NATIONAL ACADEMY OF SCIENCES

DAVID LOCKE WEBSTER II

1888—1976

A Biographical Memoir by

PAUL KIRKPATRICK

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November 6, 1888–December 17, 1976

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THE LIFE to be reviewed here was that of a professional physicist, an educator, a national servant, a family man, and a keen appreciator of the natural earth—its rock, its air, its water, and its celestial environment. He was avid about his hobbies and always made science out of them by studying them in productive depth. Near the end, he said that he should have specialized in geology rather than physics, but few physicists would second this tardy preference. As with able and versatile men in general, there was a variety of good lives open to Webster; like them all, the path actually chosen was a function of the elaborate complex of unpredictables that we must call "chance."

David Webster was born in Boston, and New England was stamped on his tongue to the end, as any ear for dialect would recognize, but it would be wrong just to pronounce him a New England type except as it was typical of nineteenth-century New Englanders to resist complete uniformity. Webster had such individuality or self-dependence. To his students he was a "character," but that tells nothing precise since characters defy characterization.

FAMILY DATA

Each of Webster's parents was anteceded by at least seven generations of New England ancestors, the regressing lines vanishing at about the mid-seventeenth-century peak of immigration from Britain. All of the names seem English, and Webster has dropped a remark that his ancestors were Puritans from the northeast part of England—Yorkshire, Norfolk, and thereabouts—and that they left England, bound for America, about two jumps ahead of the sheriff. If this reference had any other than a facetious meaning, it should be realized that there must then have been some two hundred and fifty unconnected ancestors in the migratory flow that generated our subject, and it is unlikely that one denigration could fit them all.

The Webster name is best remembered in Massachusetts history because of two individuals. One of them (Daniel) shared a seventeenth-century ancestor with our subject. The other (Noah) was on an unrelated line.

Webster's father, Andrew Gerrish Webster, deprived of a college education by Civil War conditions, was of the type capable of self-education. His recorded description of himself was "Tastes simple—self-contained." His wife, Webster's mother, scorned this modesty and pointed out some of his valued services in the community of Boston, the center of his business interest, which was the tanning and wholesale distribution of leather.

Webster's mother was born Lizzie Florence Briggs in Boston in 1853. The Briggs name had been known in the shipbuilding business for more than two centuries, but in the middle of the nineteenth century steamships had improved to the point where they could drive the windjammers off the oceans. Lizzie's father (Harrison Otis Briggs) gave up the contest, moved his family to England, and got himself a job in a shipyard in Liverpool. There Lizzie got most of her schooling. For reasons unknown, the family returned to America after a dozen years, and Webster picks up the story at that point.

By the time the family returned to the United States the old square-rigged sailing ships were almost a thing of the past, and my grandfather never had built steamships. So Grandpa Briggs went into a bank instead of going back into shipping. As President of the Bank of the Republic in Boston he had a prominent part of some kind in the reconstruction of the South after the Civil War. He was very definitely not a carpetbagger. His work was entirely altruistic, and just what he did there I am not sure, but I know it was for the benefit of the Southerners. My mother once described her father as having "great sweetness and unselfishness, with dignity and reserve... a clear and quick brain, great kindness of heart and a sense of humor, very fond of music, literature, travel, and outdoor sports."*

Webster's father left his Boston leather business about 1910 at an age now considered appropriate for retirement, but he had other interests to follow, particularly real estate. He worked until his death at ninety-three. His son has cited evidence that at that age he was still "a keen man." There is also evidence that prolonged physical and mental health were Webster family characteristics, traits borne out by David Locke the second.

CHILDHOOD

Raising the young Webster from his twelve-pound birth weight to his teens was a project shared by numerous loving and unskilled hands. In his last decade of life, the product of their efforts testified: "I grew up practically alone [though he had a beloved elder brother who had been brought along under a different formula]. My childhood was deadly uninteresting. I was not allowed to play with other children because it was feared I might catch germs of one kind or another."†

When first sent to school at age five, he was completely surprised by the discovery of what it was like to play with

* Personal journal of David Locke Webster II, n.d.
† *Ibid.*

other children. His playmates found that he was under motherly orders to keep his hat on (to avoid fatal pneumonia), so naturally they knocked it off. "It was a completely wrong introduction to dealing with humanity, and I don't think I have ever really recovered from it,* he said in his eighty-seventh year.

Had Webster's career been steered by modern aptitude tests, he would never have become a physicist, for, as he confessed in later life, his most difficult elementary subject was arithmetic. His later high-level aptitude for mathematics first became perceptible in the later courses of algebra and geometry, subjects that he found easy and fun.

