NATIONAL ACADEMY OF SCIENCES

ARTHUR M. BUECHE

1920—1981

A Biographical Memoir by

ROLAND SCHMITT

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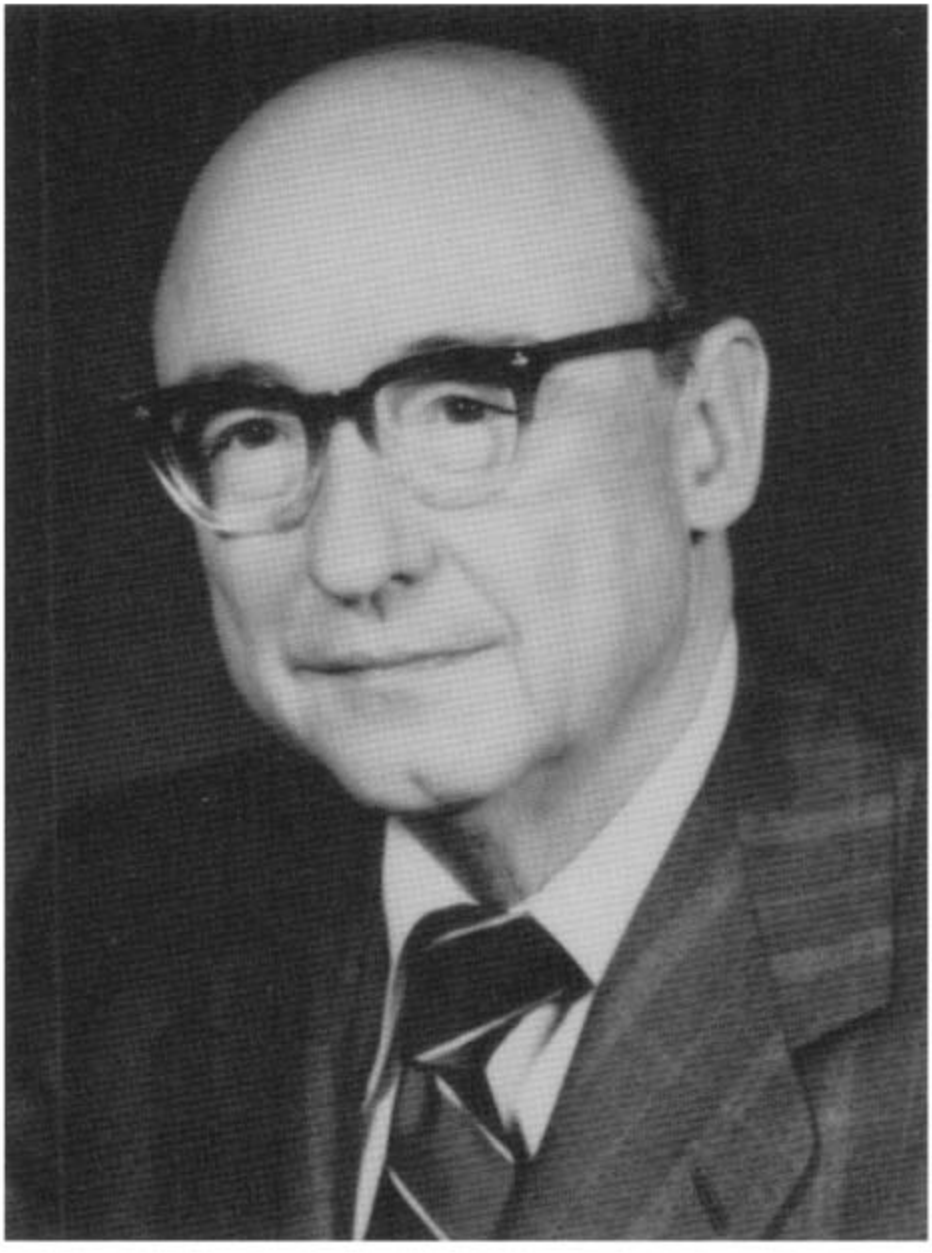

A. M. Burch

ARTHUR M. BUECHE

November 14, 1920–October 22, 1981

BY ROLAND SCHMITT

AMERICA'S "R&D TRIANGLE" was Arthur Maynard Bueche's favorite way of describing the unique contributions of universities, industry, and government to the nation's total technological strength. The soundness of that triangle was the principal focus of his extraordinary career in science, engineering, management, and statesmanship on behalf of technology.

