. She graduated from the University of Southern California with a master's degree in social work. It was a 65-year marriage, ending with her passing in 2001.

After graduation from Caltech, Wooldridge obtained a position at Bell Laboratories, which was at the time the world's leader in research and development in electronics. He became internationally known for his expertise in the application of the theory of magnetism as it applied to modern electricity. World War II was looming just over the horizon and the demands it would put on the country for new technology would center largely on electronics, especially in the emerging fields of radar and communications. This wartime demand would have a profound effect on the course of the nation and eventually the rest of the world, and the dominant technologies would be in electronics and defense work, in which Dean Wooldridge played a prominent role.

For decades after the war, the country's technological leaders were almost exclusively those who had played active roles during World War II, and Wooldridge was no exception. He stayed for the duration with Bell Labs where he was in charge of a group that developed airborne computers used to guide missiles. This was a technological first and the complexity of it, for the times, was extremely advanced. Afterward, the United States' longstanding arms race with the Soviet Union would see its most critical moments during the 1950s and 1960s. The demand for military technology to counter the threat in the East often forced defense industries to invent new schemes and produce cutting-edge engineering science at a frantic pace.

Wooldridge was instrumental in the development of the guidance system for the Nike guided missile. This missile system was designed to protect American cities in the event of Soviet bomber attacks. It consisted of about 300 sites located in or near large cities and key military installations. Each site was manned by 109 members of the military constantly ready to fire salvos of the 30-foot-long missiles. The altitudes and speeds of both bombers and missiles made the system extremely complex, requiring radar-tracking systems to be used for each missile in flight.

After the war's end, Wooldridge joined forces with Caltech classmate Simon Ramo and together they ran the research department for Hughes Aircraft's electronics department. Ramo tended to the investment and business side of things while Wooldridge was in charge of research and development. In 1948 the U.S. Air Force was created as a separate branch of the military and Hughes formed a new aerospace group to work directly with the Air Force. Both Ramo and Wooldridge made significant contributions. Among them was the design of an electronic fighter control system, a highly accurate radar-aimed machine gun system, and an air-to-air

guided missile system. At the dawning of the jet age these were the primary aspects by which a fighter plane was judged. The speed and distance involved with the new jet aircraft meant that the old iron sights of the propeller-driven craft were now obsolete. These were outstanding achievements and their designs soon became standard equipment.

Ramo and Wooldridge became discontented with the idiosyncratic and tempestuous Howard Hughes, and when Hughes refused to discuss the company's new structure with them, they jointly resigned in 1953. Bigger and better things would come after their resignation. Together they formed a research and defense company they named the Ramo Wooldridge Corporation. It began in a former Los Angeles barbershop, complete with one phone, and eventually grew into a multibillion-dollar international company. Lacking the half a million dollars they needed for startup costs, they approached the automotive and defense manufacturing company Thompson Products. They offered Thompson Products 49 percent of their new company's initial stock and from the beginning the relationship was one of affirmation and enthusiasm. The rest of the story is a well-documented case study of American industry and its progress from iron foundries to high-tech manufacturing.

Thompson Products had its beginning in 1901 as the Cleveland Cap Screw Company. They had the original idea of standardizing the sizes of cap screws used increasingly in the automotive industry. Later they branched out and patented a highly efficient alloy used to make engine valves. But a major decision to diversify occurred when they joined forces with their newly formed subsidiary the Ramo Wooldridge Company. This awarded them the opportunity to participate in the electronic industry, eventually supplying the makers of TVs, radios, and numerous aerospace industries. As propeller-driven planes and their engine valves

were phased out, Thompson began manufacturing high-tech turbofans, compressors, and shafts for the new jets. While they maintained their traditional Ohio headquarters they also oversaw creation of a new headquarters in California's Silicon Valley. In the 1960s they built a multimillion-dollar space park, which built parts for our early spacecraft and later manufactured satellites.

The company experienced steady growth but a major event occurred when they were awarded the prime contract for the design of the intercontinental ballistic missile. This was the largest single weapons system contract in history. The Ramo Wooldridge Company was responsible for the overall engineering and technical direction of the missile system. In 1958 Ramo Wooldridge merged permanently with Thompson Products to become Thompson Ramo Wooldridge Inc. (TRW Inc. in 1965). The company further expanded their role in the missile field as Thompson made parts for the Hughes Aircraft Falcon air-to-air missile. Tens of thousands of these were built and they stayed in service until 1988. For this daunting task Dean had the perfect team member in Simon Ramo. A colleague once noted, "Working together they are not the equivalent of two men, but something a little closer to 10." As Simon Ramo said, "We were exactly alike. We could finish sentences for each other…like identical twins."

While the United States had undisputed superiority in the missile and ICBM field, the launching of *Sputnik*, the first satellite to orbit Earth, was a cataclysmic event for the United States in every way and was particularly alarming and embarrassing to the country. This built the Russians' ego and the resulting insightful words of Nikita Khrushchev were, "We will bury you." This statement, made by Khrushchev in Moscow to a group of Western diplomats was seared into America's consciousness. Wooldridge was off to work again; it was a new field and a new challenge. In the space quest he

oversaw the design and manufacture of *Pioneer I*, a spacecraft later followed by the *Pioneer X*. The Pioneers achieved several firsts: *Pioneer I* was the first spacecraft built by a corporation. *Pioneer X* was the first to leave the Solar System, transmitting data from outer space back to Earth for well over 30 years. Twenty months after its launch it rendezvoused with Jupiter, sending back in real time the richest information we've ever gotten about that planet. With Wooldridge as its president, TRW became one of the world's largest defense corporations. He retired in 1962 at the age of 49.