Other detested experiences of Webster's schooling phase were compulsory dancing lessons (from about age eight), compulsory piano lessons (beginning at about ten and completely ineffective), and school athletics. He liked bodily activity and suffered from no handicapping physical disabilities, but he was deadly sick of being regimented in every way and came to the point of automatically opposing any new thrust of it.

Another form of systematic observance, which began in early childhood but never paid off to the satisfaction of those who administered it, was religious training. Perhaps it would have been more effective had it not been so competitive. He has written that he was "dragged every Sunday to one church or another ... [and] ... all through the Episcopal Sunday School,"† but on weekdays there were other pressures. His scholarly and respected paternal grandfather, a devoted Swedenborgian, bore as much responsibility, by family agreement, for the boy's upbringing as did his mother. In David's early years his mother's time was taken up by "social duties," and he spent most of his time with nursemaids, all Irish

* *Ibid.*
† *Ibid.*

Catholic, and, it appears, as much concerned with the welfare of his soul as with that of his body.

EDUCATION AND RELATED MATTERS

Such experiences were not without later effect. Early warning about Robert Ingersoll drew him into broadening critical reading. Association with his grandfather led him to appreciate Emanuel Swedenborg as a great scientist considerably ahead of Kant and Laplace on some discoveries. Webster's obligatory Sunday morning studies of the *Episcopal Book of Common Prayer* and the *Creed* made wonderful material for swearing, and he developed an ability at picturesque profanity that stayed with him for life.

Ridiculing religion is a simpler course of action than trying to think it out, and Webster's ironic experiences did not leave him an impious scoffer but a thoughtful agnostic who would sneak attendance at a Catholic mass, to see what it was like, when grounded on some long solo flight. After a sailing or flying near-miss he confessed that he could thank God without believing in him. When required to fill out a "religious preference" blank he would profess agnosticism.

In a later year at Stanford, on his morning walks to the Quad, he developed a good acquaintance with his neighbor, the university chaplain. These peripatetic philosophers wasted little time on trivialities and subsequently the chaplain, an inveterate author, expressed in the frontal pages of a book his gratitude for aid received from "Dr. David Webster, distinguished atheist of Stanford University."

Until he went to a teaching post at the University of Michigan in his twenty-eighth year, Webster had had no experience of public education. His own schooling was in Boston private schools, finishing for Harvard at Noble & Greenough's Classical School. Webster himself wrote "I went from there to Harvard because in those days no one with my background and upbringing would have thought of going to college anywhere else."*

There is nothing to be found in Webster's papers about his undergraduate years at Harvard and almost nothing in the possession of his family. He came through in the usual four years with the much less usual summa cum laude. He seems to have been less than completely satisfied with his record and to have grieved over the presence there of a single C grade.

His mother appealed to the Harvard administration about the disgraceful C and had to be satisfied with the declaration that there was nothing higher that the College could give than a summa cum laude, but if the defeated gladiator would present himself at the president's office, that official would publicly put a wreath of laurel and roses on his brow. It is comforting to know that this record did not denote any complete life switch to middle-of-the-road conformities. It surprises this reviewer of his life to find that the child nonconformist could so abruptly convert to conventional academic ideals of performance and aspiration.

RESEARCH BEGINNINGS

Following graduation Webster went on for the doctorate, working principally under the direction of veteran Professor Theodore Lyman on the optical properties of chlorine gas, a rather unexciting classical field that did not firmly hold his interest beyond the three years of degree work. Phrases like "modern physics" and "atomic physics" were resounding in the halls of science and young searchers and researchers recognized that the old classical fields no longer offered the maxima of either the prizes or the fun. Webster selected the field of X-ray physics, and it was to be the area of his chief research effort for three decades. With his new degree he

* *Ibid.*

received appointment to an instructorship. He assembled X-ray equipment and went to work on problems of his own choosing.

A brief flashback is necessary here. The three graduate-student years were not unmitigated labor: In 1911 Webster met and in 1912 married Anna Cutler Woodman. Little is known about this romance, but he has recorded that he was drawn to her because, unlike most of the girls he knew, she was training herself to do something, to become a teacher. Another strong plus for Anna was that she was just the kind who would like a honeymoon on a sailboat, sharing with him his most beloved avocation. In another year, their family of two girls and two boys started coming.

Back at the research laboratory there were interesting developments. Throughout the first decade of this century, X-rays were used but not understood. Not until 1912 was it uniformly agreed that these rays were waves much like ordinary light and not showers of submicroscopic bullets. As waves, they were in the field of the spectroscopist, but none of his instruments could disperse them or measure their wavelengths. The spectrometer that could do these things had been invented by W. Lawrence Bragg, who used a crystal in place of the familiar prism or grating, and so opened up the science of X-ray spectroscopy.

