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EDWIN RICHARD GILLILAND

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A Biographical Memoir by

THOMAS K. SHERWOOD

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EDWIN RICHARD GILLILAND was probably the best all-round chemical engineer of his generation. His exceptionally quick mind and thorough grasp of fundamentals enabled him to work very fast and to deal effectively with widely diverse technical problems. This made it possible for him to have what amounted to four parallel careers in his forty years of professional activity.

As an educator he served as department head, as chairman of the faculty, and on numerous committees at the Massachusetts Institute of Technology (MIT). At the same time, he supervised more than 100 doctoral students, many of whom later became prominent in industry and in teaching. As a research scientist, he wrote a hundred or more books and articles. Characterized by novelty and diversity, they are widely quoted. He served in many capacities in Washington, D.C.—as Assistant Rubber Director during World War II, later as a member of the President's Science Advisory Committee, on many committees of the National Academy of Sciences and the National Academy of Engineering, and the Department of Defense and other government agencies. As a consultant, he was much in demand by the chemical, petroleum, food, pharmaceutical, and textile industries. He greatly enjoyed consulting for industry, carrying practical problems back to the classroom and applying fundamental theory to the solution of industrial problems.

Gilliland was born on July 10, 1909, in El Reno, Oklahoma, but lived in Little Rock, Arkansas, from age nine until he went to the University of Illinois to study chemical engineering. His parents were of Scottish and Irish descent, and his great-grandmother's nephew was Governor James E. Cox of Ohio, the unsuccessful 1920 presidential candidate. His father, Owen Edwin Gilliland, was Chief Clerk of the Rock Island Railroad and the son of a minister of the Christian Church in Illinois. There were two other children: an older brother, Kelly, and a younger sister, Helen.

As a very young boy, Gilliland showed great intellectual curiosity as to the "how" and "why" of mechanical and electrical devices. When only six or seven he took his mother's sewing machine apart and put it back in good order. He did the same with clocks and watches. He was disconcerting to some of his teachers in school, but to others he was an "interesting challenge." Like many boys who were later to become chemical engineers, he had a small chemical laboratory—in a shack behind the garage. When very young he planned to become an electrical engineer, but his parents were insistent that he be a chemist; chemical engineering was a compromise.

After completing his early education in the public schools of Little Rock, Gilliland went to the University of Illinois at Urbana, where he received his B.S. in chemical engineering in 1930. There he was greatly stimulated by D. B. Keyes and H. F. Johnstone. The following year was spent at the Pennsylvania State College, where he received an M.S. in 1931 and published a paper with D. S. Cryder based on his master's thesis, which dealt with heat transfer to boiling liquids.

In the fall of 1931 he transferred to MIT, where he was to spend the rest of his life. His Sc.D. thesis was remarkable in that it was completed in about eighteen months and because its publication stimulated much interest in the use of wetted-wall columns for the study of mass transfer between liquids and turbulent gas streams. His basic technique has been used by many later workers, and his 1934 article is used today as a reference in laboratory courses in chemical engineering.

Following the receipt of his doctorate in 1933, Gilliland worked briefly on the mechanism of drying of solids with T. K. Sherwood, who had been his thesis supervisor. Quite on his own he developed an empirical modification of the kinetic theory equation for diffusion coefficients in binary gas systems at low pressures. Though now obsolete, this was used for many years for the estimation of diffusion coefficients in systems where data were not available.

It was not long after his arrival at MIT that Gilliland's unusual talents were recognized by Warren K. Lewis, and the two became close associates. They admired and stimulated each other and made numerous joint contributions to the literature and to the development of industrial processes. Gilliland became a co-author of the 1937 revision of the classic text *Principles of Chemical Engineering*. Lewis was much interested in distillation, and Gilliland also became intrigued by this subject, to which he contributed greatly over many years. In 1938 he revised the earlier classic book by C. S. Robinson, *Elements of Fractional Distillation,* and in 1950 was responsible for the fourth edition.

Gilliland joined Lewis as a consultant to the Standard Oil Development Company (later Esso and then Exxon) in 1934, when he was barely twenty-five, an association that continued until his death in 1973. His first contributions had to do with the cuprous ammonium acetate extraction process for olefin separation and purification, olefin complexing with solid cuprous salts, and slurry adductions of olefins and diolefins. He was co-author of a basic Esso patent on water extractive distillation of alcohols. Gilliland much enjoyed his Esso contacts and later developed similar associations with a number of other companies.