Although he was employed in industry—by a single company for thirty years—Art Bueche's energy and enthusiasm led him to devote large segments of his time and talents to academia and government, while continuing to direct the technical affairs of General Electric with a style that earned the acclaim of his associates. He recognized that he could not do his full job as a leader of industrial technology without also fostering the strong roles of partners in the "triangle." For example, one of his major efforts during the year prior to his sudden death from a heart attack on October 22, 1981, was as key technical adviser to President-elect Reagan during the pre-inaugural transition period of late 1980 and early 1981. His writings and reports of that period include balanced and insightful comments on the respective roles of industrial, academic, and government technology, along with recommendations for improving the national economy, de-

fense, and the strength of the nation's educational system through cooperation and mutual respect. (Soon after his inauguration, President Reagan offered Dr. Bueche the post of presidential science adviser. Newspaper accounts at the time said Dr. Bueche had reluctantly declined for personal reasons. Although he never discussed this matter with them, his closest friends believe he had personal premonitions about his health that made him fear he could not give the White House position the all-out effort he felt it must have.)

Arthur Maynard Bueche[1] was born in Flushing, Michigan, on November 14, 1920. His father was an enterprising small-town businessman who put his son to work as a clerk in the family grocery store when he was eleven years old, and later as a millhand and mechanic in the family farm-implement business. During high school, young Art was very much involved in extracurricular activities, including debating, student government, track, football, plays, operettas, band, glee-club, and orchestra. Near the end of his senior year, several of his high school teachers counseled him to study law at the University of Michigan. "But," as he wrote later, "it didn't work out quite that way."

Art's father wanted him to stay in Flushing and learn to run the family's flourishing businesses. His mother wanted him to go on to college, although she had misgivings about a career in law. Almost on a whim, based partly on the respect he had for his high school chemistry teacher but even more because of the ambition of a close friend and classmate, Art decided he wanted to be a chemical engineer. He enrolled at

[1] Art preferred that the name be pronounced BEEK'-uh, although he was always remarkably tolerant of the countless variations he inevitably encountered. His associates in chemistry suggested it was like "beaker," without the *r*, and a favorite in-house couplet made note of his role as GE's fourth research director:

Like Archimedes, shout 'Eureka'—
Whitney, Coolidge, Suits, and Bueche.

Flint Junior College,[2] riding a bus ten miles each day from Flushing, and ended up in a liberal arts course with a "major" in chemistry. Early on at Flint, an adviser told him he was better suited to the study of chemistry than of chemical engineering.

During his two years at the University of Michigan, where he received his B.S. in chemistry in 1943, Art began to recognize that his interests and aptitudes leaned more toward research than to formal course work. This interest survived and grew, even though his first major research effort—investigating the possibility that radioactive sulphur might have been produced in a large quantity of sodium chloride that had been stored for some years near the University's cyclotron—was, in his words, "a rather complete failure."

After nine months at Ohio State, the opportunity came for graduate work at Cornell University, which had been his original first choice. "Besides," he wrote, "Cornell paid slightly more." In some sketchy autobiographical notes written many years later, Art said, "At Cornell I shopped around for a thesis adviser and found many fine possibilities. Unfortunately, the adviser I wanted most was Professor (Peter) Debye, but he was reluctant to take on any more students. I guess I forced my way on him."