Webster, with some shop aid, put together an X-ray spectrometer on the Bragg pattern and got started observing the nature of the spectra emitted by the then recently available glass X-ray tubes developed for medical use. He could identify the range of wavelengths the tube emitted when in high-voltage operation, and he could measure in an approximate manner the relative output strengths of the different wavelengths he chose to observe.

Before going further with the laboratory data, we interpolate. Experimenters had concluded, before spectrometers came to their aid, that the X-ray power put out by the common tubes comprised a wide variety of wavelengths. It was evident that electrons in the evacuated tube were accelerated to high speeds by an applied and measurable voltage but were then abruptly stopped by their impact upon a metal target (in this case, of tungsten). The observed X-rays radiated out from the spot on the target where the electrons collided, so one had to suppose that the X-rays got their energy from what the electrons surrendered when they were stopped. But it would have been rash to suppose that *all* of the electron kinetic energy reappeared as radiation energy.

Such uncertainties had a serious importance since these were days when the old quantum theory was out on trial. It grew in credibility as it was found applicable to more phenomena. Here was a relatively uncluttered phenomenon involving electrons and a kind of light, a sort of reverse of the phenomenon of photoelectricity, which had been greatly clarified by the application of quantum concepts, particularly the doctrine that light, though demonstrably a kind of wave, dealt out its energy in little mutually exclusive packets. Physicists uncounted had wondered if something of the kind were involved in the X-ray tube. Finding out would require, among other things, quantitative X-ray measurements such as a Bragg spectrometer might facilitate.

Professor William Duane, very senior to Webster in the Harvard science escalator, was well aware of the theoretical problems in the X-ray field and of possible modes of solution. He borrowed Webster's spectrometer and assigned one of his younger men, Franklin C. Hunt, to explore with it the continuous X-ray spectra of tungsten, making careful records of the voltages used to accelerate the electrons. The investigation was a brilliant success, showing that the spectrum was abruptly terminated at its high-frequency end and that the terminal frequency there fitted into the famed Planck–Einstein energy formula, which equates the energy of an electron to that of a radiation particle (or, as we came to say later, to the energy of a *photon*).

Professor Duane promptly reported these findings to a meeting of the American Physical Society and the news went round the world under the title of the law of Duane and Hunt, and so it is still known and described in many a book on many a library shelf.

What the world did not know and found out only very recently* is that the Duane-Hunt experiment had been conceived, nicely performed, and recorded (but not publicized) earlier by David Webster.

Now the writer of this memoir must switch to the first person. I worked beside Webster at Stanford University for more than a decade and talked with him occasionally about scientific matters for three decades more. There was much talk about X-rays, but never did he tell me of his anticipation of Duane and Hunt. I do not know why. I came to know of it only because Webster was a meticulous recorder. In his postmortem effects were an uncounted number of loose-leaf ring binders—certainly between one and two hundred—among which I found his Harvard research notes. They show that he knew exactly what he was doing on March 31, 1915, when he gathered data on the tungsten continuous spectrum, plotted a curve, noted that it terminated on the shortwave side, and calculated therefrom a good value of the Planck constant h. He was aware that he had been scooped, and I do not understand why he did not try to salvage what glory was possible later. Young scientists upward bound are expected to put their best feat forward. Had he been as skilled or as well motivated in the matter of public relations as he was in

*For a discussion of David Webster's work in this connection, see P. Kirkpatrick, "Confirming the Planck–Einstein equation $h\nu = (1/2)mv^2$," *American Journal of Physics*, 48(10):803–6.

scientific performance and recording, the law of Duane and Hunt might have been Webster's law all these years.

WORLD WAR I

From Harvard, Webster went in 1917 to an assistant professorship in the University of Michigan, which turned out to be but his entrance vestibule to World War I, the first of two wars in which he was destined to render scientific service. He was caught in the general draft, but found a more useful and attractive occupation in the air service of the Army Signal Reserve Corps. He was not a flyer himself at this stage, but requested and got flight instruction. Here began a personal enthusiasm comparable to that which he had always felt, and possibly inherited, for sailing. His responsibilities started with the testing of flight instruments but progressed rapidly to testing and criticism of the many products of the suddenly created military airplane industry, and also of foreign planes. He has been called the first test pilot in American air service, but he later declined this distinction, since there was then no such recognized title.