In the middle thirties the catalytic cracking of petroleum stocks began to show great promise, and both Gilliland and Lewis became interested, stimulated by their visits to Esso. This led to studies at MIT of fluidized beds of solid catalyst particles, and the development of the fluidized catalytic cracking process proceeded rapidly. The first commercial plant, which charged 12,000 barrels per day, went on-stream at Baton Rouge late in May 1942, and the new process became important for the production of high-octane gasoline during World War II.

Lewis and Gilliland get much of the credit for this enormously important process. The first page of their joint U.S. patent 2,498,088, "Conversion of Hydrocarbons with Suspended Catalyst," is reproduced by John L. Enos in his book *Petroleum Progress and Profits,* which is a history of the development of the more important petroleum cracking processes. By 1957 fluidized-bed cracking was being used to produce 62 percent of U.S. gasoline, and the process is still used to produce much of the world's gasoline today.

Gilliland was a man of strong principle, and he believed it improper to carry out confidential work for industry in a university laboratory. Publishable scientific studies stimulated by industrial problems were acceptable and were to be encouraged, but must be open to all, even while under way.

Gilliland continued his work on fluidized beds for many years, intrigued by their potentialities in the chemical industry for carrying out various chemical reactions. His work on the application of fluidized-bed techniques for the reduction of iron ores led to several publications and a number of patents. A commercial plant is now under construction in Venezuela.

At the outset of World War II, Gilliland undertook the development of a shipboard unit to produce oxygen, using a cobalt chelate compound that Melvin Calvin had prepared and that had been brought to the attention of the National Defense Research Committee by G. N. Lewis. On a pressure swing, this would take up oxygen from the air and then release it as the pressure cycled. He was soon called to Washington, D.C., where he served from 1942 through 1944 as Assistant Rubber Director in charge of research and development, under Bradley Dewey. It was characteristic of Gilliland that he devoted much of his time to the technical problems of rubber production and that during this period he made quite important contributions having to do with butadiene manufacture.

Following the end of the war, Gilliland returned to MIT to become Deputy Dean of Engineering. He was given this post with the idea that he would be made Dean of Engineering a few months later. Although he was an excellent administrator, he found that he much preferred research and teaching. He returned to the Chemical Engineering Department and during the twenty years that followed published widely on a variety of subjects on which he had not worked before the war.

He became a member of the Board of Advisers of the American Research and Development Company in 1946. This company had been incorporated in that year to solicit venture capital to be used to finance the commercialization of new technology. One of its first moves was the formation of Ionics, Inc., for the promotion of the exciting potentialities of electrodialysis. Because of the American Research and Development Company's financial interest, Gilliland was made President of the new small company, a post he held until 1964. He then served as Chairman of the Board until he resigned in 1971.

Gilliland's administrative duties at Ionics were light, but, typically, he became much interested in the technical problems of the company and in the broader problem of water desalination by whatever method. He supervised doctoral research on separation techniques using ion exchange and membranes, and in his 1955 article, "Fresh Water for the Future," he proposed the use of an immiscible refrigerant to freeze salt water by direct contact heat transfer, the ice formed being separated, washed, and then melted to produce fresh water. This is the freezing process for water desalination in use today.

He continued his interest in fluidized beds and distillation, but he became much intrigued with a wide variety of other scientific and technical studies, in which he made important contributions. Among these were blood rheology and blood dialysis, and he co-authored a number of papers with E. W. Merrill and others describing experimental investigations in these fields. The appended list of titles of his publications illustrates the enormously wide range of his research interests during the postwar years.

Gilliland was an excellent teacher, especially stimulating to the better students. He was a popular student choice as supervisor of Sc.D. theses and was at his best in the role of a teacher. As noted earlier, he supervised more than 100 Sc.D. theses in chemical engineering, together with a large number of masters' theses. He almost never missed the weekly two-hour session of oral reports by the graduate students in the department who were engaged in thesis research.

Appointed an instructor in 1934, he became full professor in 1944, the first Warren K. Lewis Professor in 1969, and Institute Professor in 1971. He was chairman of the MIT faculty during 1952–1954 and served on many faculty committees concerned with various MIT affairs. From 1951 to 1961 he served three times as acting head of the department for periods of a year or more when W. G. Whitman was on leave for temporary assignments both in Washington, D.C. and with the United Nations. He was appointed department head in 1961 and served in that post until 1969, when he again elected to return to full-time research and teaching. From 1946 to 1952 he was Associate Director of the MIT Laboratory of Nuclear Science and Engineering. Nuclear engineering at MIT was started in 1951 within the Department of Chemical Engineering when Gilliland was acting head; it prospered and later became a separate department.