In January of 1946, soon after presenting his first paper (on thermal diffusion of polymer solutions) to the American Physical Society, Art was encouraged to forego his teaching duties—"although I enjoyed them immensely"—so that he could devote his full attention to research on synthetic rubber in a program directed by Professor Debye under contract

[2] In later years, when asked to provide biographical information for the records of various organizations or for people who were to introduce him on speaking occasions, Dr. Bueche always asked that Flint Junior College be included along with the University of Michigan, Ohio State, and Cornell. He was a firm believer in the importance of education at all levels and was a great supporter of junior colleges.

from the Office of Rubber Reserve. He later wrote: "The contribution that I made which was perhaps the most pioneering in nature was that involving the determination of the size of polymer molecules in solution. To the best of my knowledge, this was the first time that this had been done and I was encouraged by Professor Debye to use his light-scattering theories to accomplish this." (Debye had received his Nobel Prize in 1936 for studies of light-scattering phenomena.) The Debye-Bueche work on the size and shape of polymer molecules has been fundamental to further studies of solution behavior, chemical reactions, and viscosity. Bueche received his Ph.D. in physical chemistry from Cornell in 1947.

The young Cornell research assistant was lured to Schenectady, New York, and the General Electric Research Laboratory mainly on the strength of a candid—at times almost confrontational—interview with Dr. A. Lincoln Marshall. Marshall, who headed GE's chemistry research, was a crusty, driving, entrepreneurial leader whose forceful nature had played a key part in getting General Electric started down the road of manufacturing polymer products for applications other than electrical insulation. He recognized that young Bueche had unusual intellectual capacity; he hoped there was also the kind of restless spirit so essential to the job of moving research results to practical application with minimum delay. Marshall's hopes, although he later admitted he had some reservations about them at first, were to be amply fulfilled. Thus Bueche joined GE "at the bench" in 1950. He not only adapted himself to the pace of industrial research but also was soon fully enmeshed in it. One of the advanced ideas in polymer science in the late 1940s involved shooting a beam of high-energy electrons into a polymer and trying to get the electrons to cause desirable new connections—crosslinks—between the individual long chains. Marshall, who had

worked on an early version of the idea back in 1925, initiated a project in 1951. It paired Bueche with a veteran physicist, Elliot Lawton. A million volt accelerator had become available due to the Lab's earlier x-ray work. In 1952, Lawton and Bueche used it to crosslink polyethylene. GE's Chemical Products Department immediately became interested, and work got under way leading to another new product, Irrathene®, a high-performance plastic that was the first ever made by electron irradiation techniques. Making crosslinked polyethylene at all represented a substantial achievement. However, making it by electron beam irradiation turned out to be too expensive for anything but specialty applications. But it catalyzed a new insulation technology.

The first half-dozen years in Schenectady, from 1950 until 1956, constituted Bueche's "research years." It was a time of wide-ranging exploration into new fields of polymer chemistry, of writing papers, and of producing patents at the rate of about two each year. Although he had first assumed a managerial title in 1953 (leading a small research team then called Polymer and Interface Studies), it was not until the late 1950s that his growing responsibilities forced him to spend a majority of his time in management, rather than at the bench.

When Marshall retired in 1961, C. Guy Suits, GE's research director, recognized Bueche as the obvious choice to head the Chemistry Research Department, which by that time was deeply involved in developments that would lead to General Electric's remarkable success in the engineering plastics business. As manager of chemistry research, Bueche had demonstrated incisiveness, ability to motivate others, increased understanding of business problems and their relationships to technological opportunities, and—on a day-to-day basis—fundamentally sound management skills. It was no great surprise, then, that Arthur M. Bueche was named

to succeed Suits when the latter retired in 1965. Bueche was to continue the notable record of continuity among research directors at GE: Willis R. Whitney, the laboratory's founder, had served from 1900 to 1932; William D. Coolidge from 1932 to 1945; and Suits from 1946 to 1965. Bueche would extend this record so that the leadership of these four men would span seventy-eight years!