His flight instruction took place at Gerstner Field (Louisiana) where he had been sent to have charge of the measuring instruments intended for use in tests of the American modification of the British DH4 airplane. Though aware of his defective hearing and apprehensive about a tendency to airsickness, Webster mastered flying promptly and was told by his French instructor, "Mon Dieu! You fly like ze God Himself!"*

The new American planes were a bitter disappointment, particularly their much-touted Liberty motor, which was replacing the British Rolls-Royce. The ship was entirely disqualified from aerial combat. Webster has written about these trials:

* Personal journal of David Locke Webster II.

> Then, what really made us boiling mad was to go back to quarters each evening and read in the newspapers that the Liberty motor was doing wonderful work over the lines in France, and that the British and French generals were congratulating our generals on these glorious airplanes—when we had the only ones in the world, all six of them, on our hands, more than 6,000 miles from the lines in France. We were too unsophisticated. We should have known that the first casualty in any war is God's truth.*

In spite of these unwelcome findings, Webster stayed with the First World War until Armistice as lieutenant and as captain in the air service of the Army. Nearly all of his work was at Langley Field, Virginia. He remained in the air reserves until 1924.

TO STANFORD UNIVERSITY

With the first war behind him, Webster returned to Michigan but within the year accepted an assistant professorship at Massachusetts Institute of Technology. After a single year at MIT, which at the time was just what the name says, Webster gladly accepted from Stanford University an offer of full professorial status and Physics Department chairmanship. In 1920 Stanford was well known for its unique history and its supposed financial security, but its academic greatness was spotty. Physics was represented by a small, aging faculty, busy at their teaching and little involved in the twentieth century explosion of their discipline. In the Webster appointment Stanford had a young man (thirty-one) of unquestioned keenness, freshly developed in a center of eager scientific progress. His interests, his talents, and his experience showed a seemly balance of instruction, research, and academic citizenship. I, the writer of this account, then a graduate student at Berkeley across the Bay, met the new Stanford hope at interdepartmental physics conferences and recognized the awakening influence.

* *Ibid.*

STANFORD PROBLEMS AND EVENTS

In taking up the Stanford professorship (which was to run for thirty-four years) Webster was serving an academic employer younger than himself and smaller (2,949 students) than those he had known. The waiting tasks were as large and demanding as such things can be anywhere and left little time to grieve about the lack of a plane or a yacht. There was an atmosphere of good will all around, and his acquaintance with physical sciences other than his own gained the respect of neighboring departments. He had great freedom of action and all the facilities therefor except money.

The Bible almost says that the lack of money is the root of all evil. Among pre–World War II experimental scientists this version had many believers.

One of the things that President Wilbur hoped of Webster was that he might make Physics a significant research department. Webster's own ability in this field seems to have been evident to his Army and academic associates and he had documented it by some fifteen published papers, but his name was not yet highly visible generally. Now it was not only his wish but also his duty to build a creative investigative center at Stanford. Webster has told that in planning for research he scoured the University junkyards to pick up the material that might be converted into instruments for scientific observation and measurement. The construction was often done by the scientist himself with the help of graduate students glad of a chance to earn twenty-five cents an hour. The problem here was to find the twenty-five cents, for there was no research budget as such.

Professors necessarily did things almost incredible to their present-day counterparts. In Webster's first Stanford research, he became carpenter, plumber, lineman, pump cleaner, and freight heaver as occasion required. Fortunately his chief collaborator, Professor P. A. Ross, was well endowed with extra-professorial talents. He was the only glass blower on the Quad, had made telescope mirrors, operated all the then-known machine tools, and liked to make them do tricks beyond the intentions of their designers.

On surveying the instruction going on in his new Department, Webster found it lacking. Students were getting practically no chance to learn about what physicists were calling modern physics, not merely because their teachers were not close followers of twentieth century developments but also because available textbooks were not telling the modern story. Furthermore, Webster criticized the general physics texts then available as being catalogs of facts worth knowing, rather than training manuals for finding out.

So, working with Professor H. W. Farwell of Columbia University and Professor E. R. Drew of Stanford, he produced a new textbook entitled *General Physics for Colleges* in 1923. It was the first in America to give extended and connected treatment to the modern physics, and as such it was valued and adopted. But the insistence on thinking things through, albeit nonmathematically, though popular with the kind of students that *elect* physics, dismayed that greater number who took physics because they had to and who were used to getting grades by memory rather than by understanding.