In retirement he began a new chapter in his scientific life and undertook to learn and make contributions to neurology, microbiology, and the workings of the brain. He took no classes and received no formal training but mastered the field by reading works of the major contributors. He rented an office on Sunset Strip, and this became his workplace for the duration of his life. He became an expert on the brain and was particularly interested in the functioning of sodium channels in neurons.

He wrote four books on such topics, which were well received and published in several languages. Wooldridge was one of the pioneers in the blending of engineering concepts with biology. In fact, in the introduction he states readers will "encounter the analogies between biological processes and the properties of electronic systems." His books are wonderful panoramic views of the fields he was writing about.

In his popular book *The Machinery of Life* (1966) he explored in detail the possibilities for the origins of life on Earth. He avoided the controversial aspects of the evolution of species and stuck to his field of microbiology. He explained how the early atmosphere of primordial Earth contained the basic sources of energy: radiation, ultraviolet radiation, electrical discharges, and heat. These forces served to break up the gaseous molecules in the atmosphere, which recombined

to form more complex compounds, which then settled into the sea. The sea contained different compounds, which allowed for more molecular combinations. Among these new combinations were amino acids, linking together to form simple proteins such as sugars, phosphates, and bases. Over the eons, complex molecular chains were formed and the many possibilities allowed for closed loops of self-amplified chemical activity. Later he explains how these chemicals collected in droplets, grew by mechanical means, and eventually reproduced. Thus inorganic matter had become organic. Wooldridge doesn't so much use hypothesis about the young Earth as he uses known physical properties of compounds, chemicals, and the reproduction of cells. He explained the mechanical means used for the creation of ribosomes, DNA, and organelles like mitochondria, which attached to each other and then "reproduced" by replicating the process.

His 1963 book, *The Machinery of the Brain,* broke down the complex workings of the brain into its basic chemical makeup and function. He even described the foundation of consciousness, describing the electrochemical processes involved. Many interesting parallels were drawn between existing electronic technology and the operation of the brain. In particular, Wooldridge laid groundwork for brain activity as being a form of data processing. He noted that most of the breakthroughs in the understanding of intelligence had not come through medical research but by an understanding of the laws of computer science. Interestingly (and surely not surprisingly) Wooldridge draws an analogy to certain brain functions by describing the workings of the programming in a guided missile. He made the connection by describing neuron activity and then separately addressing the different brain functions such as hearing, taste, motor movement, feeling, and sight. The workings of the eye and vision received particular attention, involving many laboratory experiments

on monkeys. It was fascinating to learn how nerves to the brain can be cut or crisscrossed, producing responses having completely mechanical results with the animal showing no "awareness" that its perceptions were in fact the opposite of reality.

In his third book, *Mechanical Man* (1969), Wooldridge combines elements of both books. Careful to stick to physical laws and proven experimental fact, he describes the biological aspects of the human brain. Where does the brain get its energy? What happens when a neuron fires? How do they connect, disconnect, combine, and serve to form our collective being? What are memories? What are thoughts? Something so far from the common domain was an everyday practice for Wooldridge. He was absolutely optimistic about his trade, especially about its future. In *Mechanical Man* he pointed out that in the 17th century, medical science made the jump from metaphysics to physics. The functioning of the body was from then on described by cause and effect, as opposed to philosophy and conjecture. Wooldridge believed that, finally, in the last half of the 20th century the functioning of the mind could similarly be explained by cause and effect.

His fourth and final book *Sensory Processing in the Brain* continued the search to unravel the mysteries of intelligence. The book was published in 1979 and would finally mark a period of more substantial retirement for Wooldridge. This period of his life from his official TRW retirement to the writing of his final book was approximately 17 years.

Wooldridge was awarded many honors. He was a fellow of the American Physical Society, the Institute of Electrical and Electronic Engineers, and the American Institute of Aeronautics and Astronautics. He was a member of the Caltech Associates and of the Cosmos Club in Washington. He received the Citation of Honor from the Air Force Association and the

Raymond E. Hackett Award in 1955. Wooldridge received a Distinguished Service Citation for outstanding service to the state and nation from the University of Oklahoma in1960 and the AAAS-Westinghouse Award for Science Writing in 1963. He served as chairman of the National Institutes of Health Study Committee (appointed by President Johnson) in 1964 and 1965. In 1967 he was made a fellow of the American Academy of Arts of Sciences. Two years later, in 1969, he was elected to membership in the National Academy of Sciences. In 1975 he was made a member of the Board of Trustees of the California Institute of Technology.

While Wooldridge worked hard, he kept reasonable hours and was usually home in time for dinner. His only really late nights out happened when he was called on to entertain business prospects. His son Jim remembers making a C in math in one of his classes, something that was inexcusable and resulted in Dean's tutoring him for months afterward as well as working up fun math puzzles for him to work on. Although Dean was compassionate and amiable, he was a strict disciplinarian. Dean ran a tight ship with a superstrong emphasis on education.

After a brief illness Dean Wooldridge died on September 20, 2006, in Santa Barbara, California. Helene and Dean had three children, who were taught the value of dedication and hard work. They have careers that collectively mirror the interests of their father. Dean E. Wooldridge Jr. became a computer programmer, Anna Lou Eklof a physiologist, James A. Wooldridge a software engineer. He also had three grandchildren: Michael Andrew, Jonathan David, and Lisa Michelle Wooldridge.

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