Although it may not have been surprising that Bueche succeeded Suits, there were shock waves within the ranks of GE technology when, in announcing Bueche's new appointment, the company also said it was combining the Research Laboratory with the Advanced Technology Laboratories to create a new entity to be known as the General Electric Research and Development Center. Thus Art Bueche's new job brought with it a major challenge. The former Research Laboratory, an organization with a long tradition of emphasis on fundamental research, had always been supported almost completely by GE corporate funds, and it had often been cautioned in the past by company management *not* to perform engineering or development work that might detract from its science-oriented mission. The former Advanced Technology Laboratories, earlier called the General Engineering Laboratory, was an institution that had suffered a variety of ups and downs because of its broad dependence on contracts for support, a place where short-range results were the principal priority, and an organization sometimes looked on as a "poor cousin," occupying quarters in the Schenectady Main Plant that were a far cry from the glamorous surroundings created for the Research Laboratory "out on the hill" at a site overlooking the Mohawk River in nearby Niskayuna. Art Bueche's assignment was to not only integrate these two disparate organizations into a cooperative, smoothly working whole, but also—of greatest importance—to "get them connected to the company" and in tune with

General Electric's growing technological needs and objectives.

On the night before Dr. Bueche died, he was honored in absentia by the Franklin Institute with its Delmer S. Fahrney Medal. The citation read on that occasion succinctly summarized how well the challenges of 1965 were met. It read, in part:

> From 1965 to 1978, under his leadership, this combined entity (the new General Electric Research and Development Center) achieved remarkable success, with the staff grown to more than 2000, including 800 scientists and engineers, and with laboratories in many domestic and overseas locations. Dr. Bueche's leadership of these operations has been recognized as an unusually outstanding example of managerial skill. He has been highly innovative in the development of effective approaches to both strategic and operational planning of technical work, in devising new technical liaison and technical information exchange techniques, in promoting and recognizing technical excellence, and in encouraging an extremely diversified company to utilize its varied strengths in new organizational and operations approaches.

Art Bueche himself once defined his job this way: "Our fundamental task is to spot the kind of person who at least demonstrates the potential for being the one in a hundred—one in a thousand—one in a lifetime—who may have the flash of true genius. Then our job, above all others, is to give these people, and their ideas, a chance to survive and grow." He would constantly ask his associates, "What's new? What's the new idea? Why can't we get this done faster? What are the obstacles? Let's get moving." He pushed, directed, stretched, and challenged people to reach beyond what they had thought they could accomplish. As one coworker told a news reporter preparing an article about Art Bueche, "It's tough to match his effort on the job, seven days a week. He sets an example that's difficult for people to follow. And this inspires them. He won't take no for an answer. And he wants to understand everything."

The achievements of the R&D Center under his leadership were many and noteworthy. In electronics, the accomplishments included the development of an advanced computerized axial tomography (CAT) x-ray scanner; the development of the first solid-state imager based on charge-injection device technology; invention of thermomigration, a process that reduced the time required for certain semiconductor processing steps; and the invention of the surface charge correlator, a new semiconductor device for analog signal processing. Achievements in new materials technology included development of a commercial process for fabricating cubic boron nitride, a man-made material second in hardness only to diamond; invention of polycrystalline diamond "compacts" for metal-cutting tools; the creation in the laboratory of the first synthesized gem diamonds; the first simple and inexpensive technique for fabricating ceramic parts of silicon carbide; invention of silicon/silicon carbide composites; and several high-performance plastics, including a family of resins based on a unique technology of polymerization by oxidative coupling. In the field of energy R&D, achievements included advances in the development of water-cooled gas turbines, sodium-sulphur batteries, coal-gasification technology, and the production of energy-efficient lamps.

Dr. Bueche's achievements brought him a variety of medals and honors, including eight honorary doctorates. They also brought him promotion within General Electric, to the post of senior vice president for corporate technology in 1978. This meant he became the company's top technical officer and spokesman and joined the corporate executive committee—but he also had to move from Schenectady to Fairfield, Connecticut. This required that he relinquish the direct day-to-day responsibility for the R&D Center, although the Center remained under his purview as a senior officer.