Books that try to comprehend a rapidly growing field go promptly out of date, and this was perhaps the worst time to do the definitive summary of modern physics. *General Physics* came out in 1923, the year in which Compton confirmed that light comes in particles and Pauli clarified atomic structures with his exclusion principle. In the next year, de Broglie suggested that particles are waves and the arrangements of electrons within atoms became clear. In the year after that, wave mechanics was born. So, in 1926 the second (and last) edition of *General Physics for Colleges* was brought out, and while the ink was drying the wave nature of all matter was proposed and convincingly defended, and Davisson and Germer were experimentally substantiating it for the important case of electrons. In the very next year, Heisenberg declared for uncertainty, shaking the foundations of general philosophies and putting a new one under physics.

THE TEACHING PHYSICIST

As a teaching physicist, Webster worked from a philosophy that has already been indicated. Students must not be allowed to think of physics as an esoteric mystery but rather as a means of understanding the why of what goes on around them and, progressively, of gaining explanations—even quantitative ones—of other phenomena far less commonly observed but pregnant with thrilling implications. Sometimes many questions may be grouped under a similar answer, from which emerges a "law." But in referring problems to laws the teacher must be careful to show that the law is a compact summarizing statement of human observations and not, in itself, a proper object of worship. Webster knew that laws are an enormous convenience, but when he introduced students to Boyle's law or Ohm's law or one of Newton's he was careful not to claim that the usual simple forms were absolutely and in all circumstances correct. In his book the three-letter statement of Ohm's law was carefully hedged with conditions about constancy of temperature, homogeneity, and ambient magnetism. This extreme care about correctness was not found ingratiating by all students. Some teachers can stand up before an advanced class and say, "What I told you last year wasn't quite true." Such methods were not for Webster, and the inquiring and well-motivated minds commended his rigor.

The above might suggest that Webster's lecture style was stiff or pedantically formal. On the contrary, it was conversational, without the meaningless sounds and ungrammatical shortcuts often condoned in such communication. As to the

Webster textbook, users agreed that it was extremely hard to find errors in it, even in the first edition. This writer, an avid critic, never succeeded in finding even one.

Webster was one of a group of physicists of standing who felt that teachers of physics, particularly at college levels, were such accidentally and were often lacking in special training and in opportunities to secure such. Since the American Physical Society did not regard teachers as physicists and elected to ignore their problems, a group including Webster founded the American Association of Physics Teachers in 1930 and solicited a membership that has since built up to nearly ten thousand. He was active in this important organization and in the years 1935 and 1936 served as its president.

At Stanford Webster was employed to be both a teacher and an active researcher in the science of physics, and though he was fond of both activities and performed them expertly, he never recognized any helpful symbiotic relationship between them. In 1957 he wrote:

> Speaking from my own experience, I have found that I could never make really good progress in any research job unless I neglected my undergraduate teaching, letting it coast along with obviously insufficient motive power. Conversely, I could never do much to improve any undergraduate course unless I let the moth and rust have their way with my research apparatus.*

RESEARCH IN X-RAY PHYSICS

Webster's productive researches may be considered in a few separable categories of which the first has to do with X-rays. His pioneer X-ray spectrometer observations have already been cited, and his Bibliography mentions a few other X-ray publications traceable to his brief terms at Harvard, Michigan, and Massachusetts Institute of Technology.

* *Ibid.*

But ideas developed faster than the possible testing of them, so he carried many of them to California for consideration in the research laboratory he was expected to develop at Stanford.

His personal research efforts on the new job were largely devoted to observation of the bombardment of metallic atoms with electrons and the measurement of the resulting characteristic radiations. If this sounds like a puerile occupation, the reader—even the scientific one—may pardon some amplification. The real purpose of the experiment was to draw out internal information about the atom, that is, about any one of the atoms in a pure sample, let us say, of gold. The collision of an electron with an atom *might* energize the atom, causing it to emit a photon (radiation quantum) of a wavelength peculiar to its species. It was part of the investigator's task to catch and count the special photons, and in Webster's work they were always X-rays. The italicized uncertainty above was necessary because the chance of a productive collision is strongly dependent upon the energy of the bombarding electron. For slow electrons the chance is zero, but with increasing speed that probability abruptly takes on a positive value, and this critical speed or energy is an important datum for the atomic theorist, who is also deeply concerned about how the probability varies with electron energy as bombardment speeds are pushed up.

This dip into atomic science will still leave the lay reader dubious about the usefulness of the early Stanford X-ray investigations, really atomic mechanics investigations in which X-rays were a by-product and a handle. The work was never understood by journalists or by the wives of physicists. Over the perspective of years, one may wonder that it ever succeeded in an era when the directing scientist designed and built his own power supply, cleaned and serviced his own vacuum pumps, and measured his high voltages and his milli-micro signal currents with homemade meters. (For a fuller acquaintance with those times, see the Webster Bibliography.)