From 1947 to 1955 he was consultant to the Brookhaven National Laboratory.

He spearheaded the drive for plans and funding for a new building for the department (the building was completed in 1975) and was largely responsible for the establishment of three endowed chairs in chemical engineering. Although engaged in many outside activities, his first loyalty throughout his career was to MIT.

Following his stint as Assistant Rubber Director during the war, Gilliland became increasingly active on government panels and boards. During the last year of the war, he was a member and Deputy Chief of Division 11 of the National Defense Research Committee, Office of Scientific Research and Development (OSRD), and the following year Deputy Chairman of the Joint Chiefs of Staff Guided Missiles Committee and a member of the Industrial Disarmament Committee. From 1944 to 1945 he had been Chief of the Jet-Propelled Missiles Panel of the OSRD's Office of Field Service. This panel prepared several reports under assignment to the Coordinator of Research and Development, U.S. Navy, for submission to the Commander in Chief, U.S. Fleet. Gilliland was the sole author of the one on rocket-powered missiles.

During the immediate postwar period, he also served as Vice Chairman of the National Advisory Committee for Aeronautics' Subcommittee on Fuels and Lubricants, Chairman of the Committee on Fuels and Lubricants Panel on Fuels Requiring Oxidizers of the Department of Defense's Research and Development Board, and later (1955–1960) as a member of the Joint Working Group on Special Fuels, Office of the Secretary of Defense.

Gilliland was appointed to the President's Science Advisory Committee in 1961 and served for four years during the Kennedy–Johnson administration, subsequently becoming a consultant to the Office of Science and Technology. Other government service during the late sixties included membership on the Ad Hoc Advisory Committee, Office of Saline Water, U.S. Department of the Interior (1965–1967), and on the National Air Pollution Research and Development Advisory Council of the Environmental Health Service, U.S. Department of Health, Education, and Welfare (1970–1972). At Oak Ridge National Laboratory he was a member of the Management Advisory Council (1962–1973) and of the laboratory's Senior Advisory Panel for Middle East Study (1968).

Following his election to the National Academy of Sciences (NAS) in 1948 and to the National Academy of Engineering in 1965, he became active in the affairs of both academies. He served as a member of the NAS's Nominating Committee (1965–1966) and of the Finance Committee from 1966 until his death, in 1973. He was Chairman of both the Section of Engineering and of Class III from 1966 to 1969. He was member-at-large of the Division of Engineering of the National Research Council, member of the Executive Committee (1969–1973), and member of the NAS's Visiting Committee for the Highway Research Board (1971–1973). His committee service for the National Academy of Engineering included membership on the Committee on the Patent System (1968–1970) and the Projects Committee (1968–1971).

Although Gilliland was a member of several professional societies and of the American Academy of Arts and Sciences, he participated relatively little in their affairs. He was, however, a director of the American Institute of Chemical Engineers from 1958 to 1960. He disliked conventions and large meetings, much preferring small groups concentrating on discussions of technical problems. On one notable occasion, however, he addressed a meeting of the American Institute of Chemical Engineers, held in Columbus, Ohio, shortly after the war. During the course of his talk, he berated the profession for its obsession with empirical studies of the packed towers used for gas absorption and distillation, suggesting forcefully that there were more important things they might be doing. The audience included a large number of professors whose thesis students were studying the performance of packed towers.

Gilliland's extensive activities in research, teaching, writing, and various MIT educational and administrative affairs, together with frequent Washington assignments, would seem to be more than enough to occupy a professional lifetime. At the same time, however, he was able to do a great deal of industrial consulting. He not only enjoyed this, but felt that the real-world technical problems he was able to bring to the classroom served greatly to stimulate students and enhance the teaching of an engineering subject. He believed that high-level consulting by educators effectively countered the growing dichotomy between industry and the university—the trend in the engineering schools toward more and more theoretical analysis of imagined industrial problems and the deficiency in fundamentals on the part of the practicing engineer. He carried real problems to the classroom and relevant theory to industry. His contacts with each of several industries was maintained over a period of years —he did not make brief visits to help solve immediate problems. His role was to guide the company's research policy and to stimulate the men working on important industrial problems. His success was largely due to the facility with which he applied the fundamentals of physics, thermodynamics, physical chemistry, and mechanics to seemingly unrelated industrial situations.