From the time he first became a company officer in 1965,

Dr. Bueche recognized his role and responsibility as a public spokesman for technology. His platform appearances, before GE and outside audiences, averaged nearly one each week over a period of fifteen years. He was in great demand as an interpreter of technology and, toward the end of his career, as a forthright spokesman on technology policy and the appropriate roles of universities, industry, and government in the "R&D triangle." He also spoke to many international audiences: in Japan, the South American nations, Mexico, Canada, France, Italy, Spain, and Germany. He served as American chairman of the World Electrotechnical Congress in Moscow during 1977. Appearances in Great Britain included a Faraday Lecture at the Royal Institution (during which Man-Made© diamonds were actually produced "on the spot") and the Kelvin Lecture for the Institute of Electrical Engineers.

As an active member of the National Academy of Sciences, he served on the Academy Forum Advisory Committee and the Finance Committee. He was a member of the National Academy of Engineering and of the Executive Committee of its Council. He served as president and a director of the Industrial Research Institute.

In government, he was active on several advisory groups to the president's office on matters related to science and technology. He also served as a member or consultant with science and technology committees of the National Science Foundation, NASA, the U.S. Air Force, the National Bureau of Standards, and the Energy Research and Development Administration.

In education, he served on the Board of Trustees of the Rensselaer Polytechnic Institute, the Albany Medical College, and the Hudson-Mohawk Valley Association of Colleges and Universities. He was a member of Visiting Committees at Massachusetts Institute of Technology, Harvard, and Duke;

of the Advisory Committee of the School of Metallurgy and Materials Science, as well as of the Board of Overseers, for the School of Engineering and Applied Science at the University of Pennsylvania; and of the Advisory Board of the Institute of Materials Sciences at the University of Connecticut. His contributions to, and associations with, his alma mater, Cornell, were legion; among his assignments was chairmanship of the Council for the College of Engineering.

While a resident of Schenectady (from 1950 to 1978), his public service included board membership of Ellis Hospital and of Sunnyview Hospital and Rehabilitation Center. He also found considerable personal satisfaction in helping guide the affairs of one of the area's largest and most progressive banking institutions, the Schenectady Savings Bank (now Northeast Savings), as an active board member.

On Monday evening, October 19, 1981, Art Bueche served as chairman of a dinner meeting at GE's Fairfield headquarters, held to honor eleven Steinmetz Award winners, people from various GE business components who had made outstanding technical contributions during their careers with the company. Early the next morning, he suffered a massive heart attack. In spite of superb medical attention, including some pioneering new techniques, he died at St. Vincent's Hospital, Bridgeport, Connecticut, on October 22, 1981.

His family[3] and associates moved at once to establish a fitting memorial: the Arthur M. Bueche Memorial Fund, currently administered by the National Academy of Engineering. Each year the NAE Awards Committee will select a recipient to be honored for "outstanding statesmanship in

[3] Dr. Bueche was survived by his four children: Kristine of Wilmington, North Carolina; A. John of Ellsworth, Maine; Margaret of Ballston Lake, New York; Elizabeth of Schenectady, New York; one grandchild; and two brothers, Frederick J. of Flushing, Michigan, and Bernard M. of Flushing, New York.

science and technology." The recipients will be asked to present lectures on science and technology issues, and a cash gift will be made to the school where the lecture is presented.

At the funeral service in St. John the Evangelist Church, Schenectady, on October 27th, one of Dr. Bueche's long-time associates said in his eulogy:

> Above all, Art Bueche was tough-minded. That was a quality he respected—highly respected—in others. And we respected, admired, envied him for his tough-mindedness—for the intellectual power—for the concentration—for the genius' attention to detail—for the searching questions that made us all recognize, so often, how far ahead of us he was in his thinking—for the willingness to devote energy, time, enthusiasm, and persistence to the task at hand, with a diligence and dedication the rest of us could only marvel at, hold in awe.

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