A more glamorous kind of X-ray research enlivened the Stanford laboratory when Webster and Professor P. A. Ross, about 1925, stepped into the controversial territory of the Compton effect, with clarifying effectiveness.

As a point of information, the Stanford word *klystron,* now heard in all the principal languages, was coined or appropriated after a visit by physicists to the Department of Classical Languages. In ancient Greek it meant something about sea waves, but in the modern definition it has to do with waves of electrons, a klystron being specifically a vacuum tube without a grid but able to control such flow in an advantageous manner utterly new to the world of 1937. Webster did little or none of the inventing but he understood more fundamentally than did its inventor and played a valuable role by elucidating its theory (see Bibliography) and by guiding the poverty-stricken Department through a new phase of contact with University administrators and the extramural world of big industry and manufacture. He lived to see the new idea build buildings for his Department and start its growth to conspicuous world visibility.

WORLD WAR II

Even before Pearl Harbor the war was molding that Department. Foresighted staff members were weighing choices of battle stations for what would be called a physicist's war.

Klystron men were at war work already: the development of the tube had been prompted from the beginning by concern for civilian populations under bomber attack and lacking microwave power for effective radar. Parenthetically we may say here that klystron design, testing, and production did get there on time to play a significant, and perhaps determinative, role in the Battle of Britain and other engagements.

Webster headed the klystron development until its size, commercial commitments, and internally competitive ambitions made it obviously not at home as a subdivision of the small Physics Department. Klystron activity went to Long Island with Sperry Gyroscope Company. To Webster, fed up with klystrons, the Pearl Harbor blitz was timely. His first comment on it was, "Thank God we are in the War before the enemy has had time to destroy all our friends!"* A few days later, he struck out in search of a fitting wartime station. Too old for flying, he considered a few thinking posts and settled into duties as assistant chief of the Army Rocket Research Branch at Aberdeen Proving Grounds in Maryland, and here he served out the duration.

Webster later wrote, "I didn't know anything about rockets, but nobody in America knew much about them; so it was easy to get right up with the best of them."† At that time, the Germans did know much about rockets, particularly large ones, and Aberdeen was developing the bazooka, a tactical weapon carried on the marksman's shoulder; a useful achievement of Webster's group was insuring that this weapon would dispatch its rocket forward instead of sideways into the soldier's head.

In the autumn of 1944, Webster was sent to England and France to judge the relative merits of different rockets. Though a civilian, he went dressed in the costume of a colonel, carrying a card stating that he had the rank of "assimilated" colonel, and furnished with decorations appropriate to that rank to pin on if taken prisoner. At such a point, he would be assimilated into the Army without gambit, a kind of plug for better accommodations for captains. His rocket study began in England and later took him to France and war zones, returning him to Aberdeen for separation in the summer of 1945.

* *Ibid.*

† *Ibid.*

WRITING TASKS

The Webster Bibliography, a part of this memoir, might stand by itself, but a few exceptional items merit individual comment. The *International Critical Tables* was an eight-volume world first as a reference source on the physical properties of all sorts of substances. Spectrum lines were included in its wide coverage, and Webster led the group who did the X-ray spectra. He more or less justified this valued job of dull scholarship by pointing out that in the poverty year of 1929 it required no apparatus or other expense to Stanford.

His airflight competence and enthusiasm had survived World War I, and he had taught classes in "Air Craft Operation" for the Civil Pilot Training Program of the Federal Civil Aeronautics Administration and had come to realize painfully that fliers were still being taught World War I superstitions about the physics of flight and how to cope with its vital problems. Flight training had been cleansed of some of its plain denials of Newton's laws of motion, but not enough in Webster's view, since very few flight instructors had learned to read differential equations of the fourth order, while every airplane understands and promptly obeys two such equations.

Webster bought a 65-horsepower Cub, flew it from California to Washington (more specifically, to College Park, Maryland), and explained that he was the man who could revise their training literature so that it would neither make the trainee dizzy nor the scientist sick. He got the paying job promptly, along with the collaboration of junior authors, and spent the summer of 1940 happily rewriting and flying.

Having been openly critical of some common textbook treatments of electric and magnetic theory, Webster was a natural candidate for membership in American Association of Physics Teachers' committees for review and recommendation in these fields. It may seem odd that in the twentieth century physics teachers could not all immediately agree upon what should be said about magnets and about electrostatically charged objects, these being matters that have been thought about for millennia. Here questions about experimental truth or mathematical rigor were few and readily answered; but matters of taste, philosophy, historical precedent, and even a little respect for tradition and authority arose to demonstrate that scientists are still humans. The Coulomb's Law Committee report was published in 1950, after two extended summer meetings of committee work. Webster, as human as any, did a great part of the writing and injected a point of view that seems more and more natural and acceptable with the passing years.