Gilliland's many years of association with Exxon and Ionics have been noted above. He was a consultant to Merck for more than twenty-five years, working with its people on the production and purification of numerous vitamins and pharmaceutical products, reaction kinetics, process design, reverse osmosis, semiconductor technology, and many other things. He served as a consultant to the Dewey and Almy Chemical Company for a similar period and was Director of that company until it was absorbed by W. R. Grace and Company in 1954.

Bradley Dewey and Gilliland had worked closely together on the rubber program during the war, and their association continued. Following his retirement from Dewey and Almy, Dewey had formed the Hampshire Chemical Company to make isocyanates, and Gilliland served as a director of that company until it, too, was taken over by Grace. It is possible that Dewey was responsible for Gilliland's connection with the textile firm Deering Milliken, for whom Gilliland was a consultant for fifteen years before his death. Textiles seem a far cry from cracking of petroleum, but chemical engineering concepts were relevant to the company's production of textile finishes, adhesives, and chemicals. The management was so impressed by Gilliland's contributions that they named their production facility at Laurens, South Carolina, the "Gilliland Plant." Their admiration for him is further evidenced by their contribution to the funding of the new MIT chemical engineering building, made with the request that the auditorium be named the "Gilliland Auditorium."

Other consulting connections, most continuing over long periods, included Halcon International, Inc., Goodyear, General Electric, and Nestlé. He never discussed his consulting work with his MIT colleagues, and it is a mark of his high ethical standards that there was never a hint of a conflict of interest in his work with so many companies. His consulting career is a fine example of how a professor's industrial contacts can benefit engineering education and at the same time assist industry in the application of basic concepts to practical problems.

Gilliland was married in 1938 to Ann Frances Miller, daughter of David and Margaret (McDonald) Miller, of Somerville, Massachusetts. Their daughter, Gail, is Mrs. Grafton J. Corbett III. Gail and her father enjoyed a close relationship and did many things together. The Gillilands led a modest social life, but Ed was not interested in golf clubs, vacation travel, or large social gatherings. He greatly enjoyed people, but preferred small groups with discussions (and arguments) about current social and economic issues, or science. Though he seldom told jokes, he had a fine sense of humor and thoroughly enjoyed stories told by others. He was never known to gossip. He managed somehow to spend a great deal of time on his hobbies, which were electronics, making and repairing antique clocks, gardening, boating, and swimming.

People who met Gilliland for the first time were impressed by his attractive personality, but especially by the intense activity of his quick mind. In talking to others and in lecturing, his thoughts tended to run ahead of his speech, and he had a peculiar habit of ending a sentence with the words "and the one," giving him a moment to synchronize his speaking and thinking.

Gilliland's first professional award was at age thirty-five, when he received the first Baekeland Medal from the American Chemical Society for achievement in industrial chemistry. The same society honored him with the Murphree Award in Industrial and Engineering Chemistry in 1945. He received the top awards of the American Institute of Chemical Engineers: the Professional Progress Award (1950), the William H. Walker Award for outstanding publications (1954), the Warren K. Lewis Award in Chemical Engineering Education (1965), and election as Fellow. Northeastern University awarded him an honorary doctorate in 1948.

Although not very active in the affairs of professional societies, he was a member of several: the American Institute of Chemical Engineers, the American Chemical Society, the American Institute of Chemists, the Society of Chemical Industry, the American Association for the Advancement of Science, the American Society for Engineering Education, Sigma Xi (chapter president, 1961–1962), Tau Beta Pi, and Phi Lambda Upsilon.

Edwin Richard Gilliland packed four remarkable careers into one modest life span: research, teaching, government service, and industrial consulting. That this was possible can be explained only by his ability to think so rapidly and arrive at sound conclusions while others were still trying to define the problem. He worked intensely, but managed to enjoy life thoroughly.

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KEY TO ABBREVIATIONS

Am. Inst. Chem. Eng. J. = American Institute of Chemical Engineers Journal
Chem. Eng. News = Chemical and Engineering News
Chem. Eng. Prog. = Chemical Engineering Progress
Chem. Eng. Prog. Symp. Ser. = Chemical Engineering Progress Symposium Series
Ind. Eng. Chem. = Industrial and Engineering Chemistry
Ind. Eng. Chem. Fundam. = Industrial and Engineering Chemistry Fundamentals Quarterly
J. Am. Chem. Soc. = Journal of the American Chemical Society
J. Appl. Physiol. = Journal of Applied Physiology

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