If a reader really wants to know what the preceding paragraph has been about, he may well turn to the *Encyclopaedia Britannica* of 1970 and read or browse Webster's fifty-seven-page general article "Electricity," a masterful presentation of a mathematical subject including general relativistic touches without mathematics beyond a little high-school reckoning.

RETIREMENT AND THEREAFTER

His postwar years at Stanford were not Webster's happiest. He has written that upon his return from the war he found himself a misfit at the University. The new University president had replaced him as department executive. His old research quarters had been revised out of recognition and were now occupied by busy younger men with younger problems. He said himself that nuclear research was a young man's game and he had voluntarily written himself out of the klystron empire, even to turning down a piece of the expected royalties.

Ever concerned about the professor's dilemma of serving two masters, Webster now turned from research to teaching and accepted the assignment of putting in order the deplorable engineering and science physics instructional program, which had slipped too much into the hands of unregulated teaching assistants. In this useful job he made himself quite a student reputation. More widely distributed benefit to physics came out of his leading role in the Coulomb's Law Committee discussed earlier.

Following his retirement in 1954, Webster issued a dozen publications of scattered character, including several on relativity matters and some ventures in astrophysics, which were facilitated by a congenial appointment at Ames Research Center, Moffett Field, California, with practically professorial freedom to pursue mathematical research in space sciences. This was a clean slate. Years earlier he had decried the attempts of aging scholars to ignore Nature's cool insistence that they were not permanently productive supermen. He was going to recognize his mental deterioration before other people did and go sail his boat. Now was the time to test such intentions, but the opportunity of an Indian-summer career with old pressures off brought him into a more attractive course and somehow a still productive one. Big modern research organizations, rapidly assembled, are staffed with smart, young, deeply specialized people, who have not taken the time to become broadly educated, even within science. A genial old man who knew so much about so much was a naturally popular consultant, both socially and professionally, in such company.

SAILING AND FLYING

Webster's life included the already mentioned avocational enthusiasms of sailing and flying. The sailing interest was nothing new in the family; his Briggs maternal ancestors had been builders and sailors of Massachusetts ships for two centuries, up to about the Civil War times. The most celebrated of these, the 220-ton Clipper ship *Columbia,* was the first American vessel to double stormy Cape Horn and ply the West Coast waters. She traded in the American Northwest, where she gave her name to a great river, continuing westward thereafter and carrying the flag of the United States around the world for the first time.

Among the Briggs sailing men was a pirate, still spoken of in the family as Uncle Tom. It is recorded of this cousin of Webster's maternal grandfather that he was in and out of English prisons, bearing his fate calmly as a godly man may.

When Webster was ten he and his brother were given a skiff with which they taught themselves to sail by doing it. He later explained that he surpassed preteen playmates in perfecting this art because at that period he didn't give a damn whether he drowned or not. As life took on value, his aquatic instruction continued and he passed the grammar school of seamanship, which was Massachusetts Bay, and the high school, which was Cape Cod.

In the Webster literature are the names of eight windborne boats that he owned in whole or in part during his sailing life, and in one of which he and two companions accomplished a round-trip cruise of 2,500 miles, circumnavigating New England, most of Nova Scotia, and slices of New York and Quebec. The closeness of sailing to his heart appears even in the choice of his first wife, Anna.

The only real disappointment about the family move to California was the discovery that the state offered no good cruising for small sailboats. Webster searched and found nothing to meet his Atlantic standards within eight hundred miles, but British Columbia held the family's desires and there they spent several consecutive summers.

Webster was interested in aviation before Kitty Hawk. He wrote, "I always wanted to get up in the air."* Boyhood para-

* *Ibid.*

chute jumps with a big umbrella ended in crash landings and he remained grounded until World War I, though in the Harvard period he took part in the building of a plane that declined to fly. He has written that World War I gave him an excellent excuse for going aloft and he remembered throughout life the elation of his first solo flight and his half-thinking, half-saying, "My God, here I am at last! *Really flying and in full control!*"*

After military flying his circumstances grounded him for several years, but in the 1930's he was getting nostalgic for the air and took steps. Although a military pilot, experienced in the flying of thirteen plane types of the period, he took his first private pilot's license in 1936 (at the age of fifty-four) and celebrated it by flying under the Golden Gate Bridge. He later acknowledged that that was a dangerous sport in that he might have lost his license for it.

With the talents of a natural seat-of-the-pants flier, Webster brought to the craft his mechanics, mathematics, meteorology, and love of nature. Flying became a fine family activity. Though Anna still preferred boats, his two sons were soon good fliers, relishing the air and finding careers in it. One became a pilot with a commercial airline and the other served as fighter pilot of the U.S. Airforce in World War II. Webster owned five successively more powerful planes. The logbook of one of them came to show at least one landing in each of the forty-eight United States of the time.

IN CONCLUSION

The two strong egos of David and Anna Webster attracted like magnets for a few decades, but a polarity reversal came and brought divorce in 1951. He soon married Olive Ross, a longtime widow of his early X-ray colleague, P. A. Ross. In the nine successful years of this marriage (until Olive's death)

* *Ibid.*

she rendered him an abundance of human understanding, literary criticism, social guidance, and flight companionship. The dearest friend of his later years was the space scientist, Alberta Alksne, with whom he wrote theoretical papers and toured Australia, New Zealand, and the Barrier Reef.

Webster stopped working at NASA in 1975, when he was eighty-six years old. He was not eager to quit, but years of battling with uremic poisoning had worn him down and he died on December 17, 1976. He retained his curiosity about the world and life to the end, asking, almost at the last, "What's it all about?"

It is not the function of these pages to praise but to recall and commemorate. In summary, David Webster in his thirties was known among physicists of his time as an X-ray man and more particularly as an experimenter rather than as a theorist. This trend of his reputation was an accidental result of his opportunities and no real choice of his own. He was conscious that he had no great gifts of digital dexterity and no kind of apprenticeship in the manual arts of the instrument shop, but at Stanford, in a delicate and budgetless experimental program, any such disadvantages were compensated by his superior understanding of what was being attempted, his mathematical familiarity with its past and presumable future, and his ability to theorize his way out of a dilemma.

In the twenties he was the only possible theorist in the small Department. He came to realize, though none too rapidly, that high-class power in such physics was an essential condition for the future growth and service of a university physics department in either its teaching or its investigative function. In this need he took the strong step of securing the appointment of Felix Bloch (1932), the more to Webster's credit inasmuch as his makeup included a trace of ethnic discrimination.

This would have been an appropriate time to swing the research emphasis of the Department into one of the new productive channels, but Webster preferred to carry on with X-ray observations using more energetic collisions. This simple-sounding extension would have required far bigger budgets than the Department had ever seen; Webster went to the foundations for such support and was turned down. This was his last attempt at major research leadership. William Hansen, meanwhile, pored over cheaper ways to get high-energy electron collisions producing the cavity oscillator, which led to the klystron and to the two-mile linear electron accelerator. In the list of Webster's life achievements the production of Hansen is not the least. This prodigious undergraduate (now long dead) was first Webster's worshipper, then his replacement in advanced lectures, and later his adversary in klystron diplomacy and management.

Webster held the fixed opinion that a university has in its work of teaching and scholarly investigation two separable functions with a degree of competition between them. He felt the dishonesty of spending tuition receipts on the showier activity of research, visible to donors and popular with most of the costly scholars. Opposing this custom in principle, he unavoidably practiced it and confessed in print that he could not serve two competing masters with fairness if he had to divide individual days between them. It was a relief to him that he lived to see research supported in relative abundance from other sources.

Webster never did set his evident capacities and less evident ambitions on any resolute pursuit of maximum professional visibility. He took up the questions of living as they addressed him. His always curious mind was intrigued by the problems of nature and he solved a few. More solutions would have meant more glory, but sometimes it appeared that his payoff was more in the solving than in the solution. It was characteristic that when he visited Hawaii and saw the destructive work of a "tidal wave," he busied himself for two years on tsunami research and determined the effects of certain idealized island forms upon the impacting sea waves. When he learned of the anomalous magnetizations frozen into historic lava flows, it was not long before he was in conference with vulcanologists about causes of the phenomena and their possible use in predicting eruptions.

The impression of Webster's personality was one of strength and gentleness. He was often charming, though certainly with no intent to charm. He had some biases and the grace to conceal them. Though not infallible in dealings with people, he was quite devoid of guile and was irritated by signs of it in others. Since successful diplomacy cannot operate without guile, his had its limits. His judgments of others were confident, but some found his condemnations exaggerated. In general, people liked him warmly and remembered him lastingly. His concern for public opinion was slight and yet detectable.

His memory became richly filled with science items now rapidly becoming historic and with details of personal experiences relevant to many continuing lives. It must always seem a definite human loss when such slowly built files are wiped out without a copy.

David Webster was elected to the National Academy of Sciences in 1923.

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